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An Inventory of Geothermal Resources in Nebraska

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Energy

GEOTHERMAL

AN INVENTORY OF GEOTHERMAL RESOURCES IN NEBRASKA

Final Report

By
William D. Gosnold
Duane A. Eversoll

June 30, 1983

Work Performed Under Contract No. AS07-79ET27205

The University of Nebraska
Lincoln, Nebraska

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AN INVENTORY OF
Geothermal Resources In Nebraska

State-Coupled Program between
U.S. Department of Energy
and
The University of Nebraska

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FINAL REPORT
June 30, 1983

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INDEX

INTRODUCTION

The goal of the State Coupled Resource Assessment Program is to identify and evaluate geothermal resources in the state, particularly low-temperature potential. Eight tasks were identified and documented in this report as follows:

TASK ONE: Bottom-hole Temperature Survey

TASK TWO: Heat Flow and Temperature Gradient Survey

TASK THREE: Data Translation Studies

TASK FOUR: Gravity Data

TASK FIVE: Substate Regions

TASK SIX: Information Dissemination

TASK SEVEN: State Geothermal Map

TASK EIGHT: Reports

The project had three major products; (1) a map "Geothermal Resources of Nebraska," (2) a significant amount of thermal data collected and documented within the state, and (3) a series of publications, presentations and meetings (documented as an Appendix).

TASK ONE

Definition

Task one was to complete a survey for available bottom-hole temperature data (BHT), produce a map showing the location of these data, and construct/contour maps depicting temperature versus depth.

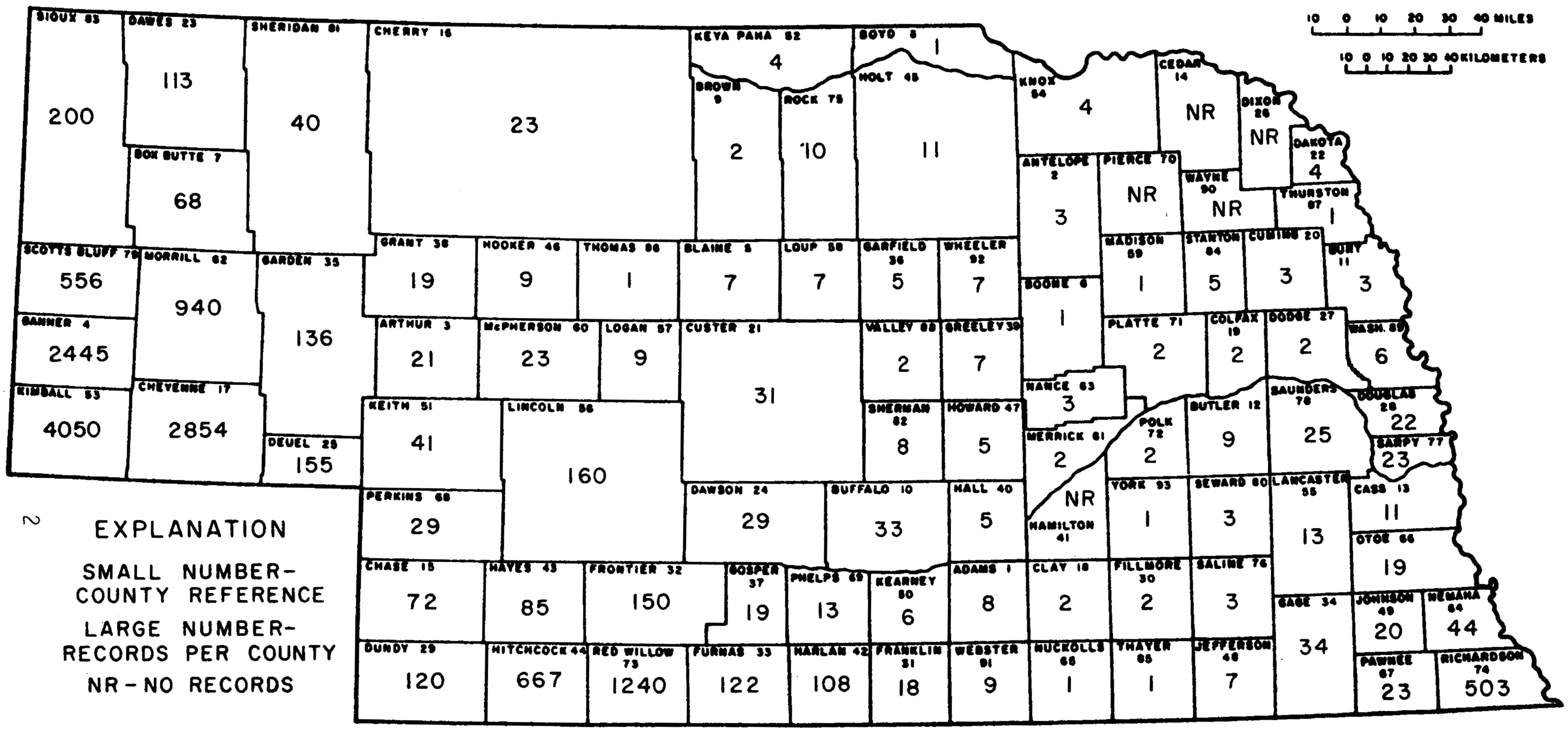
Procedure

Bottom-hole temperature data are a part of the information submitted for holes drilled for oil, gas, minerals and water. The data files for the individual holes were entered into computer storage. Appropriate software was designed for input, edit, retrieval and display. Maps were produced from this data set and compared to other similar products.

Results

More than 15,000 deep holes have been drilled in Nebraska in search of oil, gas and other minerals. Most of these holes were logged with some type of mechanical survey. The headings of these logs contain reference data pertaining to hole conditions and bottom-hole temperature (BHT). Tens of thousands of holes have been drilled as water wells, but these tests are usually quite shallow and rarely note significant temperature data. Thus, the deep hole data set was the major source for the BHT inventory.

The distribution of the BHT data points per county is illustrated on Figure 1-1. A state map (1:500,000) showing location of the deep wells with BHT data is included in the contract report and is available from the Conservation and



EXPLANATION

SMALL NUMBER- COUNTY REFERENCE

LARGE NUMBER- RECORDS PER COUNTY

NR - NO RECORDS

DISTRIBUTION BY COUNTY OF THE GEOTHERMAL DEEP WELL DATA SET
(Bottom-Hole Temperature Surveys)
March 31, 1983

Figure 1-1

Survey Division. A software management system was created in order to structure this BHT data set and provide a variety of procedures for input-output, editing and manipulation. An example of output for one well is illustrated in Figure 1-2. The abbreviations utilized are those common to the petroleum industry and definitions are available. Reference numbers are shown for key to storage for each entry. Those for county reference are included on Figure 1-1 and listed on Table 1-1. An example of selected information extracted for interpretation of BHT is shown on Figure 1-3. This sample well could be used as point source data or combined with similar printouts for special data sets.

The BHT data management system can also be interfaced with statistical or graphics software for interpretative studies. Formation tops, as noted on Figure 1-2, can be extracted with BHT and related to the stratigraphic section in Nebraska, Figure 1-4. Distribution of BHT patterns can also be mapped and compared with distribution of major rock units (Figure 1-5). Variations of BHT with depth have been compared to the major structural trends as shown on Figure 1-6.

Of obvious interest in the context of resource development is the geothermal gradient. Figure 1-7 is the average annual surface temperature. A selected BHT data set was compiled and interpreted (AAPG 1976) to produce a national geothermal gradient map. The Nebraska portion of the AAPG map is generalized on Figure 1-8. A similar map was constructed from our current BHT data set (Figure 1-9). The trends and general forms of subsurface temperature anomalies have a good correlation between Figures 1-8 and 1-9.

There are, however, significant differences in gradient values. At least part of this variability is due to the correction values utilized for the AAPG study and because their study was based upon selected wells. However, an interpretation utilizing all data is difficult due to the inconsistency of the data. These concerns are discussed under Task Three. These factors as well as

NEBRASKA COUNTY:***********1 SEC TNP/N RNG -LOCATION- LAT. :302303304
TOP CARD NUMBER:****134 *2 *3 **4 *5-*6-*7-*8-*9 LONG.:305-306307

FARM: -WELL NO.- -ELEVATION- - - DEPTH - - - -API NO.-
*************10 *12-*13 KB :**21 CASING :**55 37877 -**130
*************11 DF :**22 PBTD :***25
GL :**23 TD :***24 TD ELEV.:***301

OPERATOR:
******************14 PRODUCING FM. :*****************26 -STATUS-
******************15 SPUD :29-30-31 IP: BOD :**27 INT-CUR-YR
COMP :32-33-34 MCFD :***28 *16-*17-18

FIELD:
***********19 -WILDCAT- - - - - - - - - DATA ON FILE - - - - - - - -
***********20 56 REPORTS: -LOGS- BASIS FOR FM. TOPS :50
WCR :35 ES :42 ELECTRIC LOG :51
- - -DOWNHOLE DATA- - - - PA :36 IES :43 SAMPLE STUDY :52
DATE LOG RUN :131132133 S :37 ML :44 OPERATORS REPT. :53
BOTTOM LOG INTERV. :***57 SL :38 LL :45 SCOUT REPORT :54
SURFACE MUD TEMP.(F) :*58 SD :39 I :46
BHT (F) :*59 DL :40 R :47 RECD. BY:*49
BHT ELEVATION :***308 DT :41 OTHER:************48INPUT BY:136
HRS. SINCE CIRC. :***60 GOOD:135 DATE:137-138139

- - - - - - - - - - - - - - - - - - FORMATION TOPS - - - - - - - - - - - - - - - -

TOP OF:	DEPTH:	ELEV:	TOP OF:	DEPTH:	ELEV:
- - TERTIARY - - --	:***61	:***309	- - PENNSYLVANIAN--	:***90	:***310
- - CRETACEOUS - --	:***62	:***311	WABAUNSEE	:***91	:***312
PIERRE	:***63	:***313	TARKIO	:***92	:***314
NIOBRARA	:***64	:***315	HOWARD	:***93	:***316
FT. HAYS	:***65	:***317	SHAWNEE	:***94	:***318
CODELL	:***66	:***319	DEER CREEK	:***95	:***320
CARLILE	:***67	:***321	OREAD	:***96	:***322
GREENHORN	:***68	:***323	DOUGLAS	:***97	:***324
GRANEROS	:***69	:***325	LANSING	:***98	:***326
\`X´ BENTONITE	:***70	:***327	KANSAS CITY	:***99	:***328
DAKOTA \`D´	:***71	:***329	WYANDOTTE	:**100	:***330
HUNTSMAN	:***72	:***331	WINTERSET	:**101	:***332
DAKOTA \`J´	:***73	:***333	BASE KANSAS CITY	:**102	:***334
SKULL CREEK	:***74	:***335	MARMATON	:**103	:***336
FALL RIVER	:***75	:***337	CHEROKEE	:**104	:***338
FUSON	:**124	:***339	ATOKA	:**105	:***340
LAKOTA	:**125	:***341	MORROW	:**106	:***342
- - JURASSIC - - --	:***76	:***343	- - MISSISSIPPIAN--	:**107	:***344
MORRISON	:***77	:***345	MERAMEC - OSAGE	:**108	:***346
SUNDANCE	:***78	:***347	KINDERHOOK	:**109	:***348
- - TRIASSIC - - --	:***79	:***349	- - DEVONIAN - - --	:**111	:***350
- - PERMIAN - - - -	:***80	:***351	CHATTANOOGA	:**110	:***352
CIMARRON	:***81	:***353	HUNTON	:**126	:***354
BLAINE (MINNEKHATA)	:***82	:***355	- - SILURIAN - - --	:**112	:***356
STONE CORRAL	:***83	:***357	- - ORDOVICIAN - --	:**113	:***358
WELLINGTON	:***84	:***359	MAQUOKETA (SYLVAN)	:**127	:***360
CHASE (HERINGTON)	:***85	:***361	GALENA (VIOLA)	:**114	:***362
FORT RILEY	:***86	:***363	DECORAH (SIMPSON)	:**115	:***364
COUNCIL GROVE	:***87	:***365	ST. PETER (WILCOX)	:**116	:***366
COTTONWOOD	:***88	:***367	UPPER ARBUCKLE	:**117	:***368
ADMIRE	:***89	:***369	- - CAMBRIAN - - --	:**118	:***370
			LOWER ARBUCKLE	:**119	:***371
			LAMOTTE (REAGAN)	:**120	:***372
			- - PRECAMBRIAN - -	:**122	:***374
			WEATHERED	:**121	:***373
			FRESH	:**123	:***375

ADDITIONAL DATA:
(N C D P B M O K):*****128
COMMENTS:****************129

Figure 1 - 2

REFERENCE NUMBERS FOR COUNTIES

IN DEEP WELL DATA SET

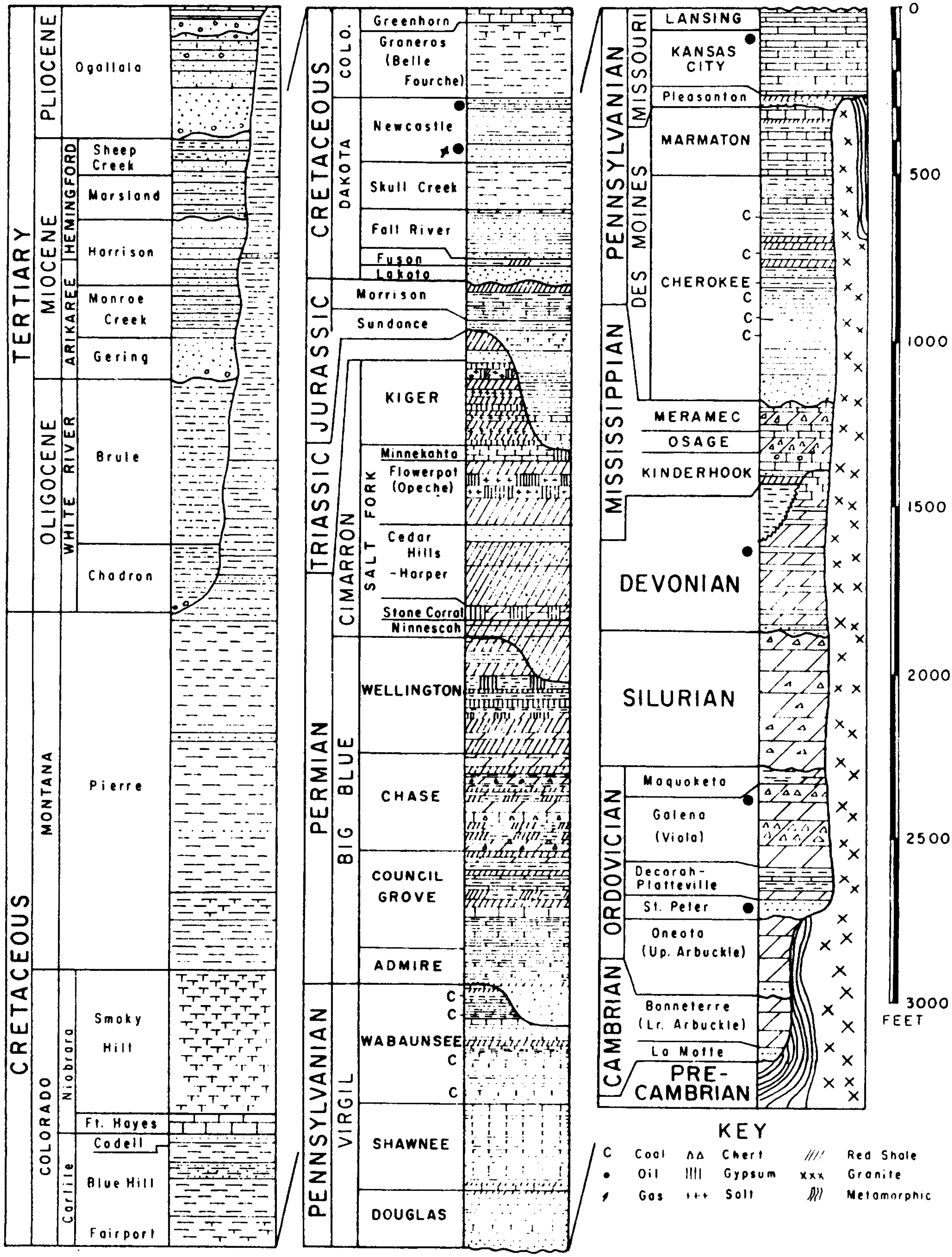
1. ADAMS
2. ANTELOPE
3. ARTHUR
4. BANNER
5. BLAINE
6. BOONE
7. BOX BUTTE
8. BOYD
9. BROWN
10. BUFFALO
11. BURT
12. BUTLER
13. CASS
14. CEDAR no records 3/31/83
15. CHASE
16. CHERRY
17. CHEYENNE
18. CLAY
19. COLFAX
20. CUMING
21. CUSTER
22. DAKOTA
23. DAWES
24. DAWSON
25. DEUEL
26. DIXON no records 3/31/83
27. DODGE
28. DOUGLAS
29. DUNDY
30. FILLMORE
31. FRANKLIN
32. FRONTIER
33. FURNAS
34. GAGE
35. GARDEN
36. GARFIELD
37. GOSPER
38. GRANT
39. GREELY
40. HALL
41. HAMILTON no records 3/31/83
42. HARLAN
43. HAYES
44. HITCHCOCK
45. HOLT
46. HOOKER
47. HOWARD
48. JEFFERSON
49. JOHNSON
50. KEARNEY
51. KEITH
52. KEYA PAHA
53. KIMBALL
54. KNOX
55. LANCASTER
56. LINCOLN
57. LOGAN
58. LOUP
59. MADISON
60. McPHERSON
61. MERRICK
62. MORRILL
63. NANCE
64. NEMAHA
65. NUCKOLLS
66. OTOE
67. PAWNEE
68. PERKINS
69. PHELPS
70. PIERCE no records 3/31/83
71. PLATTE
72. POLK
73. REDWILLOW
74. RICHARDSON
75. ROCK
76. SALINE
77. SARPY
78. SAUNDERS
79. SCOTTS BLUFF
80. SEWARD
81. SHERIDAN
82. SHERMAN
83. SIOUX
84. STANTON
85. THAYER
86. THOMAS
87. THURSTON
88. VALLEY
89. WASHINGTON
90. WAYNE no records 3/31/83
91. WEBSTER
92. WHEELER
93. YORK

Table 1 - 1

```
NEBRASKA COUNTY:29            SEC TNP/N  RNG    -LOCATION-     LAT.   :**-**-**
TOP CARD NUMBER:121            2     1    39   NE-NE-  -  -    LONG.:***-**-**

FARM:               -WELL NO.-  -ELEVATION-    - - DEPTH - -       - -API NO.-
HANSEN               1  -        KB :3295      CASING :358         ***** -
                                 DF :          PBTD    :4517
                                 GL :3249      TD      :4550    TD ELEV.:******
OPERATOR:
DEVON CORP.                PRODUCING FM.  :LNSG                       -STATUS-
                            SPUD   :06-05-81     IP:   BOD   :4     INT-CUR-YR
                            COMP   :11-30-81           MCFD  :      D&A-D&A-81
FIELD:
HORSE CREEK        -WILDCAT-     - - - - - - - - DATA ON FILE - - - - - - - -
                       X          REPORTS:        -LOGS-     BASIS FOR FM. TOPS :KB
                                   WCR  :         ES  :        ELECTRIC LOG     :X
- - -DOWNHOLE DATA- - - -          PA   :X        IES :        SAMPLE STUDY     :
DATE LOG RUN      :06-08-81        S    :         ML  :        OPERATORS REPT.  :X
BOTTOM LOG INTERV. :2200           SL   :         LL  :        SCOUT REPORT     :
SURFACE MUD TEMP.(F) :85           SD   :         I   :
BHT (F)              :103          DL   :         R   :     RECD. BY:MB
BHT ELEVATION      :******         DT   :         OTHER:DIF CD CDN       INPUT BY:KAM
HRS. SINCE CIRC.    :3                                  GOOD:Y     DATE:07 -27-82
```


Figure 1 - 3



Columnar section, bedrock formations.

Figure 1 - 4

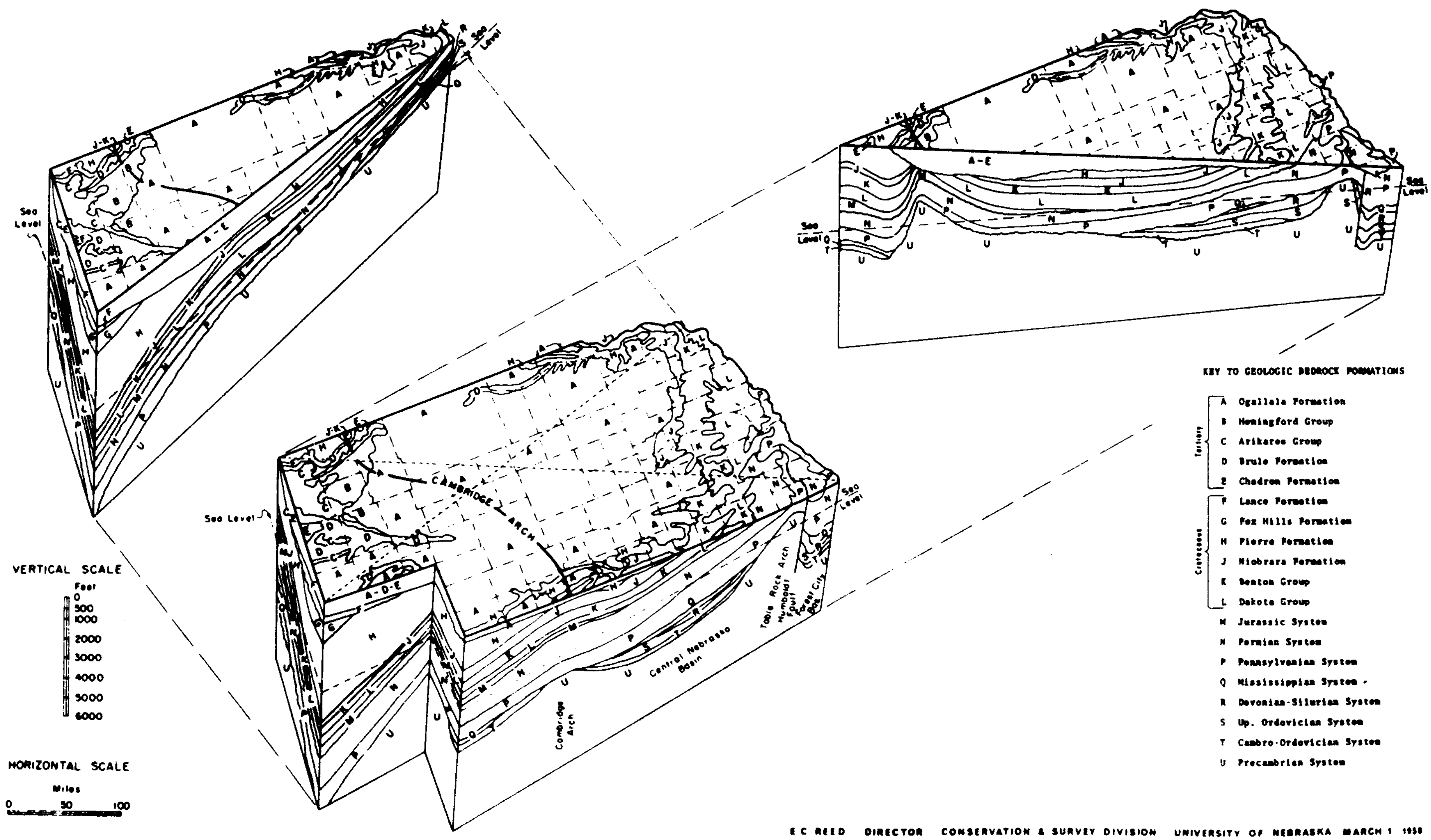


Figure 1 - 5

BLOCK DIAGRAM ILLUSTRATING THE EXTENT AND THICKNESS OF GEOLOGIC UNITS

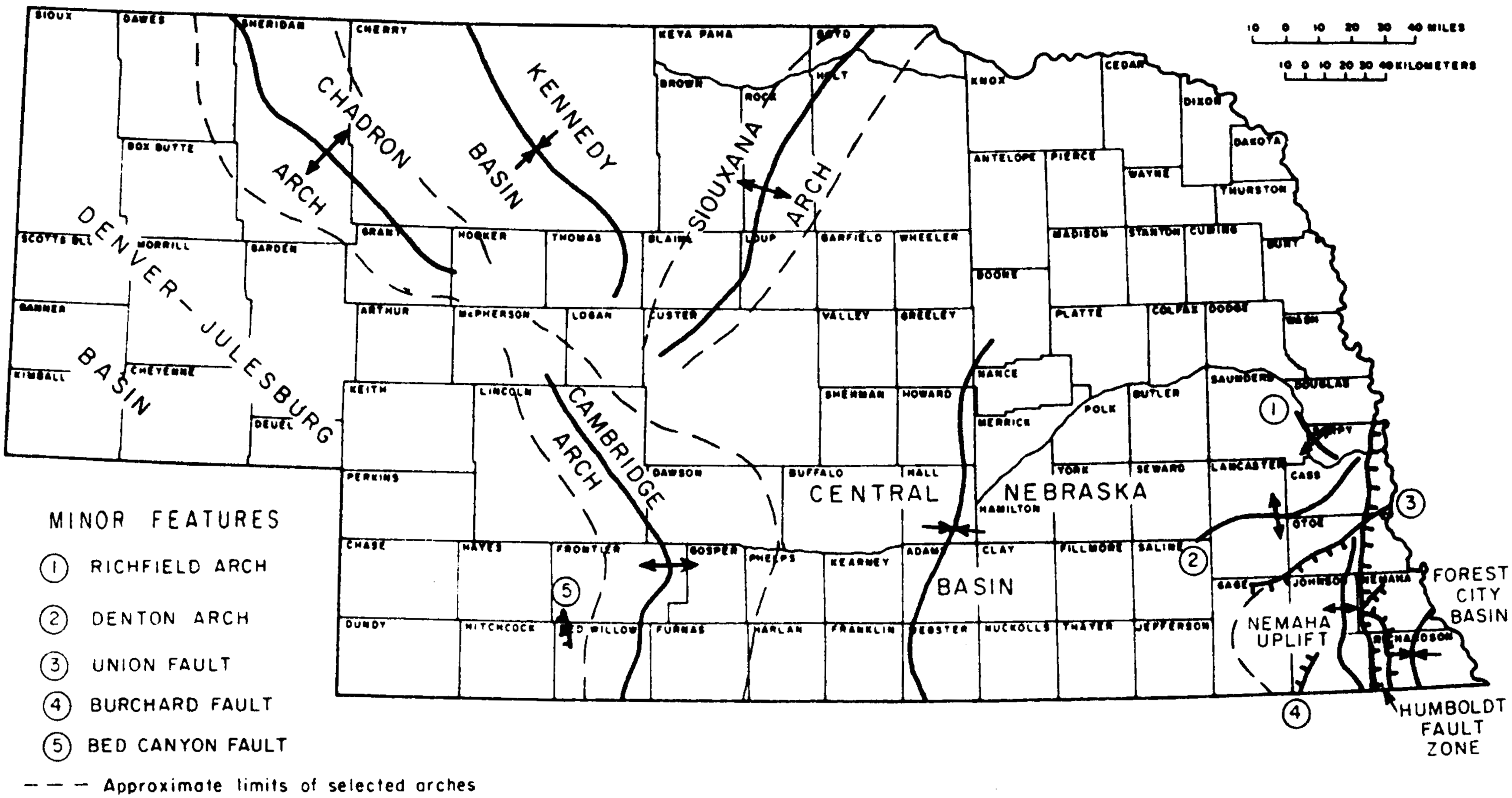
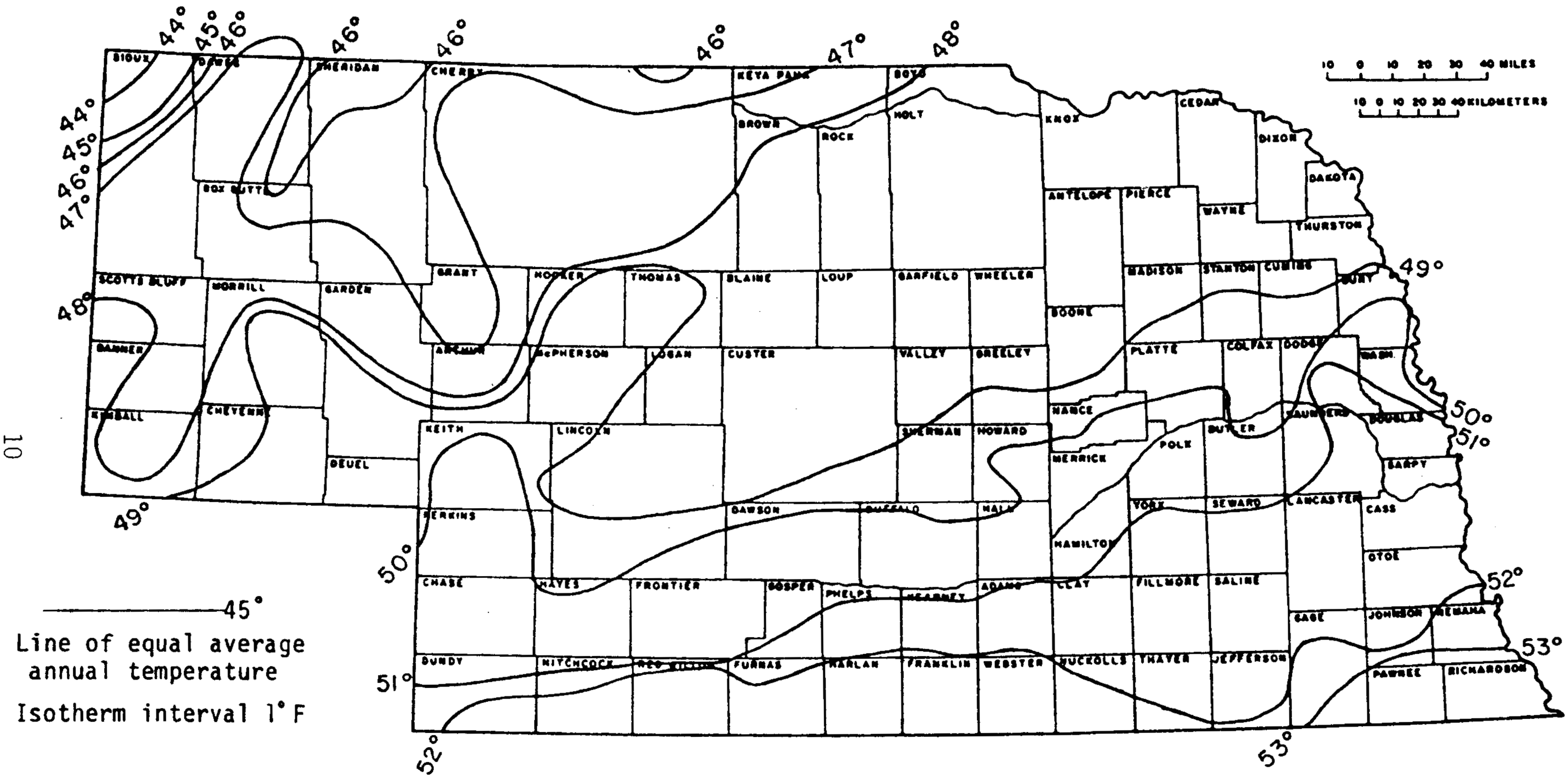


Figure 1-6

Principal structural features of Nebraska.

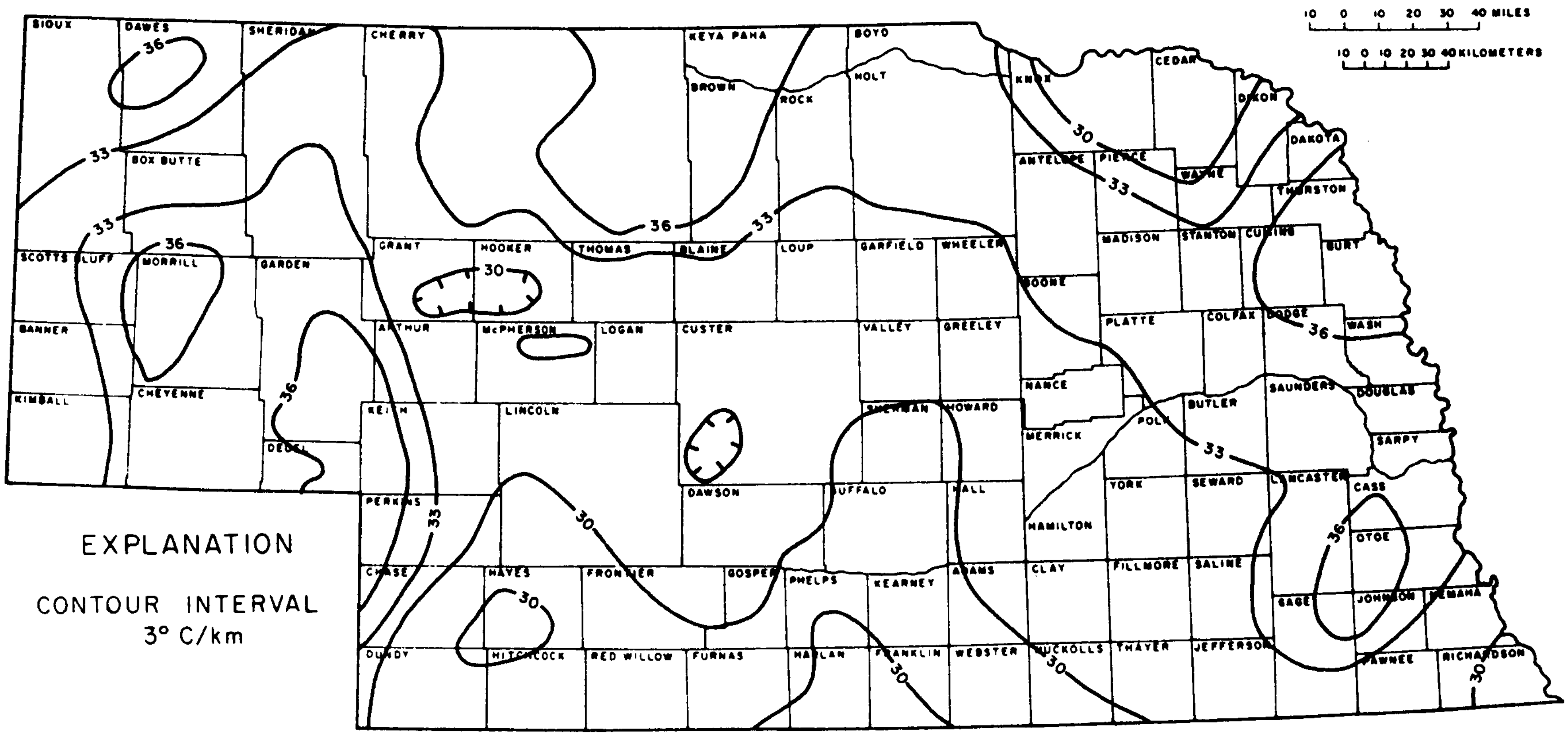


ANNUAL AVERAGE TEMPERATURE FOR PERIOD 1941-70

Point data from CLIMATOLOGY OF THE UNITED STATES NO. 81, 1973

Prepared by K.A. Messenger
2/12/80

Figure 1 - 7

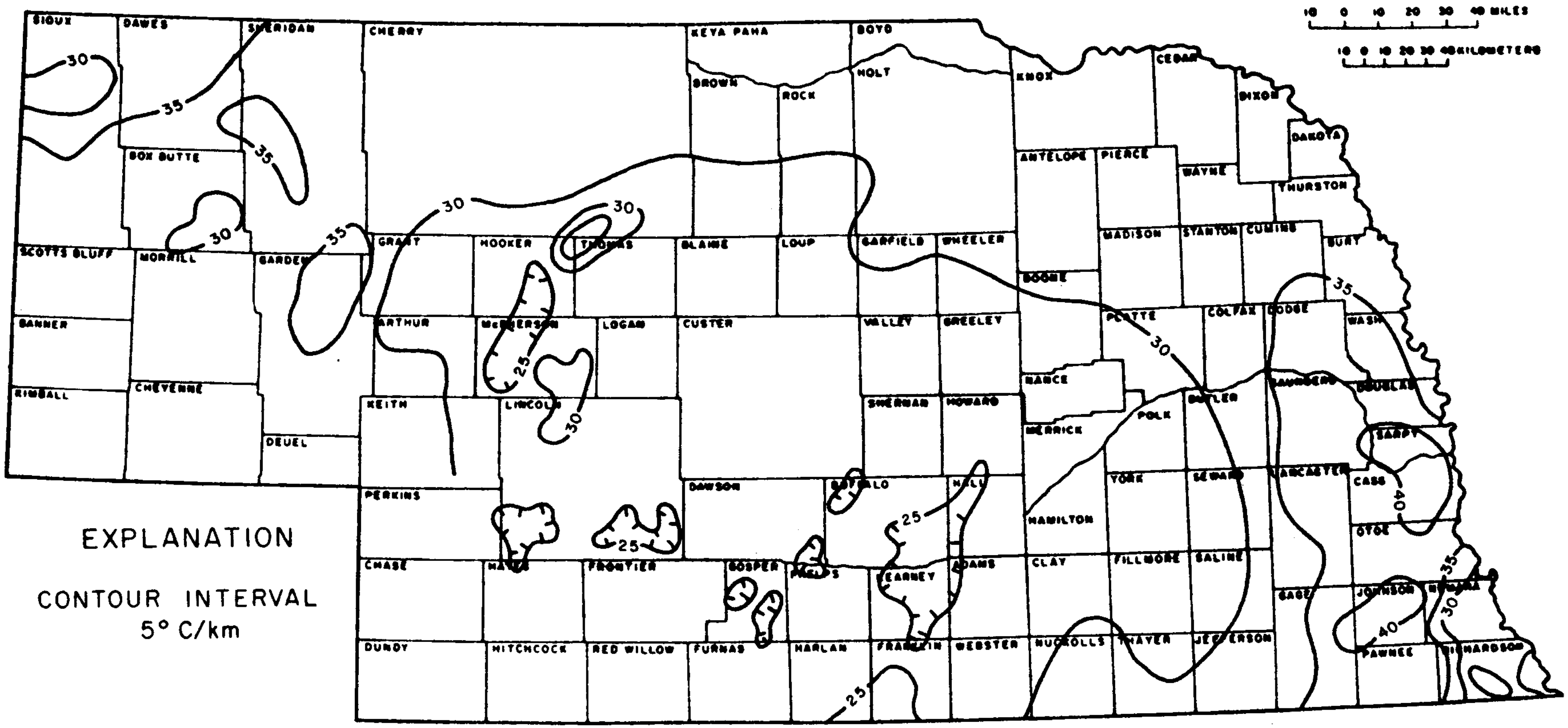


EXPLANATION

CONTOUR INTERVAL
3° C/km

GEOTHERMAL GRADIENTS
(after A.A.P.G. 1976)

Figure 1 - 8



EXPLANATION

CONTOUR INTERVAL
5° C/km

GEOTHERMAL GRADIENTS
W.D. Gosnold, Jr
1983

Figure 1 - 9

the contrasting values obtained from site specific data collected during the project forestalled a major effort for detailed gradient studies based on BHT data.

TASK TWO

Definition

Task Two was to supplement and verify the existing heat flow and temperature gradient data base.

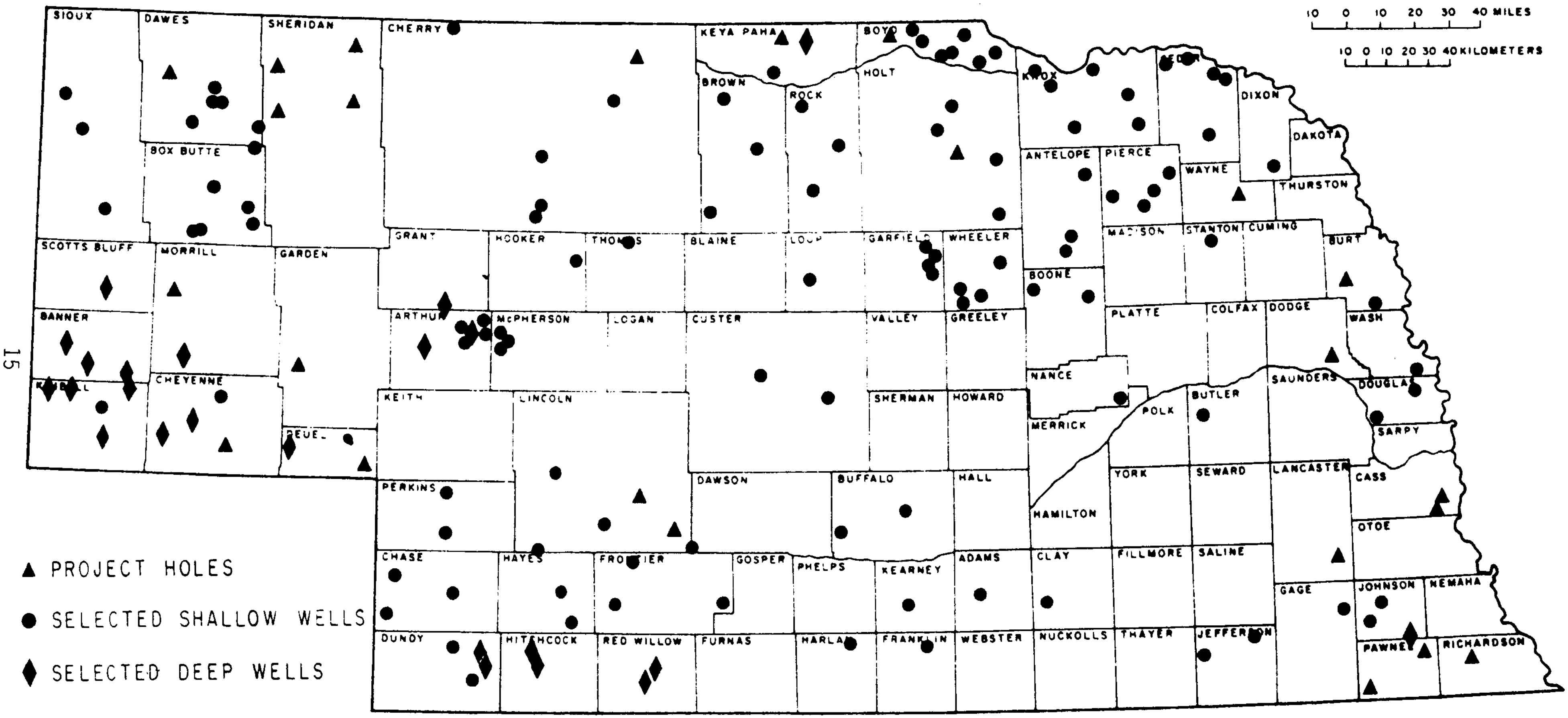
Procedure

Monitor holes were installed and measurements were made on shallow and deep holes-of-opportunity. Studies were focused on areas with a lack of verified data and in areas which have a user-population base and a possible geothermal resource.

Results

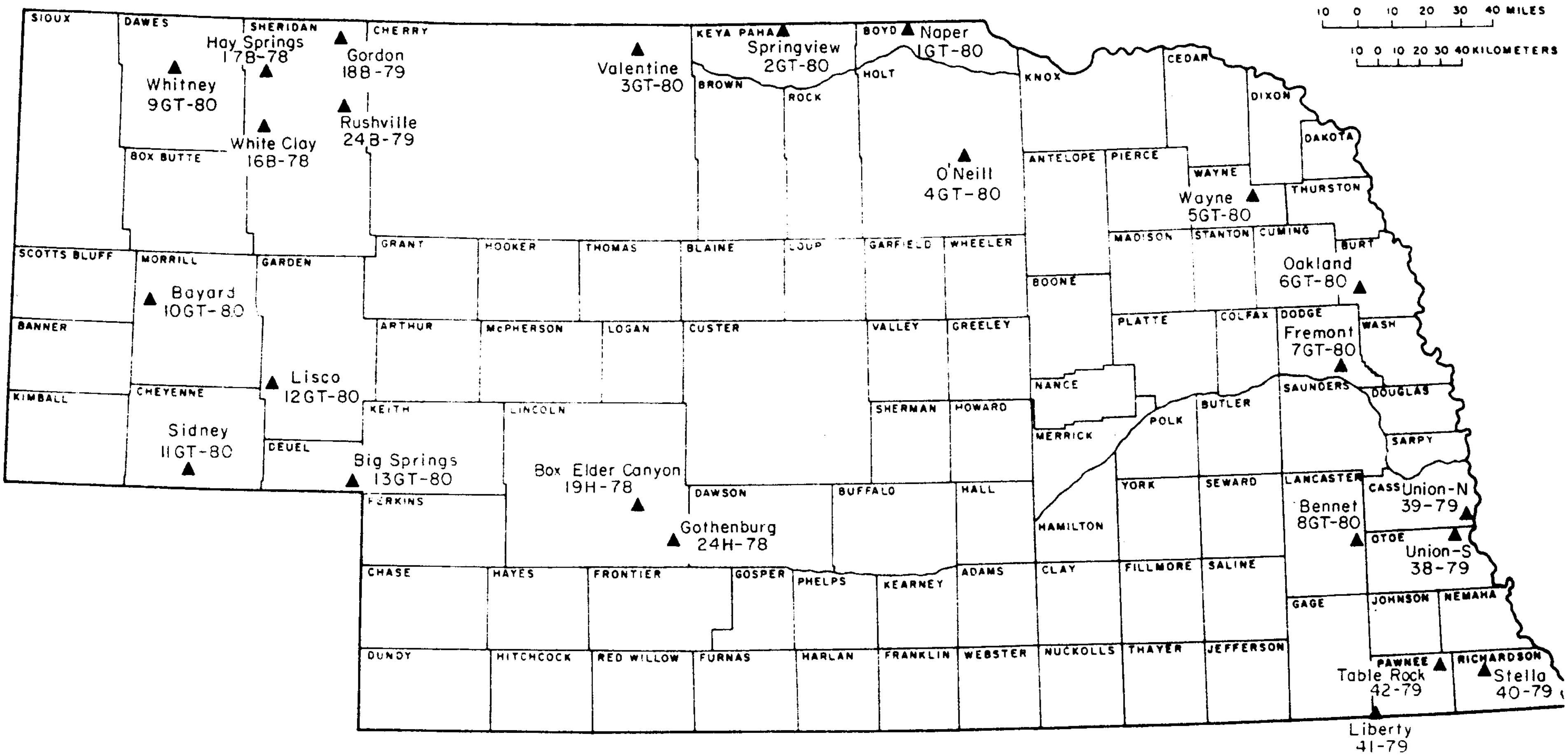
Introduction--It became apparent early in the project that the available data base was inadequate to evaluate Nebraska's geothermal resources. There was however a high level of expertise within the project staff, as a group, to properly collect, document and evaluate additional data. Institutional relationships were also supportive in gaining access to data collection opportunities. A significant portion of the project was devoted to this effort. Figure 2-1 summarizes the site specific data collection program.

Project Holes--Sites were selected across the state (Figure 2-2) for test drilling to determine rock character and obtain geothermal data. An environmental assessment was made to determine the impact of this project activity (Appendix 2-1). Twenty four sites (Table 2-1) were established consisting of holes containing one-inch (I.D.) standard weight black steel casing. Samples



LOCATIONS OF DIRECTLY MEASURED
GEOTHERMAL DATA

Figure 2-1



LOCATION OF PROJECT TEST HOLES

Figure 2-2

PROJECT TEST HOLES

Test Hole Number	County	Legal Location
16B-78	Sheridan	SE,SE, sec. 13, T 30 N, R 46 W
17B-78	Sheridan	NE,SE, sec. 31, T 33 N, R 45 W
19H-78	Lincoln	SW,SW, sec. 36, T 12 N, R 29 W
24H-78	Lincoln	SE,SE, sec. 36, T 10 N, R 27 W
38-79	Otoe	SE,SW, sec. 6, T 9 N, R 13 E
39-79	Cass	SW,SW, sec. 2, T 10 N, R 13 E
40-79	Richardson	NE,NW, sec. 34, T 3 N, R 14 E
41-79	Pawnee	SW,SW, sec. 31, T 1 N, R 9 E
42-79	Pawnee	SW,SW, sec. 16, T 3 N, R 12 E
18-B-79	Sheridan	NW,NE, sec. 24, T 34 N, R 42 W
24-B-79	Sheridan	SW,NW, sec. 1, T 30 N, R 42 W
1aGT-80	Boyd	SE,SW,SE, sec. 24, T 35 N, R 15 W
2GT-80	Keya Paha	SE,SW,NW, sec. 32, T 35 N, R 20 W
3GT-80	Cherry	NE,SE,SW, sec. 28, T 34 N, R 27 W
4GT-80	Holt	NW,NW,NW, sec. 6, T 28 N, R 11 W
5GT-80	Wayne	SE,SW,NE, sec. 14, T 26 N, R 3 E
6GT-80	Burt	NE,SW,NE, sec. 6, T 21 N, R 9 E
7GT-80	Dodge	SW,NW,NW, sec. 32, T 18 N, R 8 E
8GT-80	Lancaster	SW,SE,SW, sec. 22, T 8 N, R 8 E
9GT-80	Dawes	SE,SE,SE, sec. 2, T 32 N, R 51 W
10GT-80	Morrill	NW,NW,NW, sec. 6, T 21 N, R 51 W
11GT-80	Cheyenne	SE,SE,SE, sec. 33, T 14 N, R 49 W
12GT-80	Garden	NW,SW,NW, sec. 26, T 17 N, R 45 W
13GT-80	Deuel	NE,NW,SE, sec. 26, T 13 N, R 42 W

Table 2 - 1

and various mechanical/electrical surveys were obtained to determine the nature of the strata and their contained water. Correlated lithologic sections for each project hole are provided in Appendix 2-2. A summary of the sample description for each hole is provided in Appendix 2-3.

These project holes and several other wells were measured to determine heat flow (Table 2-2). Temperatures were recorded to the nearest 0.01 K at 5 m intervals with a thermistor probe. Temperature gradient charts for each well are provided in Appendix 2-4. Sample cuttings were submitted for thermal conductivity measurements. For intervals and wells without available rock samples, estimates were made based on local stratigraphy. Heat flow for most of Nebraska ranges from 40 mW/m^{-2} to 60 mW/M^{-2}. Several laterally extensive areas with heat flows as high as 120 mW/m^{-2} have been delineated within the sedimentary section.

<u>Other Selected Wells</u>--Over 100 shallow wells and 12 deep wells were measured to determine equilibrium temperatures (Figure 2-1). Temperature gradient charts for the deep wells are provided in Appendix 2-5. Tables of thermal gradient data for shallow wells are provided in Appendix 2-6. All of these data were obtained from non-producing wells either shut-in oil/gas wells, mineral exploration holes or shallow water table observation wells. The equilibrium temperatures were combined with heat flow data, thermal conductivity data and lithostratigraphic information to provide an interpretation on the thermal regime of Nebraska. In addition to specific items cited in the project bibliography, a map delineating "Geothermal Resources of Nebaska" was published in 1982 in cooperation with the National Oceanic and Atmospheric Administration.

Table 2 - 2

HEAT FLOW DATA

Locality	Latitude	Longitude	Gradient (K/km)	(depth interval) (m)	Conductivity (W/m/K)	Heat Flow mW/m^2
Box Elder Canyon	40°57.58'	100°34.40'	27	45-225	2.7-1.7	73-46
Gothenburg	40°47.16'	100°20.50'	30	10-235	2.7-1.7	81-51
Big Springs	42° 4.15'	102° 5.87'	59	10-135	2.7-1.7	159-100
Sidney	41° 8.09'	102°56.11'	52	20-180	2.7-1.7	140-88
Lisco	41°25.13'	102°33.50'	47	10-189	2.7-1.7	127-80
Bayard	41°49.70'	103°17.00'	60	90-153	2.7-1.7	162-102
Whitney			66	10-153	2.7-1.7	178-112
Naper	42°58.75'	99° 1.39'	86	10-155	1.7	146
Valentine	42°54.08'	100°30.25'	64	25-150	2.7-1.7	173-109
Springview	42°57.75'	99°42.35'	109	10-145	1.7	185
Gordon	42°54.94'	102°12.29'	48	10-185	2.7-1.7	130-82
Rushville	42°36.65'	102°12.26'	38	120-200	2.7-1.7	103-65
White Clay	42°47.42'	102°39.43'	48	10-235	2.7-1.7	130-82
Hay Springs	42°34.23'	102°38.88'	45	10-235	2.7-1.7	122-77
Cross Ranch	41°36.36'	101°48.20'	54	200-570	1.7	92
Milldale Ranch	41°39.70'	101°28.68'	49	240-470	1.7	83
O'Neill	42°26.15'	98°38.97'	50	105-150	1.7	85
Wayne	42°13.77'	97° 2.53'	62	65-115	1.7	105
Oakland	41°49.46'	96°27.30'	9	75-140	4.2	38
Fremont	41°29.50'	96°33.44'	15	60-115	4.2	63
Bennet	40°38.40'	96°30.79'	28	10-150	2.4	67
Union-north	40°51.42'	95°48.91'	23	95-100	2.4	55
			20	120-125	2.9	58
Union-south	40°46.20'	95°59.64'	23	75-80	2.4	55
Stella	40°11.15'	95°50.00'	30	60-80	1.8	54
Table Rock	40°49.05'	96° 4.58'	18	140-155	3.0	54
Liberty	40° 3.00'	96°27.50'	30	120-145	1.7	51
Elk Creek	40°15.90'	96°10.97'	32	200-240	3.3	106

TASK THREE

Definition

Task three was to define relationships among bottom-hole temperature data, known geohydrology and measured deep well temperatures. Uniform characteristics within and between data sets would be defined. Software programs would be utilized to make statistical translation of petroleum industry bottom-hole temperature data into real-value temperatures. A summary interpretation of the validity, application, and limitations of these integrated data sets would be made as they relate to geothermal potential in Nebraska.

Procedure

The bottom-hole temperature data set (BHT) for Nebraska consists of over 14,000 tests drilled by the petroleum industry. The major focus of the study was the relation between the uncorrected BHT data and the temperature data collected during the project. The procedures and assumptions for data collection and several products derived from these data were reviewed. A summary and analysis of the relationships was prepared (Gosnold, 1982) and is discussed below.

Results

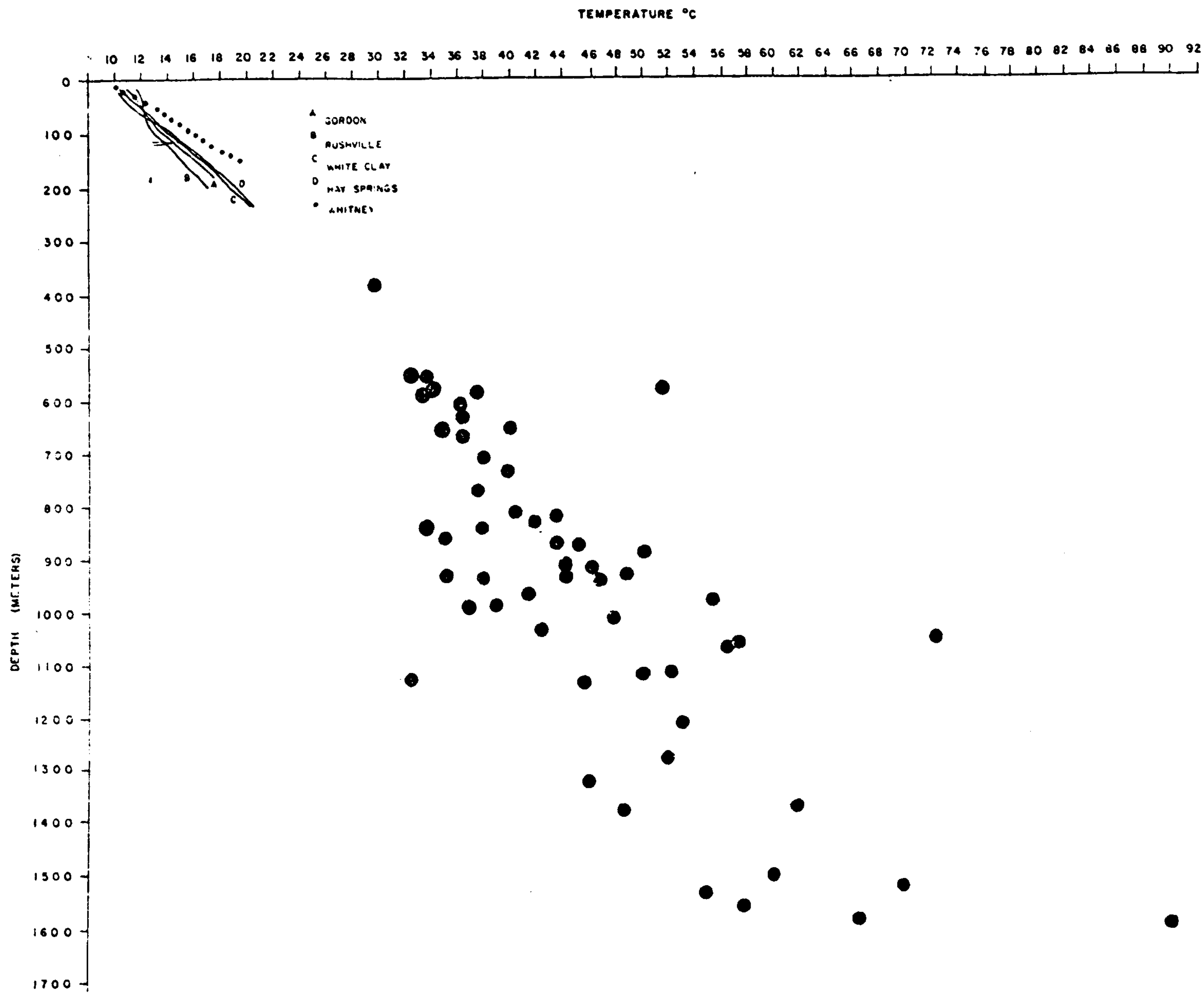
Heat Flow Projections As a part of the project, a number of heat flow measurements were made in shallow wells. These data were plotted and compared to BHT data in nearby deep wells. An example of these comparative data are illustrated in Figure 3-1 for a series of wells in western Nebraska. Two somewhat deeper wells are illustrated in Figure 3-2 for west-central Nebraska. Figure 3-3 is a location map for the well data on the previous figure. Extrapolation of the equilibrium gradients to the equivalent depths of the deeper data shows that the BHT data are generally 10°C to 20°C lower.

Direct Temperature During the course of the study, fourteen deep wells that were comparable to those tests in the BHT data were measured after they had attained thermal equilibrium (Appendix 2-5). These temperature-depth plots were compared with the BHT data nearby, in most cases within a six mile radius. The general conclusion was that the BHT data is lower by several tens of degrees when compared to actual formation temperature.

Derivative Maps A comparison of geothermal gradients and temperatures on top of the Dakota Group was made between measured values and BHT data as portrayed on the A.A.P.G. Geothermal Gradient Map of North America. The geothermal gradient existing above the Dakota Group (Cretaceous) is illustrated on Figure 3-4 on the basis of equilibrium temperatures measured at the sites indicated. A comparable portrayal of data (Figure 3-5) was obtained by converting the published map of North America (A.A.P.G., 1976) from English units to S.I. units and to the nearest integer. Values are significantly different between the two maps and a number of apparent anomalys are present on the Nebraska portion of the national map.

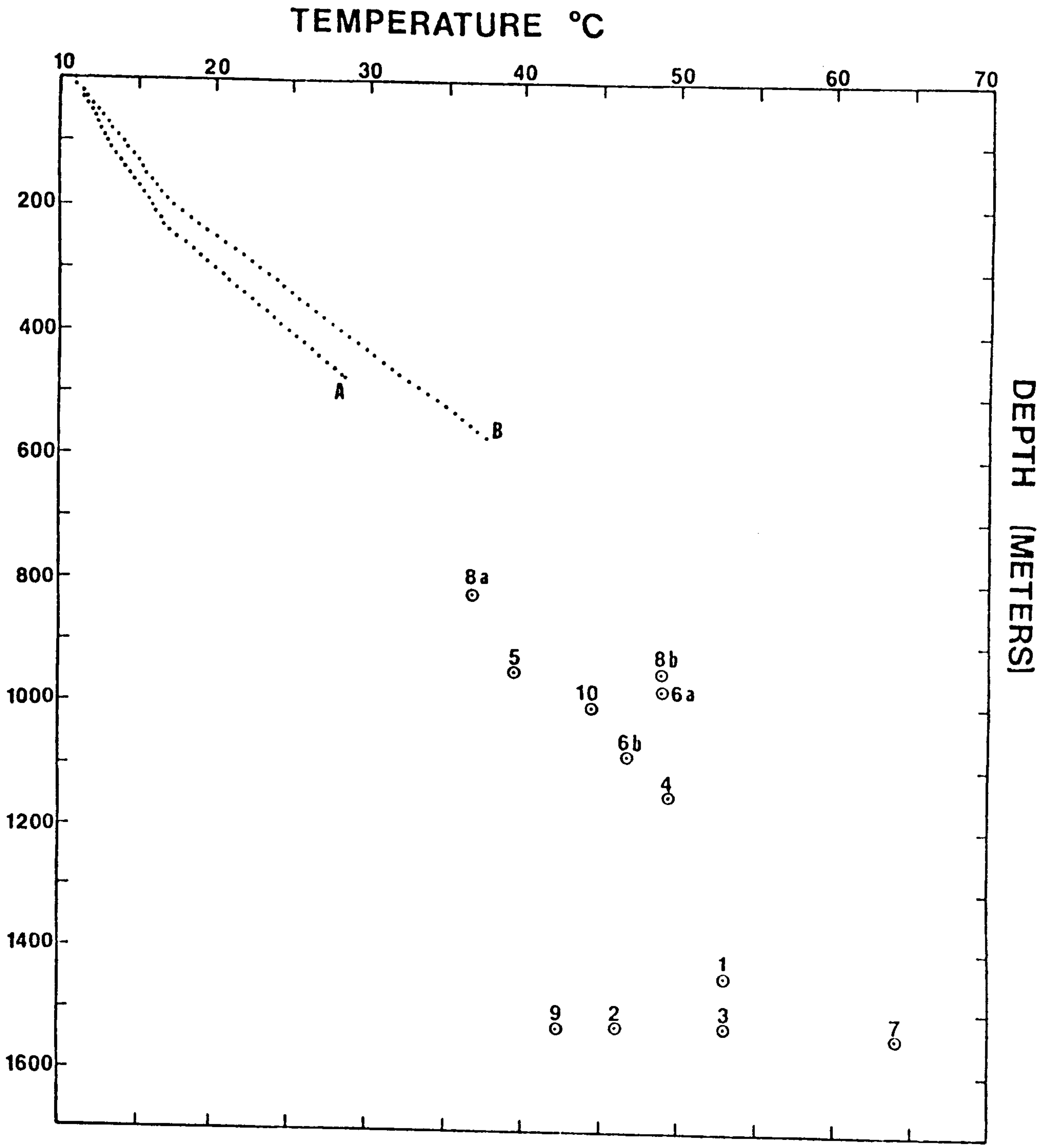
A similar set of maps was constructed illustrating temperature data on top of the Dakota Group (Cretaceous). The trends are similar between the map based on project data (Figure 3-6) and the illustration (Figure 3-7) derived from the national map. There is however a significant difference in values.

Summary A number of studies have focused on statistical methods to correct BHT data. However when several of these methods were applied to the Nebraska BHT data set and compared to measured data, results were disappointing. The



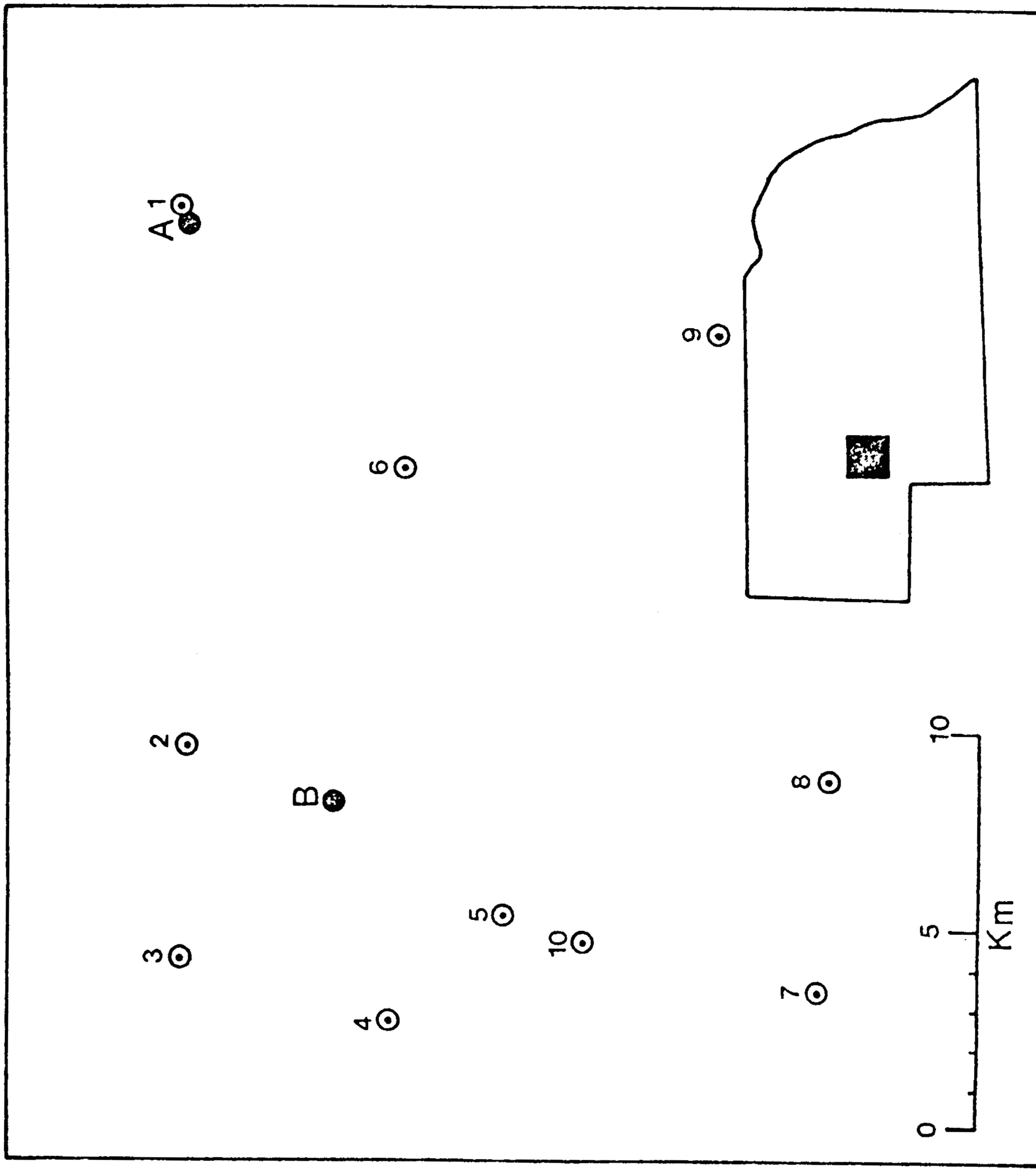
Comparison of heat flow gradients and BHT data in western Nebraska

Figure 3 - 1



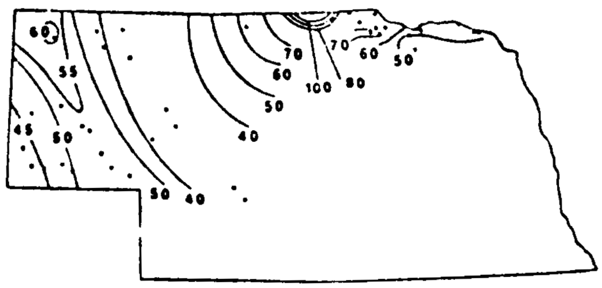
Comparison of heat flow gradients and BHT data
in west central Nebraska

Figure 3 - 2

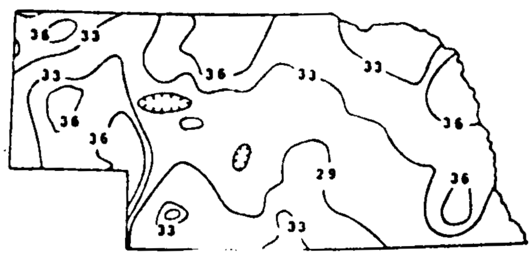


Location of heat flow and BHT data sites for Figure 3-2

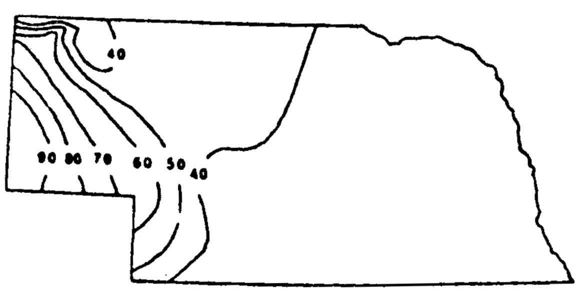
Figure 3 - 3



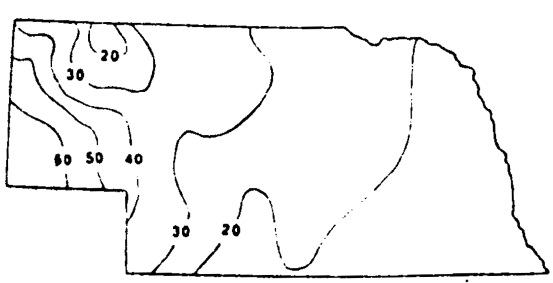
3-4 Geothermal gradient (interval - 10°C/km) above the Dakota Group, measured sites indicated.



3-5 Geothermal gradient derived from Map of North America (AAPG, 1976).



3-6 Temperatures on top of the Dakota Group (interval - 10°C) based on measured values.



3-7 Temperatures on top of the Dakota Group (interval - 10°C) derived from Map of North America (AAPG, 1976).

Figures 3 - 4,5,6,7

variance from the national map (A.A.P.G., 1976) can partially be explained by the inappropriate corrections applied for thermal conductivity of the sedimentary section. Of more concern is the apparent inconsistency in recording BHT data for each well.

In a total of more than 14,000 well logs, few instances were found where the elapsed time since circulation was not recorded in one hour increments. The elapsed time is a critical factor in deriving a corrected value. The recorded mud temperatures are also suspect as indicated by the frequency of occurrence of certain temperatures. This phenomenon is observed for all areas of our study and raise questions as to the validity of the data and the feasibility of correcting the data. It is especially disturbing that the "common" temperatures fall within the bulk of the data and would not be considered suspect in statistical treatment of the data.

Using BHT data as filed or even as corrected by the A.A.P.G. gradient map would underestimate the low temperature geothermal resource of Nebraska by about 80%. Correction programs were attempted for the BHT data, both statistical and based on the geohydrology. Unfortunately the problem seems to lie with the fact that the BHT information is not scientifically recorded and is therefore not susceptible to structured analysis. Data users should be aware that BHT data sets, at least in Nebraska, tend to underestimate both the actual formation temperature and the geothermal gradients and would thus overlook a significant portion of the low temperature geothermal resource.

TASK FOUR

Definition

Task Four was to compile existing gravity data for the state, relate these data to basement rock configuration and rock type and determine implications for geothermal resources.

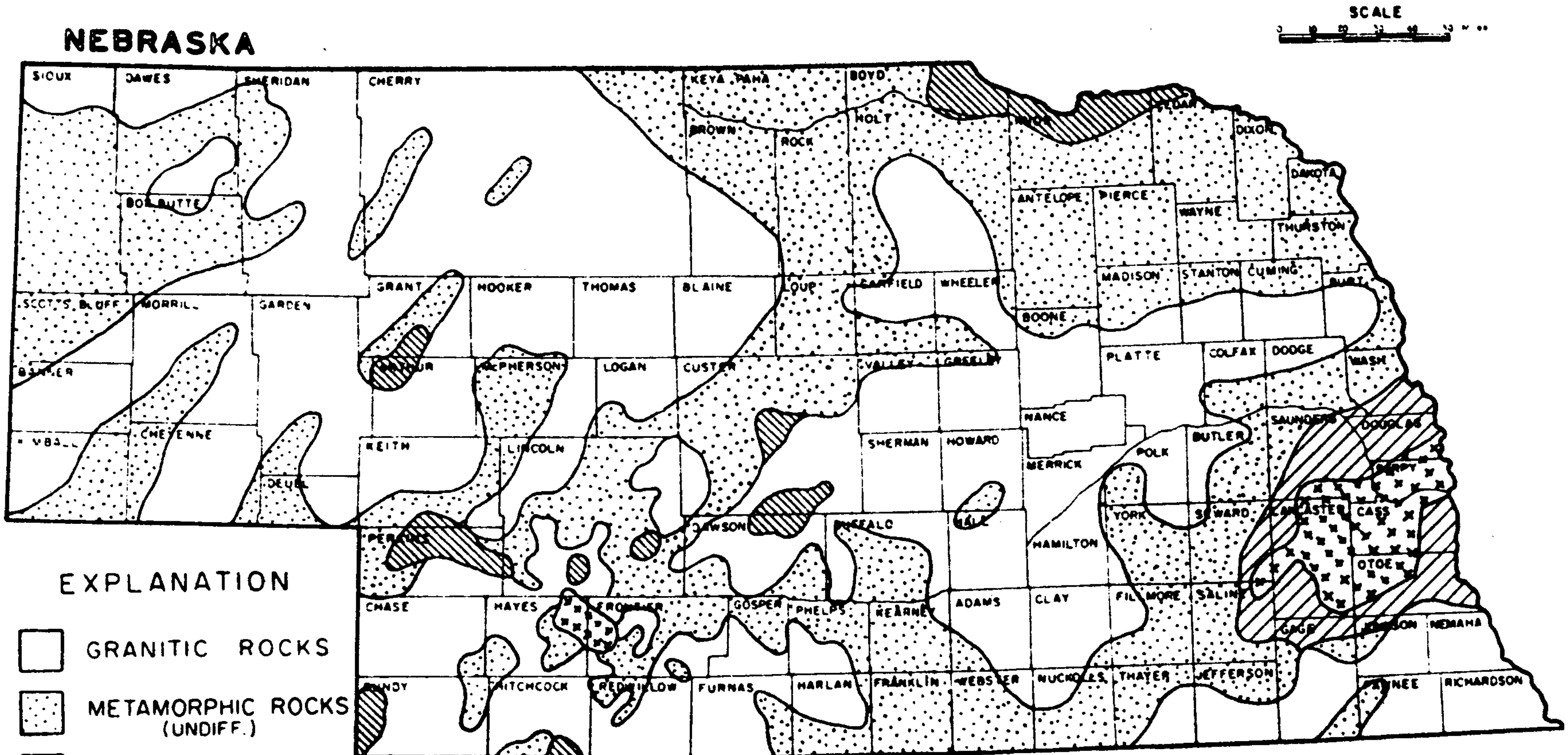
Procedure

Both published and file data from the Conservation and Survey Division were compiled at appropriate scale and contour interval. An additional evaluation of gravity data was assembled under Gosnold's direction. All of these data were compared, analyzed and produced at appropriate scale for this report.

Results

Geothermal resource, particularly those at high temperature, can be related to a thermal anomaly in the underlying basement rock in many areas of the world. In these instances, basement heat sources are created either by a genetic relationship to deep-seated materials or by the inherent geochemical characteristics of the rock. It was anticipated that any significant heat flow data measured in Nebraska could be related to basement rock characteristics.

As a corollary to this activity, it was felt that a better understanding of the basement rock would allow a predictive analysis of potential geothermal resources. Basement rock type (Figure 4-1) and configuration data (Figure 4-2) had been interpreted by Carlson (1969) primarily from deep well data. Gravity data had become available which allowed Burchett (1982) to publish a 5 milligals



EXPLANATION

GRANITIC ROCKS

METAMORPHIC ROCKS (UNDIFF.)

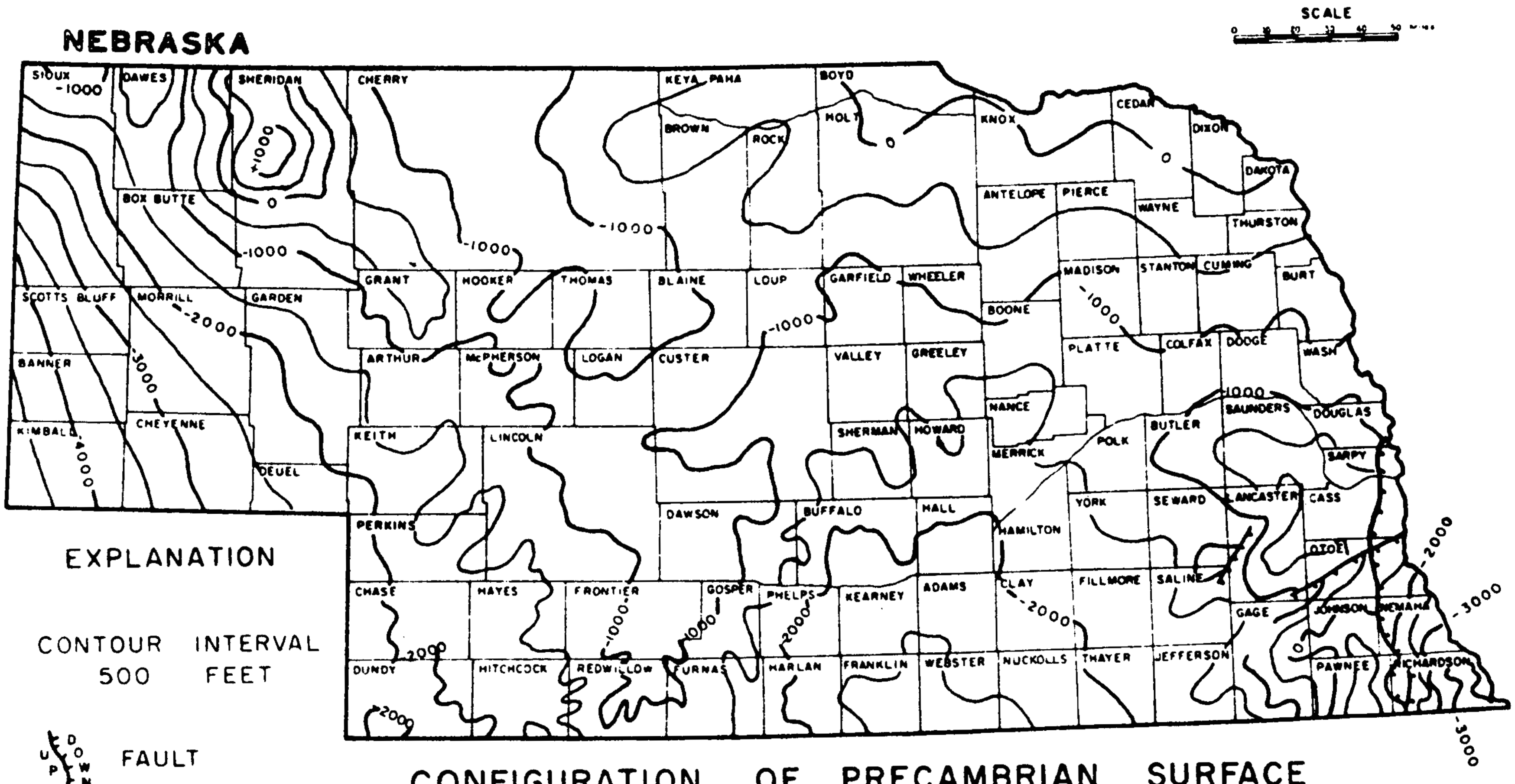
QUARTZITE

BASALT - GABBRO

SEDIMENTARY ROCKS ("RED CLASTICS")

ROCK TYPE OF THE PRECAMBRIAN SURFACE
(Carlson, 1969)

Figure 4 - 1



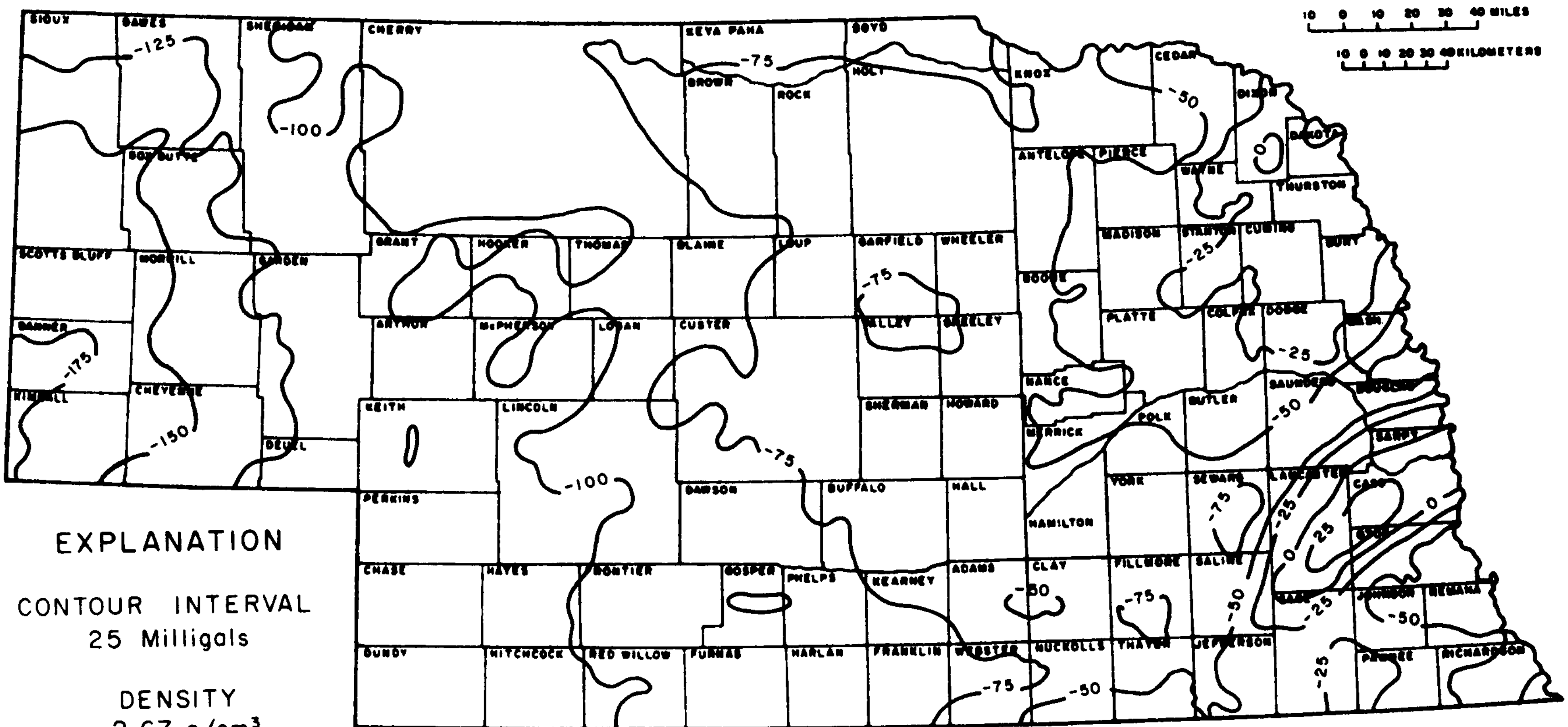
CONFIGURATION OF PRECAMBRIAN SURFACE
(Carlson, 1969)

Figure 4 - 2

contour map of the state based upon an assumed density of 2.67g/cm^3 (Figure 4-3). A second interpretation of gravity data was prepared under Gosnold's direction utilizing an assumed density of 2.2g/cm^3 (Figure 4-4).

The more intensive integration of these data for this research project was not pursued for the following reasons: 1) the initial map products did not indicate any significant new correlation of gravity and known basement rock; 2) all of the expected derivative maps were not created due either to lack of expertise or processing constraints; and 3) the heat flow patterns provided from site measurements did not indicate that there was a direct genetic relationships with underlying basement rock.

It should be noted, however, that the Precambrian terrain is highly complex in parts of Nebraska. Even though our statewide inventory did not identify obvious areas of relationships, site specific research could yield the potential for local geothermal resources. These developments might result from new low-temperature technology, a hot dry rock project, or possible exploitation of deep drilling into the metasediments.



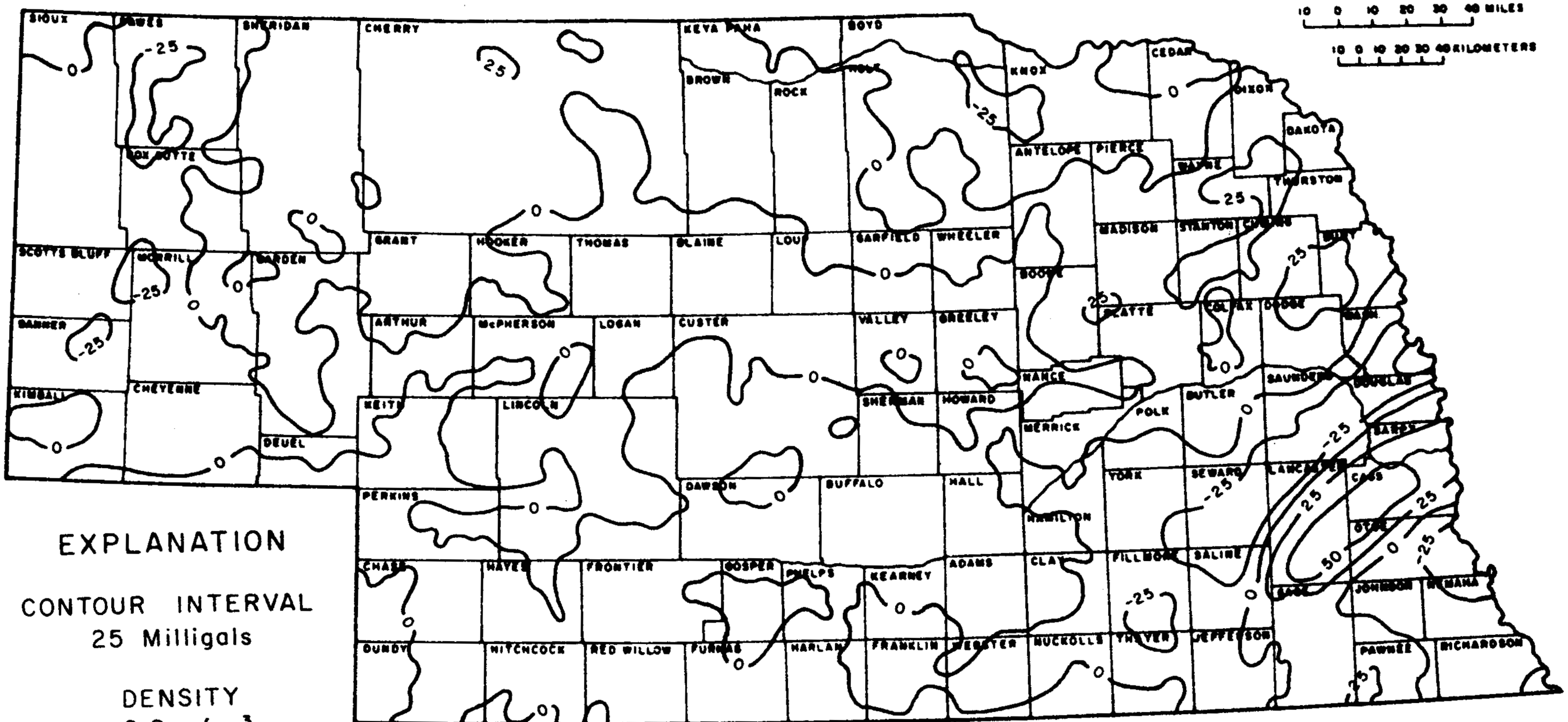
EXPLANATION

CONTOUR INTERVAL
25 Milligals

DENSITY
2.67 g/cm³

BOUGUER GRAVITY
(after Burchett, 1982)

Figure 4 - 3



EXPLANATION

CONTOUR INTERVAL
25 Milligals

DENSITY
2.2 g/cm³

BOUGUER GRAVITY

Figure 4 - 4

TASK FIVE

Definition

Task Five was to compile available geoscience information pertinent to geothermal resources and interpret it for selected substate regions of the state.

Procedure

Data were collected for heat flow, thermal gradient, bottom-hole temperature, stratigraphy, thermal conductivity, structure, geophysics and aquifer characteristics. A synthesis of these data indicated that Nebraska contains broad areas of consistent patterns of geothermal resources rather than site specific or substate regions. Efforts were focused upon the preparation of a state-wide perspective and the creation of a data base for specific project evaluation as the interest emerges.

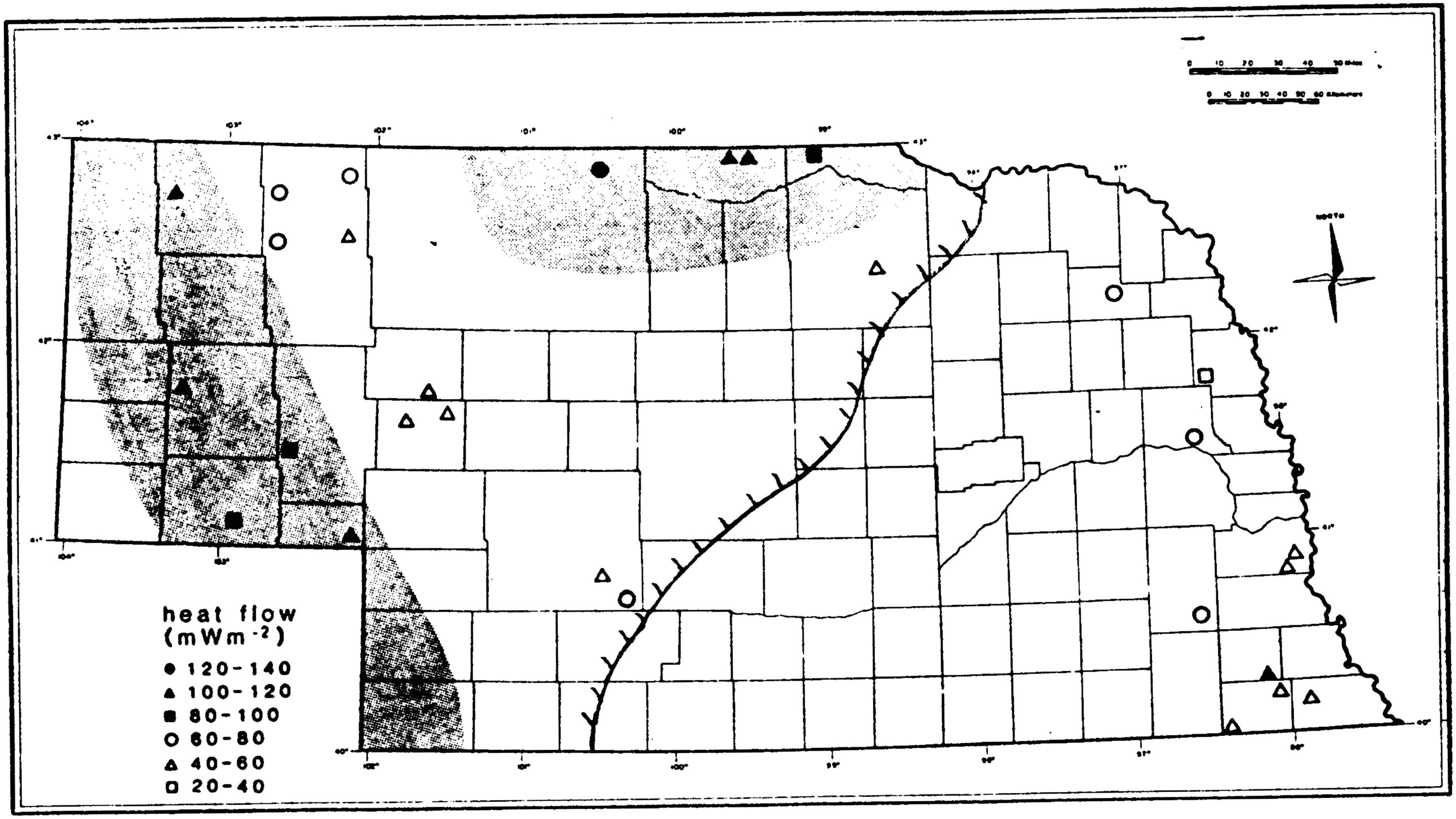
Results

The product considered most suitable for the current user-audience was the state map at a scale of 1:500,000. This map, "Geothermal Resources of Nebraska," was published in 1982 and over 4,000 copies have been distributed. It has proven to be the appropriate product to make visable the availability of low-temperature thermal water and has established a continuing interest in the potential for development of geothermal resources.

The base data for the various geoscience and thermal information activities have been presented in the designated Task Sections within this report. Other, more technical or interpretative products have been published in appropriate journals. Other application-oriented products have been submitted to the annual State Coupled Resource Assessment Workshops. Of particular interest for potential resource development are the heat flow data provided on Figure 5-1. Two areas of significance are generally outlined by the shaded areas. Across western Nebraska is an area where heat flow appears to range from 80-120 mWm^{-2} which reflects the Denver Basin. In north Nebraska, values were obtained in excess of 120 mWm^{-2}.

The other resource requirement in addition to heat flow is a suitable aquifer. The Pleistocene and Tertiary (Ogallala) groundwater reservoirs, the major aquifers utilized in Nebraska, have little potential as a geothermal resource by current definition. The Dakota Group (Cretaceous) has both the aquifer potential and the thermal characteristics to serve as a low-temperature resource in the western half of the state (hachured line, Figure 5-1). Other, less well-documented groundwater reservoirs, are the Paleozoic rocks in the deeper basinal areas. An example would be the Madison Group (Mississippian in northwest Nebraska). A thick sequence of Precambrian metasediments in eastern Nebraska have yet to be adequately investigated.

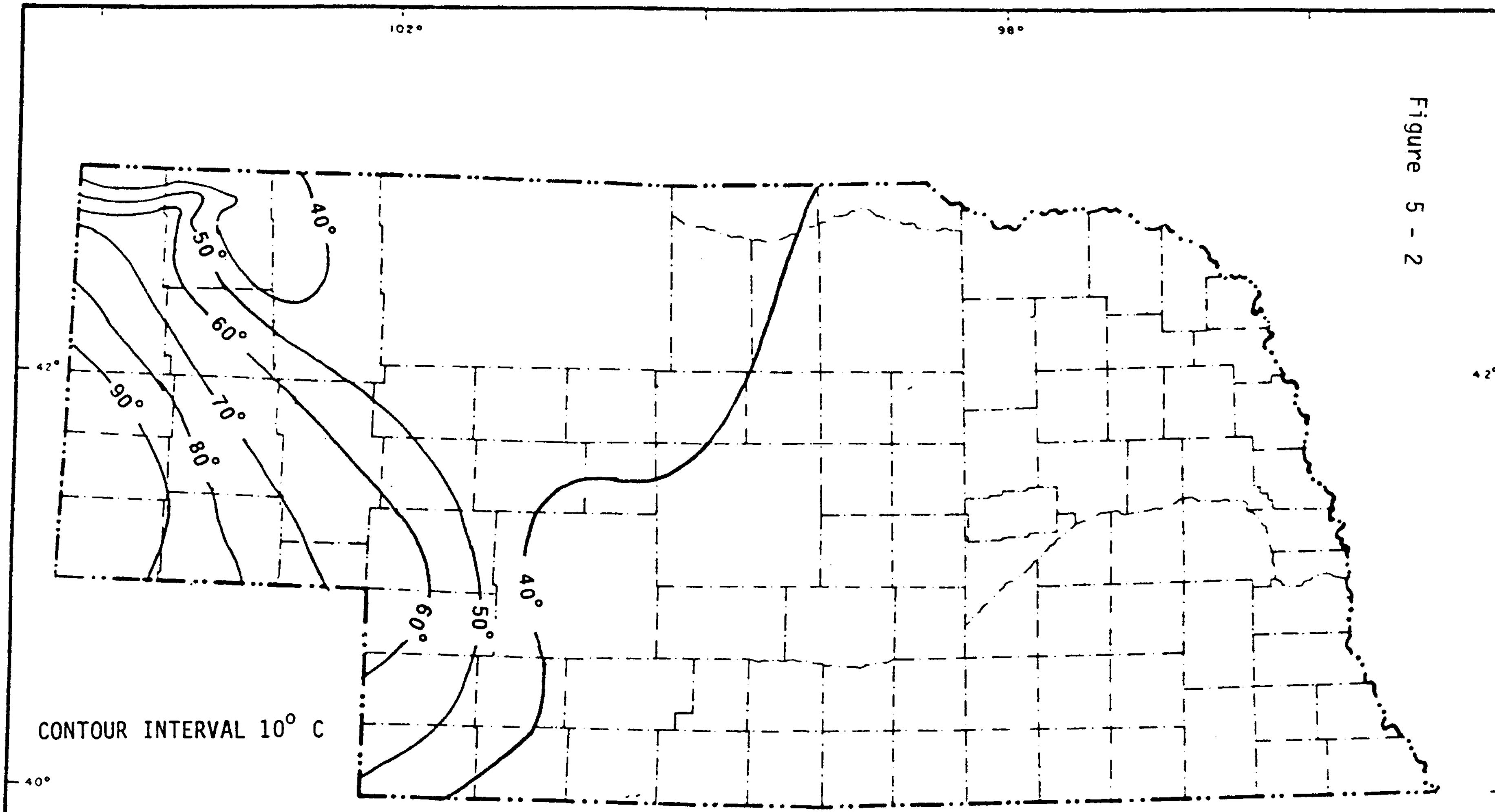
It was the conclusion of this inventory program that the Dakota Group has the most immediate potential as a geothermal resource (Figure 5-2). One project in western Nebraska has received preliminary approval for the state-supported grant program. An activity which tends to promote interest in geothermal energy is the expanding utilization of groundwater heat pumps. As in many other areas, the potential for hot dry rocks projects exists in Nebraska but no interest has been expressed. The vast resources of low-temperature thermal waters could however undergo rapid development if a technological or cost-effective utilization became available to displace current energy sources.



DISTRIBUTION OF HEAT FLOW DATA AND THE POTENTIAL LOW-TEMPERATURE RESOURCE

Figure 5 - 1

Figure 5 - 2



PROJECTED TEMPERATURE CONTOURS ON TOP OF THE DAKOTA GROUP (Cretaceous) IN NEBRASKA

TASK SIX

Definition

Task Six was to disseminate geoscience information about the geothermal resource in Nebraska.

Procedure

A major function of the Conservation and Survey Division is to serve as a technical data and information base for natural resources. The new geothermal data, general background and potential applications in Nebraska were all integrated into the Division's information system. Activities were carried out locally, statewide, nationally and internationally.

Results

Many of the formal information dissemination activities are documented in Appendix 6-1. This compilation includes: Publications, Presentations, Meetings Attended, and Meetings Sponsored. There were, of course, a number of informal information service contacts and media coverage integrated with other geoscience, energy and environmental programs.

A major publication was the map "Geothermal Resources of Nebraska" published in 1982 in cooperation with the National Oceanic and Atmospheric Administration. Over 4,000 copies of this map have been distributed. By use of diagrams, inset maps and area discussion; this publication served a wide variety of informational and educational needs. Other more formal publications disseminated both Nebraska data as well as resource interpretations to a more technical audience.

No site-specific or substate regional reports were published. Instead the state map was supplemented with materials provided to local media. Both the data collection activity as well as project interpretations were given high visibility. A two page article was published in the Nebraska Farmer (McCabe, 1982) other statewide coverage was provided by numerous articles in the major newspapers of Omaha and Lincoln. A geothermal fact sheet was distributed through the Cooperative Extension Service (Burbank, 1982, copy included).

An obvious response to the information provided by this project was the actions taken by the Nebraska Legislature and appropriate state regulatory agencies in 1982. LB 708 defined geothermal resources and provided guidelines for regulation. LB 799 created a state-supported grant program to develop geothermal resources. Project staff were technical advisors throughout this process of legislation and preparation of regulations. A workshop was sponsored as a part of the project activity (see attached) to provide background for state agency and legislative personnel.

Throughout the information dissemination activity, the emphasis has been on the low temperature characteristics of the geothermal resource. There was no intent to promote the development of a large-scale geothermal industry. The information provided has however, encouraged the creation of a project to assess the potential for space heating of Nebraska Western College. Other similar projects are being discussed. Any significant breakthrough in technology for more cost-effective utilization of low-temperature geothermal resources will be of significant interest to a broad, well-informed audience in Nebraska.

Geothermal Energy Resources in Nebraska

The Nebraska Legislature enacted two bills in 1982 relating to geothermal resources which were signed by Governor Thone. The purpose of this paper is to briefly summarize the provisions of the legislation, review data on geothermal resources in Nebraska, and discuss potential for development of geothermal resources in the state.

Legislation

LB 708 - is an "act relating to minerals; to provide that geothermal deposits shall be treated as mineral interests; to define terms; and to provide for permits."

As defined in the act, "geothermal resources shall mean (a) the natural heat of the earth and the energy produced by that heat, including pressure, and (b) the material medium containing that energy." The terms "geothermal fluids," "geothermal occurrence" and "material medium" are also defined in the act. The act provides that the right to develop and produce geothermal resources is included with any division of the mineral rights (estate) and the owner of the mineral estate will have the right to enter the overlying surface property at reasonable times and in a reasonable manner to prospect for, produce and transport the geothermal resources. Mineral rights granted prior to this act are not affected unless geothermal resources were specifically included.

Any person who desires to withdraw ground water for geothermal resource development must first obtain a permit from the Director of Water Resources. The Water Resources Department will adopt rules and regulations governing issuance of the permits. Permits will be issued in consultation with the Department of Environmental Control and development and production of geothermal resources will be subject to rules and regulations developed under the Environmental Protection Act.

LB 799 - is an act relating to energy which amends the revised statutes of Nebraska to provide grants to assist in developing geothermal energy sources. In this act, geothermal energy is defined as "all products of geothermal processes embracing indigenous steam, hot water, and hot brines..." "Any political subdivision which derives a portion of its funds from property tax may apply to the State Energy Office for a geothermal energy utilization grant." The grant will require 50-50 matching funds. The grants may be used for "projects which will reduce conventional energy use and utilize geothermal energy in public buildings." Funds were appropriated to the Nebraska Energy Office to carry out the provision of this portion of LB799. More information on this legislation can be obtained from Mr. Buck Balok, Director, Nebraska Energy Office, PO Box 95085, Lincoln, Nebraska 68509 (402) 471-2867.

Geothermal Resources in Nebraska

The Conservation and Survey Division, IANR, is coordinating a four-year (1979-1983) agreement with the U.S. Department of Energy (DOE) to investigate and compile data relating to the geothermal resource potential of Nebraska. Principal investigators for the project are Duane A. Eversoll of the Conservation and Survey Division and William D. Gosnold from Department of Geography-Geology UN-O. From these data a map of "Geothermal Resources of Nebraska-1982" has been published by the National Oceanic and Atmospheric Administration (NOAA) for the

U.S. Department of Energy. This map is available from the Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, Nebraska 68588-0517. There is no charge over the counter, or they may be ordered by mail for $1.00 folded, $1.50 rolled.

The map of geothermal data compiled by the University of Nebraska shows that development of geothermal resources is believed to have the greatest potential in the Dakota geologic unit in the western half of Nebraska generally west of a line from McCook to Niobrara. Another potential aquifer is the Madison geologic unit that is limited to the extreme northwest corner of Nebraska. The map legend briefly describes the geothermal resource in Nebraska and explains how the map was developed.

The geothermal resources of Nebraska are identified as Low-Temperature Thermal Waters. They are warm water at temperatures lower than 100°C, but warm enough to be used as practical heat sources. Existing knowledge does not permit the inference that thermal waters may be found everywhere within the Dakota and Madison group. The actual existence of sufficient thermal waters in any given location can only be determined by drilling a test well.

It should be noted that the use of ground water heat pumps is not affected by this legislation. Such heat pumps utilize water pumped from the shallow ground water aquifers and are not considered a geothermal resource. In Nebraska, the geothermal resource generally lies below 600 meters (1,968.6 feet) in depth. Proper development of geothermal waters would have no effect upon the shallow ground water aquifer used for irrigation and other purposes in Nebraska.

As pointed out in "Nebraska Water Law Update" Number 45 (May 17, 1982, Page 5), "The Nebraska Supreme Court has ruled that ground water belongs to the public." However, "...LB 708 establishes that heat in geothermally heated ground water belongs to the overlying landowner" (or the owner of the mineral rights). "Whether this creates a significant legal inconsistency and what significance this legal inconsistency has remains to be seen."

Potential For Development

The potential for geothermal resource development in Nebraska is largely unknown at the present time. The cost of development is very expensive and risky, and generally precludes exploration and utilization by individual developers. The resource might however be developed as a group effort for use in public buildings, a group of homes or businesses, or for agribusiness uses such as grain drying, fish farming, and heating greenhouses and livestock buildings. Many agribusiness uses do not require high temperatures, and thus can utilize the geothermal resource after some heat has already been extracted for other purposes.

Some wells in north central Nebraska, primarily Boyd, Knox and Keya Paha Counties, produce warm water from the Dakota geologic unit. Many of these wells are artesian and have potential for use as a low-temperature direct heat source.

Persons interested in developing geotheraml resources may obtain additional background data from the UNL Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, Nebraska 68588-0517 (402) 472-3471 or the Nebraska Oil and Gas Conservation Commission, Sidney, Nebraska (308) 254-4595.

Prepared By:

John A. Burbank, Cooperative Extension Service, University of Nebraska-Lincoln

July 23, 1982

University of Nebraska Lincoln
Institute of Agriculture and Natural Resources

Conservation and Survey Division
113 Nebraska Hall
901 North 17th Street
Lincoln, NE 68588-0517
Telephone (402) 472-3471

Geological and Natural Resources Surveys

WORKSHOP ON THE
Potential for Low-Temperature Geothermal Resources
In Nebraska

Monday May 24, 1982, 9:00-11:59 a.m.
Nebraska Center for Continuing Education

The preliminary results of an inventory of geothermal resources in Nebraska indicate that at least one half of the state has a low-temperature geothermal potential. The possibility of utilizing this resource for direct heating has created both legislative and regulatory issues. The purpose of this workshop is to acquaint public officials with the resource data, the current technology and the management implications of developing geothermal resources in Nebraska.

Topics to be covered include:

1. Definition and data base
2. background and geologic framework
3. resource potential
4. deep drilling
5. utilization

You or a designated representative are invited to participate in the panel presentation and discussion. It is anticipated that the 1:500,000 scale map "Geothermal Resources of Nebraska" will be available for distribution. No registration fee is required but the return of the enclosed form would be appreciated.

Convener
Marvin P. Carlson
402/472-3471

TASK SEVEN

Definition

Task Seven was to compile a user-oriented state geothermal resource map.

Results

A map entitled "Geothermal Resources of Nebraska" at a scale of 1:500,000 was published in 1982. The geothermal data collected as the result of this project and additional geoscience information were compiled and interpreted by project staff. Publication was in cooperation with the National Oceanic and Atmospheric Administration. The map is included as Appendix 7-1 in this original report. Additional copies are available from the Conservation and Survey Division, University of Nebraska-Lincoln.

TASK EIGHT

Definition

Task Eight was to prepare, submit and distribute appropriate reports.

Procedure

A major reporting activity was the preparation and distribution of a summary of monthly activity (see attached example for August 1982). These progress reports fulfilled a formal reporting requirement to D.O.E. as well as served as an informal newsletter to a much broader audience. The numerous products and activities cited in the Bibliography (Appendix 6-1) also served to report project accomplishments to appropriate audiences. Their Final Report is the other formal reporting activity required.

AN INVENTORY OF

Geothermal Resources In Nebraska

State-Coupled Program between

U.S. Department of Energy

and

The University of Nebraska

PRINCIPAL INVESTIGATORS

William D. Gosnold

Duane A. Eversoll

PROJECT COORDINATOR

Marvin P. Carlson

DE-AS07-79ET27205 Mod. A003

Progress Summary August 1982

Geothermal Monthly Report

August 1982

The Department of Energy modified cooperative agreement DE-AS07-79ET27205 Mod A003 specifies eight research tasks to be performed by the Nebraska State-Coupled Geothermal team. The progress of these eight tasks is summarized in this report.

Task 1. Bottom-Hole Temperature (BHT) Survey

Work in the BHT survey concentrated on further development of the master data management program referred to as DWELL. The DWELL program provides the user with the options of creating new records for addition to the data set, display and editing of existing records and the ability to print all or part of the entered records. Editing for the DWELL program was performed by student research specialist Mary Mittelstaedt under the direction of research assistant Karen Messenger.

Task 2. Heat Flow and Temperature Gradient Survey

Six deep wells in southwestern Nebraska were logged by personnel from Southern Methodist University. Temperature depth logs and plots of temperature vs. depth and gradient vs. depth were recorded for these wells. The wells were logged continuously and the data were printed in half-meter intervals. Several important observations were made from the new data. The data from southwestern Nebraska verified the temperatures that were projected for the Dakota Formation on the basis of shallow well heat flow data. These data also show that the location of the limit of the low-temperature geothermal resource area for the Dakota was accurately predicted. Another observation is that the gradient vs. depth plots can be used to correlate some stratigraphic units on the basis of temperature gradient. The correlation is possible because of the contrasting thermal conductivities in the units penetrated by the wells. A final observation is that certain "spikes" in the gradient vs. depth plots seem to correlate between wells and may be due to inherent properties of certain lithologic units. Exothermic reactions such as the oxidation of sulfides in contact with drilling fluids is one possible explanation for the "spikes" in the curves.

In addition to the wells in Southwestern Nebraska, the SMU crew also logged the Baker #1 heat flow hole at Burton, in north-central Nebraska. The data show that the heat flow for all lithologic units is about 107 mW m^{-2}. The constant heat flow within the well indicates that the Dakota Aquifer is not responsible for the high heat flow in the area. Two possibilities are under consideration as heat sources: 1) updip flow in weathered basement rocks or in gravels derived from the basement; or 2) high radioactive heat generation in the Precambrian basement. W. D. Gosnold and D. A. Eversoll submitted an abstract to the American Geophysical Union Fall Meeting on the results of the well log.

The University of Nebraska at Omaha field crew finished its field season with a total of about 50 wells logged. The new data are being processed and should be available for analysis by October 1982.

Task 3. Data Translation Studies

The information gathered from task 2 during this report period will be combined with all previously collected data to generate programs that will define the relationship between the BHT inventory and the actual measured deep well temperatures. A paper by W. D. Gosnold titled "Geothermal Resource Maps and Bottom Hole Temperature Surveys" has been accepted by the Geothermal Resource Council for the October 1982 meeting.

Task 4. Gravity Map

The first rough draft gravity maps should be available by September-October 1982. The maps are being compiled by personnel from the University of Texas-Dallas with supervision from W. D. Gosnold.

Task 5. Substate Region Investigations

Work in this area during this report period consisted mainly in gathering and compiling data as outlined in tasks 1 through 4. These data will be combined into the final report to meet contractual agreements. Papers presented at the various Geo-Science meetings have provided user-oriented information pertaining to the geothermal potential in certain areas within Nebraska.

Task 6. Dissemination of Information

The Nebraska team continues to work with state agencies and the general public having regional and site-specific geological/geothermal requests relating to the geothermal potential within Nebraska. Specifically, information, comments, and technical advice have been provided to the State Energy Office in developing "Guidelines For The Nebraska Energy Office Geothermal Grant Program, 1982-1983." The Guidelines will be available by September 1982 (Appendix A).

Task 7. State Geothermal Map

The "Geothermal Resources of Nebraska" maps which were released in May 1982 are being distributed by the Conservation and Survey

Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Task 8. Reporting Requirements

This monthly report, along with the research papers, reports, and poster sessions presented throughout the grant, consitutes the reporting requirements of the grant agreement.

CHARLES THONE
GOVERNOR

State of Nebraska
Nebraska Energy Office
Box 95085
Lincoln, Nebraska 68509—5085
(402) 471-2867

V.B. BALOK
DIRECTOR

GUIDELINES FOR THE NEBRASKA ENERGY OFFICE GEOTHERMAL GRANT PROGRAM, 1982 - 1983

SEPTEMBER 17, 1982

Appendix 2-1

Environmental Assessment

ENVIRONMENTAL ASSESSMENT

TITLE

Evaluation of the Geothermal Resources in Nebraska

DESCRIPTION OF THE PROPOSED ACTION

This proposed project consists of a test drilling and casing program to determine the strata underlying certain areas of Nebraska (see figure 1), and to enable later geothermal investigations. The project includes the drilling and casing of 13 test holes to an average depth of 500-600 feet. The objectives will be to a) provide a one-inch steel cased hole thru which geothermal measurements will be made at a later date by Conservation and Survey Division personnel or their affiliates, b) obtain high quality representative samples of the geological strata, c) provide test holes for the measurement of a variety of electrical characteristics of both the strata and their contained fluids. The test holes will be cased to the bottom of the test hole with one-inch (I.D.) standard weight black steel casing. The one-inch casing will extend a minimum of 3 feet above the natural ground level.

This series of test holes are being drilled and cased to serve as a monitoring data-base for other subsidary information collected as part of an in-depth two year geothermal study of Nebraska. The project "An Evaluation of Geothermal Resources In Nebraska" is funded by Department of Energy (DOE) Contract No. DE-AS07-79ET27205. All test holes were located on private property and were drilled with permission from the landowners. The casing will be pulled or cut-off 3' below ground level at the end

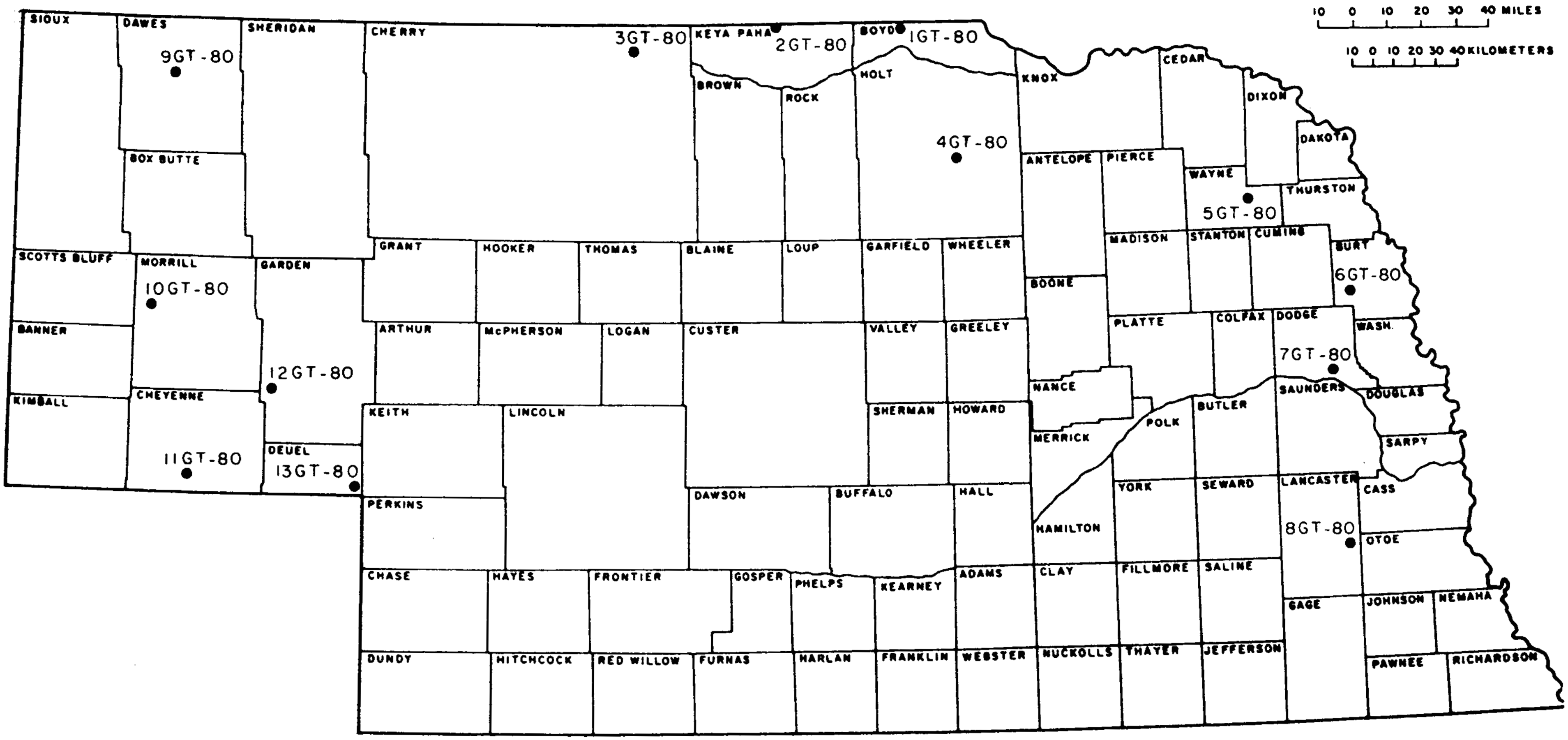


FIGURE 1.

LOCATIONS OF 1980 GEOTHERMAL DRILLING SITES of the project.

DESCRIPTION OF THE EXISTING ENVIRONMENT

The test holes in this proposed project occur in thirteen different areas of Nebraska and therefore a description of the existing environment for each proposed drilling site will be described. See figure 1 for general location of the thirteen sites. Figure 2 shows the Average Annual Temperatures for Nebraska.

Site 1. Located on the Naper 7½ minute topographic quadrangle map in the NW NE sec. 25, T. 35N., R. 15W. The proposed site is in an unpopulated area that has been previously disturbed by farming methods. The site lies along the edges of Ponca Creek Valley. It is characterized by a continental subhumid climate with light rainfall (ave. 23"/yr.), cold winters, warm summers, and frequent changes in weather conditions. Ponca Creek drains part of a high plain remnant that has not been significantly modified by erosion. The flow of Ponca Creek is derived almost entirely from overland runoff and very little from underground seepage. Most of the drainage area consists of exposed Cretaceous Age Pierre Shale, which has rapid runoff due to steep slopes and a very slow absorption rate. Soils in the valleys formed mainly in alluvial and colluvial material. The soil at this site is classified by the Soil Conservation Service as being Cass, which is a fine sandy loam with 0 to 2 percent slopes.

The vegetation primarily consists of short to medium mixed native prairie grasses. The fauna consists mainly of mule and whitetail deer, wild turkey, pheasant, bobwhite quail, eastern red squirrel, raccoon, opossum, and cottontail rabbit. Predators,

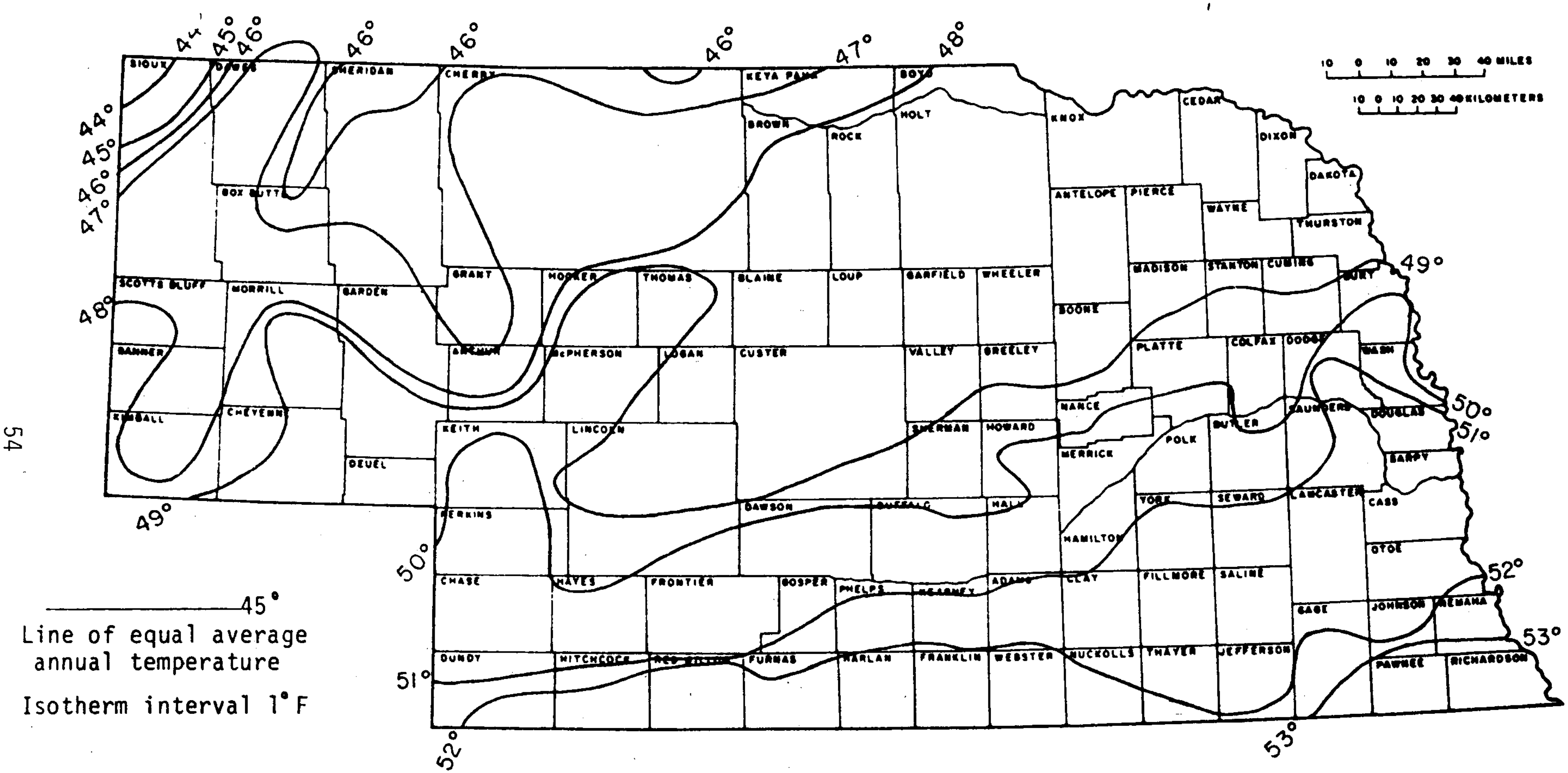


FIGURE 2.

ANNUAL AVERAGE TEMPERATURE FOR PERIOD 1941-70

Point data from CLIMATOLOGY OF THE UNITED STATES NO. 81, 1973

Prepared by K.A. Messenger
2/12/80

such as hawks, owls, and coyotes also inhabit the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal in the opinion of the researchers and landowners.

Site 2. Located on the Springview NW 7½ minute topographic quad map in the SW NW of sec. 32 T. 35N., R. 20W. The proposed site is in an unpopulated rural farm and ranch area. The proposed site lies in the Holt Creek valley. The site is characterized by a continental subhumid climate with fairly high summer and moderate to low winter temperatures. The average annual temperature is approximately 47° F (period 1941-70). The average rainfall is about 18 inches per year. Holt Creek a tributary to the Keya Paha River, is entrenched in the underlying Cretaceous Age Pierre Shale and in this area is a permanent stream. The soil at the site is classified by the S.C.S. as Boyd, which is a fine silty loam that ranges from nearly level to slightly sloping.

The native vegetation is predominantly grasses, such as little bluestem, grama, buffalo grass and wheatgrass however, at the site the area is under cultivation. In some adjacent areas a thin native tree population exists which could include elm, ash, burr oak, hackberry, boxelder, cottonwood and willows. The fauna consists of mule and whitetail deer, raccoon, pheasant, grouse, quail, red squirrel, cottontail rabbits, coyote, hawks, owls and some species of songbirds.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cummulative and Long-Term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal in the opinion of the researchers and landowners.

Site 3. Located in Cherry County Nebraska on the Sparks 15 minute topographic quadrangle map in the SE SE sec. 28 T. 34N., R. 27W. The proposed site is three miles east of Valentine Nebraska in northcentral part of the state. The site lies in the valley of the Niobrara River approximately 45 feet above water level. It is adjacent to a rural residence in an area that is currently under cultivation. The site is characterized by a continental climate with extremes of temperature and a marked seasonal variation in rainfall (average 18.23 inches per year). The Niobrara is a swift-flowing stream that is entrenched about 150-180 feet into the surrounding area. The flow is fairly even and consists of clear water as the volume varies very little thru-out the year. Most of the drainage area consists of sandy soils and there is little run-off. Most of the precipitation is absorbed into the ground and eventually becomes united with the groundwater. The Niobrara cuts into Tertiary aged White River Group siltstones, claystones, silts and fine grained sandstones. Soils in the valley formed mostly on alluvial and colluvial materials. The soil at site 3 is classified as Elsmer-Loup-Sarpy a loamy fine sand, by the Soil Conservation Service.

The vegetation is dominated by grasses with some trees in and along the sides of the valleys. Most of the grasses consist of prairie grasses, while there exist both deciduous and conifer trees at the drilling site. The wildlife ranges from muletailed deer, antelope, coyotes, small fur-bearers (raccoon, skunk, mink and muskrats), rabbits, ground squirrel, to small rodents (mice). Many different types of song birds (meadowlark, lark sparrow, morning dove), upland game birds (prairie chicken, grouse) and predators (hawks, owls) are found in the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 4. Located in Holt County Nebraska on the O'Neill 7½ minute topographic quad map in the NW NW sec. 6, T. 28N., R. 11W. The proposed site is 1½ miles south of O'Neill, Nebraska in the northeastern part of the state. Site #4 is located along the southern edge of the Elkhorn River Valley about 10 feet above the water level. It is situated in a grassed area next to a rural residence.

The site is characterized by a climate that is continental and is subjected to a wide variation in winter and summer temperature. It is well suited for farming of small grains. The average rainfall is 21.43" according to official records of the United States Weather Bureau.

The topography at this site is fairly flat with fair to poor drainage. The proposed hole is located on a river terrace. The Elkhorn River is a slow flowing river with many "oxbows" and dry older partially silted-in channels. The Soil Conservation Service classifies the soils at this site as Cass, a loamy fine sand.

The vegetation primarily consists of grasses, such as big bluestem and needlegrass, although directly at the site seeded lawn-type grasses prevail. The wildlife at this particular site is restricted because of the close proximity to the rural residence. However coyote, badger, rabbit, raccoon, skunk, mice etc. are found in the area, along with the usual predators, such as hawks and owls.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowner.

Site 5. Located in Wayne County, Nebraska on the Wayne 7½ minute topographic quadrangle map in the SW NE sec. 14, T. 26N., R. 3E., The proposed site is ½ mile south and 1¼ mile west of Wayne, Nebraska along the north side of South Logan Creek and Deer Creek Valleys. The surrounding area is presently under cultivation for the growing of grain crops. The proposed drill site is about 30-40 feet above the creek level on a south-southwest facing hillside on the end of a windbreak planted with various types of trees.

The climate of this area is continental with warm summers and cold winters (annual average temperature is approximately 49° F). The rainfall is classed as moderate with a yearly average of 25.9 inches. The temperature and rainfall is highly variable from day to day and season to season. The area surrounding site #5 is characterized by long slopes, and rolling hills.

South Logan Creek has a low gradient with a fairly narrow valley upstream from the site. It converges with Deer Creek approximately three-fourths of a mile east of the drill site. The two creeks share the same valley which is about 1 mile wide. The surficial deposits in this area are mostly Pleistocene aged glacial materials (till etc.). Runoff is therefore fairly fast in this area and coupled with the large thunderstorms that occur as downpours in short periods of time, produce a great deal of erosion in unprotected areas. The soils at this site are classified by the Soil Conservation Service as Judsen silt loam, with

2 to 7 percent slopes. This soil is on stream terraces and foot slopes at the base of upland soils.

The vegetation at the site is restricted to grain cropland with some grasses developed in the pastures and along the roadsides. Other vegetation found nearby ranges from deciduous trees to the important grasses, such as bluestem, switchgrass and indiangrass. The wildlife normally found nearby includes, some white-tailed deer, coyotes, badgers, raccoons, skunks, pheasant, quail, red squirrel and cottontail rabbit. The predators include the hawks and owls with many different species of song birds in the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 6. Located in Burt County, Nebraska on the Oakland 7½ minute topographic quadangle map in the NW of sec. 6, T. 21N., R. 9E. The site is approximately ½ mile east, ½ mile south of Oakland, Nebraska in a rural farming area. The climate is generally temperate with hot, sultry summers and cold rather severe winters. The average annual temperature is approximately 50° F, the average rainfall is 30.64 inches per year according to U.S. Weather Bureau records.

The proposed drilling site is located on the east side of Logan Creek Valley about 130 feet above the bottom of Logan Creek. Surficial deposits are clays, silts and sands of glacial origin that overlie Cretaceous age Dakota sandstone. Soil at the site is classified as Marshall silt loam by the Soil Conservation Service. Typical Marshall topography is undulating to rolling, being irregular in those areas adjacent to the major streams. Drainage in the area is good with some problems associated with erosion of the exposed areas.

The native vegetation was prairie grasses with trees in and along the drainage areas. Farming has replaced the grasses with grain crops and a majority of the native trees were cut in the early 1900's. Farm operations have diminished the wildlife at this proposed site. However, coyote, raccoon, pheasant, quail, rabbit, eastern red squirrel, hawks, owls and some species of song birds may inhabit the adjacent areas.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 7. Located in Dodge County, Nebraska on the Fremont West 7½ minute topographic quadrange map in the NW sec. 32, T. 18N.,

R. 8E. It is 4 miles north and 3 miles west of Fremont, Nebraska in a rural farming area. The county has a continental climate with hot summers, cold winters and moderate rainfall. The average yearly precipitation is 31.1 inches while the annual average temperature is approximately 50° to 51° F.

The proposed drilling site is located on the north side of the Platte River Valley about 10 feet above the valley floor, in a farm pasture. The valley at this site is 4 to 5 miles wide. Depth to groundwater ranges from 10 to 15 feet. Surficial deposits are alluvial silts and sands that mantle possible glacial deposits. Bedrock in this area is Cretaceous age Dakota sandstones and shales which unconformably overlies limestone, shales and sandstones of Pennsylvanian age. Soils at the site are classified by the Soil Conservation Service as Judson silt loam with 2 to 6 percent slopes. It is characterized as being well drained on colluvial-alluvial foot slopes.

Prairie grasses in the valleys and uplands and trees mostly along the drainage areas were native to this part of Nebraska. However farming methods have wiped out a majority of the grasses and trees. Small grain crops alfalfa and wild hay are now found on a majority part of the land. The wildlife in the area ranges from song birds (meadowlark, dove, swallow etc.) to coyotes, rabbits, skunks, raccoon and red squirrel with some predators such as owls and hawks. Small rodents, such as ground squirrels, mice and moles are commonly found in the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 8. Located in Lancaster County, Nebraska on the Bennett 7½ minute topographic quadrangle map in the SE SW sec. 22, T. 8N., R. 8E. The test hole is 3 miles south and ½ mile west of Bennett, Nebraska in a rural farming area on an abandoned farmstead. Lancaster County is cold in winter and is quite hot with occasional cool spells in summer. The average yearly precipitation is 22 inches and the annual average temperature is approximately 50° to 52° F.

The test hole site is located in an upland area on the west side of a small drainage valley that drains to the north eventually running into the Little Nemaha River two miles north of the site. The relief surrounding the area is classified as gently sloping. A majority of the surrounding area has been disturbed by farming. Unconsolidated sediments, consisting of loess and glacial clays-silts-sands and till all of Quaternary age overlies the bedrock in the area. The bedrock at this site is Permian and Pennsylvanian age limestone which is interbedded with shales and shaley limestone. The soil is classified by the Soil Conservation as Wymore silty clay loam with 3 to 7 percent slopes. The vegetation primarily consists of grasses commonly found in most southeastern Nebraska pastures. The grasses consist mainly of big bluestem, little bluestem, side-oats grama, prairie dropseed, needlegrass and Junegrass. Some wildrye and Indiangrass is found in the bottom-land. Trees near the site include cottonwood, burr oak, locust, ash, elm and boxelder. The fauna found in this area include, raccoon, red squirrel, cottontail rabbit, coyote, red fox, mule deer, pheasant, quail, hawks owls and songbirds.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 9. Located in Dawes County, Nebraska on the Fort Robinson 2 SE (Advance Print) 7½ minute topographic quadrangle map in the SE SE of sec. 2, T. 32N., R. 51W. The proposed site is 1 mile south and ½ mile west of the small village of Whitney, Nebraska in a rural farm and ranch area that is currently under partial cultivation. The climate of the area is semiarid and is characterized by warm summers, cold winters with an average annual precipitation of 18.2 inches.

The test hole is located along the side of the White River valley about 35 feet above the flow line and approximately ½ mile southeast of the flowing stream. The area surrounding the south of the site is classified by the Soil Conservation Service as gently rolling to hilly while the area directly to the north slopes gently to the White River valley. The soils are classified as Keith silt loam with 3 to 9 percent slopes formed on alluvium terraces and colluvium along the side of the White River. The bedrock underlying the area is the Cretaceous aged Pierre Formation, consisting mainly of black to brownish olive gray shales.

The vegetation is dominated by mixed native grasses in the pastured areas. Farm crops include alfalfa, winter wheat, oats and hay with some barley and corn. Wildlife ranges from mule and whitetail deer, antelope, coyotes, small fur-bearers to small rodents (mice etc.). Upland game birds such as wild turkey and pheasants inhabit the area as do numerous song birds and predators (owls, hawks).

POTENTIAL ENVIRONMENTAL IMPACTS

Contruction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 10. Located in Morrill County, Nebraska on the Bayard 7½ minute topographic quad map in the NW, NW sec. 6, T. 21N., R. 51W. The test hole is 5 miles north and 2 miles east of Bayard, Nebraska in a rural farm and ranch area on a farm home site. Climate of the area is classed as semiarid and typical of the Great Plains - cold winters and warm short summers. The mean annual precipitation is about 17 inches with a mean annual temperature of 47 - 48^c F.

The test hole is located in a small wide valley that runs from the northwest to the southeast, eventually connecting with Red Willow Creek about 4-5 miles to the southeast. The site lies in an area dominated by the remmants of old alluvial fan deposits mixed with high stream terraces which developed into small gently rolling lowland drainages. The soil is classified by the Soil Conservation Service as Bridgeport very fine sandy loam. The bedrock underlying this site is Brule silt and siltstones of the White River Group, Ogliocene Series, Tertiary System which was encountered at 20 feet.

Vegetation in the area is primarily farm crops with some native mixed grasses in the pastureland to the north. These include needle grass, sand grass, bunch grass, grama and buffalo grass. The farm crops include corn, alfalfa, and sugar beets which at this site are irrigated from the Tri-State Canal that cuts diagonally NW to SE across the section. The test hole is approximately .2 of a mile southwest of the Tri-State Canal. The fauna includes both mule and whitetail deer, antelope, raccoon, opossum, rabbit, coyote, squirrel and other small rodents. Others include owls, hawks, game birds such as pheasant, and many species of songbirds.

POTENTIAL ENVIRONMENTAL IMPACTS

Contruction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 11. Located in Cheyenne County, Nebraska on the Sidney 7½ minute topographic quad map in the SE, SE sec. 33, T. 14N., R. 49W. The test hole is located 2 miles east and one mile south of Sidney, Nebraska in a rural farm and rangeland area in a ranch pasture. Cheyenne County climate is characterized by a wide variation in temperature typical of the High Plains - Cold winters with short and hot summers. The mean average yearly precipitation is approximately 17 inches while the mean annual temperature is 48 - 49° F.

The test hole is located along the south side of Lodgepole Creek Valley about ¼ mile south of Lodgepole Creek. The site is located near the base of the valley sides on remnants of smooth low terraces, 20-25 feet above the stream. 500 feet west of the site a small drainage-way has developed that drains the immediate area to the south. The soil is classified as Cheyenne gravelly sandy loam, which is derived from the alluvial-terrace materials and from alluvial and colluvial wash that has partly filled the valleys. Bedrock is encountered at 22.5 feet and consists of Brule siltstone and silt of the White River Group, Ogliocene Series, Tertiary System.

The vegetation at the site ranges from farm crops north in the valley to pastureland in the southern area. The farm crops range from corn, alfalfa and hay to wheat and barley. Pastures are mainly dominated by native grasses. Wildlife found near the site is characteristic of the fauna found on the High Plains. Coyotes, deer, antelope, small fur-bearers, rabbits and rodents are common. Game birds such as pheasant and quail also inhabit the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 12. Located in Garden County, Nebraska on the Coumbe Bluff 7½ minute topographic quadrangle map in the SW NW sec. 26, T. 17N., R. 45W. The test hole is about 7 miles west of Oshkosh, Nebraska in a rural ranch area and on the edge of a ranch pasture. Long cold winters and short hot summers are characteristic of the area. The mean annual temperature is about 48 - 49^{o} F and the mean annual precipitation is 19 inches.

The test hole is located in the North Platte Valley approximately 1½ miles south-southwest of the North Platte River. It is near the base of Coumbe Bluff on remnants of low terraces about 25 feet above the river level. The Soil Conservation Service classified the soil as Tripp fine silty loam that is composed of sediments carried down from the adjoining uplands. The bedrock encountered at 55 feet is silt and siltstone belonging to the Brule Formation of the White River Group, Ogliocene Series, Tertiary System.

Vegetation at the site is dominated by native grasses which is either grazed as pastureland or cut as hay. Wildlife found in the area ranges from both mule and whitetailed deer to antelope and small fur bearers. Many predators such as coyotes, owls and hawks can be found nearby as can many different species of High Plains song birds.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Site 13. Located in Deuel County, Nebraska on the Big Springs 7½ minute topographic quadrangle map in the NE NW SE sec. 26, T. 13N., R. 42W. The test hole is about 1-1/3 mile northwest of Big Springs, Nebraska in a rural farm-ranch area on the edge of a ranch pasture. The climate is characteristic for the High Plains, cold winters with hot short summers. The mean annual temperature is 48 - 49° F. and the mean annual precipitation is 17 inches.

The test hole is located in a small drain along the bluffs on the north side of the South Platte Valley about 1½ miles north of the main South Platte River and approximately 80-85 feet above the flow line. This draw drains to the South Platte Valley in a southeasterly direction. The soil is Rosebud gravelly sandy loam as classified by the Soil Conservation Service. The Rosebud series are derived mainly from the Tertiary age, Ogallala Formation. The topography at this site is classed as gently undulating to very hilly and steeply rolling. 25 feet of alluvial and colluvial deposits were found overlying the Ogallala Formation. The Ogallala is composed of clay, silt, sand and gravel which in places is cemented with calcium carbonate or silica.

Vegetation is dominated by the mixed native grasses commonly found in this area of the High Plains - little bluestem, gramma, big bluestem, Indian grass, buffalo grass, wild grass and sand grass. Coyotes, antelope, deer, small fur-bearers, small rodents, owls, hawks, pheasant and some quail, raccoon, opossum, rabbits and snakes are commonly found in the area.

POTENTIAL ENVIRONMENTAL IMPACTS

Construction: This proposed project occurs in an area that has been previously disturbed by farming methods. The primary objective of the test drilling is to install the 1" cased test hole and will involve approximately 1000 sq. feet for installation purposes.

Site Restoration: The hole shall be sealed and plugged around the one-inch casing with bentonite and clay type cuttings from the test hole, to specifications furnished by the Conservation and Survey Division. Excess drilling mud and cuttings shall be properly disposed of and retention pits removed or filled. The site shall be cleared and as nearly as possible be restored to its original condition.

Cumulative and Long-term Environmental Effects: It is anticipated that this proposed project will not in itself create or produce any negative environmental effects. There will be no significant irretrievable commitments of natural resources involved in this project.

COORDINATION WITH FEDERAL, STATE, REGIONAL, OR LOCAL PLANS

All Federal, state and local laws, ordinances, plans or regulations in any manner affecting this project shall be at all times observed and complied. No test hole drilling permits were required for this proposed project.

ANTICIPATED BENEFITS AND ALTERNATIVES

Benefits: The completion of this project will provide information of potential geothermal characteristics and any application values that may be available for this area.

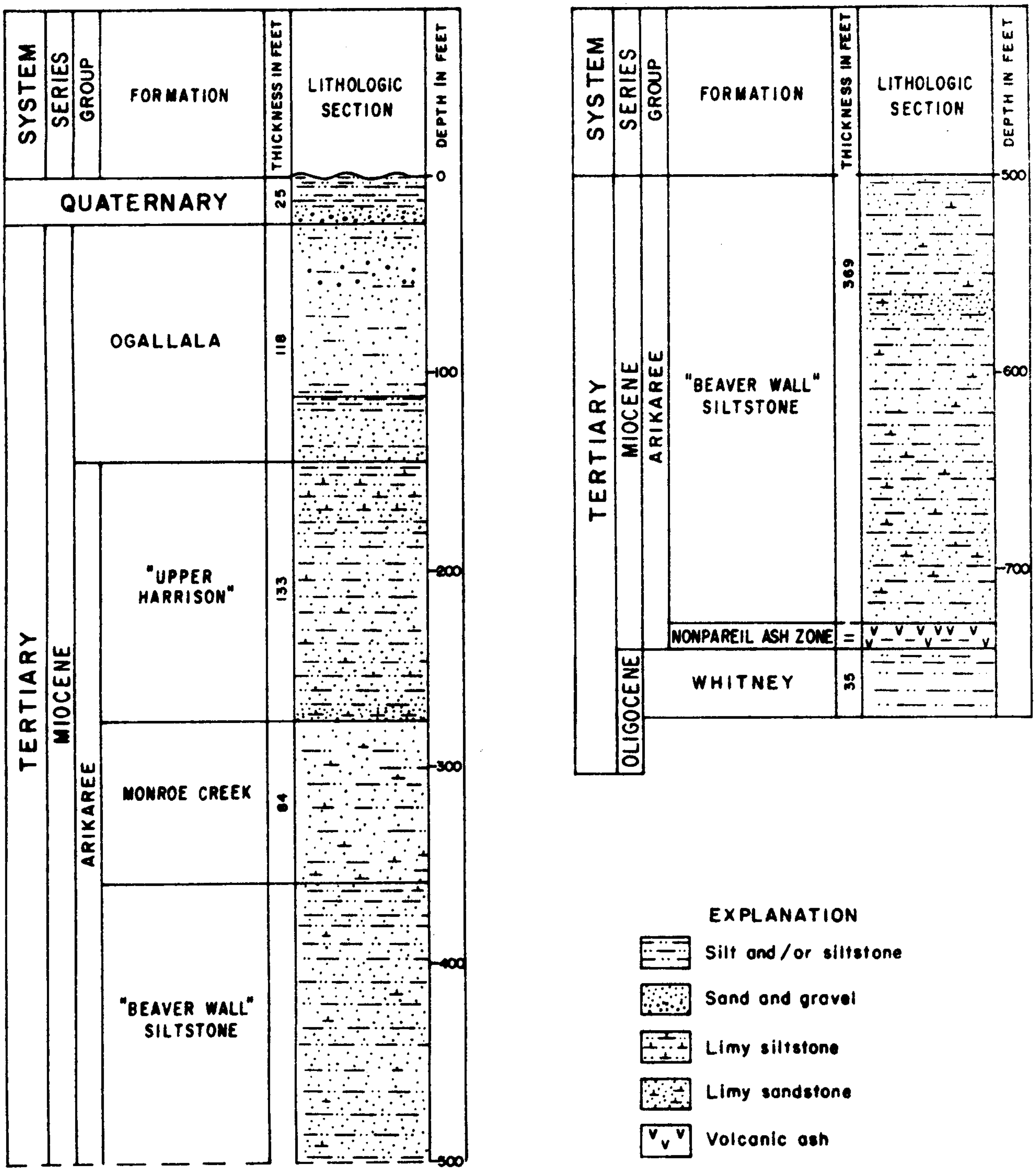
Alternatives: There are two alternatives for this project. 1) Not to implement this proposal which would result in leaving the potential for geothermal application in question and 2) Move this proposed site to another less desirable location. Such alternatives could be implemented but they would not be as amendable and cost effective as the proposed sites. The sites chosen seem to be the most suitable and economical solution to the proposal, in the opinion of the researchers and landowners.

Appendix 2-2

Lithologic Logs of Project Test Holes

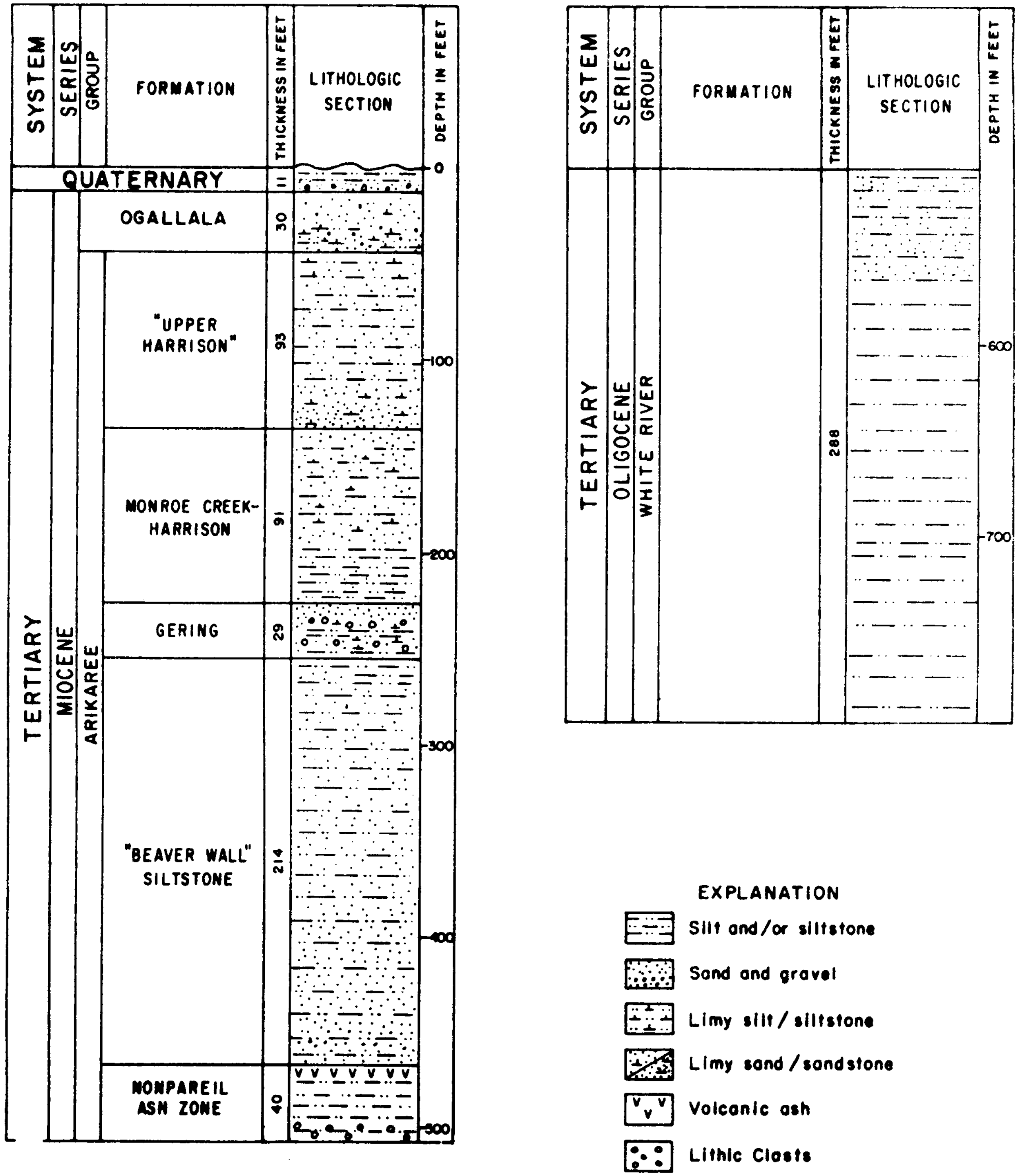
LITHOLOGIC LOGS OF PROJECT TEST HOLES

Test Hole Number	County	Legal Location
16B-78	Sheridan	SE,SE, sec. 13, T 30 N, R 46 W
17B-78	Sheridan	NE,SE, sec. 31, T 33 N, R 45 W
19H-78	Lincoln	SW,SW, sec. 36, T 12 N, R 29 W
24H-78	Lincoln	SE,SE, sec. 36, T 10 N, R 27 W
38-79	Otoe	SE,SW, sec. 6, T 9 N, R 13 E
39-79	Cass	SW,SW, sec. 2, T 10 N, R 13 E
40-79	Richardson	NE,NW, sec. 34, T 3 N, R 14 E
41-79	Pawnee	SW,SW, sec. 31, T 1 N, R 9 E
42-79	Pawnee	SW,SW, sec. 16, T 3 N, R 12 E
18-B-79	Sheridan	NW,NE, sec. 24, T 34 N, R 42 W
24-B-79	Sheridan	SW,NW, sec. 1, T 30 N, R 42 W
1aGT-80	Boyd	SE,SW,SE, sec. 24, T 35 N, R 15 W
2GT-80	Keya Paha	SE,SW,NW, sec. 32, T 35 N, R 20 W
3GT-80	Cherry	NE,SE,SW, sec. 28, T 34 N, R 27 W
4GT-80	Holt	NW,NW,NW, sec. 6, T 28 N, R 11 W
5GT-80	Wayne	SE,SW,NE, sec. 14, T 26 N, R 3 E
6GT-80	Burt	NE,SW,NE, sec. 6, T 21 N, R 9 E
7GT-80	Dodge	SW,NW,NW, sec. 32, T 18 N, R 8 E
8GT-80	Lancaster	SW,SE,SW, sec. 22, T 8 N, R 8 E
9GT-80	Dawes	SE,SE,SE, sec. 2, T 32 N, R 51 W
10GT-80	Morrill	NW,NW,NW, sec. 6, T 21 N, R 51 W
11GT-80	Cheyenne	SE,SE,SE, sec. 33, T 14 N, R 49 W
12GT-80	Garden	NW,SW,NW, sec. 26, T 17 N, R 45 W
13GT-80	Deuel	NE,NW,SE, sec. 26, T 13 N, R 42 W



LITHOLOGIC SECTION OF TEST HOLE 16-B-78

K.A. Messenger 8/83



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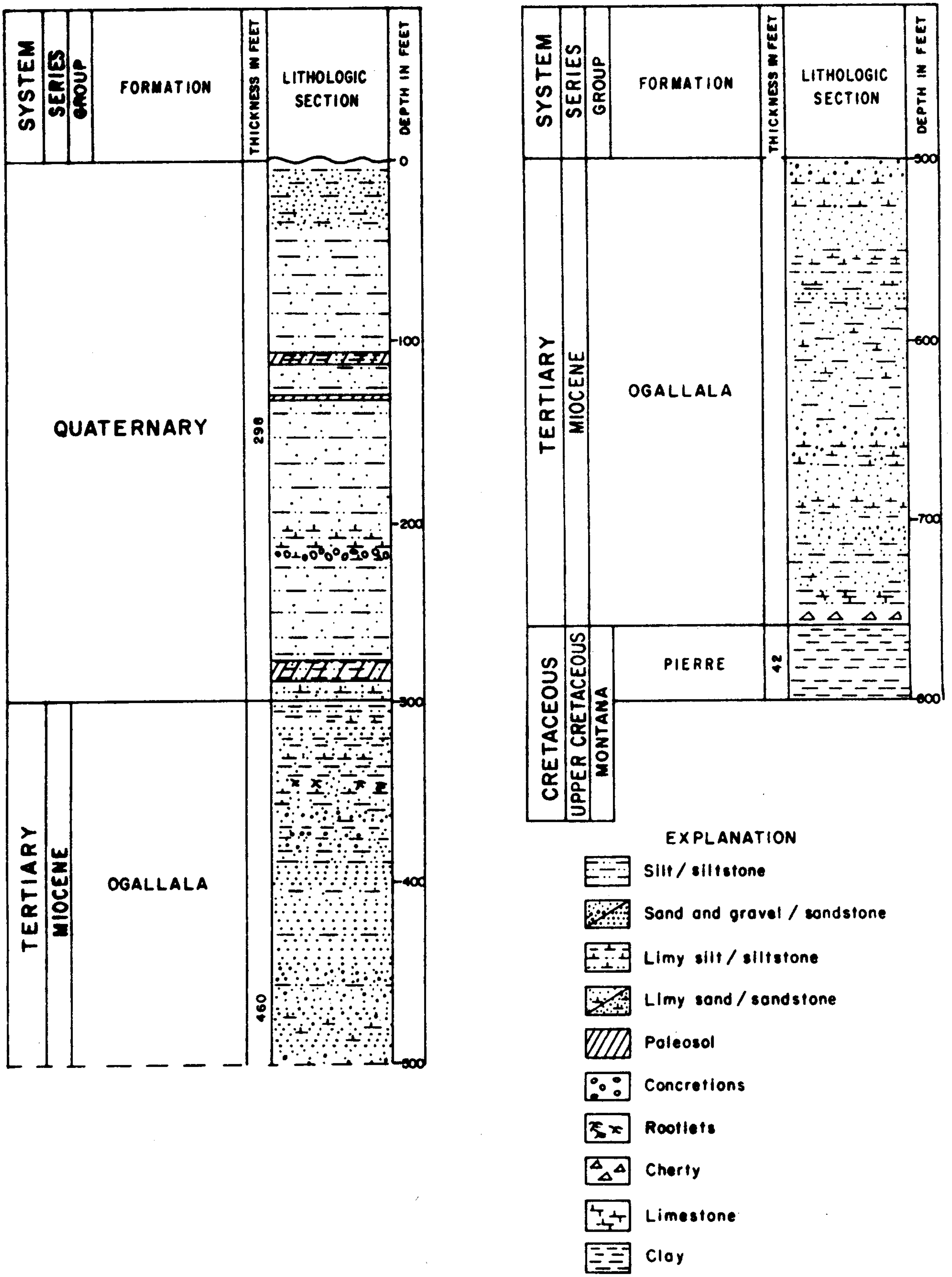
K.A. Messenger 8/83



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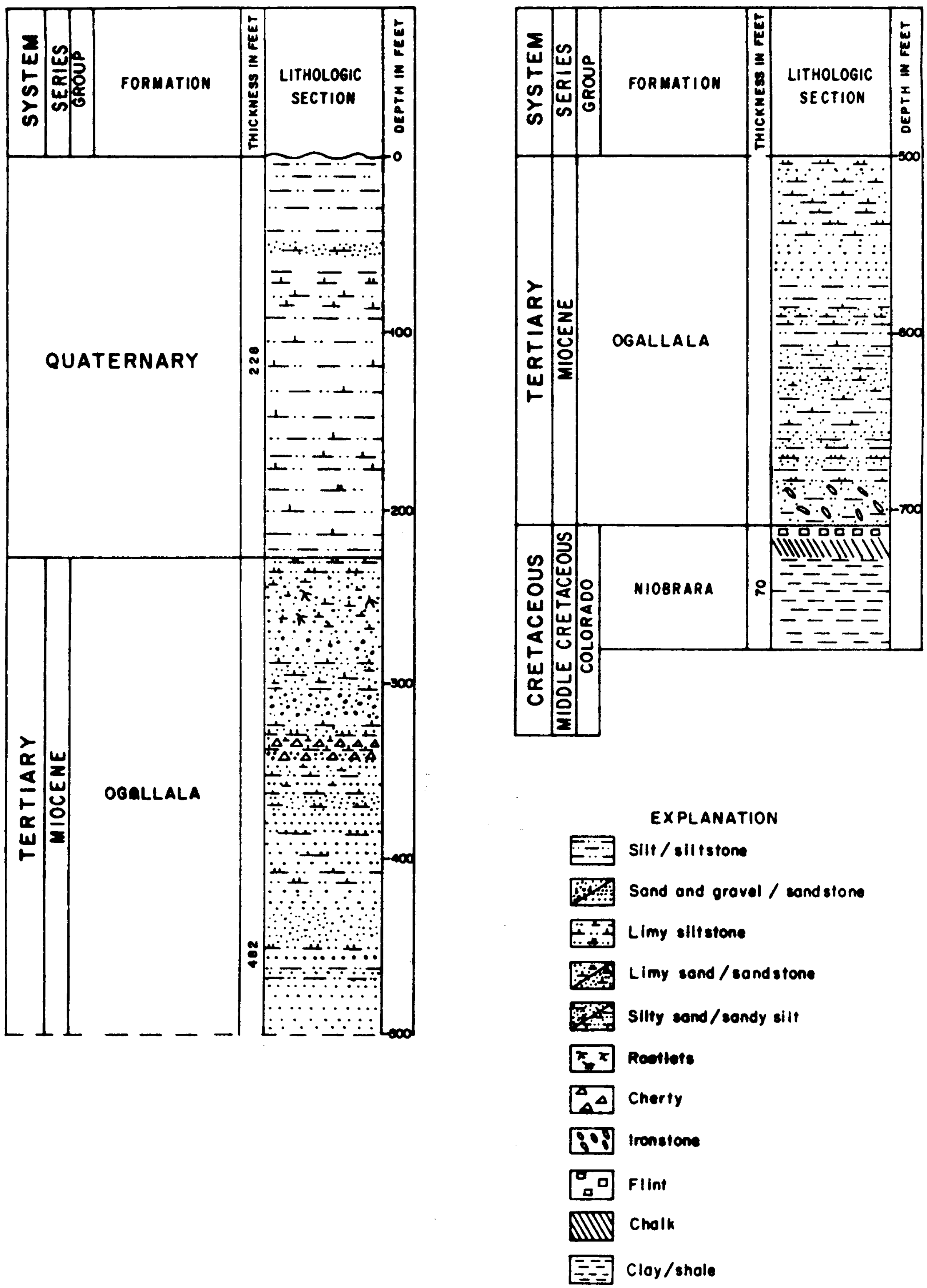
K.A. Messenger 8/83



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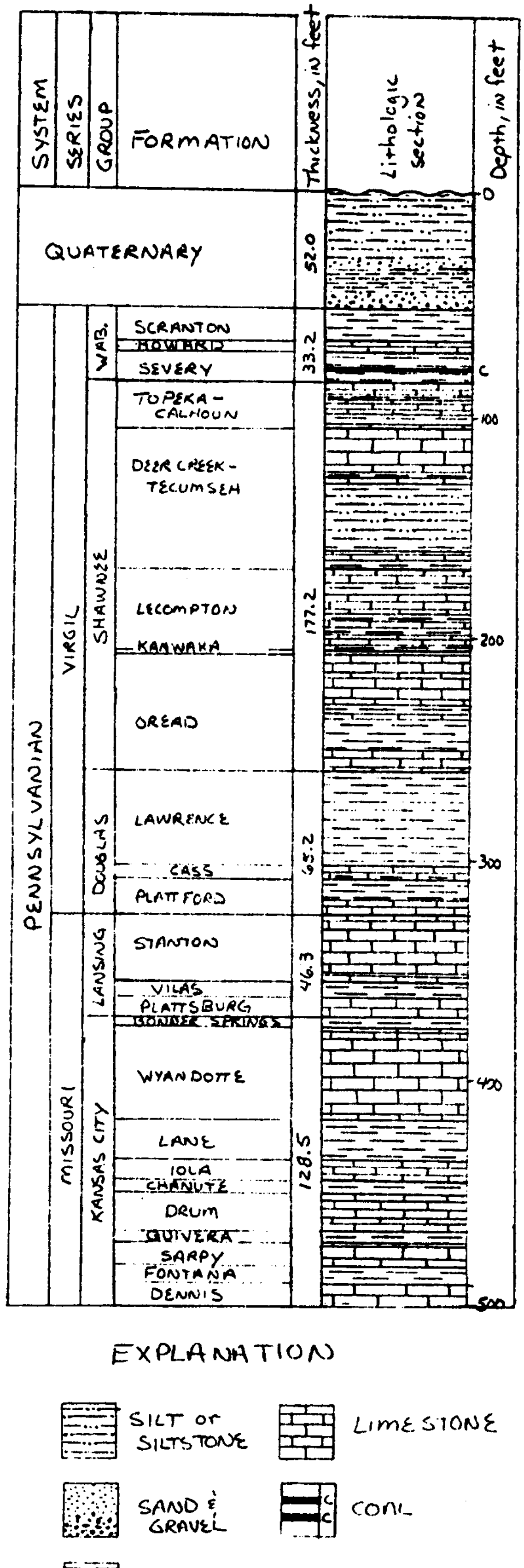
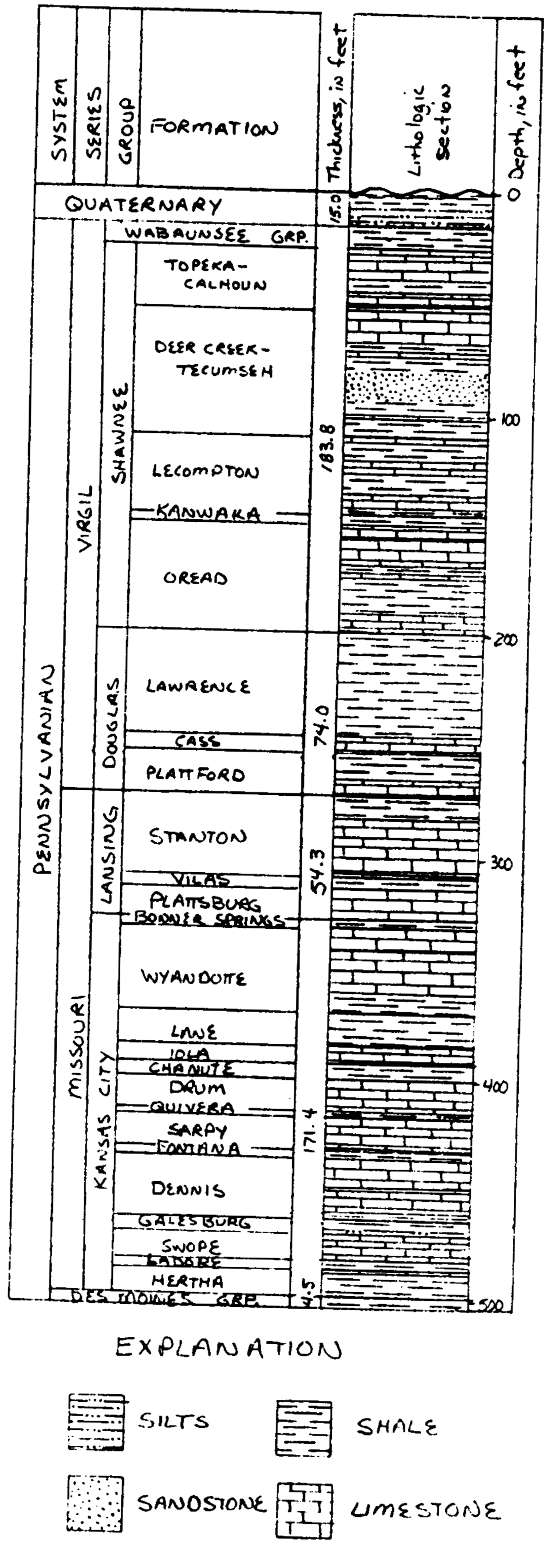


LITHOLOGIC SECTION OF TEST HOLE 38-79



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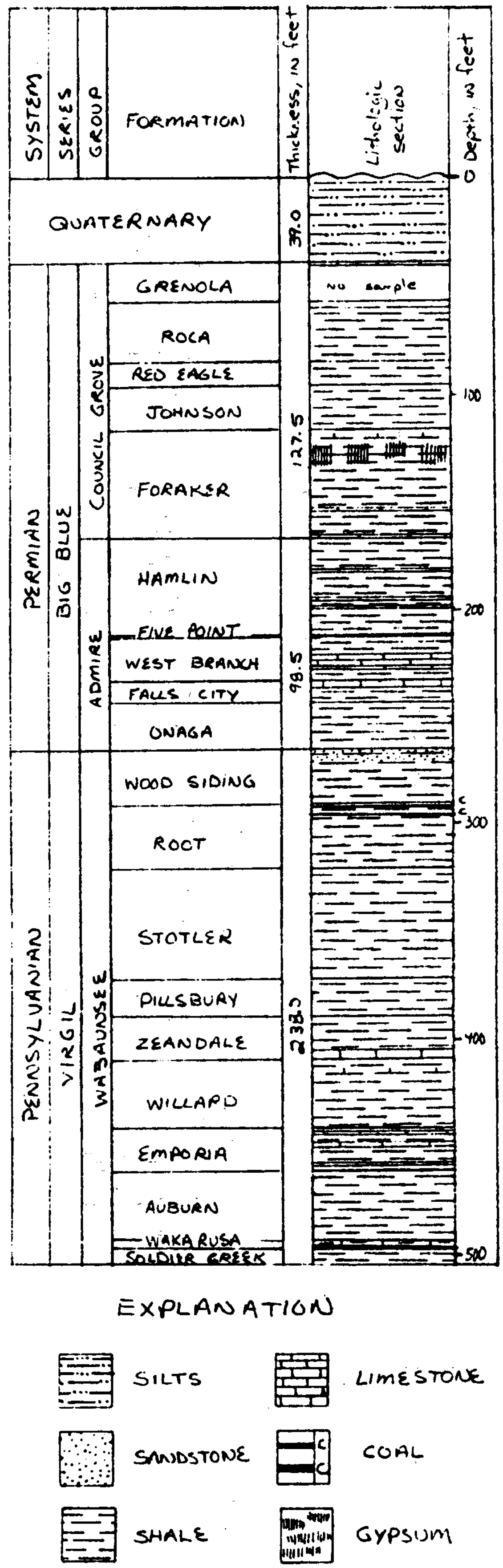

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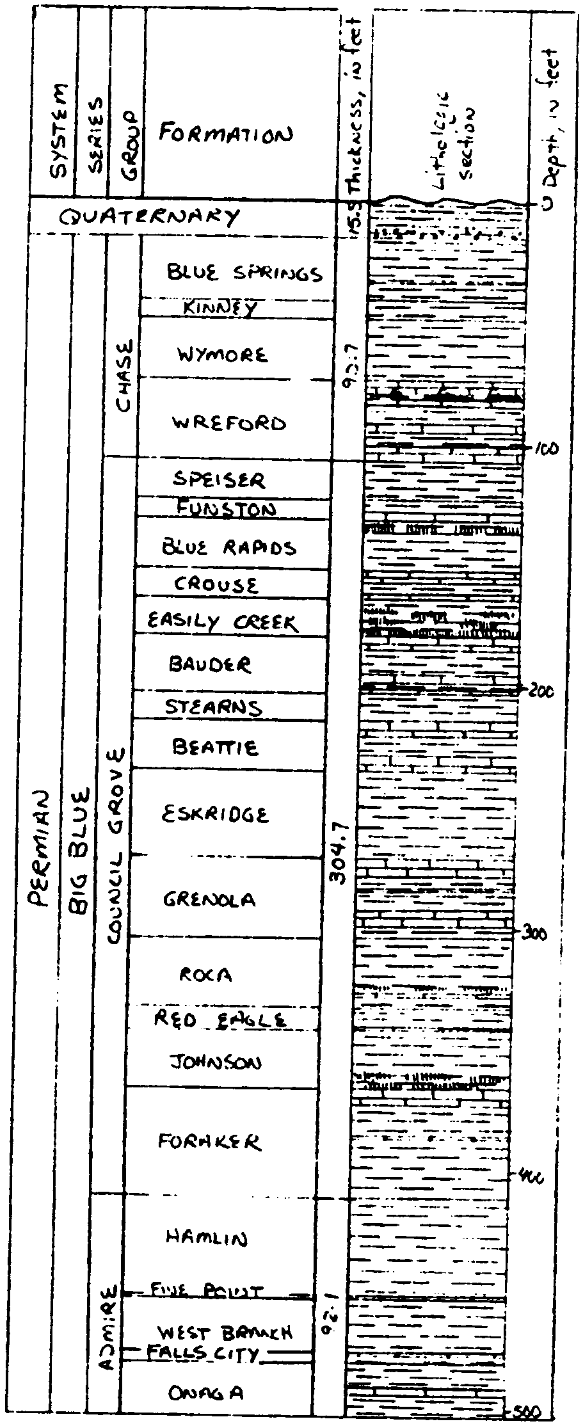
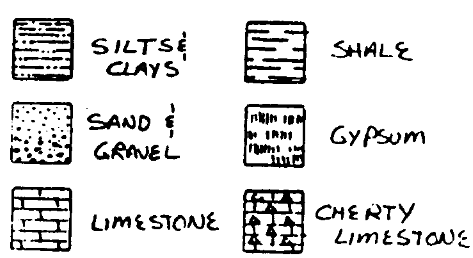


EXPLANATION



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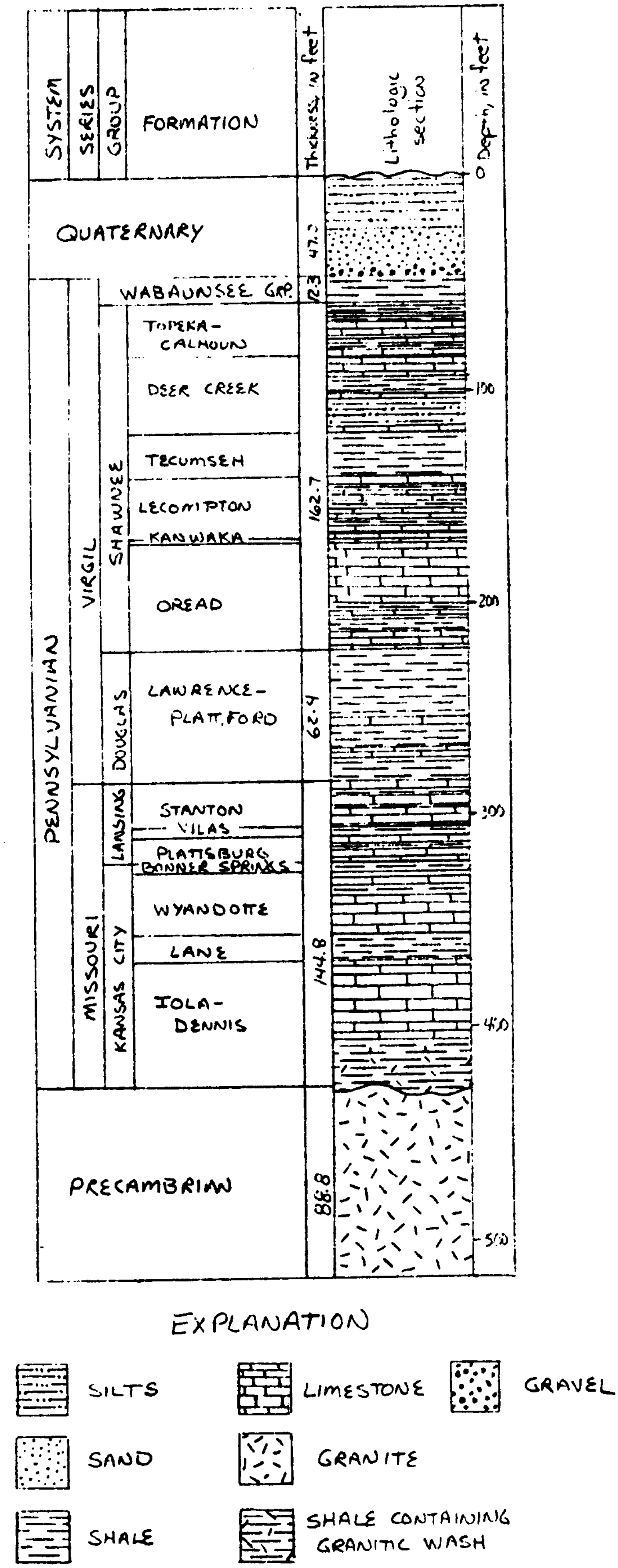
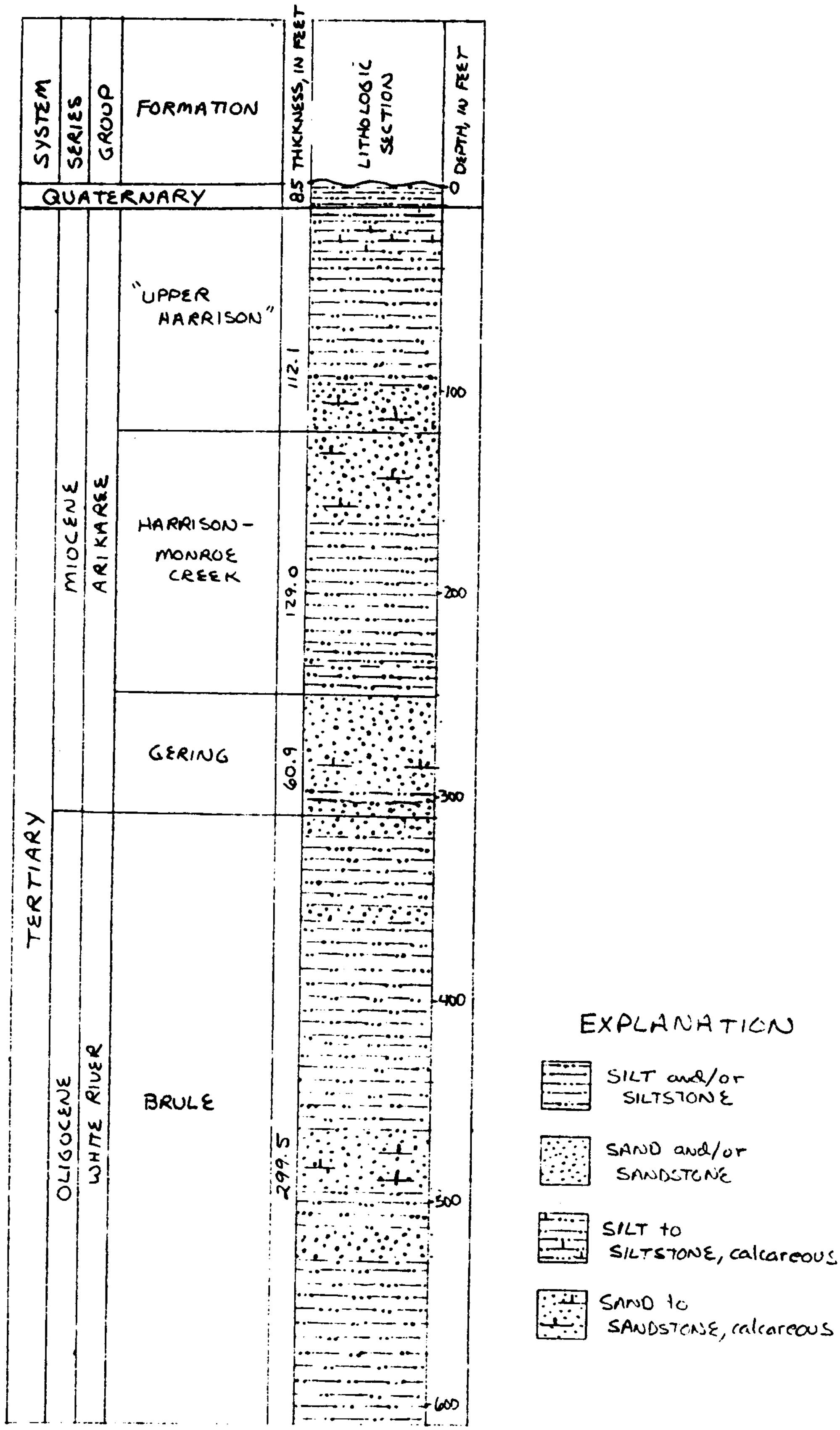


LITHOLOGIC SECTION OF TEST HOLE 42-79



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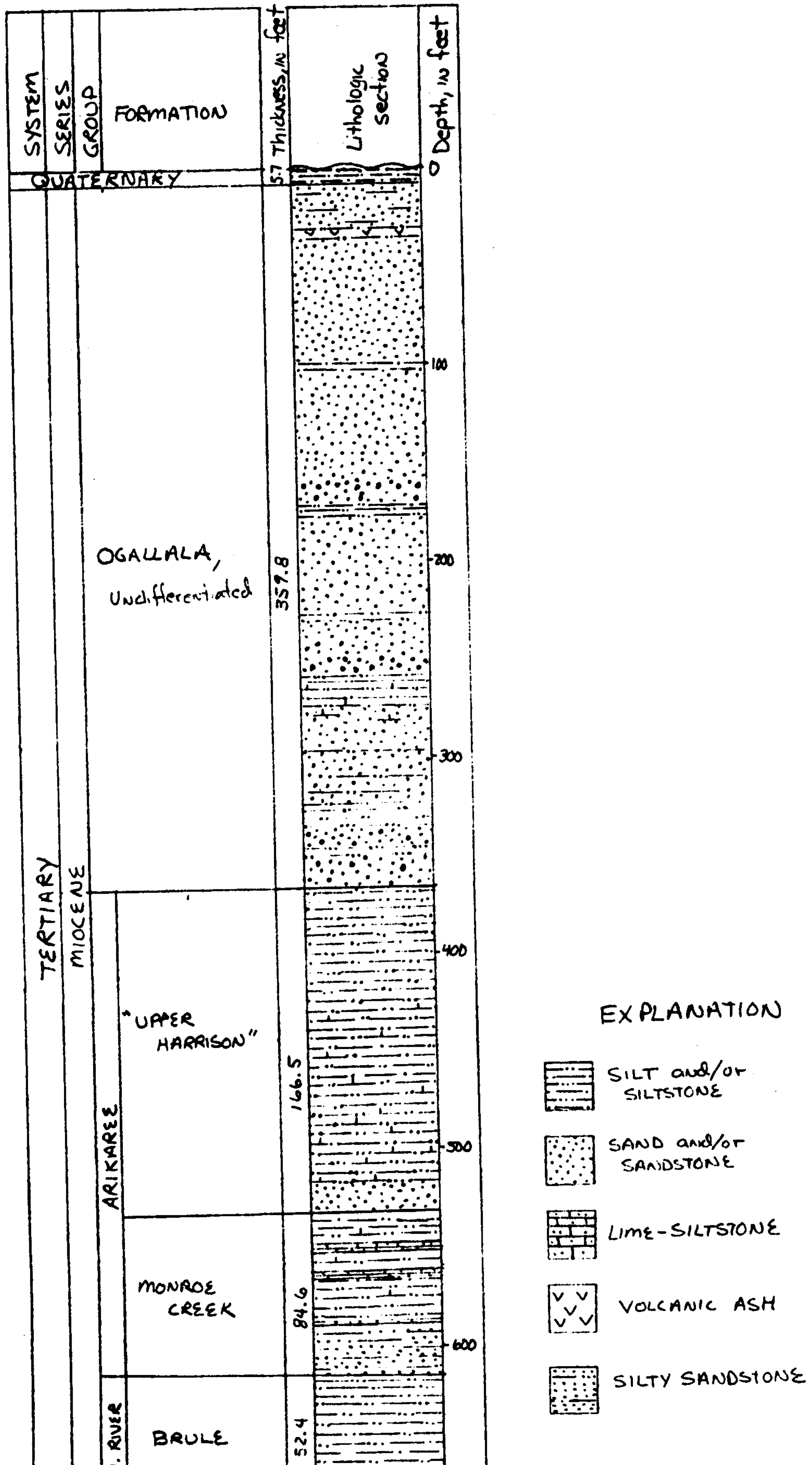

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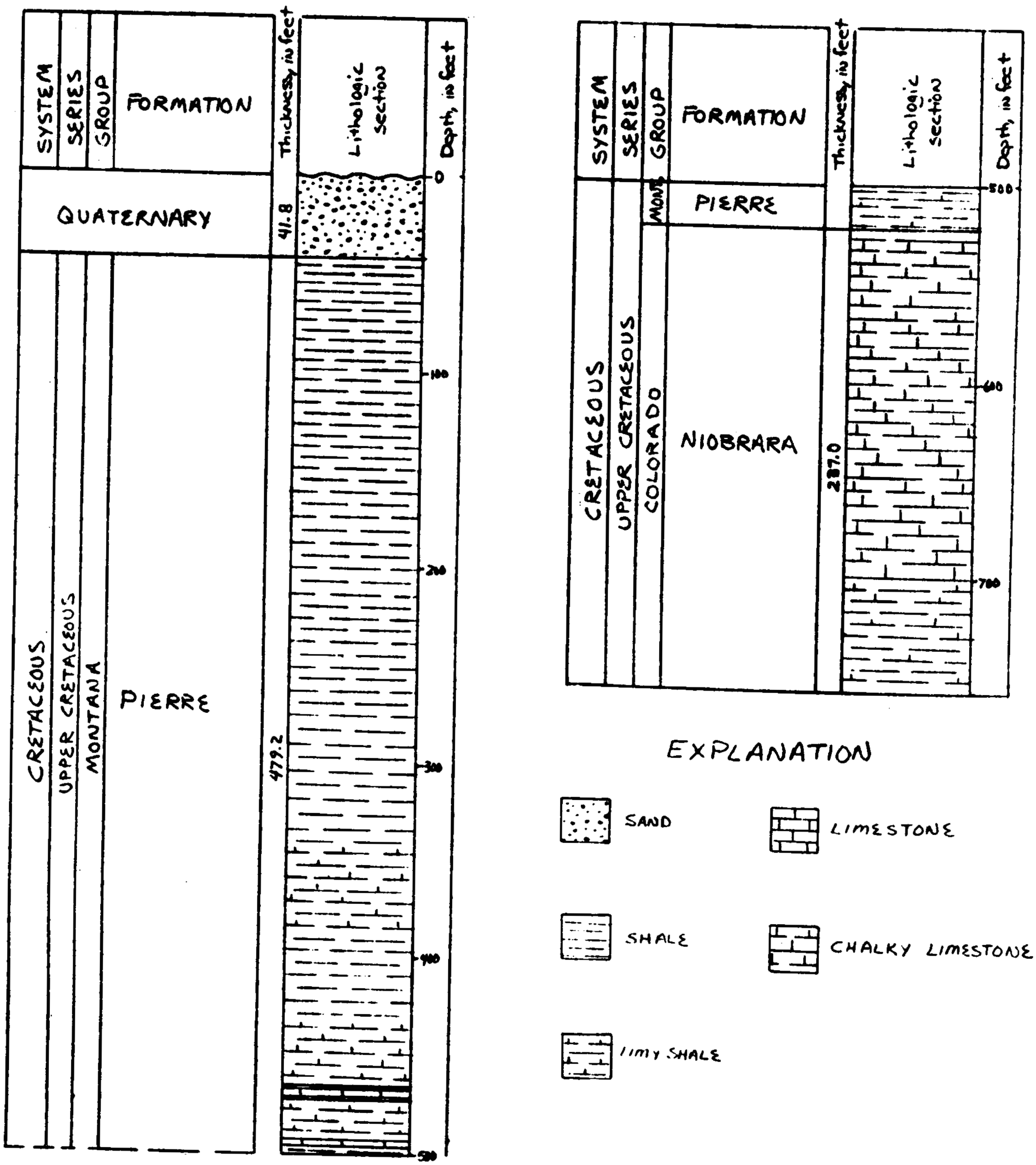
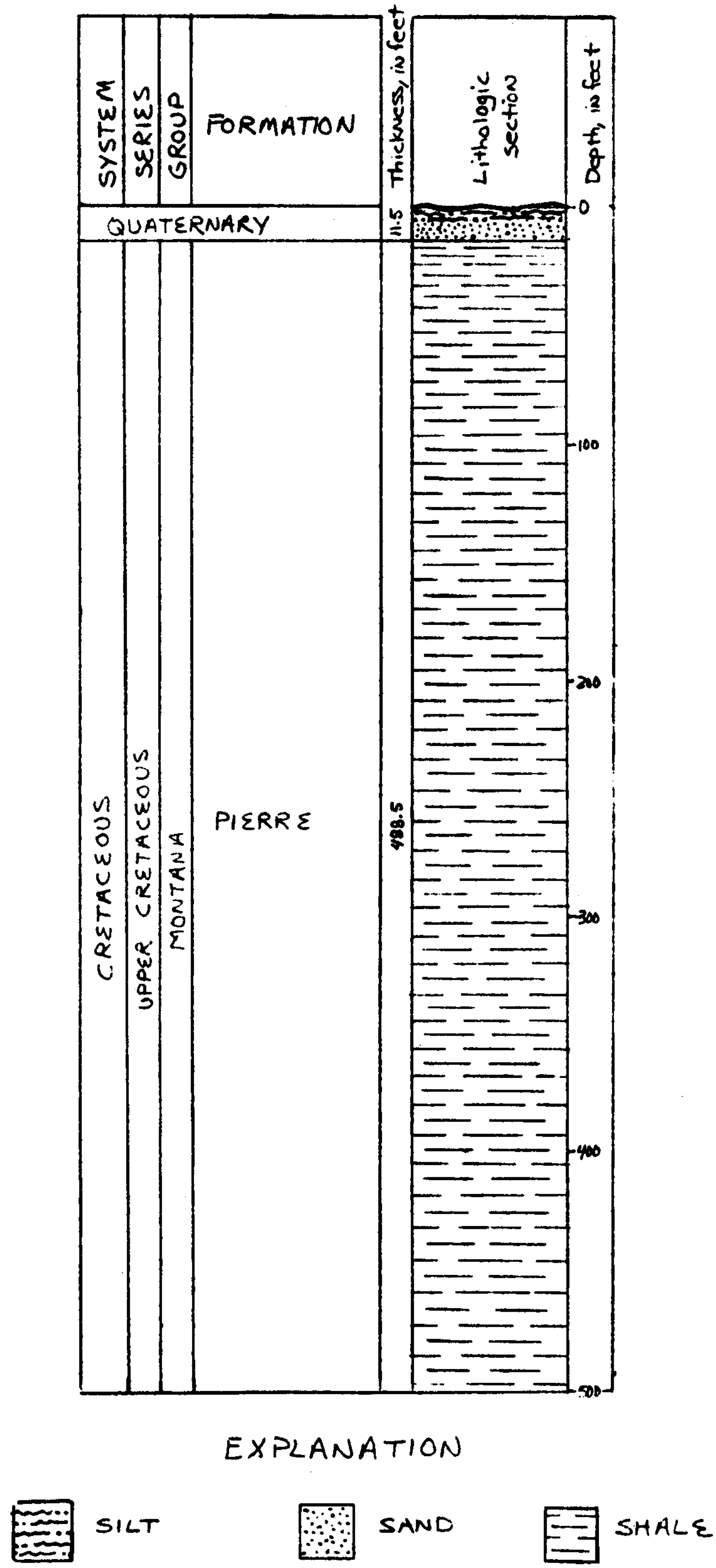


LITHOLOGIC SECTION OF TEST HOLE 1a-GT-80

D.A.W. 8/80



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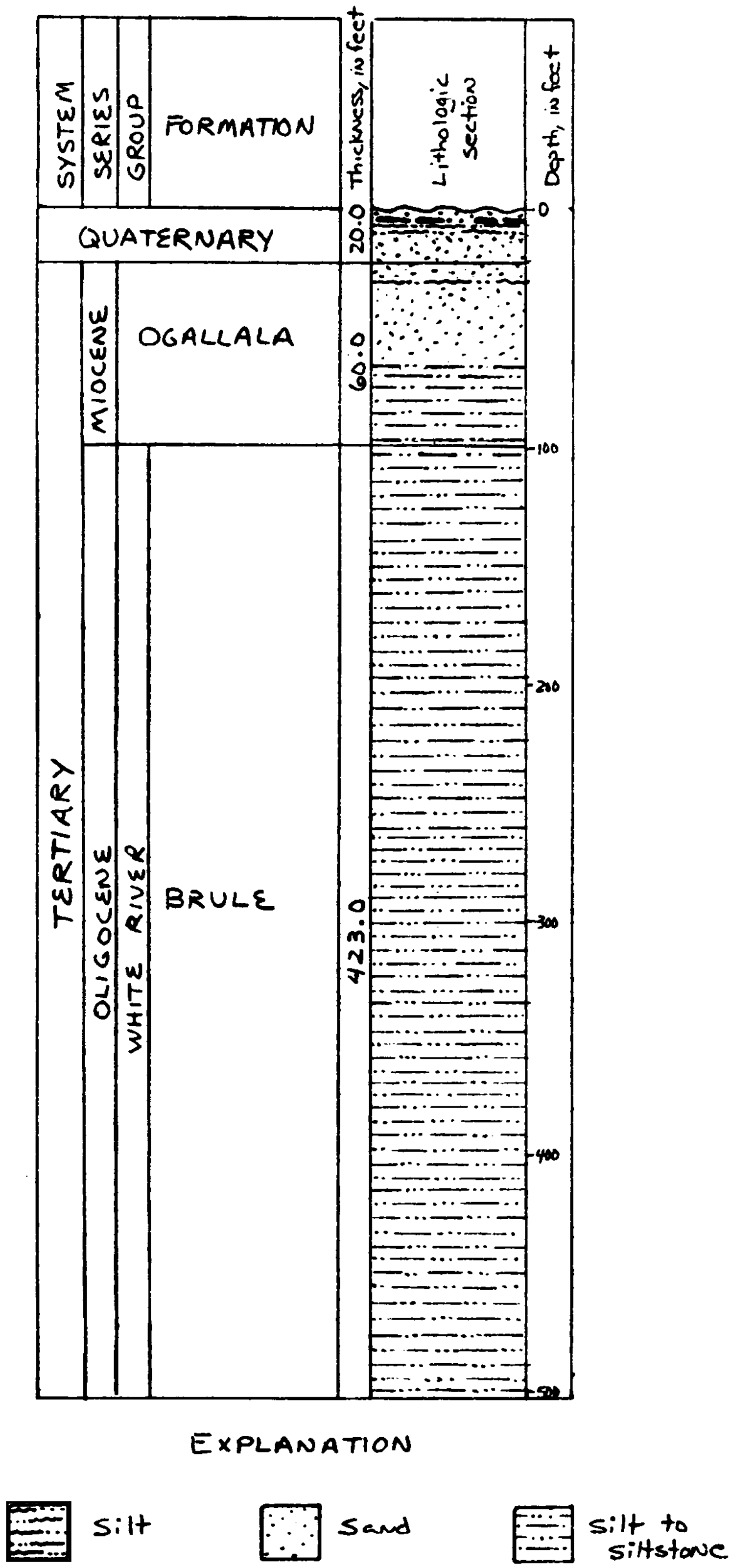

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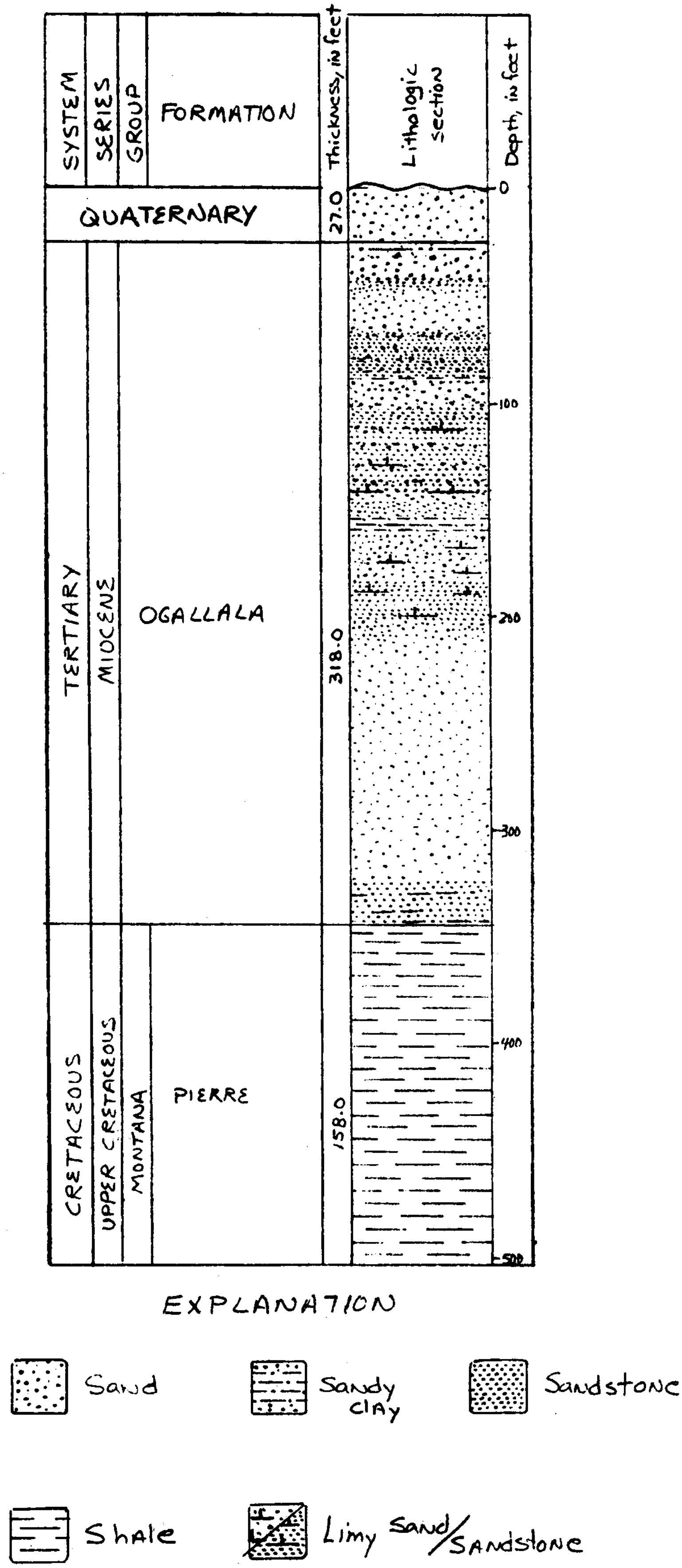

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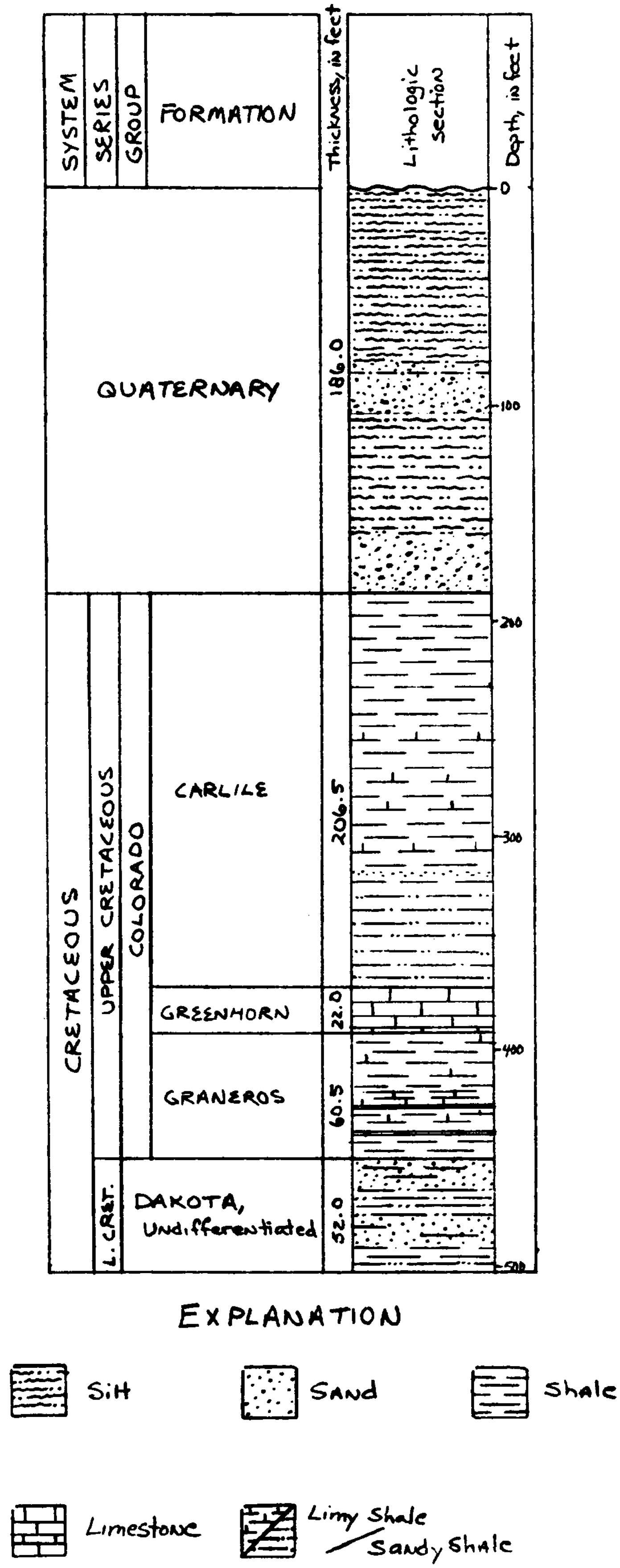

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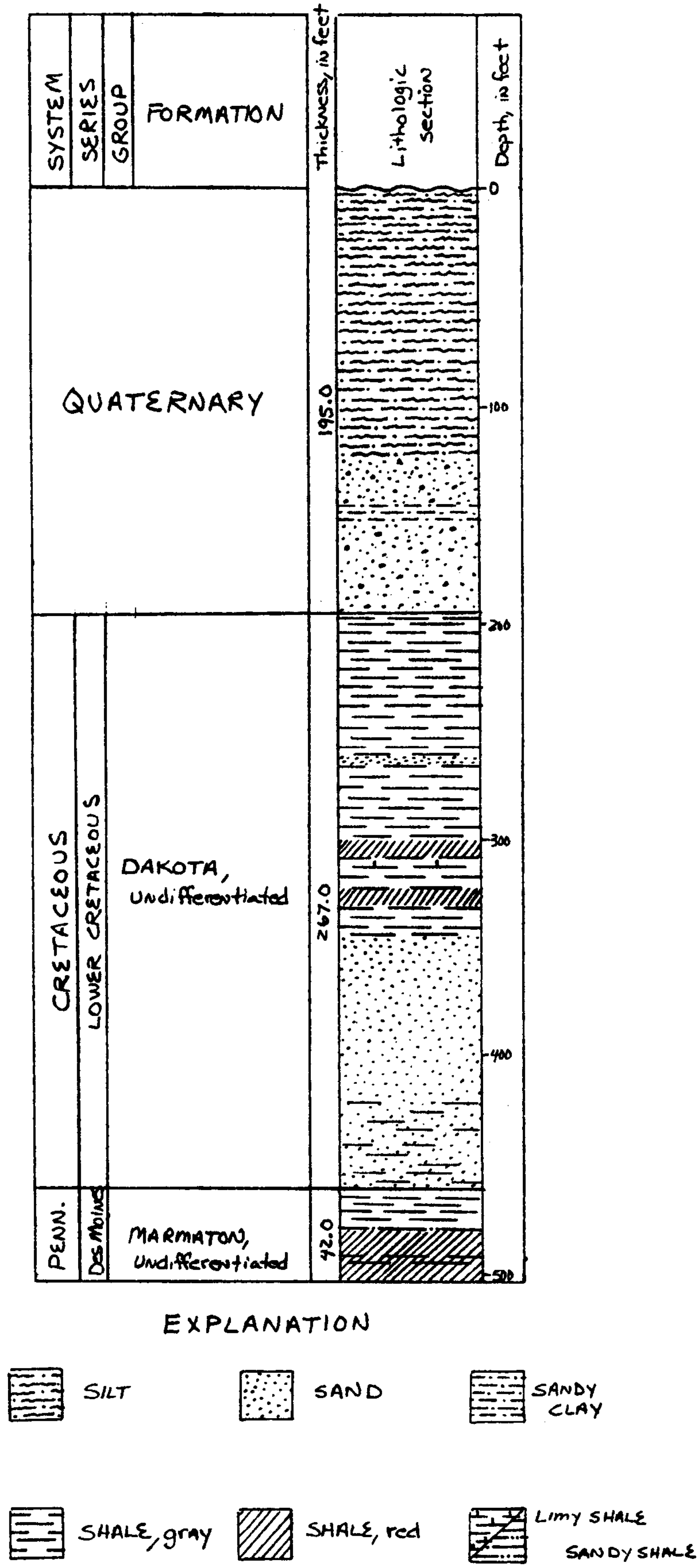

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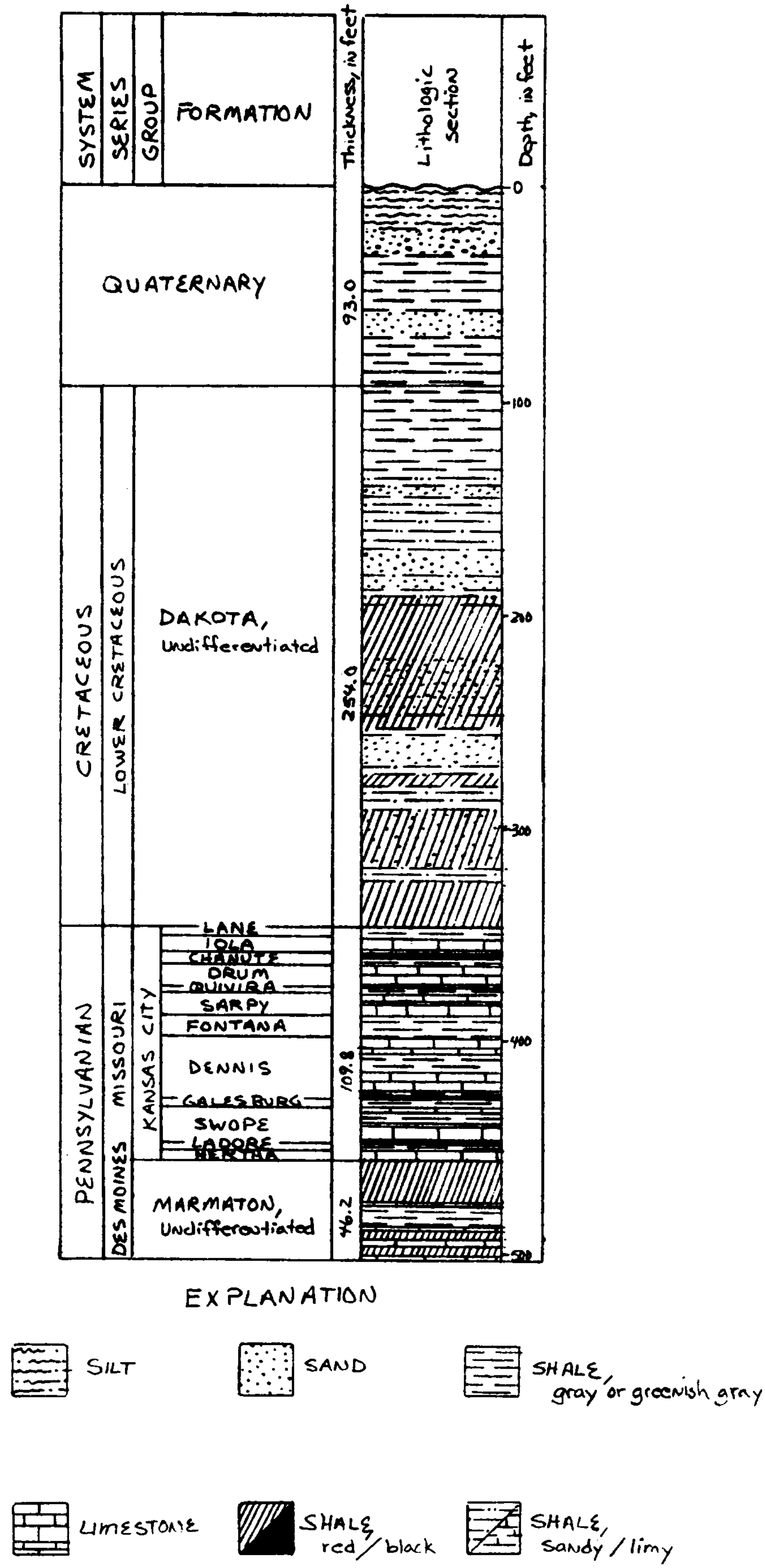

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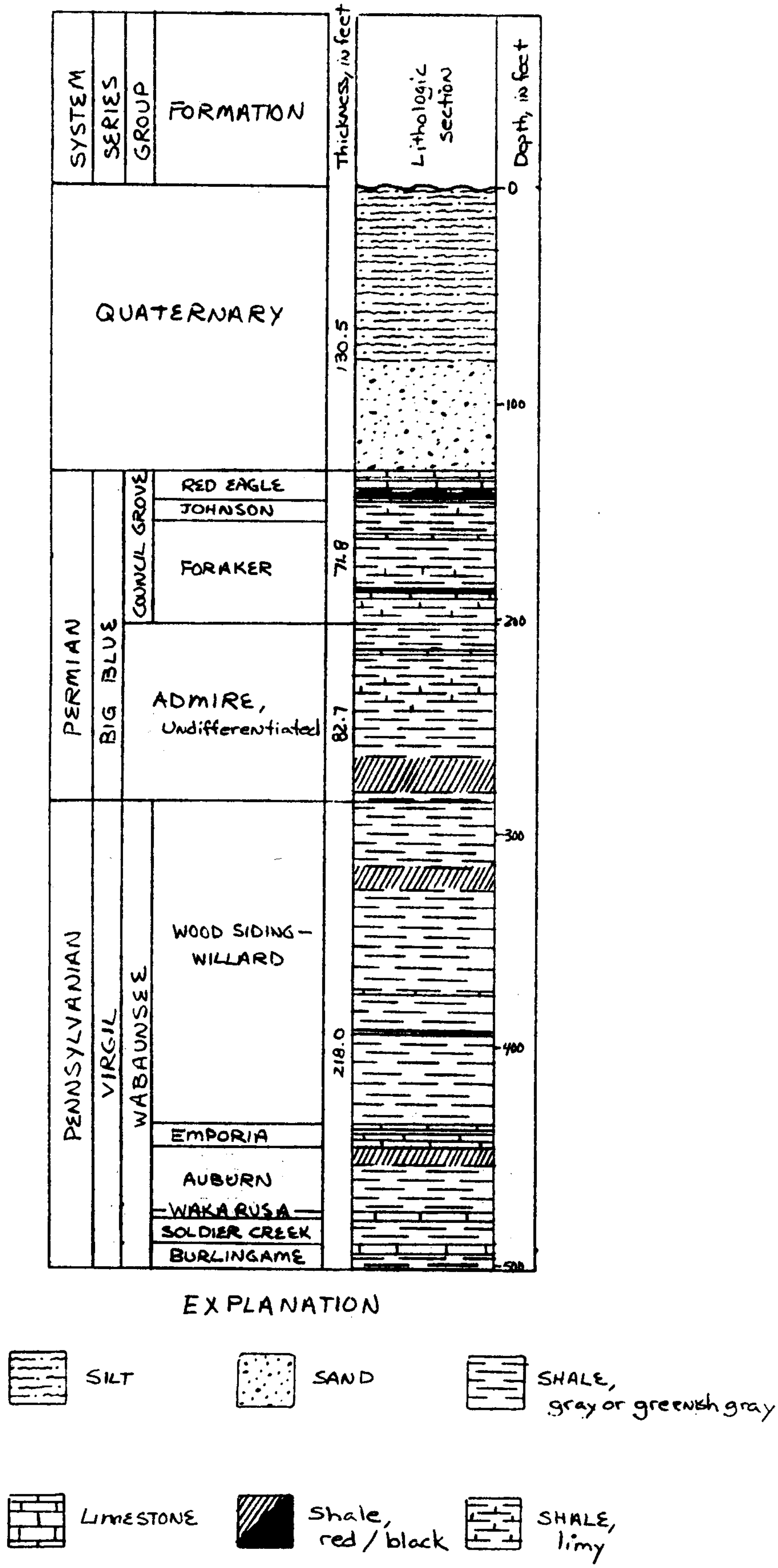

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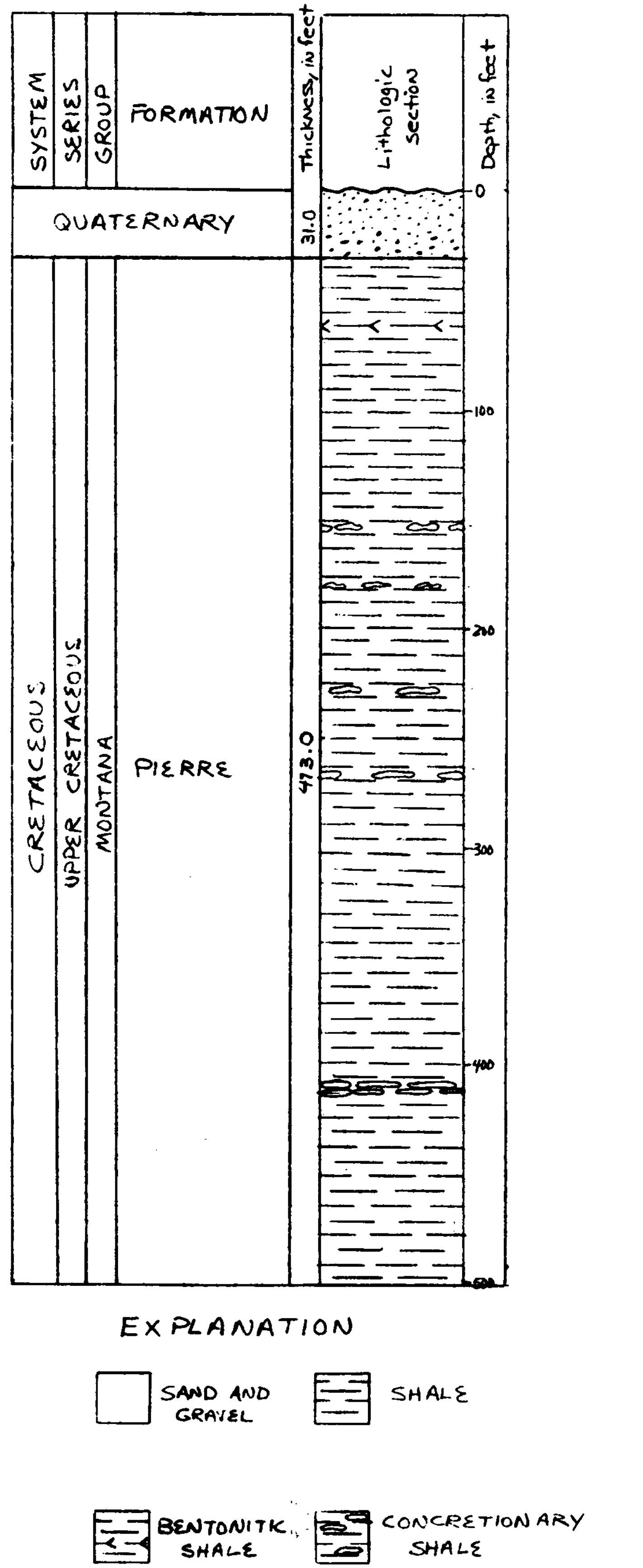

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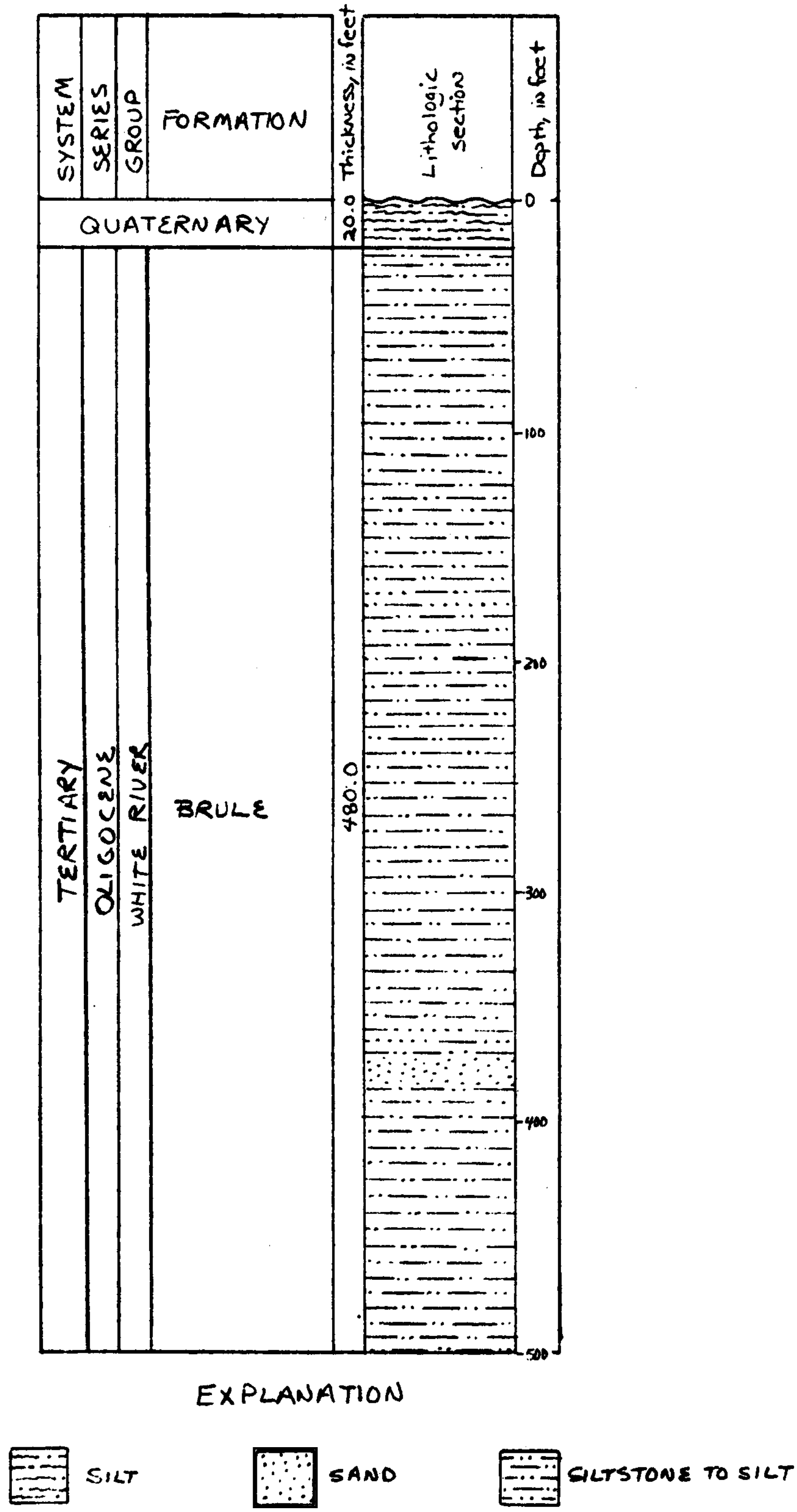

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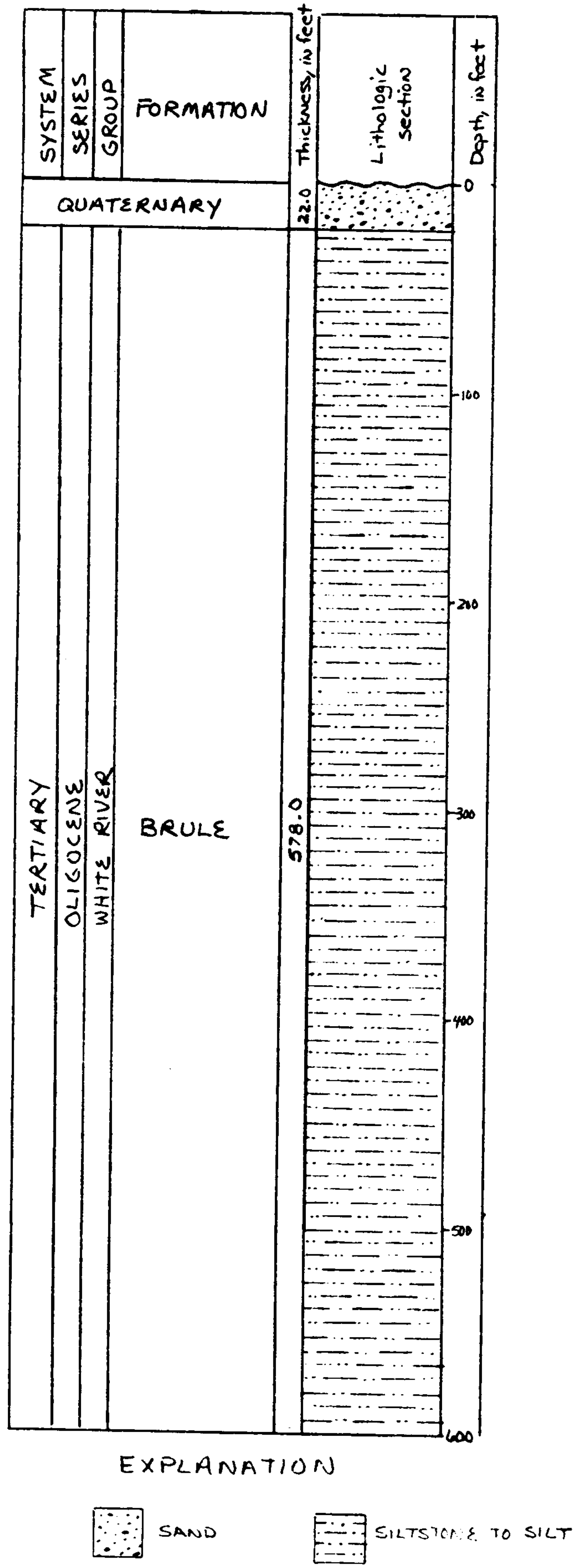

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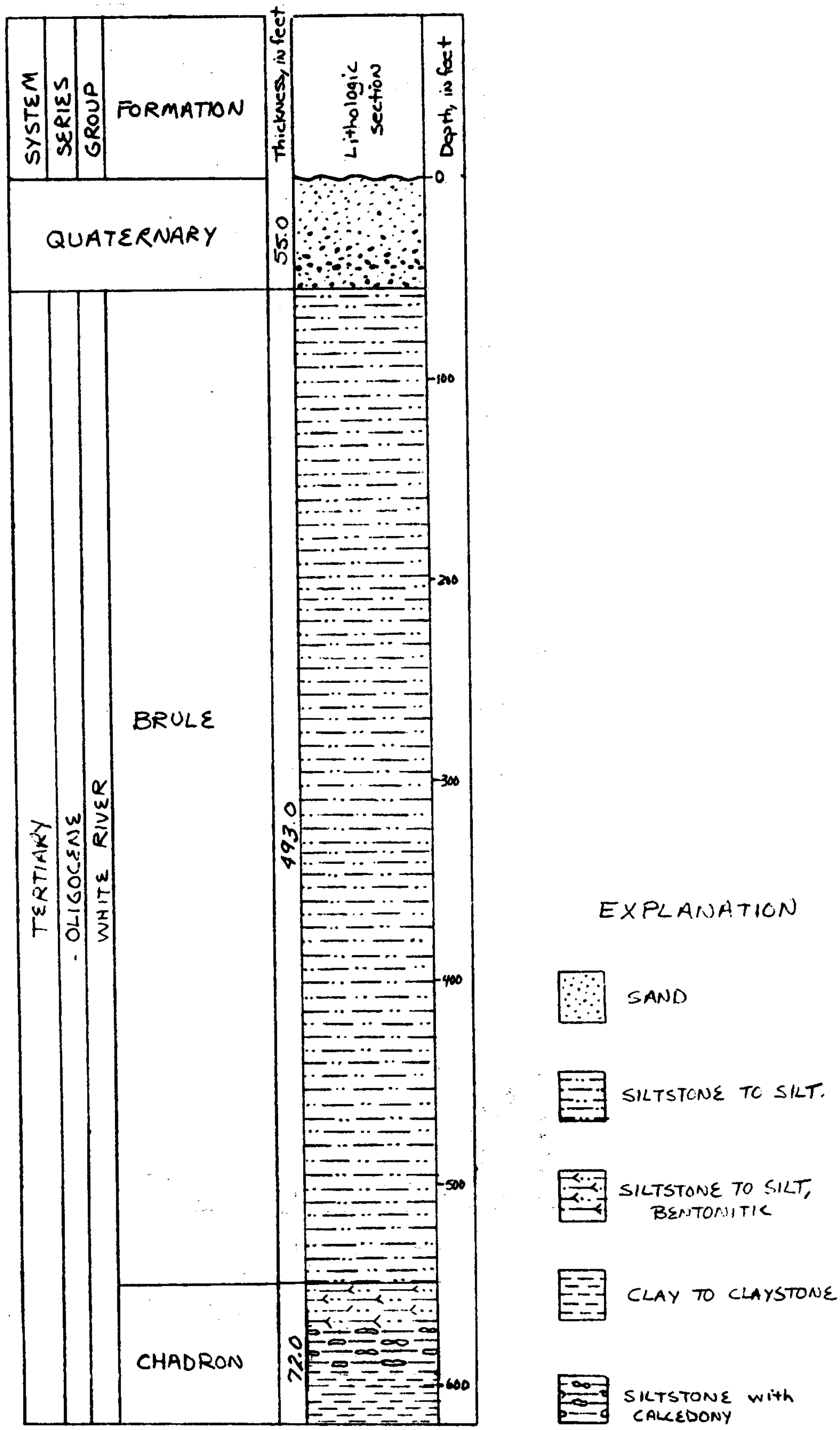

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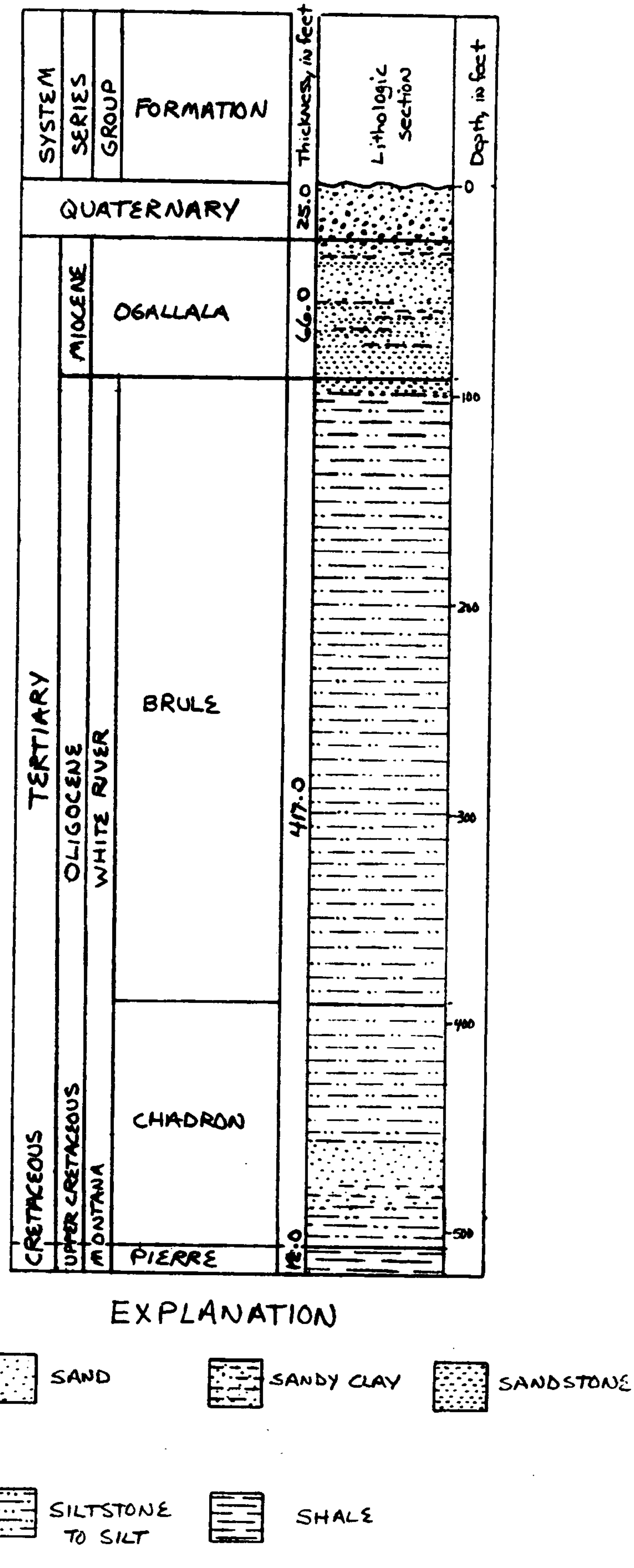


LITHOLOGIC SECTION OF TEST HOLE 13-GT-80

Appendix 2-3

Lithologic Descriptions of Project Test Holes

LITHOLOGIC DESCRIPTIONS OF PROJECT TEST HOLES

Test Hole Number	County	Legal Location
16B-78	Sheridan	SE,SE, sec. 13, T 30 N, R 46 W
17B-78	Sheridan	NE,SE, sec. 31, T 33 N, R 45 W
19H-78	Lincoln	SW,SW, sec. 36, T 12 N, R 29 W
24H-78	Lincoln	SE,SE, sec. 36, T 10 N, R 27 W
38-79	Otoe	SE,SW, sec. 6, T 9 N, R 13 E
39-79	Cass	SW,SW, sec. 2, T 10 N, R 13 E
40-79	Richardson	NE,NW, sec. 34, T 3 N, R 14 E
41-79	Pawnee	SW,SW, sec. 31, T 1 N, R 9 E
42-79	Pawnee	SW,SW, sec. 16, T 3 N, R 12 E
18-B-79	Sheridan	NW,NE, sec. 24, T 34 N, R 42 W
24-B-79	Sheridan	SW,NW, sec. 1, T 30 N, R 42 W
1aGT-80	Boyd	SE,SW,SE, sec. 24, T 35 N, R 15 W
2GT-80	Keya Paha	SE,SW,NW, sec. 32, T 35 N, R 20 W
3GT-80	Cherry	NE,SE,SW, sec. 28, T 34 N, R 27 W
4GT-80	Holt	NW,NW,NW, sec. 6, T 28 N, R 11 W
5GT-80	Wayne	SE,SW,NE, sec. 14, T 26 N, R 3 E
6GT-80	Burt	NE,SW,NE, sec. 6, T 21 N, R 9 E
7GT-80	Dodge	SW,NW,NW, sec. 32, T 18 N, R 8 E
8GT-80	Lancaster	SW,SE,SW, sec. 22, T 8 N, R 8 E
9GT-80	Dawes	SE,SE,SE, sec. 2, T 32 N, R 51 W
10GT-80	Morrill	NW,NW,NW, sec. 6, T 21 N, R 51 W
11GT-80	Cheyenne	SE,SE,SE, sec. 33, T 14 N, R 49 W
12GT-80	Garden	NW,SW,NW, sec. 26, T 17 N, R 45 W
13GT-80	Deuel	NE,NW,SE, sec. 26, T 13 N, R 42 W

Test Hole 30N-46W-13ddd
(Field No. 16-B-78)

Location: 24 ft. north and 527 ft. west of southeast corner of sec. 13, T. 30 N., R. 46 W.
Ground altitude: 3,780 ft. (Hays Springs SW 7.5-minute quadrangle)
Depth to water: 28.2 ft. (October 26, 1978)

	Depth, in feet	
	From	To
Quaternary:		
Soil and subsoil	0	4
Silt, clayey, sandy, brown	4	17
Gravel, sandy, silty; gravel mostly composed of lithic clasts; sand is mostly very fine to medium	17	25
Ogallala:		
Sand, silty, very pale brown and pale yellow, with some interbedded silt; sand is very fine to medium	25	35
Sand and sandstone, fine to coarse, mostly pale brown; some very coarse sand and trace fine gravel below 40 ft.; some interbedded silt	35	47
Sand and sandstone, mostly very fine to medium, mostly pale brown, interbedded with silt, sandy, very pale brown; sand is mostly very fine to medium but contains a trace of coarse in parts; sand is silty in parts; about 50% sand beds throughout the interval with no bed more than 4-ft. thick	47	97
Sand and sandstone, very fine to medium, very pale brown; contains a few, thin, silt beds	97	108
Clayey silt and sandy silt, light gray, very pale brown, and light yellow-brown, with some interbedded sand; sand is mostly very fine to medium	108	120
Sand and sandstone, mostly very fine to medium, mostly very pale brown; contains some thin, sandy silt beds	120	133
Silt, sandy, light gray	133	136
Sand and sandstone, gravelly, very fine sand to medium gravel, trace of coarse gravel	136	143
Upper Harrison:		
Silt, sandy, slightly clayey in parts, mostly brown; sand is very fine to fine; limy zones common; large mud loss at 145 ft	143	170
Silt, sandy, mostly light brown; grades to very silty sand near top and below 260 ft.; sand is mostly very fine; contains a few limy zones	170	270
Sand and sandstone, silty, brown; sand is very fine to fine; lime-cemented below 274 ft	270	276
Monroe Creek-Harrison:		
Sand and sandstone, very silty, mostly brown; sand is mostly very fine with some fine; intermittent limy zones throughout	276	360

Test hole 30N-46W-13ddd - continued

	Depth, in feet From	To
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, very sandy mostly brown; sand is very fine; less sandy below 560 ft.; contains some small limy zones	360	620
Silt and siltstone, mostly slightly sandy, mostly brown; more sandy from 660-680 ft.; few limy zones	620	729
Nonpareil ash zone:		
Volcanic ash, very impure, pinkish white	729	731
Silt, probably very ashy, light yellow-brown	731	740
Whitney:		
Silt and siltstone, light yellow-brown	740	775

Test hole 33N-45W-31dad
(Field No. 17-B-78)

Location: About 1,600 ft. north and 128 ft. west of southeast corner of sec. 31, T. 33 N., R. 45 W.
Ground altitude: 3,985 ft. (White Clay SW 7.5-minute quadrangle)
Depth to water: Unable to measure

	Depth, in feet From	To
Quaternary:		
Soil	0	2
Silt, slightly clayey, yellow-brown	2	5
Sand, silty, pebbly, pale brown; pebbles are mostly lithic clasts	5	11
Ogallala:		
Sand, silty, pale brown; sand is very fine to fine with some medium sand to fine gravel; one limy zone	11	15
Sand and sandstone, very fine to medium with some coarse to very coarse and a little fine to coarse gravel; contains numerous limy zones and some interbedded silt	15	41
Upper Harrison:		
Silt, moderately to very sandy, brown and yellow-brown; sand is very fine to fine; limy zones common in upper part	41	101
Sand and sandstone, silty in upper part, brown and yellow-brown; sand is fine to very fine; trace of medium sand from 120-134 ft.; and trace of coarse sand below 130 ft.; contains some limy zones	101	134
Monroe Creek-Harrison:		
Sand, mostly moderately silty, mostly brown; sand is very fine to fine; contains few limy zones	134	189
Mostly silt, very sandy, yellow-brown and brown; sand is very fine to fine	189	225
Gering:		
Sand, silty, light brown and light gray; sand is very fine to fine; contains lithic clasts from 225-230 ft.; few limy zones	225	243
Sand and sandstone, silty in parts with small amount of pink claystone; sand is very fine to medium with some coarse; lithic clasts and limy zones common	243	254
Beaver Wall siltstone:		
Silt, sandy, yellow-brown to brown; grades to very silty sand; sand is mostly very fine	254	460
Silt, very sandy, and sand, very silty, yellow-brown; sand is very fine to fine; contains lithic clasts	460	468
Nonpareil ash zone:		
Volcanic ash, very impure, very pale brown	468	473
Silt, slightly sand, yellow-brown; sand is very fine	473	489
Silt, very sandy, brown; sand is very fine to fine; lithic clasts common	489	508

Test hole 33N-45W-31dad - continued

	Depth, in feet From	To
Whitney:		
Silt, slightly sandy, slightly clayey, mostly yellow-brown and brown; very sandy in parts; sand is very fine	508	554
Silt, slightly clayey in parts, light brown	554	600
Silt, slightly to moderately clayey, mostly brown; contains a few limy zones	600	796

Test Hole 12N-29W-36ccc (19-H-78)

Location: 327 ft. north and 156 ft. east of southwest corner
Date drilled: August 23, 1978
Ground Altitude: 3020 ft. (t)
Depth to water: Approximately 260 ft.
Total depth: 800 ft.

	Depth, in feet From	To
Quaternary System, Undifferentiated:		
Top soil, silt, gray black-very dark brown	0	3
Silt, sandy, dark brown	3	20
Sand, very fine-medium, silty, humic	20	35
Silt, slightly sandy, very fine sand, trace iron stain, yellow brown	35	105
Silt, slightly sandy, paleosol, reddish brown	105	110
Silt, trace very fine sand, in part limy, yellow brown-very pale brown, pale brown 128.5-130 ft., paleosol	110	193
Silt, limy streaks-concretions, manganese stains, trace very fine sand, slightly clayey, very pale brown	193	208
Silt, limy streaks-concretions, 208-215 ft., trace very fine sand and manganese staining, pale brown	208	272
Silt, paleosol?, trace very fine sand, limy streaks, brown-gray	272	286
Silt, trace very fine sand, limy, brown-green-white	286	298
Tertiary System, Ogallala Group:		
Sandstone, very fine sand, slightly silty and limy, pinkish brown	298	302
Sandstone, very silty, very fine sand, greenish gray	302	319
Silt, very limy, white	319	321
Sandstone, very silty, very fine sand, greenish gray	321	324
Sandstone, slightly silty, very fine sand, rootlets, light green	324	339
Silt, very limy, white	339	340
Sandstone, very fine-coarse sand, moderately silty, greenish gray	340	342
Silt, slightly clayey, reddish brown with greenish streaks	342	345
Sand and gravel, very fine sand-coarse gravel, moderately silty	345	347
Silt, slightly sandy, fine-very coarse sand, trace fine gravel, reddish brown	347	356
Sand and gravel, fine sand-fine gravel, trace medium gravel	356	364
Silt, slightly sandy, trace siltstone, grayish white	364	369
Sand and gravel, fine-very coarse sand, trace fine-medium gravel	369	375
Silt, very limy, slightly cemented, grayish white	375	376
Sand, very fine-fine, moderately silty, reddish brown	376	378
Silt, very sandy, very fine-medium sand, much fine reddish brown	378	384
Sandstone, very fine-medium sand, moderately silty, moderately-very limy, pale-very pale brown	384	392
Sand, very fine-medium sand, much fine-medium, trace coarse-very coarse, slightly silty, brown	392	400

Test Hole 12N-29W-36ccc (19-H-78) continued

	Depth, in feet From	To
Sandstone, very fine-medium sand, trace coarse, much medium, slightly-very limy, and cemented, moderately silty, very pale brown-brown	400	414
Silt, very sandy, slightly clayey, slightly-very limy, very pale reddish brown-pale reddish brown	414	419
Sand-sandstone, very fine-very coarse, much medium, rare fine gravel, slightly-moderately limy, brown-pale brown	419	434
Sand-sand and gravel, fine sand-fine gravel much coarse sand	434	444
Silt, slight-moderately clayey, olive green	444	446
Sand and gravel, fine sand-fine gravel, much coarse-very coarse sand	446	460
Sand-sandstone, very fine-very coarse, much very fine-medium, trace fine gravel, moderately silty, slightly limy, trace lime cement, pale brown	460	480
Sand and gravel, fine sand-fine gravel, much coarse-very coarse	480	496
Sand, very fine-coarse, much fine, moderately silty and lime cemented, very pale brown-white	496	504
Sand, very fine-very coarse, much medium-coarse	504	509
Silt, moderately-very limy, moderately-very clayey, moderately sandy, pale brown	509	512
Sand, fine-very coarse sand, trace fine gravel, slightly silty at 537 ft., slightly greenish-olive gray-brown-white	512	544
Silt, very clayey, pale olive	544	548
Sandstone, very fine-medium sand, moderately silty, cemented, pale olive	548	560
Silt, very sandy, very fine-medium, trace coarse sand, pale olive	560	568
Sand, very silty, very fine-medium sand, much fine-medium, in part slightly clayey, slightly limy, trace lime cement, olive-pale olive	568	618
Sand, very fine-medium, much fine, slightly-moderately silty, gray-brown	618	629
Sand-sand and gravel, very fine sand-fine gravel, much medium-coarse sand, gray	629	635
Silt, very sandy, very fine-coarse sand, much medium, very limy, white	635	642
Silt, very sandy, very fine-coarse, moderately silty, slightly limy, pale gray-brown	642	645
Silt, very sandy, very fine-coarse sand, slightly limy, pale gray-brown	645	651
Sand, very fine-coarse, much medium-coarse, slightly silty, slightly limy, gray-gray brown-slightly olive	651	680
Silt, very sandy, very limy, white	680	683
Sand, very fine-medium, trace coarse, moderately silty, moderately limy, very pale brown	683	690
Sandstone, very fine, medium sand, moderately silty, pale brown-olive brown	690	700
Silt, very sandy, very fine-medium sand, trace brown siltstone and claystone, pale olive	700	711

Test Hole 12N-29W-36ccc (19-H-78) continued

	Depth, in feet From	To
Sand, very fine-medium, much fine-medium, slightly silty, pale olive gray-brown........	711	726
Silt with olive claystone, white limestone fragments with dendritic manganese stains, sandy at 736 ft., olive-pale olive........	726	756
Claystone and chert, dark green........	756	758
Cretaceous System, Pierre Formation:		
Clay, yellow-gray 770 ft., black 770-780 ft., very hard 787 ft........	758	800

Test Hole 10N-27W-36ddc (24-H-78)

Location: 156 ft. north and 1210 ft. west of southeast corner
Date drilled: September 14, 1978
Ground altitude: 2850 ft. (t)
Depth to water: Approximately 230 ft.
Total depth: 780 ft.

	Depth, in feet From	To
Quaternary System, Undifferentiated:		
Top soil, silt, slightly clayey, very dark brown-yellow-brown	0	10
Silt, slightly sandy and clayey, gray-brown, humic, sandier and light brown shells 24-29 ft.	10	29
Silt, slightly clayey, trace lime concentrations 75-95 ft. yellow brown, sandier and brownish yellow 51-59 ft. and 62-66 ft.	29	95
Silt, slightly-moderately clayey, very pale brown-brownish yellow, lime concretions, slightly-very limy, trace very fine sand 101-106 ft. and 145-158 ft.	95	180
Silt, moderately clayey, very pal brown, very limy in parts	180	228
Tertiary System, Ogallala Group:		
Silt, slightly sandy, very fine sand, moderately clayey, very limy, lime cemented, white	228	233
Sandstone, very fine-coarse sand, much fine, moderately limy, trace rootlets, gray brown-pale reddish brown	233	268
Sand and gravel, very fine sand-fine gravel, much coarse-very coarse sand, trace medium-coarse gravel, reddish	268	282
Silt, moderately-very sandy, very fine-medium sand, slightly-moderately limy, trace thin sandstone seams, pale gray brown-very pale brown-reddish brown	282	296
Sand and gravel, fine sand-fine gravel, much very coarse sand-fine gravel, rare medium gravel	296	314
Silt, very sandy, very fine-medium sand, trace coarse, slightly limy, pale reddish brown-pale olive	314	325
Silt, very limy with white opaline chert, white	325	330
Sandstone, very fine-medium sand with white opaline chert, reddish brown-brown	330	335
Sandstone and silt, interbedded, very fine-coarse sand, trace very coarse, much fine, silt, very sandy, slightly-moderately limy, reddish brown-very pale reddish brown	335	353
Sand, very fine-very coarse, moderately-very silty, pale reddish brown	353	357
Silt, moderately sandy, very fine sand, slightly-very limy, in part lime cemented, pale brown-gray brown	357	362
Sandstone, very fine-very coarse sand, much fine with thin reddish brown-olive-olive gray silt-siltstone seams, sandstone is moderately silty with trace lime cement, pale gray brown-reddish brown	362	392
Silt, very sandy, very fine-medium sand, slightly-moderately clayey, slightly-moderately limy, gray brown-very pale brown	392	408

Test Hole 10N-27W-36ddc (24-H-78) continued

	Depth, in feet	
	From	To
Sand-sandstone, very fine-very coarse sand, trace fine gravel, much medium, gray brown	408	420
Sand and gravel, fine sand-fine gravel, much very coarse sand-fine gravel, trace medium gravel, granite red	420	438
Silt, moderately clayey, very limy, very pale brown	438	441
Sandstone and silt interbedded, sandstone very fine-coarse, gray brown-brown	441	459
Sand-sandstone, very fine-medium sand, much reddish brown claystone, and pale gray brown sandy silt, brown	459	487
Sand-sandstone, very fine-medium, trace coarse, very limy with lime cement, moderately-very silty with thin olive-gray brown silt-siltstone seams, gray white-gray brown-pale olive	487	516
Silt, very sandy, very fine-medium sand, very limy with lime cement, trace sandstone, pale olive-white	516	530
Sandstone, very fine-coarse, much medium, moderately-very silty, brown-pale olive	530	551
Silt, moderately-very clayey, olive-white	551	567
Sand, very fine-coarse, trace very coarse, very silty, slightly-moderately limy, brown-pale brown	567	578
Silt-siltstone, slightly sandy, very fine-coarse sand, slightly-moderately clayey, slightly limy, olive-olive gray-brown	578	592
Sand, very fine-medium, trace coarse, moderately silty, brown	592	600
Silt-siltstone, reddish brown and olive	600	602
Sand, very fine-very coarse, very silty, slightly clayey, slightly-moderately limy, pale olive-pale gray	602	613
Silt, slightly-moderately sandy, very fine-medium, slightly-moderately limy, slightly clayey, some siltstone and olive claystone with iron stain, pale olive-olive gray-olive and brown	613	636
Sandstone, very fine-fine, olive	636	640
Silt, moderately-very sandy, some siltstone and sandstone, trace dark green-black chert fragments, olive	640	645
Silt, slightly-moderately clayey, very limy, white	645	650
Sand, very fine-very coarse, moderately limy	650	654
Silt, slightly-very clayey, slightly-moderately limy, very pale brown	654	664
Sand, very fine-very coarse, trace fine gravel, moderately silty with interbedded pale brown silts, much weathered shale and ironstone	664	700
Sand and gravel, fine sand-fine gravel, much very coarse sand, much ironstone and very pale yellow clay	700	710
Cretaceous System, Niobrara Formation:		
Flint, very hard, yellowish brown-pale yellow-red siliceous	710	711.5
Chalk, limy, bright yellow-orange-dark brown	711.5	727

Test Hole 10N-27W-36ddc (24-H-78) continued

	Depth, in feet From	To
Clay, shaley, gray, occasional pyrite, very calcareous, speckled, yellow-orange-dark brown claystone pebbles and fragments 744-745 ft....................................	727	745
Clay, shaley black-gray black with silver blue streaks and trace ironstone and yellow-orange, speckled, some pyrite....	745	780

Test Hole 38-79

Location: Otoe County, SE corner SW sec. 6, T. 9 N., R. 13 E., approximately 20 feet north of south section line and 152 feet west of half section line.

Ground-level elevation: 1,045.5 feet above mean sea level.

Started: June 20, 1979. Completed: June 25, 1979.

Total depth: 500.0 feet.

Description	Depth, in feet From		To
Quaternary System:			
Soil, dark brown, silty, clayey	0.0	-	4.0
Silt, brown, clayey	4.0	-	5.0
Silt, light brown, clayey	5.0	-	10.0
Silt, light brownish gray, clayey	10.0	-	16.5
Silt, pale reddish brown, clayey, sandy	16.5	-	22.0
Silt, very light tannish gray, clayey	22.0	-	30.0
Sand, medium to very coarse, and gravel, very fine to coarse	30.0	-	32.5
Silt, light tannish gray, clayey, silty	32.5	-	35.0
Clay, light gray, silty	35.0	-	37.0
Clay, dark gray, silty	37.0	-	44.0
Clay, light gray, silty	44.0	-	47.5
Sand, fine to very coarse, and gravel, very fine to medium; contains limestone fragments	47.5	-	52.0
Pennsylvanian System - Virgil Series - Wabaunsee Group:			
Scranton Formation:			
White Cloud Member:			
Shale, pale olive	52.0	-	56.5
Shale, dark gray with traces of olive mottling	56.5	-	62.0
Shale, medium gray	62.0	-	66.6
Howard Formation:			
Limestone, medium gray very finely to finely crystalline, shaley; contains pyrite	66.6	-	68.2
Limestone, dark tannish gray, very finely to finely crystalline; contains brachiopods, algal material, and abundant ostracods	68.2	-	70.6
Severy Formation:			
Shale, dark gray	70.6	-	71.0
Shale, black	71.0	-	72.0
Shale, medium gray	72.0	-	72.3
Shale, black	72.3	-	72.9
Shale, medium to light gray	72.9	-	79.5
Coal, black	79.5	-	80.1

Test hole 38-79 continued

	Depth, in feet	
	From	To
Shale, light gray	80.1	81.7
Limestone, dark gray, finely crystalline	81.7	83.4
Shale, medium gray	83.4	84.8
Shawnee Group:		
Topeka Formation:		
Coal Creek Member:		
Limestone, dark gray, finely crystalline	84.8	85.2
Limestone, medium gray, finely crystalline; contains fusulinids and pyrite; interbedded with shale, dark gray, at 86.0-86.1	85.2	87.2
Shale, dark gray	87.2	87.6
Limestone, medium to dark gray, finely crystalline; contains brachiopods and abundant crinoids	87.6	88.5
Shale, medium gray, limy	88.5	89.0
Limestone, medium gray, finely crystalline; contains crinoids and brachiopods	89.0	89.4
Holt Member:		
Shale, dark gray	89.4	90.1
Shale, black	90.1	91.3
DuBois Member:		
Limestone, medium to dark gray, finely crystalline; contains brachiopods and pyrite	91.3	91.8
Shale, medium to dark gray, limy	91.8	92.3
Limestone, light gray to light greenish gray, finely crystalline, shaley; contains crinoids	92.3	93.0
Turner Creek Member:		
Shale, light to medium gray	93.0	94.8
Sheldon Member:		
Limestone, very light tan, finely crystalline; pseudo-oolitic; contains Osagia, brachiopods, and gastropods	94.8	99.4
Jones Point - Iowa Point Members:		
Shale, light gray; interbedded with thin limestones	99.4	102.0
Shale, medium gray; interbedded with thin limestones	102.0	103.5
Hartford Members:		
Limestone, very light gray, very finely to finely crystalline; contains crinoids, glauconite, and abundant fusulinids	103.5	105.5
Calhoun Formation:		
Shale (no sample)	105.5	105.6
Deer Creek - Tecumseh Formations:		
Ervine Creek Member:		
Limestone, very light tan, very finely to finely crystalline; contains gastropods	105.6	107.3

Test hole 38-79 continued

	Depth, in feet From	To
Limestone, light tannish gray, very finely to finely crystalline; contains brachiopods, algal material, and bryozoans	107.3	- 111.0
Limestone, very light gray to white, very finely crystalline; contains coral, fusulinids and pyrite	111.0	- 115.4
Limestone, dark tannish gray, finely crystalline; contains crinoids and fusulinids	115.4	- 121.1
Shale, medium to dark gray, hard, contains fusulinids and crinoids	121.1	- 121.9
Limestone, light to medium gray, finely crystalline; contains crinoids	121.9	- 123.3
Shale, medium gray	123.3	- 124.6
Limestone, light gray, finely crystalline; contains crinoids	124.6	- 125.3
Larsh Member:		
Shale, medium gray	125.3	- 125.8
Shale, dark gray to black	125.8	- 126.4
Rock Bluff Member:		
Limestone, medium tan, very finely crystalline; contains brachiopods and fusulinids	126.4	- 129.2
Oskaloosa - Rakes Creek Members:		
Shale, medium gray	129.2	- 131.6
Silt, light bluish gray	131.6	- 142.0
Silt, light bluish gray; interbedded with sandstone, light bluish gray, at 143.0-144.0	142.0	- 147.0
Silt, light bluish gray; interbedded with sandstone, light bluish gray, at 151.6	147.0	- 157.0
Shale, medium to light gray	157.0	- 158.5
Shale, reddish brown	158.5	- 161.3
Ost Member:		
Limestone, light gray to light greenish gray, very finely to finely crystalline; interbedded with shale, reddish brown	161.3	- 164.5
Shale, pale reddish gray; interbedded with thin limy zones	164.5	- 165.0
Limestone, very light greenish gray, finely crystalline, shaley	165.0	- 165.8
Kenosha Member:		
Shale, reddish brown with traces of gray to greenish gray	165.8	- 169.0
Shale, gray to greenish gray with traces of reddish brown	169.0	- 170.0
Lecompton Formation:		
Avoca Member:		
Limestone, tannish gray, finely crystalline, shaley; contains crinoids	170.0	- 171.2
Limestone, dark gray, finely crystalline, shaley; contains crinoids and fusulinids	171.2	- 171.4

Test hole 38-79 continued

	Depth, in feet	
	From	To
Limestone, medium gray, finely crystalline; contains crinoids and fusulinids	171.4	- 174.0
King Hill Member:		
Shale, medium gray	174.0	- 175.0
Shale, reddish brown	175.0	- 177.5
Limestone, brown, finely crystalline, shaley	177.5	- 178.0
Shale, greenish gray	178.0	- 180.3
Beil Member:		
Limestone, light tan, very finely crystalline, pseudo-oolitic in part; contains <u>Osagia</u>, algal material, and fusulinids	180.3	- 183.3
Limestone, light tan, very finely crystalline; contains pyrite, brachiopods, and crinoids; interbedded with shale, greenish gray	183.3	- 185.0
Limestone, light tan, very finely crystalline; contains crinoids, brachiopods, fusulinids, and pyrite	185.0	- 187.4
Queen Hill Member:		
Shale, light gray	187.4	- 188.0
Shale, dark gray	188.0	- 189.0
Shale, black; contains carbonaceous material	189.0	- 192.3
Big Springs Member:		
Limestone, tannish gray, very finely to finely crystalline, impure; contains fusulinids, crinoids, and brachiopods	192.3	- 194.1
Doniphan Member:		
Shale, light to medium gray; interbedded with thin limy zones at 195.0 and 196.0	194.1	- 197.0
Spring Branch Member:		
Limestone, light tan, finely crystalline; contains crinoids and algal material; interbedded with shale, greenish gray	197.0	- 198.3
Limestone, light gray, very finely crystalline; contains crinoids, algal material, and glauconite	198.3	- 202.6
Shale, dark gray	202.6	- 203.4
Shale, light gray, limy	203.4	- 204.6
Kanwaka Formation:		
Stull Member:		
Shale, light gray	204.6	- 206.0
Clay Creek Member:		
Limestone, medium gray, finely crystalline, shaley; contains crinoids and abundant brachiopods	206.0	- 206.7
Jackson Park Member:		
Shale, medium gray	206.7	- 207.8
Oread Formation:		
Kereford Member:		
Limestone, light gray to tannish gray, finely crystalline; contains ostracods	207.8	- 209.7

	Depth, in feet From	To
Limestone, very light tan, very finely crystalline; contains fusulinids, ostracods, pyrite, and glauconite	209.7	- 212.0
Limestone, very light gray to white, very finely to finely crystalline; contains brachiopods, pyrite, and abundant fusulinids	212.0	- 215.2
Heumader Member:		
Shale, light gray, limy	215.2	- 215.5
Plattsmouth Member:		
Limestone, light gray to very light tan, very finely to finely crystalline, pseudo-oolitic; contains fusulinids and chert	215.5	- 219.8
Limestone, medium gray to tannish gray, finely crystalline; contains chert and abundant fusulinids	219.8	- 223.0
Limestone, tannish gray, finely crystalline, impure; contains abundant fusulinids and abundant algal material	223.0	- 227.0
Limestone, tannish gray, finely crystalline; contains crinoids, glauconite, and "black inclusions"	227.0	- 229.8
Heebner Member:		
Shale, medium gray	229.8	- 231.9
Shale, black	231.9	- 233.9
Leavenworth Member:		
Limestone, medium tannish gray, very finely crystalline; contains fusulinids, crinoids, brachiopods, gastropods, and "black inclusions"	233.9	- 235.7
Snyderville Member:		
Shale, light gray	235.7	- 242.0
Shale, light greenish gray	242.0	- 244.5
Shale, reddish brown	244.5	- 250.4
Toronto Member:		
Limestone, very light tan to white, very finely crystalline; contains brachiopods, algal material, chert, and pyrite	250.4	- 257.5
Limestone, very light tan to white, very finely crystalline; contains fusulinids; interbedded with shale, gray, greenish gray, and reddish brown	257.5	- 260.0
Douglas Group:		
Lawrence Formation:		
Shale, light gray	260.0	- 262.0
Shale, reddish brown	262.0	- 273.0
Shale, varicolored, reddish brown, gray, and greenish gray	273.0	- 278.5
Shale, medium gray	278.5	- 294.0
Shale, black	294.0	- 294.5

Test hole 38-79 continued

	Depth, in feet	
	From	To
Shale, medium gray	294.5	- 303.6
Cass Formation:		
Haskell Member:		
Limestone, medium gray, finely crystalline, impure; contains crinoids, brachiopods, and abundant fusulinids	303.6	- 306.6
Little Pawnee Member:		
Shale, medium gray	306.6	- 307.5
Shale, black	307.5	- 308.3
Shoemaker Member:		
Limestone, dark gray, finely crystalline; contains brachiopods, crinoids, and fusulinids	308.3	- 309.4
Plattford Formation:		
Unnamed Member:		
Shale, light to medium gray	309.4	- 311.0
Shale, light gray to light greenish gray	311.0	- 311.6
Shale, reddish brown	311.6	- 317.5
Nehawka Member:		
Limestone, very light tan, very finely crystalline; contains brachiopods and crinoids	317.5	- 324.0
Shale (no sample)	324.0	- 325.2
Missouri Series - Lansing Group:		
Stanton Formation:		
South Bend Member:		
Limestone, very light tan, very finely crystalline, contains crinoids	325.2	- 326.6
Rock Lake Member:		
Shale, reddish brown; interbedded with limestone, very light tan	326.6	- 329.0
Limestone, very light tan, very finely crystalline; contains fusulinids and brachiopods	329.0	- 330.0
Shale, greenish gray interbedded with reddish brown and gray	330.0	- 332.0
Stoner Member:		
Limestone, very light gray to white, very finely crystalline; contains crinoids, fusulinids, bryozoans, and algal material	332.0	- 337.0
Limestone, very light greenish gray, very finely crystalline; contains brachiopods and crinoids	337.0	- 342.0
Limestone, very light greenish gray, very finely crystalline	342.0	- 347.0
Limestone, very light bluish gray, very finely crystalline; contains fusulinids	347.0	- 348.0
Shale, light greenish gray, limy	348.0	- 349.0

Test hole 38-79 continued

	Depth, in feet From	To
Limestone, light greenish gray, very finely crystalline; interbedded with shale, light greenish gray	349.0	- 352.9
Eudora Member:		
Shale, greenish gray; interbedded with limestone, light greenish gray, very finely crystalline	352.9	- 354.3
Captain Creek Member:		
Limestone, greenish gray, finely crystalline; interbedded with shale, greenish gray	354.3	- 355.6
Vilas Formation:		
Shale, greenish gray	355.6	- 356.0
Limestone, greenish gray, finely crystalline; contains crinoids; interbedded with shale, greenish gray	356.0	- 357.0
Shale, black	357.0	- 357.4
Shale, reddish brown	357.4	- 359.0
Shale, greenish gray	359.0	- 359.1
Limestone, light tan, very finely crystalline; contains brachiopods	359.1	- 359.7
Shale, dark gray to black	359.7	- 360.0
Shale, medium gray	360.0	- 362.0
Shale, greenish gray to medium gray	362.0	- 362.3
Plattsburg Formation:		
Limestone, very light tan with greenish tint, very finely to finely crystalline; contains fusulinids and gastropods	362.3	- 366.7
Shale, light greenish gray, limy	366.7	- 368.0
Limestone, very light gray, very finely crystalline	368.0	- 371.5
Kansas City Group:		
Bonner Springs Formation:		
Shale, light bluish gray to greenish gray	371.5	- 376.5
Wyandotte Formation:		
Farley Member:		
Limestone, light tan, very finely to finely crystalline; contains crinoids, fusulinids, and algal material	376.5	- 377.0
Shale, light greenish gray, limy	377.0	- 377.6
Limestone, very light tan, very finely crystalline; contains pyrite	377.6	- 383.2
Limestone, very light tan, very finely crystalline; interbedded with shale, light greenish gray	383.2	- 388.3
Island Creek Member:		
Limestone, light tan to light greenish gray, very finely crystalline; interbedded with shale, greenish gray to white	388.3	- 390.0
Argentine Member:		
Limestone, light tan to white, very finely to finely crystalline	390.0	- 407.0

Test hole 38-79 continued

	Depth, in feet From	To
Limestone, very light tan to white, very finely crystalline; contains fusulinids and pyrite..	407.0	- 415.4
Quindara Member:		
Shale, dark gray to black......................	415.4	- 416.9
Frisbie Member:		
Limestone (electric log).......................	416.9	- 418.2
Lane Formation:		
Shale, dark greenish gray; interbedded with thin limestone seams.........................	418.2	- 436.0
Iola Formation:		
Limestone, shaley (electric log)...............	436.0	- 438.5
Limestone, light tannish gray to white with light greenish gray tint; very finely crystalline; contains algal material.........	438.5	- 443.5
Shale (electric log)...........................	443.5	- 444.5
Limestone (electric log).......................	444.5	- 445.5
Chanute Formation:		
Shale, greenish gray...........................	445.5	- 451.5
Drum Formation:		
Limestone interbedded with shale (electric log)..	451.5	- 467.5
Quivera Formation:		
Shale (electric log)...........................	467.5	- 473.0
Sarpy Formation:		
Westerville Member:		
Limestone (electric log).......................	473.0	- 483.5
Fontana Formation:		
Shale (electric log)...........................	483.5	- 490.8
Dennis Formation:		
Winterset Member:		
Limestone (electric log).......................	490.8	- 500.0

Test hole 38-79 continued

	Depth, in feet From	To
Limestone, very light tan to white, very finely crystalline; contains fusulinids and pyrite..	407.0	- 415.4
Quindara Member:		
Shale, dark gray to black......................	415.4	- 416.9
Frisbie Member:		
Limestone (electric log)......................	416.9	- 418.2
Lane Formation:		
Shale, dark greenish gray; interbedded with thin limestone seams........................	418.2	- 436.0
Iola Formation:		
Limestone, shaley (electric log)...............	436.0	- 438.5
Limestone, light tannish gray to white with light greenish gray tint; very finely crystalline; contains algal material.........	438.5	- 443.5
Shale (electric log)...........................	443.5	- 444.5
Limestone (electric log)......................	444.5	- 445.5
Chanute Formation:		
Shale, greenish gray...........................	445.5	- 451.5
Drum Formation:		
Limestone interbedded with shale (electric log)...	451.5	- 467.5
Quivera Formation:		
Shale (electric log)...........................	467.5	- 473.0
Sarpy Formation:		
Westerville Member:		
Limestone (electric log)......................	473.0	- 483.5
Fontana Formation:		
Shale (electric log)...........................	483.5	- 490.8
Dennis Formation:		
Winterset Member:		
Limestone (electric log)......................	490.8	- 500.0

Test hole 39-79 continued

	Depth, in feet From	To
Limestone, medium gray, finely crystalline, impure; contains brachiopods and "black inclusions"	32.8 -	33.4
Turner Creek Member:		
Shale, light gray	33.4 -	34.9
Sheldon Member:		
Limestone, light tan, finely crystalline, pseudo-oolitic	34.9 -	36.0
Limestone, light tan, finely crystalline, pseudo-oolitic; contains Osagia	36.0 -	38.9
Limestone, light tan, finely crystalline, shaley; contains algal material	38.9 -	39.5
Jones Point Member:		
Shale, light gray to light greenish gray, hard and limy	39.5 -	42.0
Shale, light greenish gray to medium gray, limy	42.0 -	42.6
Shale, light greenish gray to medium gray, hard and limy	42.6 -	42.9
Shale, medium greenish gray; interbedded with thin, hard, limy zones	42.9 -	44.6
Curzon Member:		
Limestone, very light gray to white, very finely to finely crystalline, shaley upper 1.0	44.6 -	46.1
Shale, light gray, hard	46.1 -	46.5
Limestone, very light tan, very finely crystalline; contains abundant chert, light bluish gray; contains sponge spicules	46.5 -	48.0
Limestone, light tan to gray, finely crystalline; contains fusulinids and crinoids	48.0 -	49.4
Iowa Point Member:		
Shale, medium greenish gray, limy	49.4 -	49.8
Shale, light to medium greenish gray, limy	49.8 -	50.0
Shale, dark gray to black, hard	50.0 -	50.3
Shale, medium greenish gray	50.3 -	50.5
Hartford Member:		
Limestone, medium brown, finely crystalline; contains dark gray and white "inclusions"	50.5 -	52.0
Calhoun Formation:		
Shale, dark gray	52.0 -	53.0
Deer Creek - Tecumseh Formation:		
Ervine Creek Member:		
Limestone, light to medium brown, very finely to finely crystalline, vuggy or "reef-like" texture; contains brachiopods and gastropods	53.0 -	56.0
Limestone, light gray mottled with tan, very finely crystalline; contains brachiopods and chert	56.0 -	57.0

Test hole 39-79 continued

	Depth, in feet From	To
Limestone, medium to dark brown, very finely to finely crystalline, "speckled;" contains algal material	57.0	- 60.0
Limestone, light tan to light gray, very finely crystalline; contains algal material and ostracods	60.0	- 60.3
Limestone, light gray to light tan, irregularly crystalline, impure; contains brachiopods, pyrite, and ostracods	60.3	- 60.8
Limestone, medium brown, finely crystalline; contains fusulinids	60.8	- 65.0
Limestone, medium brown, finely crystalline; contains abundant fusulinids	65.0	- 67.6
Shale, dark greenish gray	67.6	- 68.4
Shale, medium gray with greenish tint	68.4	- 69.0
Limestone, light tannish gray, finely crystalline; contains pyrite	69.0	- 69.9
Larsh Member:		
Shale, medium greenish gray	69.9	- 71.0
Shale, black, hard	71.0	- 72.0
Rock Bluff Member:		
Limestone, light to medium brown, very finely crystalline; contains fusulinids and dark brown "inclusions"	72.0	- 72.5
Limestone, light to medium brown, very finely crystalline; contains fusulinids	72.5	- 74.1
Oskaloosa - Rakes Creek Members:		
Shale, medium gray	74.1	- 74.5
Shale, light to medium gray, limy	74.5	- 79.0
Sandstone, light greenish gray, very finely grained	79.0	- 85.0
Sandstone, light greenish gray, very fine grained, silty	85.0	- 93.6
Shale, light greenish gray	93.6	- 95.5
Shale, light greenish gray, limy	95.5	- 98.3
Shale, reddish brown, hard	98.3	- 99.0
Ost Member:		
Limestone, light tan speckled with medium gray, irregularly crystalline; contains ostracods	99.0	- 100.0
Limestone, light greenish gray, very finely crystalline	100.0	- 102.0
Shale, light reddish brown	102.0	- 103.5
Shale, medium gray with reddish tint	103.5	- 105.5
Shale, light to medium gray	105.5	- 106.0
Limestone, light tannish gray, finely crystalline; interbedded with shale, light to medium gray	106.0	- 106.5
Kenosha Member:		
Shale, olive	106.5	- 108.5
Shale, medium gray	108.5	- 109.4

Test hole 39-79 continued

	Depth, in feet From	To
Lecompton Formation:		
Avoca Member:		
Limestone, light to medium greenish gray, very finely crystalline; contains crinoids and fusulinids	109.4	- 110.5
Shale, dark gray to black	110.5	- 110.7
Limestone, dark tannish gray, very finely to finely crystalline; contains *Osagia*	110.7	- 112.0
Limestone, medium to dark tannish gray, very finely to finely crystalline; contains crinoids and abundant fusulinids	112.0	- 112.5
King Hill Member:		
Shale, light greenish gray	112.5	- 113.5
Shale, reddish brown	113.5	- 116.8
Shale, reddish olive	116.8	- 118.0
Shale, light greenish gray, limy	118.0	- 120.0
Beil Member:		
Limestone, light tan, very finely crystalline	120.0	- 121.3
Limestone, light tannish gray, very finely to finely crystalline; contains coral, brachiopods, and fusulinids	121.3	- 122.0
Limestone, light tannish gray, finely crystalline; contains abundant coral	122.0	- 123.6
Limestone, light tannish gray, very finely to finely crystalline; contains coral	123.6	- 124.1
Limestone, light to medium greenish gray, finely crystalline; contains brachiopods and pyrite	124.1	- 125.2
Queen Hill Member:		
Shale, light to medium greenish gray	125.2	- 127.4
Shale, dark olive gray	127.4	- 128.5
Shale, black, hard	128.5	- 130.4
Big Springs Member:		
Limestone, medium tannish gray, very finely to finely crystalline; contains pyrite and crinoids	130.4	- 131.7
Doniphan Member:		
Shale, medium greenish gray	131.7	- 135.3
Spring Branch Member:		
Limestone, light to medium tan, irregularly crystalline, impure, conglomeritic-like texture; contains "black inclusions"	135.3	- 136.0
Limestone, light tannish gray, irregularly crystalline, conglomeritic-like texture; contains "black inclusions"	136.0	- 137.2
Limestone, light tan, finely crystalline; contains brachiopods and algal material	137.2	- 138.0
Limestone, light tannish gray, very finely to finely crystalline; contains algal material	138.0	- 139.7

Test hole 39-79 continued

	Depth, in feet From	To
Limestone, light tan with gray tint, very finely to finely crystalline; contains brachiopods	139.7	- 141.5
Shale, olive brown	141.5	- 142.0
Shale, dark olive to black	142.0	- 144.0
Shale, medium gray (may be poor sample)	144.0	- 145.0
Kanwaka Formation:		
Stull Member:		
Shale, medium gray, hard and limy	145.0	- 147.8
Clay Creek Member:		
Limestone, light tan, finely crystalline; contains brachiopods and "black inclusions"	147.8	- 148.6
Jackson Park Member:		
Shale, light to medium olive gray	148.6	- 150.0
Oread Formation:		
Kereford Member:		
Limestone, medium tan, finely crystalline	150.0	- 150.1
Chert, medium brown with light blue mottling, very microfossiliferous; interbedded with limestone, medium tan, finely crystalline; contains fusulinids	150.1	- 150.7
Limestone, very light tan, finely crystalline; contains brachiopods and abundant fusulinids	150.7	- 155.3
Heumader Member:		
Shale, medium gray, limy	155.3	- 156.0
Plattsmouth Member:		
Limestone, light to medium tan, very finely to finely crystalline; contains fusulinids, _Osagia_, and abundant algal material	156.0	- 160.0
Limestone, medium gray, very finely to finely crystalline; contains abundant fusulinids	160.0	- 161.8
Limestone, medium tan mottled with light tan, very finely to finely crystalline; contains fusulinids	161.8	- 165.0
Limestone, light to medium gray, finely crystalline; contains crinoids, pyrite, and fusulinids	165.0	- 167.0
Heebner Member:		
Shale, medium gray	167.0	- 168.0
Shale, black, hard	168.0	- 171.3
Leavenworth Member:		
Limestone, medium tannish gray, very finely crystalline; contains fusulinids	171.3	- 173.1
Snyderville Member:		
Shale, light to medium greenish gray	173.1	- 178.5
Shale, light to medium gray with traces of pale reddish brown	178.5	- 179.0
Shale, light to medium greenish gray	179.0	- 181.0
Shale, reddish brown	181.0	- 189.0

Test hole 39-79 continued

	Depth, in feet From	To
Shale, medium greenish gray, limy..............	189.0	- 189.8
Toronto Member:		
Limestone, light tan, very finely to finely crystalline..................................	189.8	- 191.1
Limestone, light greenish gray, very finely crystalline; contains pyrite and algal material..................................	191.1	- 191.8
Limestone, light tan, very finely crystalline; contains chert, gray.........................	191.8	- 193.0
Limestone, light greenish gray, very finely to finely crystalline, impure, conglomeritic-like texture................................	193.0	- 194.3
Limestone, light greenish gray with traces of pale red, very finely to finely crystalline..	194.3	- 195.5
Shale, reddish brown, limy.....................	195.5	- 198.2
Limestone, light greenish gray mottled with tan, finely crystalline; contains brachiopods and abundant pseudo-oolites.................	198.2	- 198.8
Douglas Group:		
Lawrence Formation:		
Shale, reddish brown...........................	198.8	- 209.0
Shale, reddish brown mottled with olive........	209.0	- 214.0
Shale, light to medium greenish gray...........	214.0	- 214.5
Shale, olive...................................	214.5	- 216.0
Shale, olive gray..............................	216.0	- 218.0
Shale, medium gray.............................	218.0	- 229.0
Shale, medium gray; interbedded with sandstone, medium gray, fine grained............	229.0	- 229.7
Shale, medium gray.............................	229.7	- 235.6
Shale, black, hard.............................	235.6	- 235.9
Shale, light gray..............................	235.9	- 240.0
Shale, light gray with olive tint..............	240.0	- 240.6
Shale, medium gray with olive tint.............	240.6	- 243.0
Shale, medium gray.............................	243.0	- 246.0
Cass Formation:		
Haskell Member:		
Limestone, medium gray mottled with dark gray, finely crystalline; contains brachiopods and crinoids....................................	246.0	- 247.3
Limestone, medium gray mottled with dark gray, finely crystalline, shaley..................	247.3	- 247.8
Limestone, medium gray mottled with dark gray, finely crystalline; contains brachiopods, crinoids, and glauconite....................	247.8	- 250.6
Little Pawnee Member:		
Shale, dark gray interbedded with black in middle......................................	250.6	- 252.3
Shoemaker Member:		
Limestone, medium to dark gray, finely crystalline.................................	252.3	- 253.4

Test hole 39-79 continued

	Depth, in feet From	To
Plattford Formation:		
Unnamed Member:		
Shale, medium gray	253.4	- 258.0
Shale, medium gray with olive tint	258.0	- 258.5
Shale, medium brown with red tint	258.5	- 264.5
Nehawka Member:		
Limestone, light tan mottled with white, very finely crystalline; contains brachiopods and pyrite	264.5	- 270.6
Unnamed Member:		
Shale, medium gray	270.6	- 272.8
Missouri Series - Lansing Group:		
Stanton Formation:		
South Bend Member:		
Limestone, light gray with tannish tint, very finely crystalline; contains fusulinids and *Osagia*	272.8	- 273.9
Rock Lake Member:		
Shale, light to medium gray, limy	273.9	- 277.6
Shale, reddish gray with green tint, limy	277.6	- 277.9
Shale, light to medium greenish gray	277.9	- 282.0
Stoner Member:		
Limestone, light gray, finely crystalline; contains pyrite	282.0	- 282.8
Limestone, very light tan, very finely to finely crystalline; contains fusulinids	282.8	- 285.6
Limestone, very light tan to white, very finely crystalline	285.6	- 290.0
Limestone, light greenish gray, very finely to finely crystalline	290.0	- 301.6
Limestone, light greenish gray, very finely crystalline; interbedded with shale, light to medium gray	301.6	- 303.0
Limestone, medium greenish gray, very finely to finely crystalline; contains fusulinids; interbedded with shale, light to medium gray	303.0	- 303.7
Limestone, medium gray, very finely to finely crystalline	303.7	- 305.0
Eudora Member:		
Shale, medium gray	305.0	- 306.0
Shale, black	306.0	- 306.8
Captain Creek Member:		
Limestone, medium gray with tan tint, finely crystalline; contains ostracods	306.8	- 307.2
Vilas Formation:		
Shale, dark gray to black	307.2	- 308.0
Limestone, medium gray, very finely to finely crystalline, impure	308.0	- 308.6
Shale, dark gray	308.6	- 310.3

Test hole 39-79 continued

	Depth, in feet From	To
Limestone, medium to dark gray, very finely to finely crystalline; contains brachiopods.....	310.3	- 310.8
Shale, light to medium greenish gray...........	310.8	- 313.5
Plattsburg Formation:		
Limestone, medium tan, finely crystalline; contains abundant algal material.............	313.5	- 314.7
Limestone, light greenish gray, finely crystalline; contains ostracods and abundant algal material; interbedded with shale, light greenish gray..................	314.7	- 315.0
Limestone, light gray, very finely crystalline; contains chert, fusulinids, crinoids, ostracods, and abundant algal material.......	315.0	- 318.0
Limestone, medium tannish gray, very finely to finely crystalline, shaley................	318.0	- 318.6
Limestone, light tan, very finely to finely crystalline; contains chert and pyrite.......	318.6	- 321.0
Limestone, light gray, very finely to finely crystalline; contains chert and brachiopods..	321.0	- 323.2
Limestone, dark gray, very finely crystalline; shaley; contains crinoids..................	323.2	- 325.4
Limestone, dark greenish gray, very finely crystalline; contains brachiopods............	325.4	- 327.1
Kansas City Group:		
Bonner Springs Formation:		
Shale, medium to dark gray.....................	327.1	- 330.0
Shale, medium greenish gray....................	330.0	- 332.3
Wyandotte Formation:		
Farley Member:		
Limestone, light tan, finely crystalline; contains pyrite.............................	332.3	- 334.0
Limestone, light tan, finely cyrstalline; contains chert, light blue to light tan......	334.0	- 337.0
Limestone, light gray, very finely to finely crystalline................................	337.0	- 340.2
Island Creek Member:		
Shale, light to medium gray, limy.............	340.2	- 341.1
Argentine Member:		
Limestone, very light tan, very finely crystalline; contains fusulinids.............	341.1	- 345.0
Limestone, very light tan, very finely crystalline; contains brachiopods............	345.0	- 355.4
Limestone, light tan, very finely crystalline; contains brachiopods, crinoids, and fusulinids................................	355.4	- 356.0
Limestone, light gray, very finely crystalline; contains crinoids and brachiopods......	356.0	- 357.0
Limestone, light gray, very finely crystalline; contains brachiopods..................	357.0	- 361.9

Test hole 39-79 continued

	Depth, in feet	
	From	To
Shale, medium gray; interbedded with limestone, light gray, very finely crystalline	361.9	- 369.3
Quindaro Member:		
Shale, medium gray	369.3	- 370.0
Shale, black	370.0	- 370.8
Frisbie Member:		
Limestone, medium gray, very finely crystalline; contains fusulinids and abundant brachiopods	370.8	- 371.3
Lane Formation:		
Shale, light to medium gray	371.3	- 374.7
Limestone, medium gray, very finely crystalline; contains brachiopods, pelecypods, and pyrite	374.7	- 375.2
Shale, medium gray	375.2	- 385.4
Iola Formation:		
Limestone, light to medium greenish gray, very finely crystalline	385.4	- 387.0
Limestone, light tan, very finely crystalline	387.0	- 391.3
Limestone, light to medium greenish gray, very finely crystalline; contains crinoids; interbedded with shale, medium gray	391.3	- 392.5
Limestone, light tan, very finely to finely crystalline; contains glauconite and abundant algal material	392.5	- 393.5
Chanute Formation:		
Shale, medium gray	393.5	- 395.1
Shale, black	395.1	- 396.0
Shale, medium gray	396.0	- 399.4
Drum Formation:		
Limestone, light to medium gray with tannish tint, very finely crystalline; contains Osagia; interbedded with shale lower 0.5	399.4	- 401.5
Limestone, light to medium tannish gray, very finely to finely crystalline; contains fusulinids, ostracods, and brachiopods	401.5	- 404.5
Limestone, medium gray, very finely to finely crystalline, shaley; contains crinoids, and abundant fusulinids	404.5	- 404.9
Limestone, light to medium tan, very finely to finely crystalline; contains brachiopods and fusulinids	404.9	- 408.3
Limestone, medium gray, very finely crystalline; contains brachiopods and abundant fusulinids; interbedded with shale, gray	408.3	- 410.4
Limestone, medium tannish gray, very finely to finely crystalline; contains pelecypods and abundant fusulinids	410.4	- 414.0

Test hole 39-79 continued

	Depth, in feet From	To
Shale, dark greenish gray, limy	414.0	- 415.3
Limestone, dark gray, very finely crystalline; contains "black inclusions"	415.3	- 416.1
Quivira Formation:		
Shale, medium greenish gray	416.1	- 418.3
Sarpy Formation:		
Westerville Member:		
Limestone, very light to light greenish gray, very finely crystalline, shaley	418.3	- 419.6
Limestone, light gray, finely crystalline; contains fusulinids	419.6	- 427.4
Limestone, light gray, finely crystalline; contains abundant fusulinids; contains shaley partings	427.4	- 429.5
Wea Member:		
Shale, black, hard	429.5	- 432.1
Fontana Formation:		
Shale, medium greenish gray	432.1	- 436.0
Dennis Formation:		
Winterset Member:		
Limestone, light gray, very finely to finely crystalline; contains pseudo-oolites	436.0	- 442.0
Limestone, light gray, very finely crystalline	442.0	- 448.1
Shale, medium gray	448.1	- 450.0
Limestone, light to medium tannish gray, very finely crystalline; contains fusulinids	450.0	- 454.6
Limestone, light to medium tannish gray, very finely crystalline, shaley; contains pyrite	454.6	- 456.5
Limestone, light to medium tannish gray, very finely crystalline; contains brachiopods	456.5	- 458.1
Limestone, medium tannish gray, very finely crystalline; contains crinoids and brachiopods; contains shaley partings	458.1	- 460.0
Stark Member:		
Shale, medium gray, limy	460.0	- 460.8
Shale, black, hard	460.8	- 463.4
Canville Member:		
Limestone, dark tannish gray, very finely to irregularly crystalline; contains brachiopods, crinoids, *Osagia*, pseudo-oolites, and abundant algal material	463.4	- 464.1
Galesburg Formation:		
Shale, greenish gray	464.1	- 466.3
Siltstone, light greenish gray	466.3	- 471.8
Swope Formation:		
Bethany Falls Member:		
Limestone, light tan, very finely crystalline; contains pseudo-oolites and abundant algal material	471.8	- 474.0

Test hole 39-79 continued

	Depth, in feet	
	From	To
Shale, very light greenish gray; contains hard limy zones	474.0	- 474.8
Limestone, light tan, very finely to finely crystalline; contains chert, light bluish gray	474.8	- 477.2
Shale, light gray	477.2	- 478.0
Limestone, light tan, very finely to finely crystalline; contains crinoids	478.0	- 481.3
Limestone, gray, irregularly crystalline, shaley; contains brachiopods, crinoids, algal material, and glauconite	481.3 -	481.7
Hushpuckney Member:		
Shale, dark gray	481.7	- 482.3
Ladore Formation:		
Shale, medium gray	482.3	- 486.3
Hertha Formation:		
Limestone, light to medium gray, finely to irregularly crystalline, pseudo-oolitic; contains brachiopods, bryozoans, and abundant algal material	486.3	- 488.9
Shale, light to medium gray	488.9	- 491.0
Shale, pale reddish brown	491.0	- 491.8
Shale, dark gray to black	491.8	- 492.9
Shale, reddish brown	492.9	- 493.7
Shale, greenish gray, limy	493.7	- 498.0
Limestone, light to medium tannish gray, very finely to irregularly crystalline; contains brachiopods, algal material, pseudo-oolites, and foraminifera	498.0	- 498.5
DesMoines Series - Marmaton Group:		
Shale, reddish brown	498.5	- 503.0

Test Hole 40-79

Location: Richardson County, NE NW sec. 34, T. 3 N., R. 14 E., approximately 19 feet south of north section line and 195 feet west of half section line.

Ground-level elevation: 1,051.0 feet above mean sea level.

Started: July 19, 1979. Completed: July 27, 1979.

Total depth: 503.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Silt, dark gray	0 -	2.0
Silt, medium brown, clayey	2.0 -	8.0
Silt, light to medium tan with iron staining, clayey	8.0 -	12.0
Silt, medium reddish brown, clayey; contains traces of sand	12.0 -	17.0
Silt, medium reddish brown, sandy	17.0 -	19.5
Silt, medium reddish brown; contains sand, very fine to coarse, and gravel, fine	19.5 -	28.5
Silt, medium tannish gray, clayey	28.5 -	32.0
Silt, medium reddish brown, clayey	32.0 -	36.0
Silt, light to medium tan, clayey	36.0 -	39.0
Permian System - Big Blue Series - Council Grove Group:		
Grenola Formation:		
Neva Member:		
Limestone, light to medium yellowish brown, finely crystalline, weathered; contains abundant algal material	39.0 -	41.0
Salem Point - Sallyards Members:		
Shale (no sample - circulation loss)	41.0 -	43.0
No sample taken (circulation loss)	43.0 -	57.0
Roca Formation:		
No samples taken (circulation loss)	57.0 -	60.0
Shale, reddish brown	60.0 -	61.0
Shale, medium gray	61.0 -	66.0
Shale, light gray; interbedded with thin limestone, light gray, finely crystalline	66.0 -	67.5
Shale, light gray	67.5 -	70.4
Shale, light yellowish tan	70.4 -	71.5
Limestone, light to medium olive gray, very finely crystalline; interbedded with shale, light tan	71.5 -	72.5
Shale, light to medium tan	72.5 -	73.5

Test hole 40-79 continued

	Depth, in feet	
	From	To
Shale, olive	73.5 -	77.0
Shale, light olive tan	77.0 -	84.0
Red Eagle Formation:		
Howe Member:		
Shale, light to medium olive	84.0 -	85.0
Bennett Member:		
Shale, dark gray, hard	85.0 -	88.2
Shale, medium to dark gray	88.2 -	90.0
Shale, black; contains carbonaceous material	90.0 -	94.8
Glenrock Member:		
Limestone, medium to dark gray, finely crystalline	94.8 -	95.6
Johnson Formation:		
Shale, medium gray	95.6 -	107.0
Shale, medium to dark gray	107.0 -	113.7
Foraker Formation:		
Long Creek Member:		
Shale, medium gray with olive tint; interbedded with siltstone, medium gray	113.7 -	115.3
Shale, light to medium gray	115.3 -	116.3
Shale, olive; interbedded with limestone, medium gray, finely crystalline; contains brachiopods	116.3 -	117.3
Shale, light to medium gray with olive tint	117.3 -	119.0
Shale, medium gray; interbedded with limestone, medium gray, finely crystalline; contains crinoids and sponge spicules	119.0 -	121.0
Hughes Creek Member:		
Shale, medium to dark gray	121.0 -	122.0
Shale, medium gray; contains traces of gypsum at 124.0-127.0	122.0 -	127.0
Shale, dark gray; contains traces of gypsum	127.0 -	129.6
Shale, medium gray to olive; contains traces of gypsum upper 2.0	129.6 -	133.5
Shale, black; contains carbonaceous material	133.5 -	136.5
Limestone, medium gray, finely crystalline, shaley; contains abundant fusulinids and brachiopods	136.5 -	137.0
Shale, medium to dark gray, limy at 142.4	137.0 -	143.6
Shale, medium to dark gray, limy at 145.0	143.6 -	145.3
Shale, medium to dark olive gray	145.3 -	148.3
Limestone, dark gray, finely crystalline; contains crinoids, brachiopods, and pyrite	148.3 -	148.9
Shale, dark gray	148.9 -	152.5
Limestone, dark gray, finely crystalline, impure; contains brachiopods, ostracods, and crinoids; interbedded with shale, dark gray	152.5 -	154.0
Shale, medium to dark gray	154.0 -	161.5
Shale, medium olive gray	161.5 -	161.8

Test hole 40-79 continued

	Depth, in feet From	To
Shale, medium gray, limy	161.8 -	164.6
Americus Member:		
Limestone, medium to dark gray, finely crystalline; contains crinoids, brachiopods, bryozoans, and pyrite	164.6 -	165.0
Shale, black	165.0 -	166.0
Limestone, medium gray, finely crystalline; contains brachiopods, pyrite, and foraminifera	166.0 -	166.5
Admire Group:		
Hamlin Formation:		
Oaks Member:		
Shale, dark gray	166.5 -	168.4
Shale, light gray, limy	168.4 -	170.0
Shale, light to medium gray with bluish tint	170.0 -	175.0
Shale, medium gray	175.0 -	178.1
Shale, light greenish gray	178.1 -	180.5
Houchens Creek Member:		
Limestone, light tan, finely crystalline	180.5 -	181.0
Shale, light greenish gray	181.0 -	181.5
Limestone, light tan, finely crystalline	181.5 -	182.2
Stine Member:		
Shale, light olive gray; interbedded with limestone, medium brown, finely crystalline	182.2 -	183.2
Shale, light gray	183.2 -	184.0
Shale, medium to dark olive gray	184.0 -	194.0
Limestone, medium gray, finely crystalline; contains foraminifera and quartz filled vugs	194.0 -	196.0
Shale, medium gray	196.0 -	198.0
Limestone, medium gray, very finely crystalline; contains pyrite	198.0 -	199.3
Shale, dark gray	199.3 -	201.8
Shale, light greenish gray; interbedded with limestone, light greenish gray, very finely crystalline, impure; contains foraminifera and quartz filled vugs	201.8 -	202.8
Shale, light to medium olive	202.8 -	205.0
Shale, olive	205.0 -	209.0
Shale, dark gray	209.0 -	210.6
Five Point Formation:		
Limestone, light to medium gray with tannish tint, very finely crystalline; contains foraminifera and abundant brachiopods	210.6 -	211.3
West Branch Formation:		
Shale, medium gray	211.3 -	212.0
Shale, medium to dark gray	212.0 -	218.0
Shale, medium bluish gray, limy	218.0 -	220.0
Limestone, light gray, very finely crystalline, shaley	220.0 -	223.3

Test hole 40-79 continued

	Depth, in feet From	To
Limestone, light gray, very finely crystalline; contains quartz filled vugs; interbedded with shale, light bluish gray	223.3	225.0
Shale, dark gray	225.0	226.0
Limestone, medium gray, very finely crystalline, shaley	226.0	227.0
Shale, dark gray	227.0	233.0
Falls City Formation:		
Lehmer Member:		
Limestone, medium to dark gray, finely crystalline, impure; contains gastropods, pyrite and abundant very small shell fragments (immature brachiopods or ostracods)	233.0	234.1
Limestone, medium gray, finely crystalline, impure; contains pyrite; interbedded with shale, medium gray	234.1	236.0
Reserve Member:		
Shale, medium gray	236.0	239.4
Shale, dark gray	239.4	243.0
Miles Member:		
Limestone, medium gray, finely crystalline; contains foraminifera and dark grey "pelletoid" inclusions	243.0	243.6
Onaga Formation:		
Hawxby - Towle Members:		
Shale, light to medium bluish gray	243.6	247.5
Shale, light to medium gray	247.5	254.4
Shale, light gray with greenish tint	254.4	255.0
Shale, light bluish gray	255.0	256.5
Shale, medium reddish brown; interbedded with siltstone, medium greenish gray	256.5	260.0
Shale, medium reddish brown	260.0	265.0
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Wood Siding Formation:		
Brownville-Plumb Members:		
Shale, medium gray with olive tint; interbedded with sandstone, medium gray to tan, very fined grained	265.0	271.0
Shale, medium gray	271.0	289.5
Nebraska City Member:		
Shale, light to medium gray; interbedded with limestone, medium tan, very finely crystalline; contains brachiopods, pyrite, and bryozoans	289.5	290.7
Root Formation:		
French Creek Member:		
Shale, medium gray	290.7	291.7

	Depth, in feet From	To
Coal, black	291.7 -	292.2
Shale, medium gray	292.2 -	295.8
Coal, black	295.8 -	296.3
Shale, medium gray	296.3 -	297.8
Shale, light to medium greenish gray	297.8 -	299.1
Shale, light gray with olive tint	299.1 -	302.0
Shale, light gray	302.0 -	305.2
Shale, medium to dark gray	305.2 -	309.0
Jim Creek Member:		
Shale, medium gray, limy	309.0 -	310.0
Friedrich Member:		
Shale, medium olive gray	310.0 -	313.5
Shale, medium gray	313.5 -	320.5
Shale, light gray	320.5 -	321.5
Stotler Formation:		
Grandhaven Member:		
Shale, light gray with reddish tint	321.5 -	323.0
Dry Member:		
Shale, light to medium gray	323.0 -	326.3
Shale, light gray	326.3 -	329.0
Shale, light olive gray	329.0 -	334.0
Shale, olive gray	334.0 -	334.5
Shale, reddish brown, limy	334.5 -	336.5
Shale, reddish brown; interbedded with limestone, light to medium cream, very finely crystalline	336.5 -	337.3
Shale, reddish brown	337.3 -	341.0
Shale, medium gray with reddish tint	341.0 -	343.0
Shale, medium gray	343.0 -	357.0
Shale, medium gray with reddish tint	357.0 -	362.0
Shale, medium gray	362.0 -	370.0
Dover Member:		
Shale, medium gray, limy	370.0 -	372.0
Pillsbury Formation:		
Shale, medium reddish olive	372.0 -	377.0
Shale, medium gray	377.0 -	389.0
Zeandale Formation:		
Maple Hill Member:		
Shale, medium gray	389.0 -	391.0
Wamego Member:		
Shale, dark gray to black	391.0 -	392.0
Shale, medium gray	392.0 -	397.0
Shale, olive	397.0 -	398.5
Shale, reddish olive	398.5 -	402.0
Shale, light greenish gray	402.0 -	404.0
Tarkio Member:		
Limestone, light cream to gray, finely crystalline, impure; contains fusulinids, algal material, and pyrite; interbedded with shale, medium olive gray	404.0 -	407.0
Limestone, light gray to white, very finely to finely crystalline; contains		

	Depth, in feet From	To
brachiopods, algal material, crinoids, and fusulinids	407.0 -	409.5
Willard Formation:		
Shale, light olive tan	409.5 -	410.7
Shale, dark gray with reddish brown	410.7 -	413.5
Shale, light to medium gray; interbedded with limestone, light gray to white, finely crystalline; contains fusulinids, pelecypods, and pyrite	413.5 -	416.3
Shale, light to medium greenish gray	416.3 -	417.8
Shale, medium greenish gray	417.8 -	418.1
Shale, medium to dark gray	418.1 -	437.0
No sample (probable shale)	437.0 -	441.0
Emporia Formation:		
Elmont - Reading Members:		
No sample (probable limestone)	441.0 -	444.0
Shale, medium gray	444.0 -	447.2
Limestone, medium gray with brownish tint, finely crystalline; contains brachiopods, crinoids, pyrite, and chert; interbedded with shale, medium gray	447.2 -	448.0
Shale, medium to dark gray, limy	448.0 -	449.0
Limestone, light gray to cream, very finely crystalline; contains brachiopods; interbedded with shale, very light to light gray	449.0 -	450.3
Shale, medium gray	450.3 -	451.0
Shale, medium to dark gray	451.0 -	452.0
Shale, medium gray, limy	452.0 -	456.0
Limestone, light gray mottled with dark gray and light tan, finely crystalline, shaley; contains crinoids and pyrite	456.0 -	458.2
Shale, medium gray	458.2 -	458.5
Limestone, light tan to light gray, finely crystalline	458.5 -	459.0
Auburn Formation:		
Shale, medium gray	459.0 -	460.0
Shale, light to medium greenish gray	460.0 -	460.5
Shale, reddish brown	460.5 -	470.0
Shale, light greenish gray	470.0 -	477.0
Shale, medium gray, limy	477.0 -	493.0
Wakarusa Formation:		
Limestone (poor sample), shaley	493.0 -	497.0
Soldier Creek Formation:		
Shale, medium olive gray	497.0 -	503.0

Test Hole 41-79

Location: Pawnee County, SW SW sec. 31, T. 1 N., R. 9 E., approximately 114 feet north of south section line and 14 feet east of west section line.

Ground-level elevation: 1,307.5 feet above mean sea level.

Started: July 23, 1979. Completed: July 24, 1979.

Total depth: 503.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Soil, black	0	5.0
Silt, medium brownish gray	5.0	13.0
Silt, medium tannish gray; interbedded with gravel, very fine to medium	13.0	15.5
Permian System - Big Blue Series - Chase Group:		
Blue Springs Formation:		
Shale, reddish brown	15.5	16.5
Shale, light greenish gray mottled with red	16.5	17.0
Shale, reddish brown mottled with green	17.0	18.0
Limestone, light greenish gray, finely crystalline	18.0	18.6
Shale, reddish brown interbedded with greenish gray at 21.0 - 21.7 and 24.0 - 24.5	18.6	26.0
Shale, greenish gray	26.0	29.0
Shale, reddish brown	29.0	32.0
Limestone, light tan, finely crystalline	32.0	33.0
Shale, dark gray	33.0	33.3
Shale, light greenish gray	33.3	37.0
Shale, dark gray; contains gypsum at 37.6	37.0	41.0
Kinney Formation:		
Shale, medium to dark gray, hard and limy	41.0	47.0
Shale, medium to dark gray, limy; contains crinoids	47.0	48.0
Shale, light gray	48.0	48.9
Wymore Formation:		
Shale, medium gray; interbedded with gypsum at 50.0 - 51.0	48.9	51.0
Shale, light greenish gray	51.0	54.0
Shale, reddish brown	54.0	55.0
Shale, reddish brown interbedded with greenish gray	55.0	58.0
Shale, reddish brown; interbedded with gypsum at 58.0 - 59.5	58.0	61.0

Test hole 41-79 continued

	Depth, in feet From	To
Shale, medium greenish gray	61.0 -	62.0
Shale, medium reddish brown	62.0 -	63.5
Shale, medium greenish gray; interbedded with limestone, light greenish gray to white, finely crystalline	63.5 -	63.8
Shale, medium greenish gray	63.8 -	66.4
Shale, light greenish gray; contains gypsum, pink	66.4 -	67.2
Shale, light to medium greenish gray	67.2 -	69.2
Shale, dark gray	69.2 -	69.3
Shale, light greenish gray; contains gypsum, pink	69.3 -	71.5
Shale, light to medium greenish gray	71.5 -	71.7
Shale, dark gray	71.7 -	73.6
Wreford Formation:		
Schroyer Member:		
Limestone, dark gray, finely crystalline; contains brachiopods and pelecypods	73.6 -	74.3
Limestone, medium gray, finely crystalline; interbedded with shale, medium gray with reddish tint	74.3 -	76.8
Chert, dark bluish gray; contains abundant microfossils	76.8 -	78.1
Shale, medium gray, limy	78.1 -	80.0
Limestone, light tan, finely crystalline, silty	80.0 -	83.5
Havensville Member:		
Shale, medium gray; contains thin limy zones at 86.5 and 89.0	83.5 -	90.0
Limestone, medium gray, finely crystalline; contains brachiopods	90.0 -	91.5
Limestone, medium gray, finely crystalline; contains shaley partings lower 1.0	91.5 -	94.3
Shale, dark greenish gray	94.3 -	100.0
Three Mile Member:		
Limestone, medium tannish gray, finely crystalline; contains chert and pyrite; shaley at 100.3 - 100.5	100.0 -	103.5
Limestone, medium tannish gray, finely crystalline, shaley	103.5 -	103.7
Shale, medium to dark greenish gray, limy	103.7 -	104.0
Limestone, medium gray, finely crystalline, cherty; contains bryozoans, foraminifera, and brachiopods	104.0 -	105.0
Shale, medium gray, limy	105.0 -	105.3
Chert, dark bluish gray, microfossiliferous	105.3 -	105.7
Limestone, light to medium gray, finely crystalline, impure; contains diatoms, brachiopods and chert	105.7 -	106.2

Test hole 41-79 continued

	Depth, in feet From	To
Council Grove Group:		
Speiser Formation:		
Shale, medium gray	106.2	109.2
Shale, medium gray; interbedded with limestone, light tan, finely crystalline	109.2	110.3
Shale, light to medium greenish gray	110.3	112.0
Shale, light greenish gray	112.0	114.0
Shale, medium greenish gray with reddish tint	114.0	117.0
Shale, light reddish gray	117.0	118.3
Shale, light gray with reddish tint	118.3	119.1
Shale, light greenish gray, limy	119.1	120.0
Shale, reddish brown	120.0	121.0
Shale, medium greenish gray	121.0	122.3
Shale, medium brown	122.3	123.0
Shale, medium greenish gray	123.0	123.5
Funston Formation:		
Limestone, light tan, very finely crystalline; contains ostracods	123.5	124.7
Shale, medium greenish gray	124.7	126.5
Limestone, light tan to medium gray, very finely crystalline; contains gastropods and ostracods	126.5	127.2
Shale, medium gray	127.2	128.0
Limestone, medium tan, very finely to finely crystalline; contains brachiopods, gastropods, and chert	128.0	129.1
Limestone, medium tannish gray, very finely to finely crystalline, shaley	129.1	131.3
Blue Rapids Formation:		
Shale, dark gray; contains gypsum	131.3	135.6
Shale, very dark gray	135.6	138.5
Shale, medium gray	138.5	139.5
Limestone, light gray with tannish tint, very finely to finely crystalline, impure, shaley; contains ostracods	139.5	140.6
Shale, light greenish gray	140.6	147.0
Shale, medium reddish gray	147.0	148.0
Shale, medium greenish gray	148.0	151.3
Crouse Formation:		
Limestone, light tan, very finely to finely crystalline	151.3	152.5
Limestone, medium tannish gray, finely crystalline; interbedded with shale, medium gray; contains gypsum	152.5	156.7
Shale, medium gray	156.7	162.0
Limestone, light gray, finely crystalline, silty, shaley; contains ostracods	162.0	163.8
Easily Creek Formation:		
Shale, light greenish gray	163.8	165.0

	Depth, in feet From	To
Shale, light to medium reddish gray with greenish tint, limy at 165.4 - 167.0	165.0	167.0
Shale, light greenish gray with reddish tint	167.0	168.0
Shale, reddish brown; contains traces of gypsum, light pink	168.0	169.0
Shale, light to medium greenish gray; contains gypsum, very light pink to white	169.0	169.7
Shale, light to medium reddish brown with greenish gray interbedded	169.7	176.7
Gypsum, light tan to white	176.7	179.3
Bauder Formation:		
Middleburg Member:		
Limestone, light tan, finely crystalline, pseudo-oolitic; contains abundant algal material, <u>Osagia</u>, and foraminifera	179.3	180.0
Limestone, dark gray, finely crystalline; contains ostracods and algal material	180.0	182.2
Limestone, dark gray, finely crystalline; interbedded with shale, medium to dark gray	182.2	184.3
Limestone, medium gray, finely crystalline; contains gastropods, crinoids, and abundant ostracods; interbedded with shale, medium gray	184.3	184.8
Hooser Member:		
Shale, medium gray	184.8	185.3
Shale, light greenish gray	185.3	189.8
Shale, medium greenish gray	189.8	191.3
Shale, reddish brown	191.3	191.5
Shale, light greenish gray	191.5	195.6
Eiss Member:		
Limestone, light to medium tan, very finely to finely crystalline; contains algal material	195.6	198.0
Limestone, medium olive gray, finely crystalline, silty; contains gypsum lower 0.1	198.0	198.6
Shale, medium gray	198.6	201.0
Shale, medium gray; contains gypsum, light pink to white	201.0	201.2
Limestone, medium gray, finely crystalline; contains microfossiliferous siliceous inclusions	201.2	201.5
Limestone, medium tan, finely crystalline, pseudo-oolitic	201.5	203.0
Stearns Formation:		
Shale, dark gray	203.0	205.0
Limestone, medium tan with gray tint, finely crystalline, silty, shaley	205.0	205.5
Shale, medium greenish gray with bluish tint	205.5	206.5
Shale, light greenish gray	206.5	207.0
Shale, medium greenish gray with reddish tint	207.0	212.0

Test hole 41-79 continued

	Depth, in feet From	To
Shale, medium to dark greenish gray............	212.0 -	213.0
Shale, light greenish tan......................	213.0 -	213.7
Beattie Formation:		
Morrill Member:		
Limestone, light tan, very finely to finely crystalline; contains microfossiliferous siliceous and pyrite inclusions..............	213.7 -	217.3
Limestone, light tan, very finely to finely crystalline; contains shaley partings; contains gypsum............................	217.3 -	219.4
Shale, black...................................	219.4 -	220.0
Limestone, dark greenish gray, finely crystalline, silty, shaley..................	220.0 -	220.4
Florena Member:		
Shale, dark gray fissile.......................	220.4 -	223.0
Cottonwood Member:		
Shale, medium gray, contains gypsum............	223.0 -	223.3
Shale, medium gray, hard at 224.3..............	223.3 -	227.0
Shale, medium gray, limy.......................	227.0 -	228.0
Limestone, medium tannish gray, finely crystalline, impure; contains abundant fusulinids.....................................	228.0 -	231.2
Limestone, medium gray, finely crystalline, impure; contains pelecypods..................	231.2 -	234.8
Eskridge Formation:		
Shale, medium gray, limy.......................	234.8 -	236.2
Shale, light greenish gray.....................	236.2 -	243.0
Shale, varicolored, medium gray, greenish gray, and reddish gray.......................	243.0 -	244.0
Shale, medium olive gray.......................	244.0 -	245.0
Shale, reddish brown...........................	245.0 -	246.5
Shale, reddish gray; contains traces of gypsum...	246.5 -	247.8
Shale, reddish brown to gray...................	247.8 -	251.0
Shale, light gray to white with reddish tint....	251.0 -	251.8
Shale, medium reddish tan......................	251.8 -	253.9
Shale, light to medium gray with olive tint.....	253.9 -	254.1
Shale, medium reddish gray; contains abundant gypsum, light pink to white.................	254.1 -	256.0
Shale, medium to dark greenish gray............	256.0 -	259.0
Shale, dull reddish brown......................	259.0 -	264.0
Shale, medium greenish gray with reddish tint; contains traces of gypsum....................	264.0 -	265.0
Shale, dull reddish brown......................	265.0 -	267.0
Shale, medium greenish gray....................	267.0 -	270.7
Grenola Formation:		
Neva Member:		
Limestone, light to medium tannish gray, finely crystalline..................................	270.7 -	272.0

	Depth, in feet From	To
Limestone, medium tannish gray, finely crystalline	272.0 -	272.7
Limestone, medium gray, finely crystalline, impure; contains fusulinids and ostracods	272.7 -	278.4
Shale, medium gray to dark gray	278.4 -	279.0
Shale, light to medium tannish gray	279.0 -	280.0
Shale, black	280.0 -	280.8
Limestone, medium tannish gray, finely crystalline, shaley	280.8 -	281.3
Shale, black	281.3 -	283.7
Limestone, medium gray with tannish tint, finely crystalline, shaley	283.7 -	284.8
Salem Point Member:		
Shale, medium greenish gray	284.8 -	287.0
Shale, light greenish gray	287.0 -	291.0
Burr Member:		
Shale, light greenish gray; contains abundant gypsum, white	291.0 -	292.0
Limestone, medium tannish gray, finely crystalline, silty, impure; contains gastropods	292.0 -	292.5
Limestone, medium gray, finely crystalline, impure; contains ostracods and abundant algal material	292.5 -	293.2
Limestone, light to medium tannish gray, finely crystalline, impure; contains brachiopods, crinoids, and *Osagia*	293.2 -	298.7
Legion Member:		
Shale, medium gray	298.7 -	301.0
Sallyards Member:		
Shale, medium gray; contains abundant gypsum, white	301.0 -	302.0
Gypsum, white; interbedded with shale, medium gray	302.0 -	302.7
Shale, medium to dark gray	302.7 -	303.6
Roca Formation:		
Shale, medium gray with olive tint	303.6 -	306.0
Shale, light to medium greenish gray	306.0 -	308.4
Shale, medium olive gray	308.4 -	309.4
Shale, medium greenish gray with reddish tint	309.4 -	310.5
Shale, varicolred, greenish gray, reddish gray, and medium gray	310.5 -	313.0
Shale, medium greenish gray with reddish tint	313.0 -	317.0
Shale, medium gray	317.0 -	318.4
Shale, light to medium gray	318.4 -	320.4
Shale, medium gray	320.4 -	321.0
Shale, medium olive gray	321.0 -	324.0
Shale, reddish brown	324.0 -	325.0
Shale, light to medium greenish gray	325.0 -	326.0
Limestone, light to medium tan, very finely crystalline; contains ostracods	326.0 -	327.8

	Depth, in feet From	To
Shale, light to medium greenish gray	327.8 -	331.3
Red Eagle Formation:		
Howe Member:		
Limestone, medium tan, very finely to finely crystalline, impure; contains pyrite	331.3 -	332.0
Limestone, medium tannish gray, finely crystalline, shaley lower 1.0; contains pyrite	332.0 -	335.2
Bennett Member:		
Shale, black	335.2 -	340.0
Glen Rock Member:		
Limestone, medium tannish gray, very finely to finely crystalline, impure; contains fusulinids and abundant algal material and Osagia	340.0 -	341.3
Johnson Formation:		
Shale, dark gray; interbedded with limestone, medium gray, finely crystalline	341.3 -	342.0
Limestone, medium gray, finely crystalline; contains fusulinids and pyrite	342.0 -	343.4
Shale, light to medium gray with olive tint	343.4 -	343.8
Shale, medium gray with olive tint	343.8 -	345.0
Shale, light to medium gray with tannish tint	345.0 -	347.0
Shale, medium greenish gray	347.0 -	352.0
Shale, medium olive gray	352.0 -	357.8
Limestone, very light tan, very finely crystalline	357.8 -	358.6
Shale, medium olive gray, limy; contains gypsum, white	358.6 -	361.0
Shale, medium olive gray, contains abundant gypsum, white	361.0 -	365.8
Foraker Formation:		
Long Creek Member:		
Limestone, medium tan, very finely to finely crystalline, shaley	365.8 -	367.0
Shale, light olive gray, limy; contains gypsum	367.0 -	367.5
Limestone, medium tannish gray, finely crystalline, silty	367.5 -	370.0
Limestone, medium gray, finely crystalline, silty	370.0 -	372.4
Hughes Creek Member:		
Shale, medium olive gray	372.4 -	376.0
Shale, dark gray with reddish tint interbedded with medium gray with reddish tint	376.0 -	381.0
Shale, medium gray mottled with reddish brown	381.0 -	383.5
Shale, medium reddish gray	383.5 -	386.0
Limestone, medium gray, finely crystalline, silty, shaley; contains dark gray "inclusions"	386.0 -	387.2
Shale, medium gray	387.2 -	390.0

Test hole 41-79 continued

	Depth, in feet From	To
Shale, medium greenish gray	390.0 -	391.0
Shale, dark gray mottled with red	391.0 -	397.0
Limestone, medium gray, finely crystalline, impure; contains crinoids, pyrite, and fusulinids	397.0 -	398.1
Shale, medium gray with reddish tint	398.1 -	401.2
Limestone, medium gray, finely crystalline, impure; contains brachiopods	401.2 -	402.4
Shale, medium gray mottled with red	402.4 -	405.0
Shale, medium to dark gray	405.0 -	410.3
Americus Member:		
Shale, dark gray; interbedded with siltstone, medium gray	410.3 -	410.9
Admire Group:		
Hamlin Formation:		
Shale, dark gray to black, fissile	410.9 -	411.2
Shale, dark gray	411.2 -	413.0
Shale, light to medium greenish gray	413.0 -	425.0
Shale, light reddish gray	425.0 -	426.0
Shale, light greenish gray	426.0 -	428.1
Shale, medium gray	428.1 -	431.8
Shale, medium olive	431.8 -	434.0
Shale, medium gray with olive tint	434.0 -	436.0
Shale, medium to dark gray mottled with reddish brown	436.0 -	439.0
Shale, medium reddish gray	439.0 -	440.5
Shale, medium gray with reddish tint	440.5 -	445.0
Shale, medium greenish gray	445.0 -	452.1
Five Point Formation:		
Shale, medium tannish gray, limy	452.1 -	453.4
West Branch Formation:		
Shale, medium gray with olive tint	453.4 -	460.5
Shale, light to medium greenish gray	460.5 -	462.4
Shale, light to medium greenish gray with reddish tint	462.4 -	466.0
Shale, medium gray	466.0 -	471.2
Shale, medium gray; interbedded with thin limestones, medium tan, finely crystalline	471.2 -	475.5
Falls City Formation:		
Lehmer Member:		
Limestone, medium tan, finely crystalline, shaley	475.5 -	477.2
Reserve - Miles Members:		
Shale, medium gray	477.2 -	480.0
Limestone, light to medium gray, impure; contains ostracods and algal material	480.0 -	480.3
Onaga Formation:		
Hauxby Member:		

Test hole 41-79 continued

	Depth, in feet From	To
Shale, medium gray, limy at 487.2 - 489.1......	480.3 -	489.1
Shale, medium greenish gray....................	489.1 -	490.3
Aspinwall Member:		
Limestone, light to medium gray, finely crystalline, silty, impure; contains algal material; interbedded with shale, medium greenish gray..............................	490.3 -	493.1
Towle Member:		
Shale, medium gray with olive tint, limy.......	493.1 -	495.0
Shale, medium gray with olive tint.............	495.0 -	500.0
Shale, reddish brown...........................	500.0 -	501.0
Shale, medium gray.............................	501.0 -	503.0

Test Hole 42-79

Location: Pawnee County, SE corner SW SW sec. 16, T. 3 N., R. 12 E., approximately 17 feet north of south section line and 273 feet west of quarter section line.

Ground-level elevation: 1,048 feet above mean sea level.

Started: July 26, 1979. Completed: July 31, 1979.

Total depth: 518.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Soil (no sample)	0 -	1.0
Silt, light yellowish tan with iron staining	1.0 -	9.0
Silt, medium to dark tan, sandy	9.0 -	12.0
Silt, medium tannish brown, sandy	12.0 -	15.5
Silt, medium tannish brown, sandy, clayey	15.5 -	21.0
Sand, medium tannish brown, very fine to fine	21.0 -	25.0
Sand, medium yellowish tan, very fine to coarse, and gravel, very fine to medium	25.0 -	43.5
Gravel, very fine to coarse, and sand, medium to coarse; contains shale, light to medium gray	43.5 -	47.0
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Severy Formation:		
Shale, medium gray	47.0 -	59.3
Shawnee Group:		
Topeka Formation:		
Coal Creek Member:		
Limestone, light to medium gray, very finely to finely crystalline, impure; contains pyrite and abundant brachiopods	59.3 -	61.1
Holt Member:		
Shale, medium gray, limy	61.1 -	61.4
Shale, dark gray, fissile	61.4 -	61.7
Shale, black, fissile	61.7 -	63.8
DuBois Member:		
Limestone, medium gray, finely crystalline; contains brachiopods and crinoids	63.8 -	65.0
Turner Creek Member:		
Shale, medium gray	65.0 -	65.2
Shale, light gray	65.2 -	68.3
Sheldon Member:		

Test hole 42-79 continued

	Depth, in feet	
	From	To
Limestone, very light to light tan, very finely to finely crystalline, pseudo-oolitic; contains *Osagia* and abundant algal material	68.3 -	71.5
Limestone, medium tannish gray, very finely crystalline; contains brachiopods and fusulinids	71.5 -	72.3
Jones Point Member:		
Shale, medium to dark gray, limy	72.3 -	73.0
Curzon Member:		
Limestone, medium gray, very finely crystalline; contains brachiopods, crinoids, and pyrite	73.0 -	74.2
Shale, light gray	74.2 -	76.2
Limestone, medium gray, very finely to finely crystalline; contains brachiopods and fusulinids	76.2 -	77.0
Limestone, medium gray, very finely to finely crystalline; contains pyrite, fusulinids, and abundant brachiopods	77.0 -	78.0
Iowa Point Member:		
Shale, medium gray	78.0 -	80.5
Hartford Member:		
Limestone, light to medium gray with tannish tint, very finely to finely crystalline; contains abundant ostracods	80.5 -	81.0
Shale, light gray with greenish tint	81.0 -	81.3
Limestone, light to medium tan, very finely crystalline; contains pyrite, brachiopods, and abundant ostracods	81.3 -	82.1
Shale, medium gray	82.1 -	82.4
Limestone, medium tannish gray, finely crystalline, pseudo-oolitic in part; contains gastropods, brachiopods, algal material, and abundant ostracods and *Osagia*	82.4 -	83.3
Calhoun Formation:		
Shale, light to medium gray	83.3 -	84.2
Deer Creek Formation:		
Ervine Creek Member:		
Limestone, light to medium tan, very finely to finely crystalline; contains pseudo-oolites, and algal material	84.2 -	85.2
Limestone, light gray with tannish tint, very finely to finely crystalline, silty, shaley; contains crinoids and pyrite	85.2 -	87.0
Limestone, light cream to tan, very finely to finely crystalline; contains brachiopods, ostracods, and algal material	87.0 -	91.0

Test hole 42-79 continued

	Depth, in feet From	To
Limestone, light to medium tannish gray, very finely to finely crystalline, impure; contains brachiopods, crinoids, and algal material	91.0 -	93.0
Limestone, medium gray, finely crystalline, shaley; contains crinoids	93.0 -	93.9
Shale, light to medium gray	93.9 -	99.6
Larsh Member:		
Shale, medium gray	99.6 -	100.0
Shale, black, fissile	100.0 -	101.1
Rock Bluff Member:		
Limestone, light to medium tan, very finely crystalline; contains brachiopods	101.1 -	103.7
Oskaloosa Member:		
Shale, medium gray	103.7 -	105.0
Siltstone, light greenish gray	105.0 -	107.0
Siltstone, grading to claystone, light cream with reddish tint	107.0 -	109.0
Sandstone, light greenish gray	109.0 -	110.3
Siltstone, light gray, clayey	110.3 -	113.5
Shale, reddish brown	113.5 -	116.0
Ozawkie Member:		
Limestone, light tan, very finely crystalline; contains rounded quartz grains and abundant ostracods	116.0 -	119.3
Tecumseh Formation:		
Shale, reddish brown; interbedded with thin limestones, light tan	119.3 -	123.1
Shale, medium gray, limy	123.1 -	123.7
Shale, dark olive gray	123.7 -	129.0
Shale, medium to dark olive gray	129.0 -	131.0
Shale, dark gray	131.0 -	135.0
Shale, medium gray	135.0 -	141.0
Lecompton Formation:		
Avoca Member:		
Limestone, medium gray, finely crystalline, shaley; contains crinoids and brachiopods	141.0 -	141.5
Shale, medium gray; interbedded with limestone, medium gray, finely crystalline	141.5 -	142.0
Limestone, medium gray, finely crystalline, impure; contains gastropods, pelecypods, brachiopods, pyrite, and abundant fusulinids	142.0 -	144.5
King Hill Member:		
Shale, light greenish gray	144.5 -	146.4
Beil Member:		
Limestone, light greenish gray, very finely crystalline, shaley; contains brachiopods and pyrite	146.4 -	147.0

	Depth, in feet From	To
Limestone, light greenish gray, very finely crystalline; contains *Osagia* and abundant fusulinids and algal material......	147.0 -	150.6
Limestone, light gray, very finely crystalline, contains algal material........	150.6 -	152.1
Queen Hill Member:		
Shale, light gray with greenish tint..........	152.1 -	153.0
Shale, black, fissile........................	153.0 -	155.8
Big Springs Member:		
Limestone, medium gray, very finely crystalline..................................	155.8 -	158.2
Shale, medium to dark gray...................	158.2 -	158.5
Limestone, light gray, finely crystalline; contains fusulinids........................	158.5 -	160.0
Doniphan Member:		
Shale, medium to dark greenish gray...........	160.0 -	164.3
Spring Branch Member:		
Limestone, light to medium tan with gray tint, finely crystalline; contains fusulinids, *Osagia*, and abundant algal material.........	164.3 -	165.0
Limestone, light to medium tan, finely crystalline..................................	165.0 -	167.0
Shale, dark gray to black, limy..............	167.0 -	167.9
Limestone, light gray, finely crystalline, shaley; contains fusulinids and brachiopods.................................	167.9 -	170.3
Kanwaka Formation:		
Limestone, light gray, finely crystalline, shaley; contains algal material and abundant fusulinids........................	170.3 -	171.8
Oread Formation:		
Kereford Member:		
Limestone, light gray, finely crystalline.....	171.8 -	176.0
Limestone, light gray, very finely crystalline; contains fusulinids...........	176.0 -	180.3
Limestone, light gray, very finely crystalline..................................	180.3 -	181.3
Heumader Member:		
Shale, medium gray, limy.....................	181.3 -	181.5
Plattsmouth Member:		
Limestone, light tannish gray, very finely crystalline; contains fusulinids, *Osagia*, and abundant algal material................	181.5 -	185.0
Limestone, light tannish gray, very finely crystalline; contains fusulinids and brachiopods.................................	185.0 -	190.0
Limestone, light to medium tan, very finely to finely crystalline; contains fusulinids, bryozoans, and brachiopods.................	190.0 -	195.0

Test hole 42-79 continued

	Depth, in feet	
	From	To
Limestone, light gray with tannish tint, very finely to finely crystalline, impure; contains brachiopods; shaley lower 0.1	195.0	201.3
Heebner Member:		
Shale, light to medium gray	201.3	201.8
Shale, black, carbonaceous	201.8	204.2
Leavenworth Member:		
Limestone, light to medium gray, very finely to finely crystalline; contains brachiopods.	204.2	206.0
Snyderville Member:		
Shale, light gray	206.0	212.5
Shale, reddish brown	212.5	213.0
Shale, reddish brown with greenish gray tint	213.0	213.4
Toronto Member:		
Limestone, very light tan, very finely to finely crystalline; contains *Osagia* and abundant fusulinids, algal material, and brachiopods	213.4	214.8
Limestone, very light tan, very finely to finely crystalline; interbedded with shale, reddish brown	214.8	222.0
Douglas Group:		
Lawrence - Plattford Formations:		
Shale, light to medium gray	222.0	225.0
Limestone, tan, irregularly crystalline, pseudo-oolitic; contains bryozoans and fusulinids	225.0	225.8
Shale, reddish brown	225.8	229.8
Shale, reddish brown, limy	229.8	237.0
Shale, medium gray mottled with reddish brown	237.0	240.0
Shale, medium gray	240.0	253.8
Limestone, light gray, finely crystalline; contains brachiopods, pyrite, and fusulinids	253.8	258.1
Shale, medium gray	258.1	268.9
Limestone, medium gray, irregularly crystalline; contains abundant crinoids and brachiopods; interbedded with shale, medium gray	268.9	273.0
Shale, medium gray; interbedded with limestone, medium gray, finely crystalline; contains crinoids and brachiopods	273.0	276.5
Shale, light greenish gray	276.5	280.0
Shale, reddish brown	280.0	281.0
Shale, light greenish gray	281.0	284.4
Missouri Series - Lansing Group:		
Stanton Formation:		
South Bend Member:		
Limestone, light tan to white, very finely crystalline; contains crinoids and algal		

	Depth, in feet From	To
material	284.4 -	288.3
Shale, light greenish gray, limy	288.3 -	291.0
Limestone, light gray, very finely to finely crystalline; contains fusulinids, bryozoans, brachiopods, and abundant algal material and *Osagia*	291.0 -	293.0
Limestone, light gray, very finely to finely crystalline; contains gastropods, crinoids, bryozoans, pyrite, and abundant fusulinids; interbedded with shale, medium gray	293.0 -	295.0
Rock Lake Member:		
Shale, medium gray	295.0 -	297.1
Stoner Member:		
Limestone, very light gray, very finely to finely crystalline; contains abundant bryozoans, crinoids, and pyrite	297.1 -	301.0
Limestone, very light gray, very finely to finely crystalline; contains pyrite	301.0 -	304.7
Shale, light greenish gray, limy	304.7 -	306.0
Vilas Formation:		
Shale, light greenish gray; interbedded with thin limestones at 308.2 and 309.3	306.0 -	309.9
Plattsburg Formation:		
Limestone, light tan, very finely crystalline; contains abundant algal material	309.9 -	310.8
Shale, light gray	310.8 -	311.0
Limestone, light gray, very finely crystalline; contains algal material	311.0 -	313.4
Shale, light to medium gray; interbedded with thin limy zones	313.4 -	316.4
Limestone, light gray, very finely crystalline	316.4 -	318.0
Limestone, very light gray to white, very finely crystalline; contains algal material and bryozoans	318.0 -	321.0
Limestone, light greenish gray, very finely crystalline; contains brachiopods	321.0 -	321.5
Limestone, very light gray, very finely crystalline; contains algal material	321.5 -	323.7
Bonner Springs Formation:		
Shale, medium gray	323.7 -	327.2
Shale, light gray	327.2 -	328.2
Wyandotte Formation:		
Farley Member:		
Limestone, light to medium tan, very finely crystalline; contains bryozoans, algal material and chert	328.2 -	330.8
Limestone, light gray, very finely crystalline; contains crinoids and algal material	330.8 -	333.0

Test hole 42-79 continued

	Depth, in feet From	To
Limestone, very light tan, very finely crystalline; contains algal material and brachiopods	333.0	334.3
Shale, light gray	334.3	336.6
Limestone, light gray, very finely to finely crystalline; contains pyrite and algal material	336.6	337.0
Island Creek Member:		
Shale, light gray	337.0	339.1
Argentine Member:		
Limestone, light tan, finely crystalline; contains abundant algal material	339.1	341.0
Limestone, light gray, very finely crystalline; contains brachiopods and pyrite	341.0	345.0
Limestone, light gray, very finely crystalline, contains pyrite	345.0	350.0
Limestone, light gray, very finely crystalline	350.0	353.0
Quindaro Member:		
Limestone, light gray, very finely crystalline, shaley	353.0	354.3
Frisbie Member:		
Limestone, light gray, very finely crystalline	354.3	355.0
Shale, light gray, limy	355.0	355.6
Limestone, light gray to white, very finely crystalline; contains pyrite, glauconite, brachiopods, and algal material	355.6	356.8
Lane Formation:		
Shale, medium gray	356.8	370.1
Iola - Dennis Formations:		
Limestone, very light tan to white, very finely to finely crystalline, pseudo-oolitic; contains algal material and <u>Osagia</u>	370.1	371.8
Shale, medium gray, limy	371.8	372.5
Limestone, very light gray to white, finely crystalline; contains glauconite and abundant algal material	372.5	375.0
Limestone, very light gray to white, very finely to finely crystalline; contains pseudo-oolites and algal material	375.0	380.0
Limestone, very light gray to white, very finely to finely crystalline; contains fusulinids	380.0	385.0
Limestone, very light gray to white, finely crystalline, shaley; contains dark gray "inclusions" and abundant algal material	385.0	390.0
Limestone, very light gray to white, very finely to finely crystalline; contains algal material	390.0	400.0

Test hole 42-79 continued

	Depth, in feet From	To
Limestone, very light tan to white, very finely crystalline; contains pyrite........	400.0 -	405.0
Limestone, very light tan to white, very finely crystalline; contains fusulinids, brachiopods, and algal material............	405.0 -	406.7
Shale, light greenish gray; interbedded with limy zones at 409.6 - 410.7 and 411.1 - 411.2..............................	406.7 -	411.1
Shale, light greenish gray; contains granitic wash............................	411.1 -	414.1
Shale, reddish brown; contains granitic wash....................................	414.1 -	429.2
Precambrian System:		
Granitic rock, weathered....................	429.2 -	440.0
Granitic rock, fresh; 2 5/16" diameter core taken at intervals: run 1 - 482.0 - 488.5, 6.5 recovered; run 2 - 488.5 - 494.5, 6.0 recovered; run 3 - 512.0 - 518.0, 5.5 recovered	440.0 -	518.0

Test Hole 18-B-79

Location: Sheridan County, NW corner NE NE NW NE sec. 24, T. 34 N., R. 42 W., approximately 5-10 feet south of north section line and 996 feet east of half section line.

Ground-level elevation: 3,755 feet above mean sea level.

Started: July 13, 1979. Completed: July 14, 1979.

Total depth: 610.1 feet.

Description	Depth, in feet From	To
Quaternary System:		
Topsoil, black	0	3.0
Subsoil, silty, slightly clayey, dark brown	3.0	6.0
Silt, slightly clayey, very slightly sandy, medium yellowish brown	6.0	8.5
Tertiary System - Miocene Series - Arikaree Group:		
"Upper Harrison" Formation:		
Silt to siltstone, slightly sandy, slightly to moderately clayey, light yellowish brown to brown, non to very calcareous at 20.0 - 30.0 and 43.8 - 70.0	8.5	70.0
Silt, slightly to moderately sandy, slightly to moderately clayey, light to medium brown, non to very calcareous	70.0	94.0
Silt, sandy to very sandy, brown	94.0	100.0
Sand, very fine to fine with traces of medium, brown, non to very calcareous; interbedded with sandstone, very fine to medium grained, at 105.8 - 110.0	100.0	120.6
Harrison - Monroe Creek Formations:		
Sand to sandstone, very fine to fine grained with traces of medium, brown, non to very calcareous; slightly coarser 140.0 - 146.7	120.6	163.5
Silt, slightly to very sandy, very slightly to moderately clayey, brown to yellowish brown, non to very calcareous; contains siltstones 230.0 - 240.0	163.5	249.6
Gering Formation:		
Sand to sandstone, very fine to fine grained with traces of medium, brown to light yellowish brown; sandstone at 249.6 - 250.0 containing manganese staining	249.6	290.0

Test hole 18-B-79 Continued

	Depth, in feet From	To
Sand, fine with traces of medium and coarse, light yellowish brown, non to very calcareous	290.0	297.0
Silt, very sandy, very slightly clayey, yellowish brown, non to moderately calcareous	297.0	300.0
Sand, very fine to fine, moderately to very silty, very slightly clayey, yellowish brown; interbedded with sandstone, very fine to fine grained with traces of medium, very pale brown, very calcareous, from 302.7 - 303.4	300.0	310.5
Oligocene Series - White River Group:		
Brule Formation:		
Sand, very fine, very silty, brown; interbedded with silt, moderately sandy, slightly to moderately clayey, brown; very limy at 311.0 - 311.7	310.5	320.0
Silt to siltstone, moderately to very sandy, slightly clayey, brown, non to very calcareous	320.0	353.5
Sand, very fine to fine with traces of medium, brown	353.5	357.0
Silt to siltstone, very sandy, slightly clayey, brown	357.0	361.0
Sand, very fine to fine with traces of medium, brown, non to very calcareous	361.0	374.2
Silt to siltstone, moderately to very sandy, brown, non to very calcareous	374.2	400.0
Sand, very fine to fine, moderately to very silty, brown, non to very calcareous	400.0	420.0
Siltstone to silt, slightly to very sandy, brown to yellowish brown, non to very calcareous; contains possible volcanic ash, pale olive brown, at 442.0 - 442.1	420.0	465.5
Sand to sandstone, very fine to fine with traces of medium, brown, non to very calcareous at 475.5 - 490.0	465.5	493.0
Silt, to siltstone, moderately to very sandy, brown to yellowish brown	493.0	516.0
Sand, very fine with silt interbeds, pale brown	516.0	527.7
Silt, very sandy, very pale to pale brown, non to very calcareous upper 2.3; contains volcanic ash 532.0 - 532.2	527.7	540.0
Silt, very slightly to slightly sandy, slightly to moderately clayey, very pale to pale brown, non to moderately calcareous	540.0	610.0

Test Hole 24-B-79

Location: Sheridan County, SW NW SW SW NW sec. 1, T. 30 N., R. 42 W., approximately 370 feet north of half section line and 90-100 feet east of west section line.

Ground-level elevation: 3,652 feet above mean sea level.

Started: August 7, 1979. Completed: August 9, 1979.

Total depth: 669 feet.

Description	Depth, in feet From	To
Quaternary System:		
Soil, sandy (no sample)	0 -	4.0
Silt, sandy, yellowish brown	4.0 -	5.7
Tertiary System - Pliocene Series - Ogallala Group, Undifferentiated:		
Sandstone, silty, pale yellow to yellowish brown; contains root casts	5.7 -	30.0
Silt, light gray; contains volcanic ash	30.0 -	35.9
Sandstone, yellowish brown; contains root casts	35.9 -	40.0
Sandstone to sand, very fine to fine grained, light yellowish brown to brown; contains root casts in part	40.0 -	101.0
Silt, slightly clayey, slightly sandy, pale yellow	101.0 -	104.0
Sandstone, very fine to fine grained, pale brown to light brownish gray	104.0 -	140.0
Sandstone, fine to medium grained with traces of very fine, olive; interbedded with silts; contains gravel 157.7 - 160.0; poorly sorted 160.0 - 170.0	140.0 -	170.0
Silt, sandy, slightly clayey, pale olive; interbedded with sandstone	170.0 -	176.0
Sandstone, fine to medium grained, pale brown to olive brown; contains scattered gravel interbeds	176.0 -	224.9
Silt, sandy, light yellowish brown	224.9 -	230.0
Sandstone, fine to coarse grained with traces of very coarse, light olive brown; contains gravel, fine to medium 240.0 - 257.9	230.0 -	257.9
Silt, slightly sandy, slightly clayey, pale brown to pinkish brown, slightly to very calcareous; interbedded with sandstone	257.9 -	272.5

Test hole 24-B-79 continued

	Depth, in feet From	To
Sandstone, fine to medium grained with traces of gravel, very fine to medium, light pinkish brown, slightly to very calcareous	272.5 -	280.0
Sand to sandstone, very fine to coarse with gravel, very fine to medium, pale brown	280.0 -	295.4
Sandstone, fine to medium grained with traces of coarse, pale brown; contains interbedded silts and gravels	295.4 -	323.5
Silt, sandy, light yellowish brown to pale brown; contains traces of gravel lower 6.0	323.5 -	336.0
Sandstone, fine to coarse grained with gravel, very fine to fine, brown	336.0 -	346.5
Silt, sandy, slightly clayey, pale reddish brown; contains gravel	346.5 -	350.5
Sandstone, very fine to coarse grained with traces of fine gravel, brown	350.5 -	365.5
Miocene Series - Arikaree Group:		
"Upper Harrison" Formation:		
Siltstone, slightly sandy, slightly to moderately clayey, light to medium yellowish brown	365.5 -	390.0
Siltstone to silt, slightly sandy, slightly to moderately clayey, light yellowish brown	390.0 -	425.3
Silt to siltstone, slightly sandy, slightly clayey, very pale brown to white, non to very calcareous	425.3 -	444.0
Siltstone to silt, slightly sandy, light yellowish brown, non to slightly calcareous	444.0 -	450.0
Siltstone to silt, slightly to moderately sandy, slightly clayey, light yellowish brown, non to moderately calcareous	450.0 -	490.0
Siltstone to silt, sandy, light gray, moderately to very calcareous	490.0 -	492.8
Siltstone to silt, moderately to very sandy, light yellowish brown to light gray, non to very calcareous	492.8 -	517.0
Sandstone to sand, fine to very coarse grained, brown	517.0 -	532.0
Monroe Creek Formation:		
Siltstone to silt, very sandy, light brownish gray to pale brown, non to slightly calcarous, contains limy interbeds, sandy, at 537.7 - 539.6, 546.1 - 550.0, 560.8 - 564.4, 583.2 - 584.1, 586.4 - 588.0, and 589.5 - 590.4	532.0 -	590.4
Sand, silty, pale brown, non to slightly calcareous	590.4 -	616.6

Test hole 24-B-79 continued

	Depth, in feet	
	From	To
Oligocene Series - White River Group:		
Brule Formation:		
Silt to siltstone, moderately sandy, non to slightly clayey, yellowish brown to light yellowish brown........................	616.6 -	669.0

Test Hole 1a-GT-80

Location: Boyd County, SE SW SE sec. 24, T. 35 N., R. 15 W., approximately 143 feet north of south section line and 240 feet west of east quarter section line.

Ground-level elevation: 1,780.0 feet above mean sea level.

Started: July 8, 1980. Completed: July 12, 1980.

Total depth: 758.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand, very dark brown, fine grained with traces of medium and coarse; contains abundant organic material..................	0.0	- 3.0
Sand, yellowish brown, very fine to fine grained with small fraction of medium and traces of medium to coarse.............	3.0	- 5.0
Sand and gravel, yellowish brown, sand coarse to very coarse grained, gravel very fine to medium grained; contains abundant feldspars; very slightly clayey at 15.0-20.0.......................	5.0	- 39.0
Sand and gravel and reworked shale, sand and gravel yellowish brown, sand coarse to very coarse grained, gravel very fine to medium grained with traces of coarse; reworked shale dark yellowish brown to dark grayish brown.......................	39.0	- 41.8
Cretaceous System - Upper Cretaceous Series - Montana Group:		
Pierre Formation:		
Shale, olive gray to dark olive gray, hard....	41.8	- 45.0
Shale, very dark gray, hard, slightly fissile.	45.0	- 80.0
Shale, very dark gray, soft with interbedded hard layers; contains thin bentonite seam at 112.0 to 113.0 and very thin limy zone at 115.0............................	80.0	- 255.0
Limestone, very dark gray, very finely crystalline, very thinly bedded; contains pyrite..................................	255.0	- 255.6
Shale, very dark gray, soft with moderately hard interbeds; contains very thin bentonite seams at 323.0-330.0.............	255.6	- 340.0
Shale, dark gray to very dark gray, soft with moderately hard interbeds; contains occasional very thin limy interbeds.........	340.0	- 380.0

Test hole 1a-GT-80 continued

	Depth, in feet	
	From	To
Shale, dark gray to very dark gray, soft with moderately hard interbeds..............	380.0	- 430.0
Shale, very dark gray to dark gray, soft with moderately hard interbeds; contains occasional very thin limy interbeds at 434.0-466.0..................................	430.0	- 466.0
Limestone, gray, finely crystalline, soft, shaley....................................	466.0	- 474.0
Shale (taken from E-log), very dark gray to black; interbedded with thin limestones gray, finely crystalline, very soft..........	474.0	- 494.0
Limestone, gray, finely crystalline, sandy to silty; contains pyrite and ostracods......	494.0	- 498.0
Shale, dark gray, slightly to moderately limy..	498.0	- 521.0
Colorado Group:		
Niobrara Formation:		
Limestone, dark gray "speckled" with white to very light brown inclusions, finely crystalline, soft, chalky; contains pyrite....................................	521.0	- 523.0
Limestone, dark olive gray "speckled" with white to very light brown inclusions, finely crystalline, soft, chalky............	523.0	- 572.0
Limestone, olive gray "speckled" with white inclusions, soft, chalky....................	572.0	- 618.0
Limestone, "speckled" olive gray with "speckled" gray interbedded, finely crystalline, soft, chalky; contains scattered fish scales.......................	618.0	- 620.0
Limestone, light to dark gray with "speckled" white inclusions, soft, chalky; contains traces of pyrite and pelecypods.............	620.0	- 630.0
Limestone, gray to dark gray "speckled" with white inclusions, finely crystalline, soft, chalky....................................	630.0	- 652.0
Limestone, gray to dark gray "speckled" with white inclusions, finely crystalline, soft chalky, slightly to moderately shaley........	652.0	- 700.0
Shale, very dark gray, moderately hard, slightly to moderately limy.................	700.0	- 758.0

Test Hole 2-GT-80

Location: Keya Paha County, SE SW NW, sec. 32, T. 35 N., R. 20 W., approximately 2,360 feet south of north section line and 810 feet east of west section line.

Ground-level elevation: 2,107 feet above mean sea level.

Started: May 20, 1980. Completed: May 22, 1980.

Total depth: 500.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Topsoil, very dark grayish brown, very silty	0.0 -	1.0
Sand, dark brown, very fine grained, silty	1.0 -	5.0
Sand, grayish brown, very fine to fine grained with traces of medium; contains traces of reworked shale, dark gray in lower 1.5	5.0 -	11.5
Cretaceous System - Upper Cretaceous Series - Montana Group:		
Pierre Formation:		
Shale, dark gray, clayey, hard at 35.0-35.2, 41.0-41.1, 97.5-98.0, 123.0-123.1, 171.0-171.8, 313.0-313.1	11.5 -	500.0

Test Hole 3-GT-80

Location: Cherry County, NE SE SW sec. 28, T. 34 N., R. 27 W., approximately 975 feet north of south section line and 350 feet west of half section line.

Ground-level elevation: 2,446.0 feet above mean sea level.

Started: May 28, 1980. Completed: May 30, 1980.

Total depth; 503.0 feet.

Description	Depth, in feet From		To
Quaternary System:			
Sand, light brown, very fine to fine grained with traces of medium; contains quartzitic boulders, olive, at 3.0-5.0	0.0	-	5.0
Sand to silt, light brown, sand very fine grained	5.0	-	10.0
Sand, light brown, very fine to fine grained	10.0	-	20.0
Tertiary System - Miocene Series - Ogallala Group, Undifferentiated:			
Silt, light brown, slightly sandy, sand very fine to fine grained	20.0	-	29.0
Silt, light olive brown, very clayey	29.0	-	30.0
Sand, yellowish brown, fine grained with traces of medium, slightly clayey to moderately clayey lower 8.0	30.0	-	65.0
Silt, pale yellow, very clayey	65.0	-	80.0
Siltstone, brown, slightly clayey	80.0	-	85.0
Siltstone, light olive brown with pale yellow interbedded, very slightly clayey	85.0	-	99.0
Tertiary System - Oligocene Series - White River Group: Brule Formation:			
Siltstone to silt, light olive gray, slightly clayey	99.0	-	105.0
Siltstone to silt, light to medium olive gray, slightly to moderately clayey	105.0	-	112.0
Siltstone to silt, pale olive yellow, slightly to moderately clayey	112.0	-	122.0
Siltstone to silt, light to medium olive brown, slightly clayey	122.0	-	146.8
Silt to siltstone, brown, slightly clayey	146.8	-	165.0
Siltstone to silt, dark yellowish brown, slightly clayey	165.0	-	198.0
Silt to siltstone, light yellowish brown with olive tint, moderately clayey	198.0	-	200.0

Test hole 3-GT-80 continued

	Depth, in feet	
	From	To
Siltstone, yellowish brown, very slightly clayey	200.0	- 280.0
Siltstone to silt, brown, moderately clayey	280.0	- 286.0
Siltstone to silt, pale yellow, very clayey	286.0	- 290.5
Siltstone to silt, brown, slightly to very clayey	290.5	- 300.0
Siltstone, yellowish brown	300.0	- 311.0
Silt, light olive brown to olive brown, very clayey	311.0	- 314.0
Siltstone to silt, very pale brown, slightly clayey	314.0	- 320.0
Siltstone, brown, very slightly to moderately clayey	320.0	- 348.0
Siltstone to silt, olive brown, very slightly to moderately clayey	348.0	- 360.0
Siltstone to silt, brown, very slightly clayey	360.0	- 428.0
Siltstone to silt, greenish gray	428.0	- 440.0
Siltstone, dark greenish gray with traces of light brown	440.0	- 450.0
Siltstone, light brown with greenish gray mottling	450.0	- 460.0
Siltstone, light to dark greenish gray with light pinkish brown interbedded; contains traces of black, slightly silty and slightly to moderately clayey at 480.0-503.0	460.0	- 503.0

Test Hole 4-GT-80

Location: Holt County, NW corner NW NW sec. 6, T. 28 N., R. 11 W., approximately 72 feet south of north section line and 153 feet east of west section line.

Ground-level elevation: 1,967.0 feet above mean sea level.

Started: June 2, 1980. Completed: June 3, 1980.

Total depth: 503.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand, pale brown, medium to coarse grained with traces of fine and very coarse; contains yellowish red feldspars	0.0 -	17.0
Sand, pale brown, coarse grained with traces of medium and very coarse; contains yellowish red feldspars	17.0 -	27.0
Tertiary System - Miocene Series - Ogallala Group:		
Silt to sand, light greenish gray, sand very fine grained, very clayey	27.0 -	30.0
Sand, greenish gray, very fine grained with traces of fine to coarse, silty, clayey; contains yellowish red and pale brown varients	30.0 -	40.0
Sand, light brown, coarse to very coarse grained, clayey in part; contains yellowish red feldspars	40.0 -	42.0
Sandstone, olive gray, fine grained, slightly calcareous	42.0 -	46.0
Sand, pale red to yellowish brown, very fine to fine grained with small fraction medium, slightly clayey; interbedded with sandstone, olive gray, fine grained, very calcareous	46.0 -	54.0
Sand, light greenish gray, very fine to fine grained with coarse fraction in upper 8.0, moderately to very clayey, very calcareous.	54.0 -	65.0
Sandstone, light olive darkening to medium to dark olive gray lower 3.0, fine grained, very slightly calcareous at bottom to moderately calcareous at top	65.0 -	80.0
Sand to sandstone, medium to dark olive gray, sand coarse to very coarse grained, sandstone fine to very fine grained, very slightly calcareous	80.0 -	88.0

Test hole 4-GT-80 continued

	Depth, in feet	
	From	To
Sand, dark to medium olive gray, very fine to fine grained, very clayey................	88.0	- 90.0
Sand, light to medium olive gray, medium to coarse grained; interbedded with sandstones, very fine to fine grained; contains thin clayey zones in upper 2.0..............	90.0	- 100.0
Sand to sandstone, light olive gray, sand coarse grained, sandstone very fine to fine grained, very calcareous; contains reddish orange feldspars...........................	100.0	- 107.0
Sandstone, light olive gray to white, fine grained, slightly to very calcareous, slightly to very clayey; interbedded with sand, medium to coarse grained..............	107.0	- 140.0
Sand, olive gray, medium to coarse grained; interbedded with sandstone, very fine to fine grained; very calcareous, very slightly clayey....................................	140.0	- 144.0
Sand, light olive gray, very fine to fine grained, very clayey, very calcareous.......	144.0	- 145.0
Sandstone, light olive gray, very fine to fine grained, very slightly clayey, moderately to very calcareous; contains sandy clay at 150.0-150.5..................	145.0	- 155.0
Clay, light olive gray, very sandy, sand very fine to fine grained..................	155.0	- 160.0
Sand, light olive gray, medium to coarse grained, very slightly to moderately clayey, slightly to very calcareous; interbedded with sandstone, very fine to fine grained.............................	160.0	- 180.0
Sandstone, light olive gray, very fine to fine grained, very slightly clayey, slightly to very calcareous..........................	180.0	- 200.0
Sand, pale brown, very fine to medium grained, very slightly calcareous; interbedded with sandstone, very fine to fine grained....................................	200.0	- 220.0
Sand, pale brown, very fine to fine grained, non to very slightly calcareous............	220.0	- 305.0
Sandstone, pale yellow, very fine to fine grained, slightly to moderately clayey; interbedded with sand, very fine to fine grained....................................	305.0	- 320.0
Sand to sandstone, pale yellow, very fine to fine grained, slightly to moderately clayey....................................	320.0	- 340.0
Sandstone, light yellowish brown, very fine to fine grained, slightly clayey, slightly calcareous..............................	340.0	- 345.0

Test hole 4-GT-80 continued

	Depth, in feet	
	From	To
Cretaceous System - Upper Cretaceous Series - Montana Group:		
Pierre Formation:		
Shale, yellowish red, weathered	345.0	360.0
Shale, olive yellow, weathered	360.0	365.0
Shale, olive yellow to olive gray to dark olive, weathered	365.0	370.0
Shale, olive yellow to dark olive gray to very dark gray, slightly weathered	370.0	390.0
Shale, dark olive gray	390.0	400.0
Shale, dark olive gray with yellowish brown, soft to slightly fissile	400.0	426.0
Shale, olive with traces of medium to dark gray, soft to slightly fissile	426.0	438.0
Shale, dark olive gray to dark gray	438.0	445.0
Shale, dark olive gray with light olive brown, slightly fissile	445.0	488.0
Shale, dark gray with traces of light olive brown	488.0	503.0

Test Hole 5-GT-80

Location: Wayne County, SE SW NE sec. 14, T. 26 N., R. 3 E., approximately 525 feet north of half section line and 1,304 feet east of half section line.

Ground-level elevation: 1,498.0 feet above mean sea level.

Started: June 10, 1980. Completed: June 11, 1980.

Total depth: 504.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Topsoil, dark yellowish brown, very silty; contains abundant organic material..........	0.0 -	1.0
Silt, yellowish brown, very slightly clayey...	1.0 -	20.0
Silt, yellowish brown with light reddish tint, moderately clayey....................	20.0 -	37.0
Silt, yellowish brown with red iron staining, moderately to very clayey..................	37.0 -	50.0
Silt, brown with reddish tint, moderately to very clayey............................	50.0 -	74.0
Silt, light brownish gray, very clayey........	74.0 -	80.0
Silt, light brownish gray, slightly sandy, moderately to very clayey..................	80.0 -	82.0
Sand, light yellowish brown, coarse grained with traces of medium......................	82.0 -	85.0
Clay, light yellowish brown, slightly to very sandy.......................................	85.0 -	86.0
Sand, light yellowish brown, coarse grained with traces of medium and very coarse.......	86.0 -	88.0
Clay, light yellowish brown, slightly to very sandy..............................	88.0 -	89.0
Sand, light yellowish brown, coarse grained with traces of medium and very coarse to gravel, fine..............................	89.0 -	99.0
Sand, light yellowish brown, fine grained with traces of medium to coarse, moderately to very clayey............................	99.0 -	103.0
Silt, light gray to light olive gray, moderately clayey, soft....................	103.0 -	113.0
Silt, gray, moderately clayey, soft..........	113.0 -	152.0
Silt, gray, very clayey.....................	152.0 -	158.0
Sand, greenish gray, medium to coarse grained with traces of very coarse.................	158.0 -	162.0
Sand, greenish gray, very coarse with traces of gravel, fine...........................	162.0 -	165.0
Sand, greenish gray, medium to very coarse grained with traces of gravel, fine........	165.0 -	178.0

Test hole 5-GT-80 continued

	Depth, in feet From	To
Sand, greenish gray, coarse to very coarse grained with traces of gravel, fine to medium	178.0	- 181.0
Sand, greenish gray, fine to medium grained	181.0	- 186.0
Cretaceous System - Upper Cretaceous Series - Colorado Group:		
Carlile Formation:		
Shale, dark gray, soft, top 4.0 weathered	186.0	- 250.5
Shale, dark gray, soft; contains very thinly bedded limestones, light tan, very finely crystalline	250.5	- 265.0
Shale, dark gray, soft; contains very thinly bedded limestones, dark gray, very finely crystalline	265.0	- 300.0
Shale, dark gray, soft, limy; contains sand, very fine grained, at 317.0-318.0	300.0	- 320.0
Shale, dark gray, soft; contains very thin sandy interbeds, sand very fine	320.0	- 370.5
Greenhorn Formation:		
Limestone, dark grayish brown, very finely to finely crystalline, impure; contains pelecypods and crystalline calcite in part; slightly to moderately shaley lower 8.0	370.5	- 392.5
Graneros Formation:		
Shale, dark gray, soft, slightly limy	392.5	- 405.0
Shale, dark gray, soft, slightly to moderately limy at 420.0-425.5	405.0	- 425.5
Limestone, dark olive gray, finely crystalline, impure; contains pyrite	425.5	- 426.0
Shale, dark gray soft, limy	426.0	- 429.0
Limestone, dark olive gray, finely crystalline, impure; contains pelecypods	429.0	- 430.0
Shale, dark gray, soft, limy	430.0	- 431.5
Limestone, dark olive gray, finely crystalline, impure	431.5	- 433.0
Shale, dark gray, soft, limy	433.0	- 440.0
Shale, dark gray, soft, very slightly to slightly limy	440.0	- 451.0
Lower Cretaceous Series - Dakota Group, Undifferentiated:		
Sand, dark olive gray, very fine grained, very shaley	451.0	- 460.0
Sandstone, dark olive gray, very fine to fine grained, very shaley	460.0	- 465.0
Shale, dark olive gray, slightly to moderately sandy, sand very fine grained, very sandy at 473.0-475.0; limy at 471.0-471.5, 477.0-477.1, and 477.5-477.6	465.0	- 480.0

Test hole 5-GT-80 continued

	Depth, in feet	
	From	To
Sandstone, dark grayish brown, very fine grained, shaley; very tightly cemented at 491.0-492.0	480.0	493.0
Shale, dark olive gray, soft; contains sand to sandstone, very fine grained, at 498.0-502.5	493.0	504.0

Test Hole 6-GT-80

Location: Burt County, NE SW NE sec. 6, T. 21 N., R. 9 E., approximately 1740 feet south of north section line, and 1230 feet east of west section line.

Ground-level elevation: 1,376.0 feet above mean sea level.

Started: June 16, 1980. Completed: June 17, 1980.

Total depth: 504.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Topsoil, very dark grayish brown, very silty, very clayey; contains organic material......	0.0 -	0.5
Silt, brown, moderately clayey................	0.5 -	6.0
Silt, light olive brown, slightly to moderately clayey..........................	6.0 -	25.0
Silt, light olive brown, very slightly sandy, moderately to very clayey; becoming olive brown lower 7.0.............	25.0 -	37.0
Silt, light olive brown, moderately calcareous, slightly to moderately clayey...	37.0 -	50.0
Silt, light yellowish brown, moderately calcareous, very slightly sandy............	50.0 -	65.0
Silt, medium to dark grayish brown, slightly to moderately sandy, moderately clayey......	65.0 -	75.0
Silt, light yellowish brown, slightly sandy, slightly clayey..........................	75.0 -	98.0
Silt, light olive brown with medium to dark gray, very slightly sandy, slightly clayey..	98.0 -	114.0
Silt, dark gray, slightly sandy, slightly clayey..................................	114.0 -	120.0
Silt, light yellowish brown with dark gray, very slightly sandy, slightly clayey........	120.0 -	123.0
Sand and gravel, dark gray, sand medium to very coarse grained, gravel fine to medium, clayey..................................	123.0 -	135.0
Sand and gravel, grayish brown to dark gray, sand medium to very coarse grained, gravel fine, clayey........................	135.0 -	145.0
Clay, grayish brown, moderately sandy.........	145.0 -	152.0
Sand, olive gray, very fine to medium grained, very slightly clayey.....................	152.0 -	155.0
Sand and gravel, olive gray, sand very fine to very coarse grained, gravel fine, much greater sand fraction 162.0-165.0..........	155.0 -	183.0

Test hole 6-GT-80 continued

	Depth, in feet From	To
Sand and gravel, light olive brown, sand medium to very coarse grained, gravel fine to medium; contains iron staining....	183.0	- 190.0
Sand and gravel, olive gray to yellowish brown, sand fine to very coarse grained, gravel very fine to medium...............	190.0	- 195.0
Silt, light gray, soft, slightly clayey.....	195.0	- 215.0
Silt, light and dark gray, soft to hard and moderately clayey.........................	215.0	- 250.0
Silt, varicolored, light gray to dark gray to light pinkish gray, slightly clayey....	250.0	- 255.0
Silt, light pinkish gray, clayey...........	255.0	- 258.0
Silt, light gray with traces of black, slightly clayey; contains sand, very fine grained, from 262.0-265.0................	258.0	- 280.0
Silt, light pinkish gray with traces of black, slightly clayey...................	280.0	- 283.0
Silt, light gray with traces of black, moderately clayey.........................	283.0	- 290.0
Silt, light olive gray with traces of black, slightly clayey...................	290.0	- 300.0
Silt, pale brown with traces of black, slightly calcareous and clayey...........	300.0	- 305.0
Silt, pale reddish brown with traces of black, becoming light reddish brown below 306.0..................................	305.0	- 308.0
Silt, pale olive with traces of black, limy at 312.0-313.0, slightly clayey..........	308.0	- 313.0
Silt, light gray with traces of black, slightly clayey.........................	313.0	- 322.0
Silt, light reddish gray with traces of black, clayey...........................	322.0	- 330.0
Silt, light gray with traces of black, slightly clayey.........................	330.0	- 339.0
Silt, light gray mottled with dark gray and light yellowish gray, clayey.............	339.0	- 343.0
Silt, light gray mottled with dark gray, clayey..................................	343.0	- 344.0
Cretaceous System - Lower Cretaceous Series - Dakota Group, Undifferentiated:		
Sand, light brownish gray, very fine to fine grained, slightly shaley............	344.0	- 360.0
Sand, light brownish gray, very fine to fine grained with traces of medium, very slightly shaley; contains shale, light gray mottled with dark grayish brown, at 373.0-373.5............................	344.0	- 420.0

Test hole 6-GT-80 continued

	Depth, in feet From	To
Sand, light grayish brown, fine grained with traces of very fine and medium, slightly to moderately shaley, shale varicolored light and dark gray and reddish brown.............	420.0	- 462.0
Pennsylvanian System - Des Moines Series - Marmaton Group, Undifferentiated:		
Shale, light gray mottled with red and very dark gray, sandy; contains traces of olive shale lower 8.0............................	462.0	- 478.0
Shale, light reddish gray mottled with light and dark gray, sandy..................	478.0	- 480.0
Shale, light reddish brown interbedded with very dark gray, sandy......................	480.0	- 485.0
Shale, light olive brown interbedded with very dark gray, sandy......................	485.0	- 487.0
Shale, light brownish gray to light gray......	487.0	- 492.0
Shale, reddish brown mottled with light gray, sandy......................................	492.0	- 495.0
Shale, yellowish brown with reddish tint, sandy......................................	495.0	- 497.0
Shale, brown to grayish brown.................	497.0	- 500.0
Shale, yellowish red mottled with light gray..	500.0	- 504.0

Test Hole 7-GT-80

Location: Dodge County, SW NW NW sec. 32, T. 18 N., R. 8 E., approximately 1,210 feet south of north section line and 445 feet east of west section line.

Ground-level elevation: 1,218 feet above mean sea level.

Started: June 18, 1980. Completed: June 20, 1980.

Total depth: 503.0 feet.

Description	Depth, in feet From	-	To
Quaternary System:			
Topsoil, very dark brown, very silty, very slightly clayey; contains organic material...	0.0	-	2.0
Silt, dark brown, slightly to moderately clayey....................................	2.0	-	5.0
Silt, yellowish brown, moderately clayey.......	5.0	-	9.0
Silt, yellowish brown, very clayey, very slightly sandy..............................	9.0	-	18.0
Sand, grayish brown, fine grained with traces of very fine and medium, slightly clayey.....	18.0	-	24.0
Sand, grayish brown, coarse to very coarse grained with traces of fine and medium.......	24.0	-	31.0
Silt, light yellowish brown..................	31.0	-	49.0
Silt, dark gray to dark grayish brown......................................	49.0	-	59.0
Sand, grayish brown, fine grained with traces of very fine; contains coal fragments 69.0-69.1.................................	59.0	-	69.1
Silt, light brownish gray, moderately clayey...	69.1	-	75.0
Silt, grayish brown, slightly to moderately clayey, light gray below 83.0...............	75.0	-	84.0
Sand, grayish brown, very fine to fine grained; contains reworked shale fragments...........	84.0	-	85.0
Silt, grayish brown, slightly to moderately clayey; contains reworked shale fragments....	85.0	-	89.0
Silt, light gray to gray, slightly to moderately clayey; contains reworked shale...	89.0	-	93.0
Cretaceous System - Lower Cretaceous Series - Dakota Group, Undifferentiated:			
Shale, light yellowish brown..................	93.0	-	95.0
Shale, light gray.............................	95.0	-	105.0
Shale, grayish brown..........................	105.0	-	114.0
Shale, light gray to white....................	114.0	-	119.0
Shale, reddish brown..........................	119.0	-	121.0
Shale, grayish brown..........................	121.0	-	122.0
Shale, gray...................................	122.0	-	128.0
Shale, light gray to gray.....................	128.0	-	134.0

Test hole 7-GT-80 continued

	Depth, in feet	
	From	To
Shale, gray, slightly sandy, sand very fine grained; interbedded with sand, slightly shaley, at 134.5-136.5	134.0	- 140.0
Sand, gray, very fine grained, slightly shaley	140.0	- 142.0
Shale, gray, slightly sandy, sand very fine grained	142.0	- 143.0
Sand, gray, very fine grained, slightly shaley.	143.0	- 146.0
Shale, gray, slightly sandy, sand very fine grained; interbedded with sand, very fine grained	146.0	- 171.0
Sand, pale brown, very fine grained, moderately shaley	171.0	- 180.5
Shale, gray, very slightly sandy	180.5	- 182.0
Sand, pale brown, very fine grained, very slightly micaceous	182.0	- 186.0
Shale, gray, very slightly sandy	186.0	- 188.0
Sand, pale brown, very fine grained, very slightly micaceous	188.0	- 189.0
Shale, very light gray	189.0	- 192.5
Shale, light reddish gray	192.5	- 193.5
Shale, reddish brown	193.5	- 194.5
Shale, light gray	194.5	- 197.0
Shale, reddish brown	197.0	- 202.0
Shale, very light gray with traces of reddish brown	202.0	- 203.5
Shale, yellowish red with light gray interbedded	203.5	- 206.0
Shale, light brownish gray	206.0	- 208.0
Shale, grayish brown to light grayish brown; contains thin sandy interbeds 220.0-245.0	208.0	- 248.0
Shale, very light gray to white	248.0	- 248.5
Shale, weak red	248.5	- 251.0
Shale, brown	251.0	- 252.0
Shale, light olive brown	252.0	- 254.0
Shale, gray mottled with weak red	254.0	- 255.0
Shale, light yellowish brown	255.0	- 256.5
Sand, light yellowish brown, very fine grained, moderately shaley	256.5	- 258.0
Sand, gray, very fine grained, moderately shaley	258.0	- 267.0
Sand, light brownish gray, very fine grained, moderately shaley	267.0	- 270.0
Shale, gray, slightly sandy; contains thin sandy interbeds, sand very fine	270.0	- 275.0
Shale, brown, very slightly sandy; contains thin sandy interbeds, sand very fine	275.0	- 279.0
Shale, light gray, very slightly sandy; contains thin sandy interbeds, sand very fine	279.0	- 291.0

Test hole 7-GT-80 continued

	Depth, in feet From	To
Shale, reddish brown, very slightly sandy; contains thin sandy interbeds, sand very fine	291.0	- 299.0
Shale, yellowish brown, very slightly sandy; contains thin sandy interbeds, sand very fine	299.0	- 306.0
Shale, yellowish red, very slightly sandy; contains thin sandy interbeds, sand very fine	306.0	- 309.0
Shale, strong brown to brown, very slightly sandy; contains thin sandy interbeds, sand very fine	309.0	- 315.0
Shale, yellowish brown with olive tint, very slightly sandy; contains thin sandy interbeds	315.0	- 316.0
Shale, light olive brown, very slightly sandy; contains thin sandy interbeds	316.0	- 316.5
Shale, very light gray, very slightly sandy; contains thin sandy interbeds	316.5	- 318.0
Shale, gray to dark gray, very slightly sandy; contains thin sandy interbeds	318.0	- 326.0
Shale, mottled pale brown, very clayey	326.0	- 330.0
Shale, grayish brown	330.0	- 337.0
Shale, light olive brown	337.0	- 343.0
Shale, gray mottled with grayish brown	343.0	- 347.0
Pennsylvanian System - Missouri Series - Kansas City Group:		
Lane Formation:		
Shale, greenish gray, very slightly limy	347.0	- 350.0
Iola Formation:		
Limestone, light brownish gray, very finely to finely crystalline; contains _Osagia_ and algal material in part, slightly shaley	350.0	- 352.0
Limestone, light gray, very finely to finely crystalline; contains crinoids, fusulinids, and bryozoans; very shaley lower 1.0	352.0	- 357.5
Chanute Formation:		
Shale, black, soft	357.5	- 358.5
Shale, greenish gray	358.5	- 363.0
Drum Formation:		
Limestone, pale brown, very finely to finely crystalline; contains algal material and _Osagia_ in part, becoming abundant lower 0.5	363.0	- 364.8
Limestone, pale brown, finely to irregularly crystalline; contains abundant algal material and traces of glauconite; shaley lower 2.0	364.8	- 372.0
Limestone, pale brown, finely crystalline; contains abundant algal material, traces of pyrite, fusulinids; very shaley	372.0	- 373.0

Test hole 7-GT-80 continued

	Depth, in feet From	To
Quivira Formation:		
Shale, greenish gray, moderately to very limy..	373.0	- 376.0
Sarpy Formation:		
Westerville Member:		
Limestone, light tannish gray, irregularly crystalline; contains fusulinids; very shaley....................................	376.0	- 377.8
Shale, greenish gray..........................	377.8	- 379.0
Limestone, light tannish gray; irregularly crystalline, soft; contains abundant algal material, Osagia............................	379.0	- 379.3
Limestone, light tannish gray, irregularly crystalline; contains pyrite; shaley.........	379.3	- 380.0
Limestone, light tannish gray, irregularly crystalline, very shaley, shale varicolored..	380.0	- 384.5
Wea Member:		
Shale, black, fissile; contains carbonaceous material....................................	384.5	- 387.0
Fontana Formation:		
Shale, dark gray to dark greenish gray.........	387.0	- 397.0
Dennis Formation:		
Winterset Member:		
Limestone, light gray to cream, very finely crystalline; contains abundant algal material, Osagia, pseudo-oolites.............	397.0	- 400.0
Limestone, light greenish gray, very finely to finely crystalline; contains traces of algal material, pyrite; very shaley 401.3-401.7..................................	400.0	- 405.5
Shale, gray, moderately to very limy...........	405.5	- 409.0
Shale, gray, slightly limy.....................	409.0	- 413.0
Limestone, light tannish gray, very finely to finely crystalline, very shaley...........	413.0	- 416.0
Limestone, very dark gray, very finely to finely crystalline; contains crinoids, pyrite; shaley at 417.0-418.5...............	416.0	- 419.5
Wea Member:		
Shale, gray, limy..............................	419.5	- 422.0
Shale, black, fissile..........................	422.0	- 423.0
Block Member:		
Shale, medium to dark gray; interbedded with limestone, bluish gray, very finely crystalline.................................	423.0	- 427.6
Galesburg Formation:		
Shale, dark gray...............................	427.6	- 431.2
Swope Formation:		
Bethany Falls Member:		
Limestone, light gray to light greenish gray, very finely to finely crystalline; contains ostracods; shaley upper 0.5.................	431.2	- 434.0

	Depth, in feet	
	From	To
Shale, gray; interbedded with thin limy zones at 434.5, 434.6, 436.0, and 438.0, very limy at 438.5-439.7	434.0	- 439.7
Limestone, light brownish gray, very finely to finely crystalline; contains ostracods	439.7	- 447.0
Hushpuckney Member:		
Shale, black, fissile	447.0	- 447.5
Ladore Formation:		
Shale, gray, slightly limy	447.5	- 451.0
Hertha Formation:		
Limestone, light brownish gray, very finely crystalline, silty	451.0	- 456.8
Des Moines Series - Marmaton Group, Undifferentiated:		
Shale, pale brown, very slightly limy	456.8	- 458.0
Shale, dark brown	458.0	- 460.0
Shale, grayish brown, very slightly limy	460.0	- 462.0
Shale, dark brown, slightly limy	462.0	- 463.0
Shale, grayish brown, slightly limy	463.0	- 465.0
Shale, reddish brown, limy	465.0	- 476.0
Limestone, light gray, slightly shaley	476.0	- 478.5
Shale, light gray, limy	478.5	- 479.6
Shale, dark gray	479.6	- 481.5
Shale, gray to light brownish gray; contains limy zones, more limy lower 1.5	481.5	- 488.0
Limestone, light bluish gray, finely crystalline, hard	488.0	- 490.0
Shale, dark reddish brown; contains scattered limy zones	490.0	- 494.5
Limestone, light gray, slightly shaley	494.5	- 495.5
Limestone, light gray, slightly to moderately shaley	495.5	- 497.5
Shale, dark reddish brown, limy	497.5	- 501.0
Limestone, light gray, very finely crystalline; contains abundant algal material, pseudo-oolites, and *Osagia*	501.0	- 502.5
Shale, dark gray to dark greenish gray, limy	502.5	- 503.0

Test Hole 8-GT-80

Location: Lancaster County, SE corner SW SE SW sec. 22, T. 8N., R. 8E., approximately 135 feet north of south section line and 725 feet west of half section line.

Ground-level elevation: 1,342 feet above mean sea level.

Started: June 30, 1980. Completed: July 3, 1980.

Total depth: 503.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Topsoil, very dark brown, very silty, moderately clayey; contains organic material	0.0	3.0
Silt, light brownish gray, moderately clayey	3.0	7.0
Silt, dark reddish gray, moderately clayey	7.0	12.0
Silt, light yellowish brown, moderately clayey, very slightly to slightly sandy; contains yellow iron staining upper 3.0	12.0	28.0
Silt, light olive brown; contains silt, dark gray, clayey; slightly sandy lower 5.0	28.0	40.0
Silt, dark gray, clayey, slightly sandy	40.0	50.0
Silt, dark gray, clayey; contains traces of medium to coarse sand and fine gravel, coarsening lower 19.0	50.0	79.0
Sand and gravel, dark gray, sand fine to very coarse grained, gravel fine; contains shale, reworked,and limestone, reworked	79.0	130.5
Permian System - Big Blue Series - Council Grove Group:		
Red Eagle Formation:		
Howe Member:		
Limestone, grayish brown with olive tint, very finely crystalline; contains pyrite	130.5	132.5
Limestone, pale yellow, very finely crystalline; interbedded with shale, pale olive	132.5	137.0
Limestone, pale olive, finely crystalline, silty	137.0	139.5
Bennett Member:		
Shale, dark gray, limy	139.5	140.0
Shale, black, fissile	140.0	142.5
Glenrock Member:		
Limestone, dark gray, very finely crystalline; contains pelecypods and fusulinids	142.5	144.0

Test hole 8-GT-80 continued

	Depth, in feet From	To
Johnson Formation:		
Shale, gray to greenish gray, moderately to very limy	144.0	- 154.0
Foraker Formation:		
Long Creek Member:		
Shale, gray to greenish gray with traces of reddish brown; interbedded with limestone, very light olive brown, finely crystalline, shaley	154.0	- 160.0
Limestone, light greenish gray, finely crystalline, very silty	160.0	- 162.0
Hughes Creek Member:		
Shale, dark gray, very limy at 162.0-164.5	162.0	- 170.0
Shale, dark gray; interbedded with limestone, dark gray, finely crystalline; contains crinoids, brachiopods, at 177.6-178.0	170.0	- 180.0
Shale, gray, contains brachiopod spines	180.0	- 185.0
Shale, black, fissile	185.0	- 186.5
Limestone, gray, finely crystalline; contains brachiopods, pyrite, glauconite; interbedded with shale, gray	186.5	- 190.0
Shale, gray, limy	190.0	- 198.5
Americus Member:		
Shale, dark gray, interbedded with limestone at 198.5-199.5 and 201.0-202.3 (taken from E-log)	198.5	- 202.3
Admire Group, Undifferentiated:		
Shale, dark gray, intermittantly limy	202.3	- 209.5
Shale, very dark gray; contains brachiopods	209.5	- 214.5
Limestone, light to medium gray, very finely crystalline; contains crinoids, algal material; shaley	214.5	- 216.0
Shale, greenish gray; interbedded with limestone, light greenish gray, finely crystalline; contains brachiopods, pyrite	216.0	- 218.0
Shale, pale red mottled with greenish gray	218.0	- 220.0
Shale, greenish gray	220.0	- 226.0
Shale, reddish brown	226.0	- 228.0
Shale, gray with greenish tint; interbedded with thin limestones, light tannish gray, very finely crystalline	228.0	- 235.0
Shale, gray, slightly to moderately limy	235.0	- 240.0
Shale, dark gray, slightly to moderately limy.	240.0	- 249.0
Shale, light gray with greenish tint	249.0	- 254.0
Shale, dark gray with reddish tint	254.0	- 255.0
Shale, very light gray, limy	255.0	- 257.0
Shale, gray to dark gray	257.0	- 260.0

Test hole 8-GT-80 continued

	Depth, in feet From	To
Shale, gray to dark gray, limy	260.0	- 266.0
Shale, reddish brown, very limy at 271.0-276.0	266.0	- 276.0
Shale, reddish brown	276.0	- 280.0
Shale, dark gray	280.0	- 285.0
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Wood Siding - Willard Formations:		
Shale, dark gray; interbedded with limestone, dark gray, finely crystalline	285.0	- 291.0
Shale, reddish brown	291.0	- 293.0
Shale, light gray with greenish tint, limy	293.0	- 300.0
Shale, dark gray mottled with yellowish brown; interbedded with limestones, dark gray, finely crystalline; shaley lower 6.0	300.0	- 310.0
Shale, dark gray	310.0	- 315.0
Shale, dark gray with reddish mottling	315.0	- 319.0
Shale, reddish brown	319.0	- 325.0
Shale, olive; contains coal, 325.0-325.5	325.0	- 330.0
Shale, dark gray	330.0	- 350.0
Shale, dark gray; contains sandstone, medium gray, very fine grained	350.0	- 355.0
Shale, dark gray; contains shale, black, lower 1.0	355.0	- 362.0
Shale, medium to dark gray, moderately limy at 385.5-387.0	362.0	- 390.5
Shale, dark grayish brown with olive tint, limy at 390.5-390.8	390.5	- 393.0
Limestone, very light gray to white, finely crystalline, slightly to moderately shaley; contains algal material, glauconite	393.0	- 394.5
Shale, gray with greenish tint	394.5	- 420.0
Shale, medium to dark gray, very limy 426.0-431.0, very hard 429.0-429.5	420.0	- 431.0
Shale, medium to dark gray, very limy	431.0	- 436.2
Emporia Formation:		
Elmont Member:		
Limestone, very light tannish gray, finely crystalline; contains brachiopods	436.2	- 438.5
Harveyville Member:		
Shale, medium to dark gray	438.5	- 440.0
Reading Member:		
Limestone, very light tannish gray, very finely crystalline, slightly shaley; contains brachiopods, gastropods, crinoids	440.0	- 443.0
Limestone, grayish brown, very finely crystalline, slightly shaley in part; contains brachiopod, glauconite	443.0	- 448.5

Test hole 8-GT-80 continued

	Depth, in feet From	To
Auburn Formation:		
Shale, reddish brown, mottled with olive, hard at 451.0 and 453.5 to 454.2; more olive at base	448.5	- 454.2
Shale, dark gray	454.2	- 467.0
Shale, dark gray; contains thin limy interbeds	467.0	- 476.0
Wakarusa Formation:		
Limestone, gray,finely crystalline; contains brachiopods; slightly shaley at 478.2-478.8	476.0	- 479.4
Soldier Creek Formation:		
Shale, medium to dark gray	479.4	- 490.2
Burlingame Formation:		
South Fork Member:		
Limestone, light gray, very finely to finely crystalline; contains pyrite; interbedded with shale, 493.0-494.2	490.2	- 495.5
Winnebago Member:		
Shale, gray	495.5	- 497.0
Shale, dark gray	497.0	- 502.6
Shale, black, fissile	502.6	- 503.0

Test Hole 9-GT-80

Location: Dawes County, SE SE SE sec. 2, T. 32 N., R. 51 W., approximately 75 feet north of south section line and 242 feet west of east section line.

Ground-level elevation: 3,434.0 feet above mean sea level.

Started: July 15, 1980. Completed: July 16, 1980.

Total depth: 504.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand, brown, very fine to fine grained with traces of medium	0.0	15.0
Sand, light yellowish brown, very fine grained	15.0	22.0
Sand, light yellowish brown, very fine grained, moderately clayey	22.0	24.0
Sand, olive brown, very fine grained, moderately clayey	24.0	26.0
Sand and gravel, olive brown, sand fine grained with traces of medium to very coarse to gravel, fine	26.0	28.0
Sand and gravel, olive brown, sand medium to coarse grained with traces of very coarse to gravel, fine to coarse, rounded	28.0	31.0
Cretaceous System - Upper Cretaceous Series - Montana Group:		
Pierre Formation:		
Shale, very dark gray to black, "blocky"	31.0	45.0
Shale, very dark gray to black, moderately hard; contains thin bentonite seams, 62.0-63.0	45.0	75.0
Shale, very dark gray to black, soft to slightly hard; contains limestone concretions 229.0-229.8, 266.0-267.0, 412.3-413.0, 415.0-415.3, limestone dark olive gray to dark grayish brown, very finely crystalline; contains cephelopods 153.5, 181.8, 245.0-250.0	75.0	504.0

Test Hole 10-GT-80

Location: Morrill County, SW corner NW NW NW sec. 6, T. 21N., R. 51W., approximately 590 feet south of north section line and 123 feet east of west section line.

Ground-level elevation: 3,930.0 feet above mean sea level.

Started: July 23, 1980. Completed: July 23, 1980.

Total depth: 500.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Silt, brown, contains organic material........	0.0	- 3.0
Silt, pale brown, very slightly clayey........	3.0	- 12.0
Silt, dark grayish brown, very slightly clayey....................................	12.0	- 15.0
Silt, light yellowish brown, slightly clayey..	15.0	- 20.0
Tertiary System - Oligocene Series - White River Group:		
Brule Formation:		
Whitney Member:		
Siltstone to silt, brown, slightly to moderately clayey; contains traces of barite, clear to light bluish gray, at 60.0-65.0 and 75.0-80.0; slightly more micaceous 73.0-76.0.........................	20.0	- 93.0
Siltstone to silt, light yellowish brown, moderately clayey..........................	93.0	- 106.0
Siltstone, brown, slightly to moderately silty, slightly to moderately clayey........	106.0	- 135.0
Siltstone to silt, light brown to brown, moderately clayey; contains barite traces, 160.0-165.0; contains interbedded claystones, brown with reddish tint, 175.0-180.0.....................................	135.0	- 180.0
Siltstone to silt, light brown to brown, moderately clayey; contains traces of barite....................................	180.0	- 206.0
Orella Member:		
Siltstone, light yellowish brown to yellowish brown, slightly silty, slightly clayey......	206.0	- 230.0
Siltstone to silt, light yellowish brown to brown, moderately to very clayey; contains barite traces, 230.0-235.0.................	230.0	- 265.0
Siltstone to sandstone, light yellowish brown to brown, sandstone very fine grained; contains abundant dark minerals.........	265.0	- 275.0

	Depth, in feet From	To
Silt to siltstone, light yellowish brown to brown, moderately clayey....................	275.0	- 290.0
Siltstone to silt, light brown to brown with very slight pinkish tint, moderately clayey; contains claystones................	290.0	- 305.0
Silt to siltstone, light yellowish brown to brown, moderately clayey;contains traces of claystones upper 5.0.......................	305.0	- 340.0
Silt to siltstone, light yellowish brown to brown, moderately clayey; contains siltstones, yellowish brown; very slightly sandy, sand very fine grained...............	340.0	- 355.0
Silt to siltstone to sand to sandstone, light yellowish brown to brown, sand very fine grained, moderately clayey; contains abundant dark minerals......................	355.0	- 365.0
Silt to siltstone, yellowish brown with slight pinkish tint, slightly to moderately clayey, slightly sandy; contains dark minerals..................................	365.0	- 371.0
Sand, grayish brown, very fine to fine grained, slightly to moderately clayey; contains abundant dark minerals.............	371.0	- 387.0
Silt to siltstone to claystone, yellowish brown, slightly to moderately clayey........	387.0	- 389.0
Silt to siltstone to sand to sandstone, olive gray, sand very fine to fine grained; contains siltstone, greenish gray...........	389.0	- 403.0
Siltstone to silt, light yellowish brown with greenish gray mottling, slightly to moderately clayey..........................	403.0	- 413.0
Siltstone to silt, greenish gray, moderately clayey....................................	413.0	- 418.0
Silt to siltstone, greenish gray with olive interbedded, moderately clayey........	418.0	- 425.0
Silt to siltstone, pale brown with very slight olive tint; interbedded with silt to siltstone, greenish gray....................	425.0	- 440.0
Siltstone to silt, grayish brown with olive tint, slightly to moderately clayey.........	440.0	- 449.0
Silt to siltstone, pale brown, moderately clayey....................................	449.0	- 457.0
Silt to siltstone, light brownish gray with very slight olive tint, moderately clayey; contains greenish gray mottling.............	457.0	- 489.0
Silt to siltstone, pale brown, slightly to moderately clayey..........................	489.0	- 494.0
Silt to siltstone, light brownish gray with very slight olive tint, slightly to moderately clayey; contains greenish gray mottling.................................	494.0	- 500.0

Test Hole 11-GT-80

Location: Cheyenne County, SE SE SE sec. 33, T. 14 N., R. 49 W., approximately 56 feet north of south section line, and 71 feet west of east section line.

Ground-level elevation: 4,064.0 feet above mean sea level.

Started: July 17, 1980. Completed: July 17, 1980.

Total depth: 600.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand and gravel, dark grayish brown, sand medium to coarse with small fraction very coarse, gravel fine; contains abundant feldspars; contains organic material; becoming dark brown with less organic material lower 6.0	0.0	8.0
Sand, yellowish brown, fine to medium grained with small fraction coarse to very coarse; contains traces of gravel, fine; contains abundant feldspars, yellowish red to pink sand, yellowish brown, medium grained with small fraction fine and coarse to very coarse; contains gravel, fine; contains abundant feldspars, yellowish red to pink	8.0	12.0
Sand, yellowish brown, medium grained with small fraction fine and coarse to very coarse; contains gravel, fine; contains abundant feldspars, yellowish red to pink	12.0	22.0
Tertiary System - Oligocene Series - White River Group:		
Brule Formation:		
Siltstone to silt, pinkish brown, slightly clayey	22.0	40.0
Siltstone, pinkish brown, very slightly clayey	40.0	60.0
Siltstone to silt, pinkish brown, slightly to moderately clayey	60.0	145.0
Siltstone, pinkish brown, slightly silty, slightly clayey	145.0	150.0
Siltstone to silt, pinkish brown, slightly to moderately clayey	150.0	233.0
Silt to siltstone, yellowish red, slightly to moderately clayey	233.0	240.0

Test hole 11-GT-80 continued

	Depth, in feet	
	From	To
Silt to siltstone, pinkish brown, slightly to moderately clayey........................	240.0	- 260.0
Silt, light pinkish brown, moderately to very clayey; contains occasional interbedded siltstones.................................	260.0	- 367.0
Silt, light yellowish brown with reddish brown interbedded, moderately to very clayey; contains silt, olive gray, at 380.0-392.0................................	367.0	- 392.0
Silt, light reddish brown with yellow tint, very clayey; contains silt, greenish gray, at 416.0-420.0............................	392.0	- 420.0
Silt, greenish gray, very clayey, contains interbedded siltstones.....................	420.0	- 470.0
Silt, light greenish gray, very clayey; contains interbedded siltstones, greenish gray..	470.0	- 484.0
Silt, greenish gray, very clayey; contains interbedded siltstones.....................	484.0	- 525.0
Silt to siltstone, greenish gray, moderately to very clayey............................	525.0	- 572.0
Silt, light greenish gray to greenish gray, moderately to very clayey; contains interbedded siltstones.....................	572.0	- 600.0

Test Hole 12-GT-80

Location: Garden County, SW corner NW SW NW sec. 26, T. 17N., R. 45W., approximately 1,900 feet south of north section line and 98 feet east of west section line.

Ground-level elevation: 3,454.0 feet above mean sea level.

Started: July 20, 1980. Completed: July 20, 1980.

Total depth: 620.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand, dark grayish brown, fine to medium grained with traces of sandstone, buff, very fine grained, reworked, becoming more prominent 3.0-15.0; contains traces of organic material, upper 3.0	0.0 -	15.0
Sand, brown, medium grained with traces of coarse	15.0 -	20.0
Sand, light yellowish brown to yellowish brown, medium to coarse grained	20.0 -	28.0
Sand, pale brown, coarse grained with small fraction medium	28.0 -	30.0
Sand, pale brown, coarse to very coarse grained, coarsening towards bottom	30.0 -	33.0
Sand and gravel, pale brown, sand very coarse grained, gravel fine; contains feldspars	33.0 -	38.0
Gravel and sand, pale brown, gravel fine to medium, sub-angular to rounded, sand very coarse; contains feldspars	38.0 -	42.0
Gravel, pale brown, fine to medium sub-angular to rounded; contains feldspars and trace of anorthosites; contains small fraction sand, coarse to very coarse grained	42.0 -	45.0
Sand, pale brown, medium to coarse grained with traces of very coarse	45.0 -	50.0
Sand and gravel, pale brown, sand coarse to very coarse grained, gravel fine	50.0 -	55.0
Tertiary System - Oligocene Series - White River Group:		
Brule Formation:		
Silt to siltstone, dark yellowish brown, slightly to moderately clayey	55.0 -	70.0
Siltstone, dark yellowish brown, very slightly clayey	70.0 -	72.0

Test hole 12-GT-80 continued

	Depth, in feet	
	From	To
Siltstone to silt, light yellowish brown, moderately to very clayey	72.0	90.0
Silt to siltstone, light brown to brown, moderately to very clayey	90.0	100.0
Siltstone to silt, brown, slightly to moderately clayey	100.0	135.0
Silt to siltstone, light brown to brown, very slightly to very clayey	135.0	215.0
Siltstone to silt, light brown to brown, slightly to moderately clayey; contains traces of claystone, reddish brown	215.0	220.0
Siltstone to silt, light brown to brown, moderately to very clayey	220.0	230.0
Siltstone, brown, slightly clayey; contains silts and clay to claystone, reddish brown	230.0	235.0
Silt to siltstone, light brown to brown, slightly to very clayey; contains claystone, reddish brown, 275.0-285.0	235.0	310.0
Siltstone to silt, reddish yellow, moderately clayey	310.0	318.0
Siltstone to silt, light brown to brown, moderately to very clayey; contains scattered claystones, reddish brown, 345.0-390.0	318.0	390.0
Siltstone to silt, dull reddish yellow, slightly to moderately clayey; contains claystones	390.0	397.0
Silt to siltstone, light yellowish brown with greenish tint, moderately to very clayey	397.0	410.0
Silt to siltstone, pale olive, moderately clayey	410.0	420.0
Silt to siltstone, light yellowish brown, moderately to very clayey; greater siltstone fraction top 5.0; contains traces of mica	420.0	488.0
Silt, very pale brown, slightly to moderately clayey; contains claystones	488.0	532.0
Silt, pale olive, very clayey; contains siltstones	532.0	548.0
Chadron Formation:		
Silt, pale olive, bentonitic; contains siltstones	548.0	570.0
Silt, pale olive, moderately clayey; contains calcedony, light bluish gray to white, some reworked	570.0	585.0
Claystone, light greenish gray	585.0	595.0
Clay, reddish brown (poor sample)	595.0	605.0
Clay, brownish yellow (poor sample)	605.0	620.0

Test Hole 13-GT-80

Location: Deuel County, NE corner NE NW SE sec. 26, T. 13 N., R. 42 W., approximately 2,660 feet south of north section line and 1,360 feet west of east section line.

Ground-level elevation: 3,455.0 feet above mean sea level.

Started: July 19, 1980. Completed: July 19, 1980.

Total depth: 520.0 feet.

Description	Depth, in feet From	To
Quaternary System:		
Sand, dull reddish brown, medium grained with traces of fine and coarse to very coarse....	0.0	- 8.0
Sand and gravel, brown, sand very coarse with traces of medium to coarse, gravel fine, with medium to coarse at 8.0-10.0...........	8.0	- 15.0
Gravel, orangish brown, fine with traces of medium; contains sand, coarse to very coarse; contains silt, light brown, clayey..	15.0	- 25.0
Tertiary System - Miocene Series - Ogallala Group, Undifferentiated:		
Sand and gravel, orangish brown, sand coarse to very coarse, gravel fine to medium; contains sandstone interbeds, light pinkish brown, very fine to fine grained........	25.0	- 30.0
Sand, brown, fine grained with traces of very fine to coarse, moderately clayey in part......................................	30.0	- 35.0
Sand to sandstone, very pale brown, very fine to fine grained, very slightly clayey in part..	35.0	- 38.0
Sand, brown, very fine to fine grained with small fraction medium to coarse, moderately clayey in part............................	38.0	- 55.0
Sand to sandstone, very pale brown to pinkish brown, very fine to fine grained, slightly to moderately clayey.......................	55.0	- 75.0
Sandstone, very pale brown, very fine to fine grained, very slightly to slightly clayey...	75.0	- 91.0
Oligocene Series - White River Group:		
Brule Formation:		
Sand to sandstone, very pale brown to brown, very fine to fine grained, slightly clayey....................................	91.0	-100.0

Test hole 13-GT-80 continued

	Depth, in feet From	To
Silt to siltstone, brown, moderately clayey...	100.0	- 120.0
Silt to siltstone, brown to light brown, moderately clayey..........................	120.0	- 135.0
Silt to siltstone, light brown with yellowish tint, moderately clayey....................	135.0	- 158.0
Silt to siltstone, brown, moderately clayey...	158.0	- 165.0
Silt to siltstone, yellowish red, moderately clayey..................................	165.0	- 180.0
Silt to siltstone, light yellowish brown with reddish tint, moderately clayey............	180.0	- 188.0
Silt to siltstone, light reddish brown, moderately clayey..........................	188.0	- 196.0
Siltstone to silt, brown, moderately clayey; contains siltstones, light olive brown, at 199.0-202.0............................	196.0	- 202.0
Silt to siltstone, light yellowish brown with reddish tint, moderately clayey; contains thinly interbedded brown silt-stones......................................	202.0	- 225.0
Silt to siltstone, yellowish brown, moderately clayey..........................	225.0	- 242.0
Silt to siltstone, light yellowish brown with reddish tint, moderately clayey........	242.0	- 255.0
Silt to siltstone, light yellowish brown, moderately clayey..........................	255.0	- 290.0
Silt to siltstone, light yellowish brown with reddish tint, moderately to very clayey..................................	290.0	- 300.0
Silt to siltstone, light yellowish brown, moderately clayey..........................	300.0	- 308.0
Silt to siltstone, pale brown to light yellowish brown, moderately to very clayey..	308.0	- 340.0
Silt, light yellowish brown, moderately to very clayey; contains scattered siltstones..	340.0	- 390.0
Chadron Formation:		
Silt, light yellowish brown, moderately to very clayey; contains "floating" quartz grains, quartz milky white, rounded overgrowths, becoming very abundant lower third..................................	390.0	- 452.5
Sand, very light greenish gray, very fine grained, moderately to very clayey..........	452.5	- 455.0
Sand, very light gray to white, medium grained; interbedded with sand, very fine grained, very clayey.......................	455.0	- 456.0
Sand, very light gray to greenish gray, very fine grained, moderately to very clayey; contains yellowish orange iron staining in part......................................	456.0	- 474.0

Test hole 13-GT-80 continued

	Depth, in feet	
	From	To
Sand, very pale brown, medium to coarse grained..................................	474.0	- 476.0
Sand, light yellowish brown, medium to coarse grained............................	476.0	- 479.0
Sand, light to pale brown, medium to very coarse..................................	479.0	- 480.0
Sand, very pale gray to brown, medium to coarse grained; contains fine grained sandy clays............................	480.0	- 485.0
Sand, very pale brown, very fine to fine grained, slightly to moderately clayey....	485.0	- 486.0
Sand, yellowish red, medium to coarse grained with traces of fine...............	486.0	- 487.5
Sand, very pale brown, medium to coarse grained with traces of fine...............	487.5	- 488.5
Sand, very pale brown mottled with yellowish red and brownish yellow, very fine to fine grained, slightly to moderately clayey; contains traces of chert, black, rounded; varicolored at bottom....................	488.5	- 495.0
Silt, olive gray to gray, moderately clayey; contains reworked shale...........	495.0	- 508.0
Cretaceous System - Upper Cretaceous Series - Montana Group:		
Pierre Formation:		
Shale, gray to olive, weathered............	508.0	- 510.0
Shale, dark gray............................	510.0	- 520.0

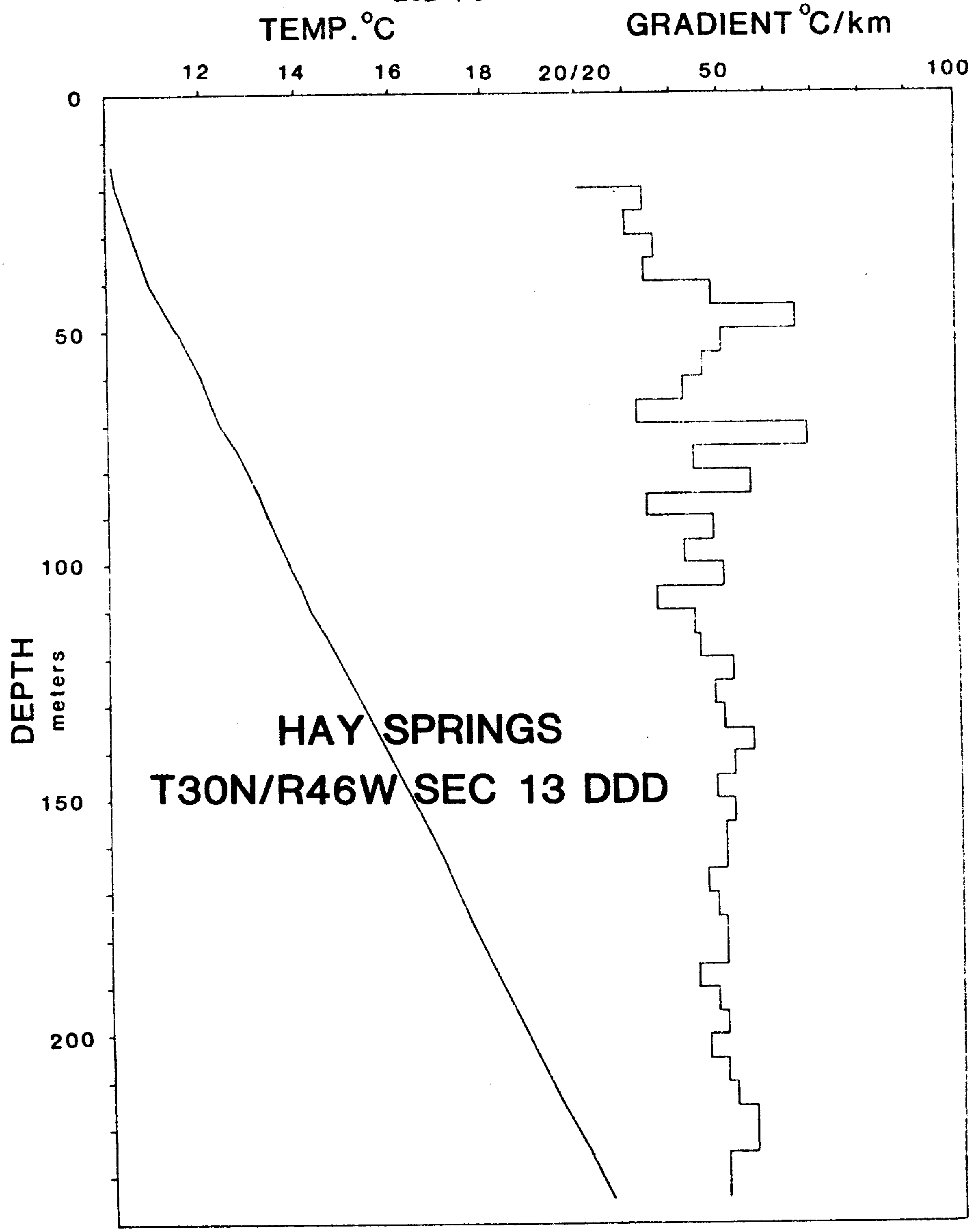
Appendix 2-4

Thermal Gradient - Shallow Holes

THERMAL GRADIENT - SHALLOW HOLES

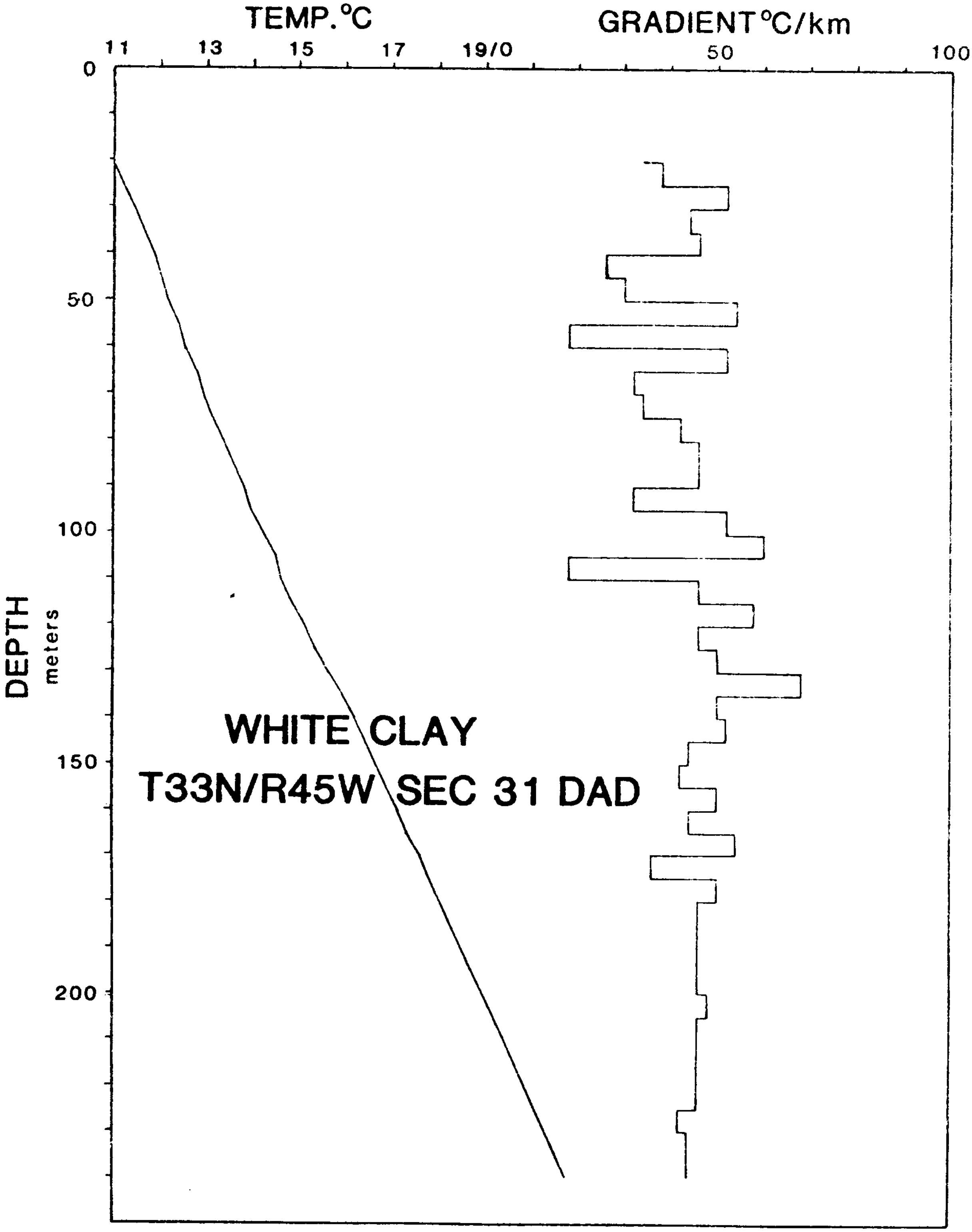
Test Hole Number	County	Legal Location
16B-78	Sheridan (Hay Springs)	SE,SE, sec. 13, T 30 N, R 46 W
17B-78	Sheridan (White Clay)	NE,SE, sec. 31, T 33 N, R 45 W
19H-78	Lincoln (Box Elder Can)	SW,SW, sec. 36, T 12 N, R 29 W
24H-78	Lincoln (Gothenburg)	SE,SE, sec. 36, T 10 N, R 27 W
38-79	Otoe (Union S.)	SE,SW, sec. 6, T 9 N, R 13 E
39-79	Cass (Union N.)	SW,SW, sec. 2, T 2,N, R 13 E
40-79	Richardson (Stella)	NE,NW, sec. 34, T 3 N, R 14 E
41-79	Pawnee (Liberty)	SW,SW, sec. 31, T 1 N, R 9 E
42-79	Pawnee (Table Rock)	SW,SW, sec. 16, T 3 N, R 12 E
18-B-79	Sheridan (Gordon)	NW,NE, sec. 24, T 34 N, R 42 W
24-B-79	Sheridan (Rushville)	SW,NW, sec. 1, T 30 N, R 42 W
1aGT-80	Boyd (Naper)	SE,SW,SE, sec. 24, T 35 N, R 15 W
2GT-80	Keya Paha (Springview)	SW,SW,NW, sec. 32, T 35 N, R 20 W
3GT-80	Cherry (Valentine)	NE,SE,SW, sec. 28, T 34 N, R 27 W
4GT-80	Holt (O'Neill)	NW,NW,NW, sec. 6, T 28 N, R 11 W
5GT-80	Wayne (Wayne)	SE,SW,NE, sec. 14, T 26 N, R 3 E
6GT-80	Burt (Oakland)	NE,SW,NE, sec. 6, T 21 N, R 9 E
7GT-80	Dodge (Fremont)	SW,NW,NW, sec. 32, T 18 N, R 8 E
8GT-80	Lancaster (Bennet)	SW,SE,SW, sec. 22, T 8 N, R 8 E
9GT-80	Dawes (Whitney)	SE,SE,SE, sec. 2, T 32 N, R 51 W
10GT-80	Morrill (Bayard)	NW,NW,NW, sec. 6, T 21 N, R 51 W
11GT-80	Cheyenne (Sidney)	SE,SE,SE, sec. 33, T 14 N, R 49 W
12GT-80	Garden (Lisco)	NW,SW,NW, sec. 26, T 17 N, R 45 W
13GT-80	Deuel (Big Springs)	NE,NW,SE, sec. 26, T 13 N, R 42 W
Baker #1	Keya Paha (Burton-Baker)	C,SE,NE, sec. 8, T 34 N, R 19 W
EC #1	Johnson (Elk Creek)	NW,SW,SW, sec. 33, T 4 N, R 11 W

16B-78



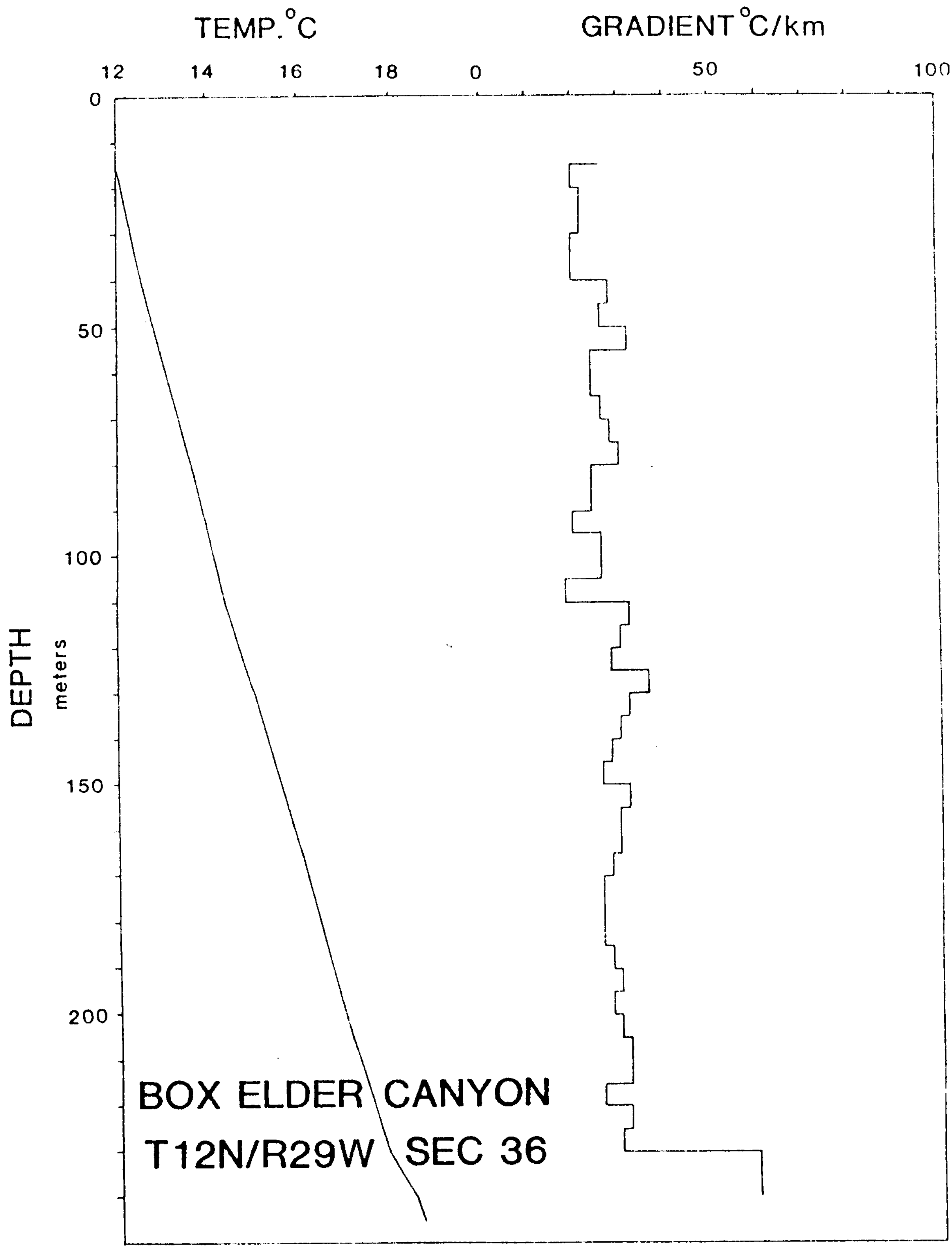
TEMP. °C
GRADIENT °C/km
12
14
16
18
20/20
50
100
0
50
100
150
200
DEPTH
meters
HAY SPRINGS
T30N/R46W SEC 13 DDD

17B-78

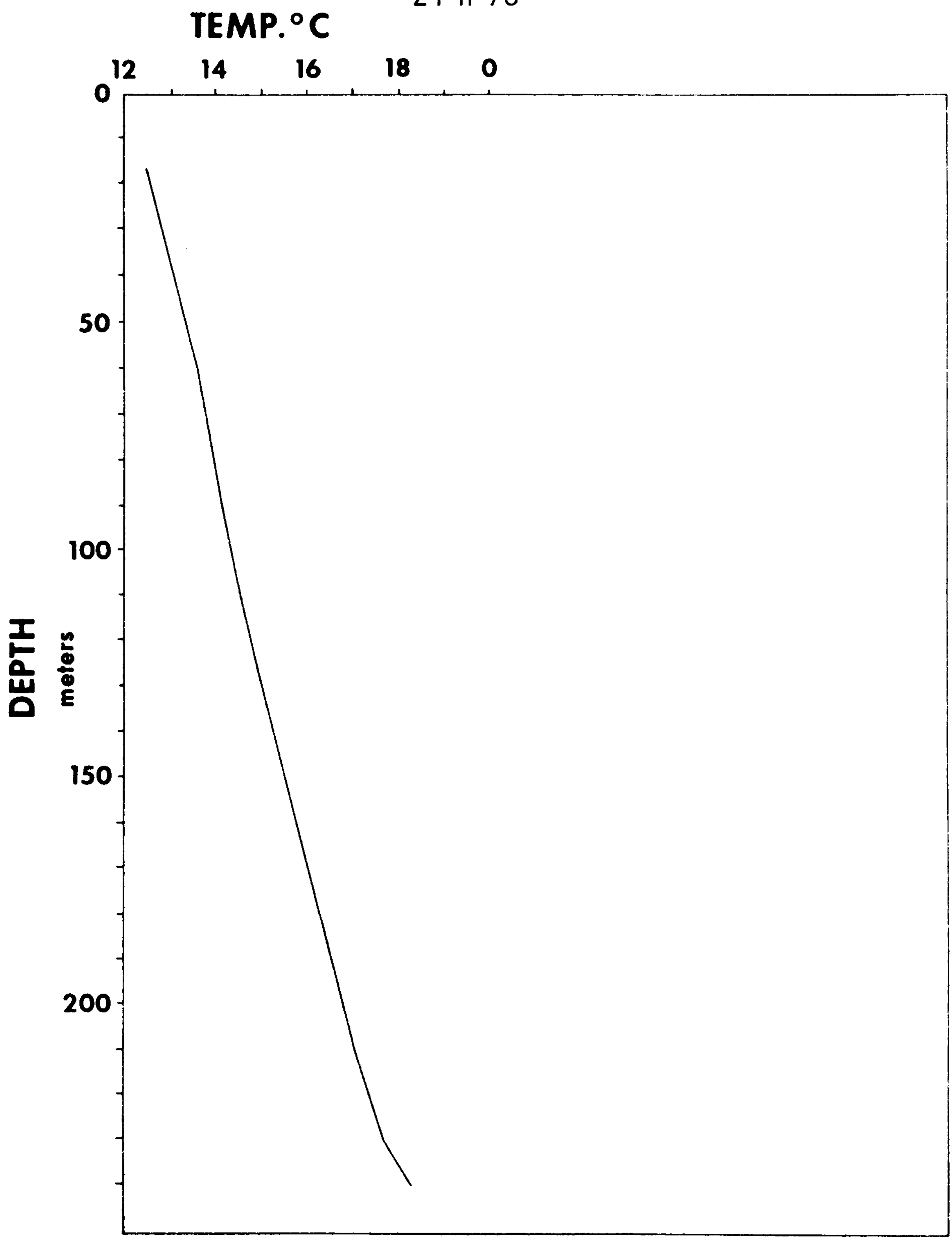


TEMP. °C
GRADIENT °C/km
11
13
15
17
19/0
50
100
0
50
100
150
200
DEPTH
meters
WHITE CLAY
T33N/R45W SEC 31 DAD

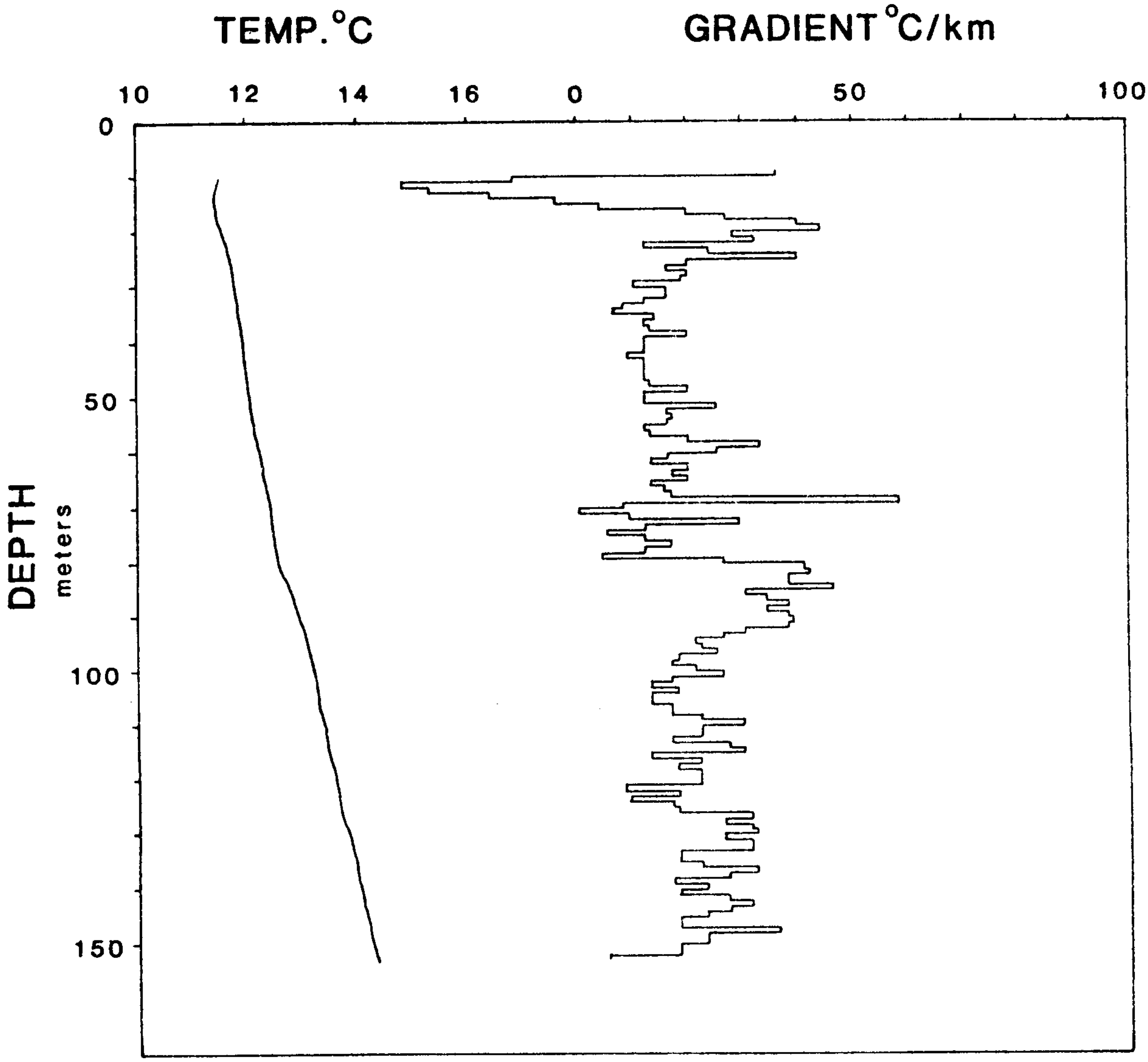
19-H-78


TEMP. °C
GRADIENT °C/km
12
14
16
18
0
50
100
0
50
100
150
200
DEPTH
meters
BOX ELDER CANYON
T12N/R29W SEC 36

24-H-78



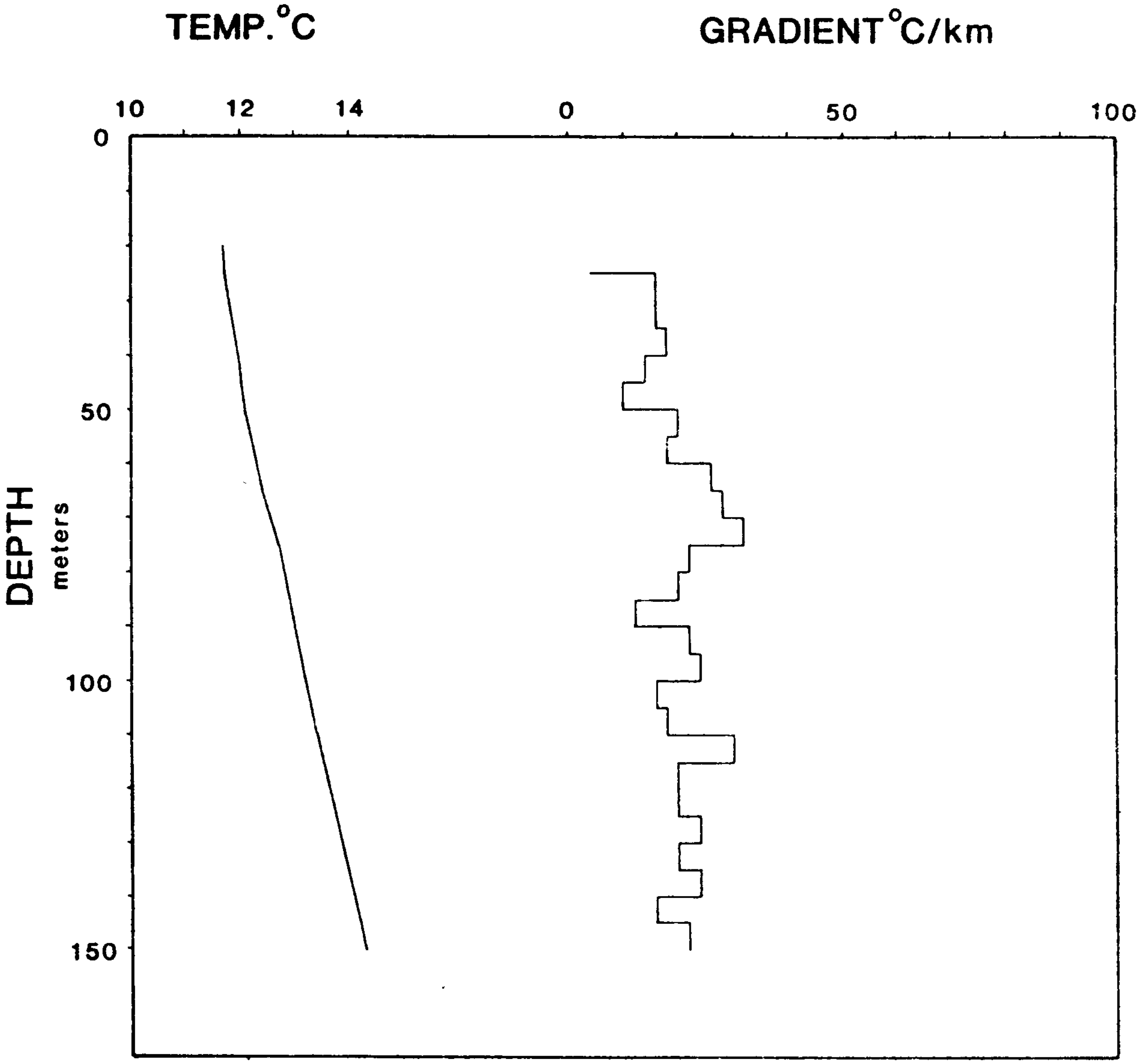
GOTHENBURG
T10N/R27W SEC 36



UNION SOUTH

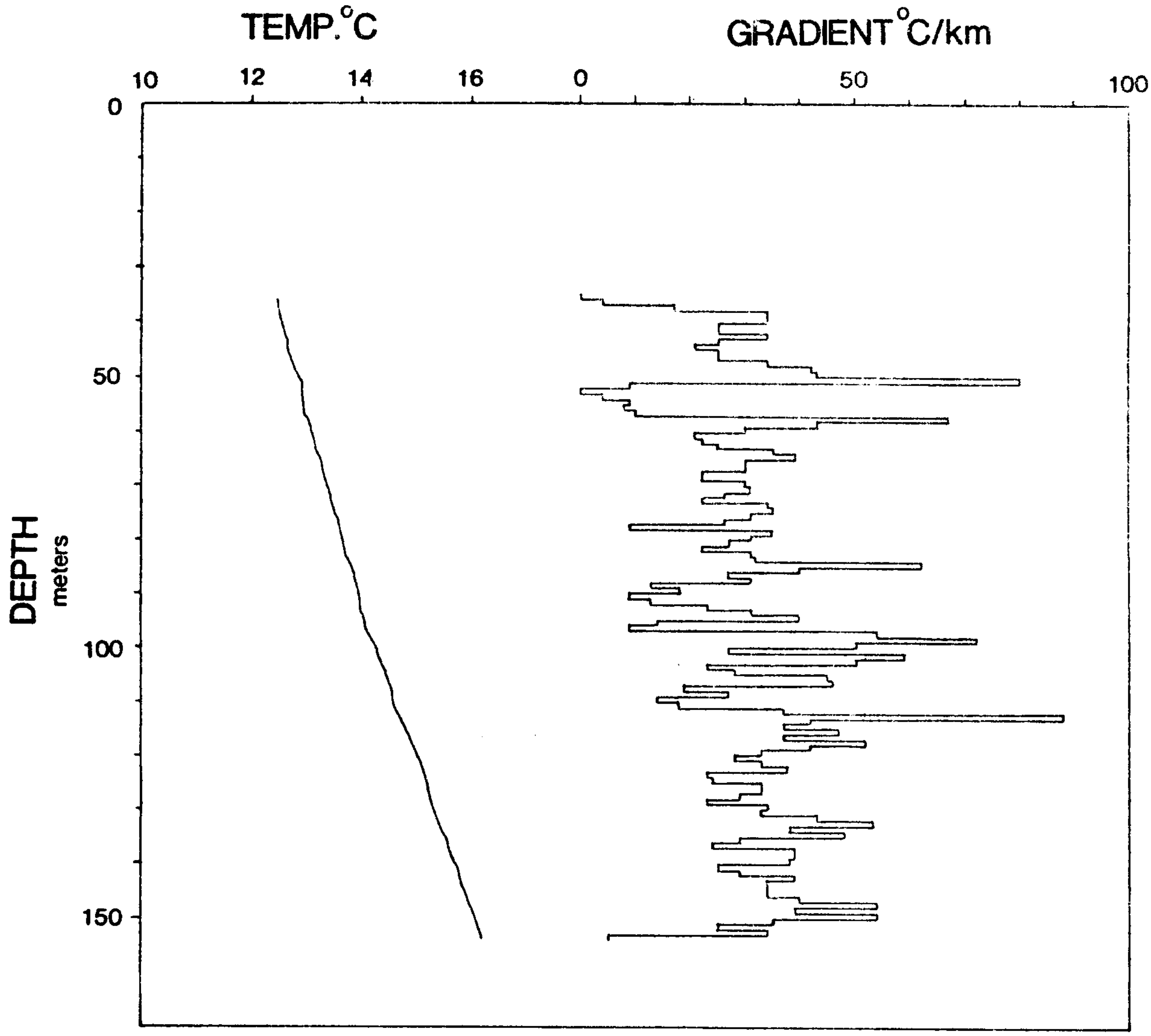
T9N/R13E/SEC 6

39-79



UNION NORTH
T10N/R13E/SEC 2 CCCC

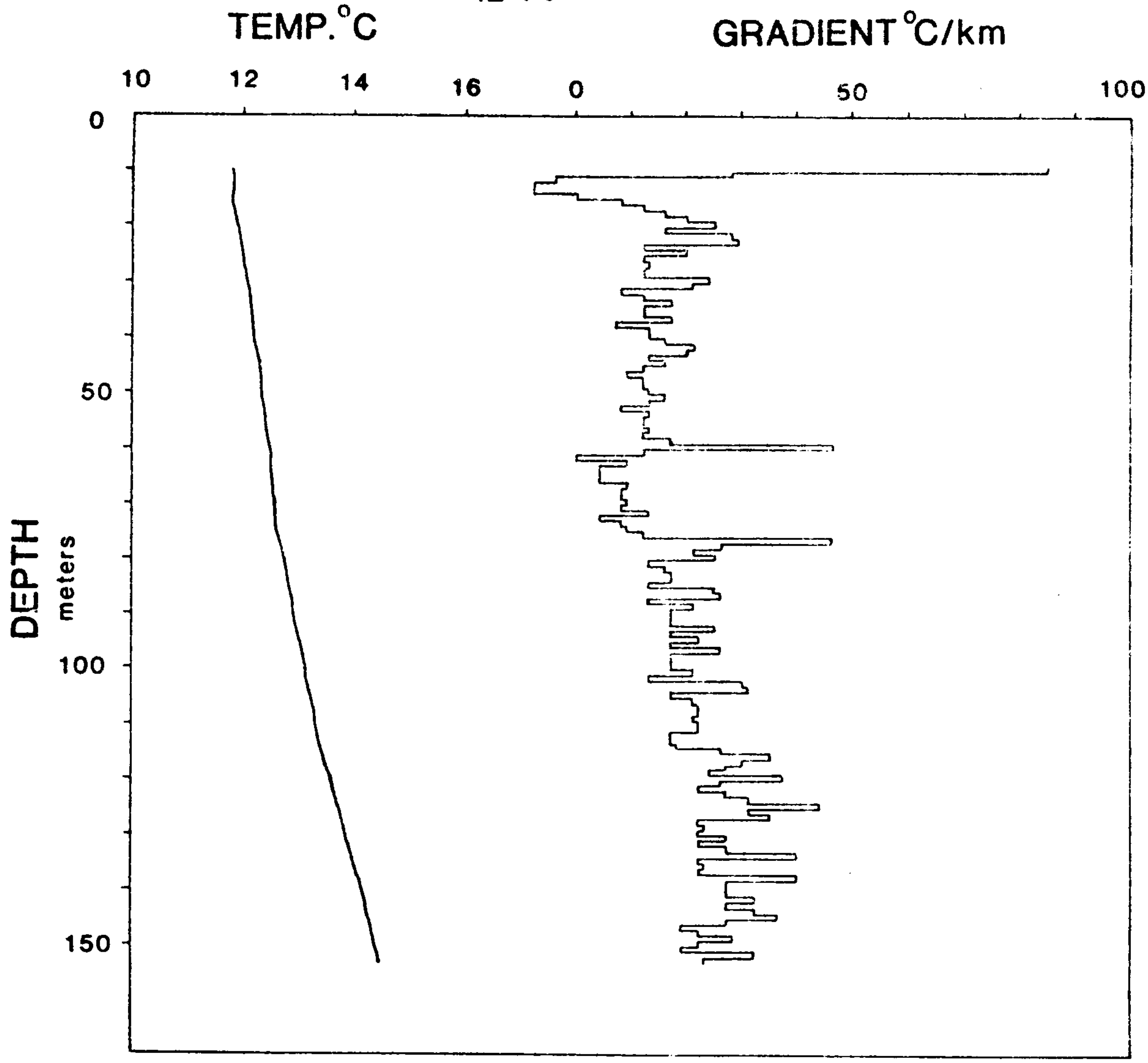
40-79



STELLA

T3N/R14E/SEC 34

41-79



LIBERTY
T1N/R9E/SEC 31

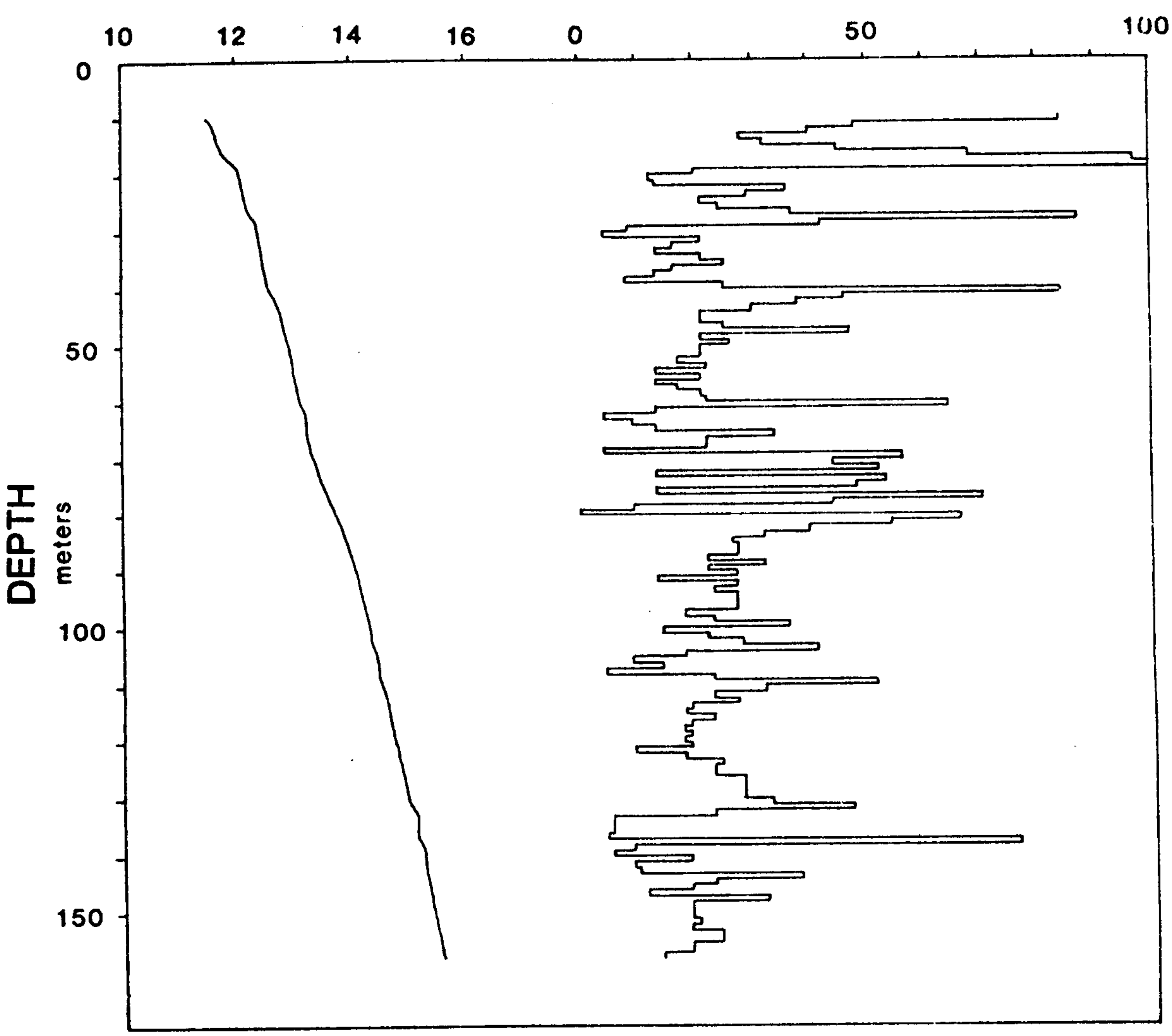
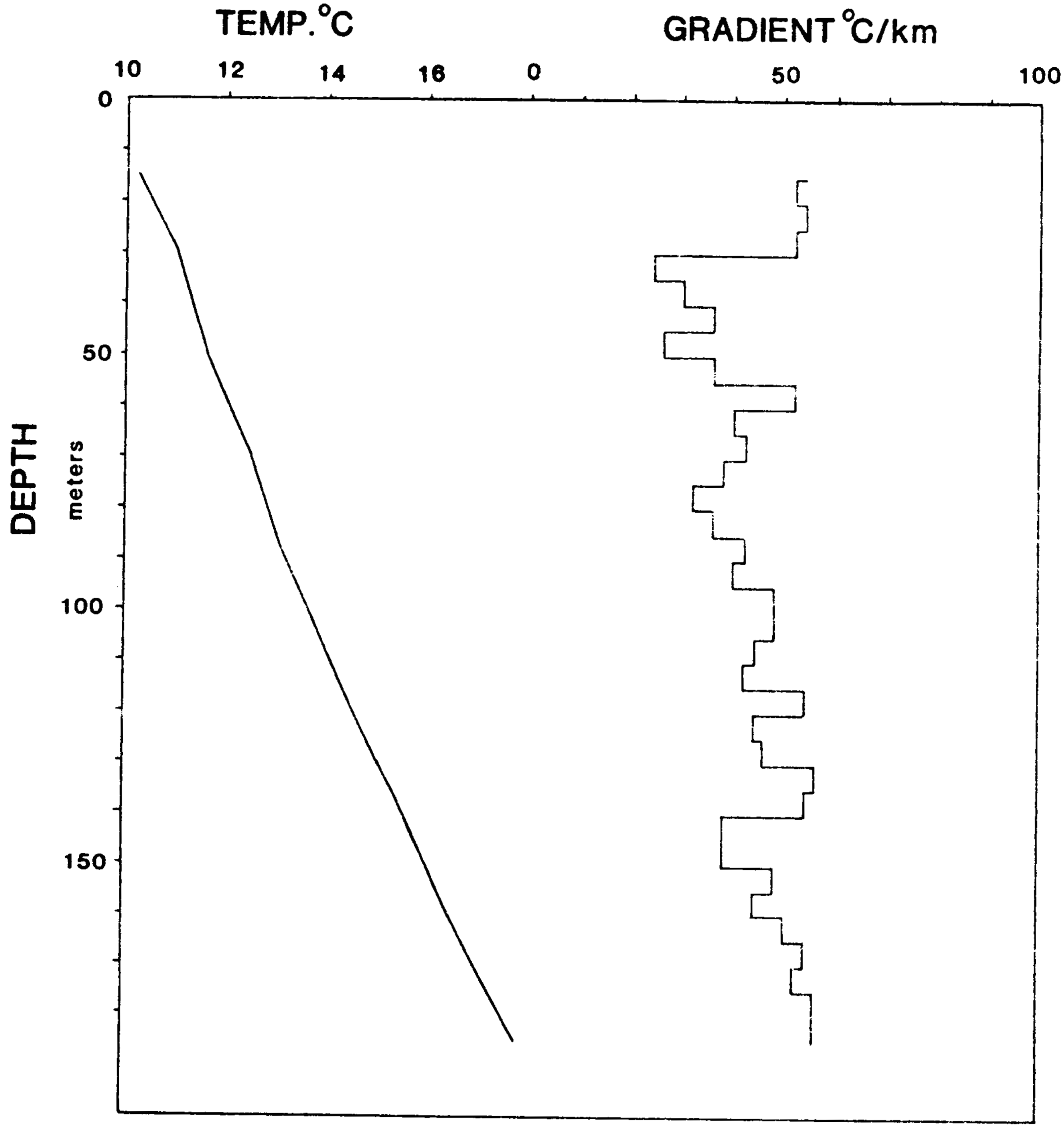


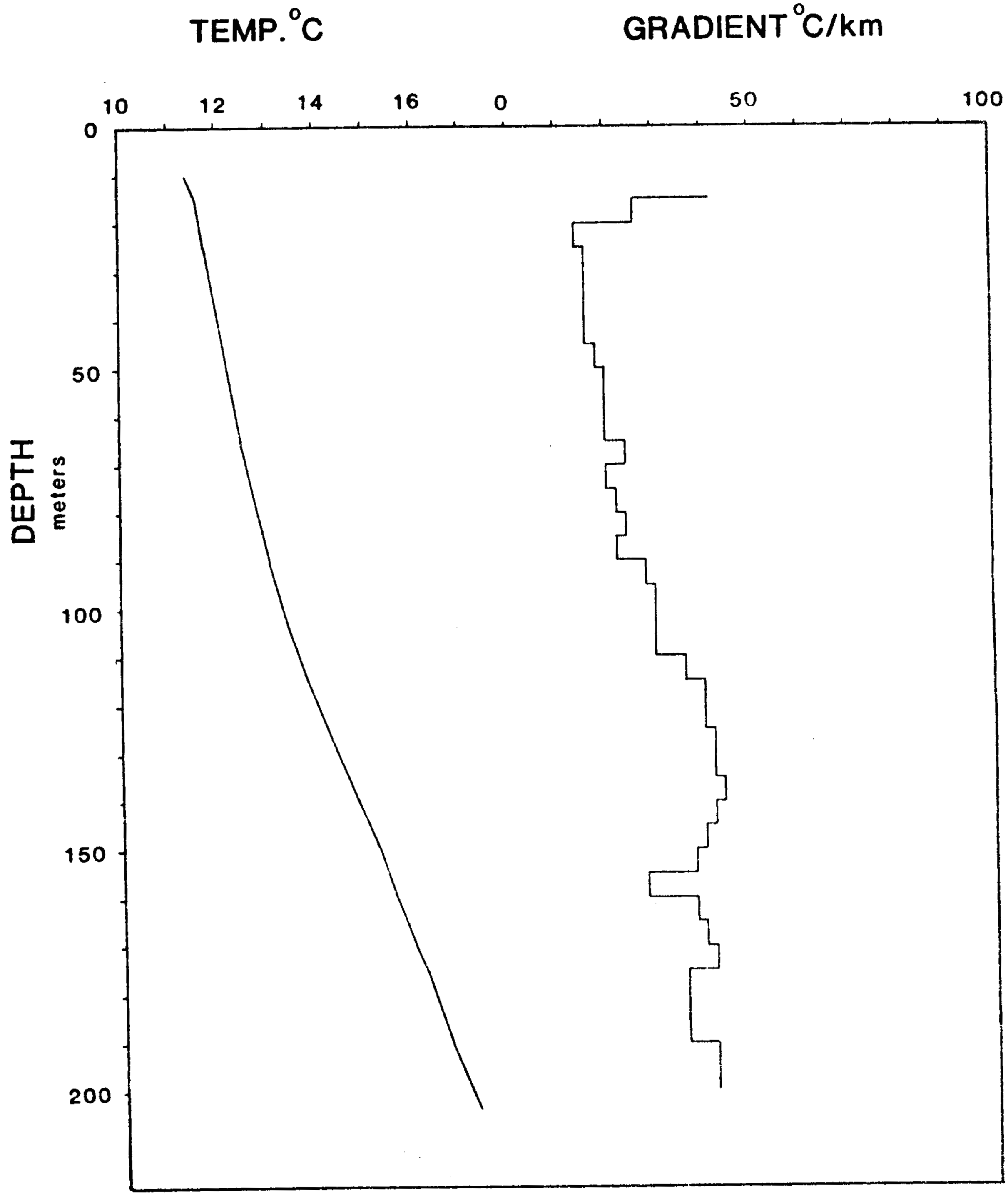
TABLE ROCK
T3N/R12E/SEC 16

18B-79



GORDON

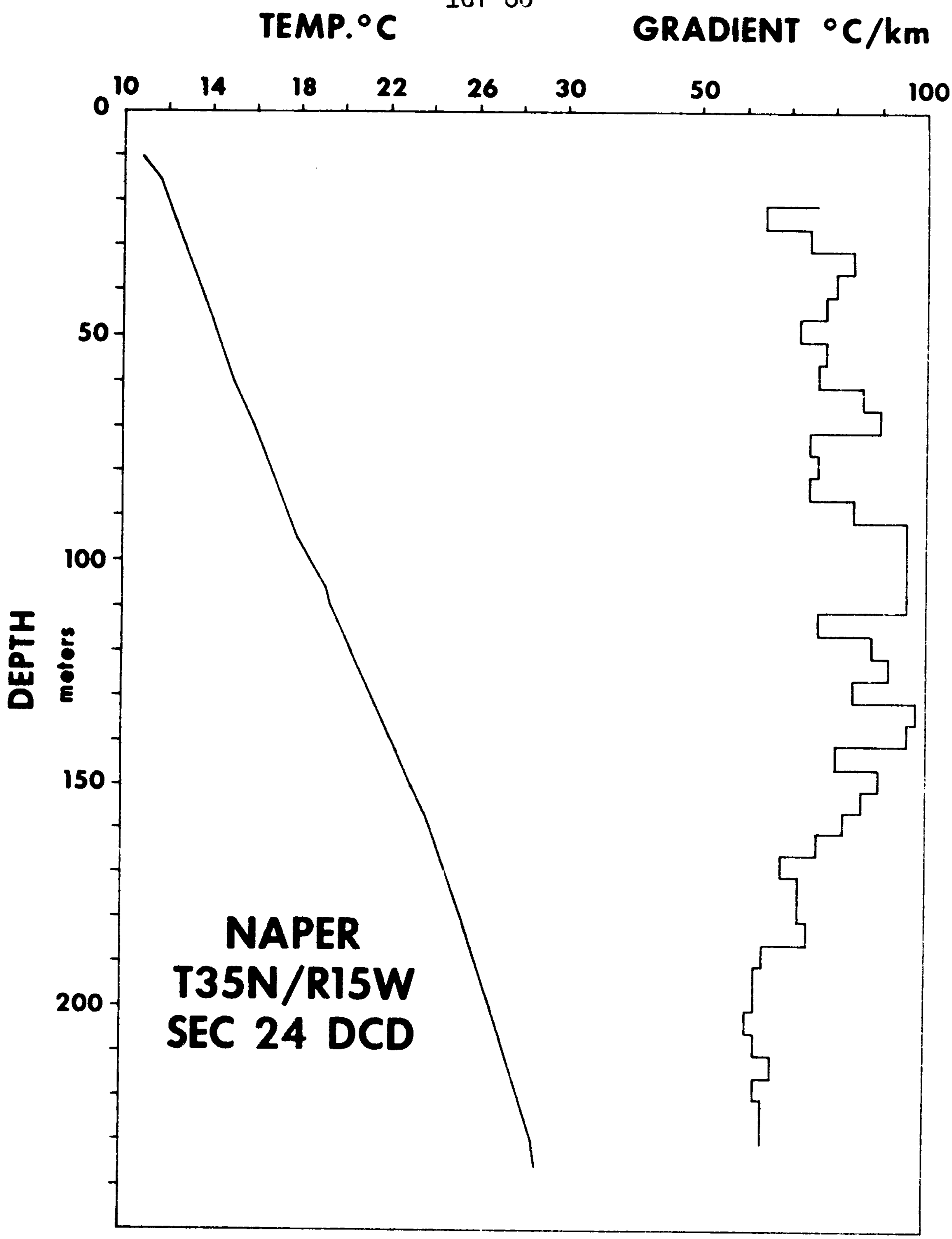
T34N/R42W/SEC 24 ABAA



RUSHVILLE

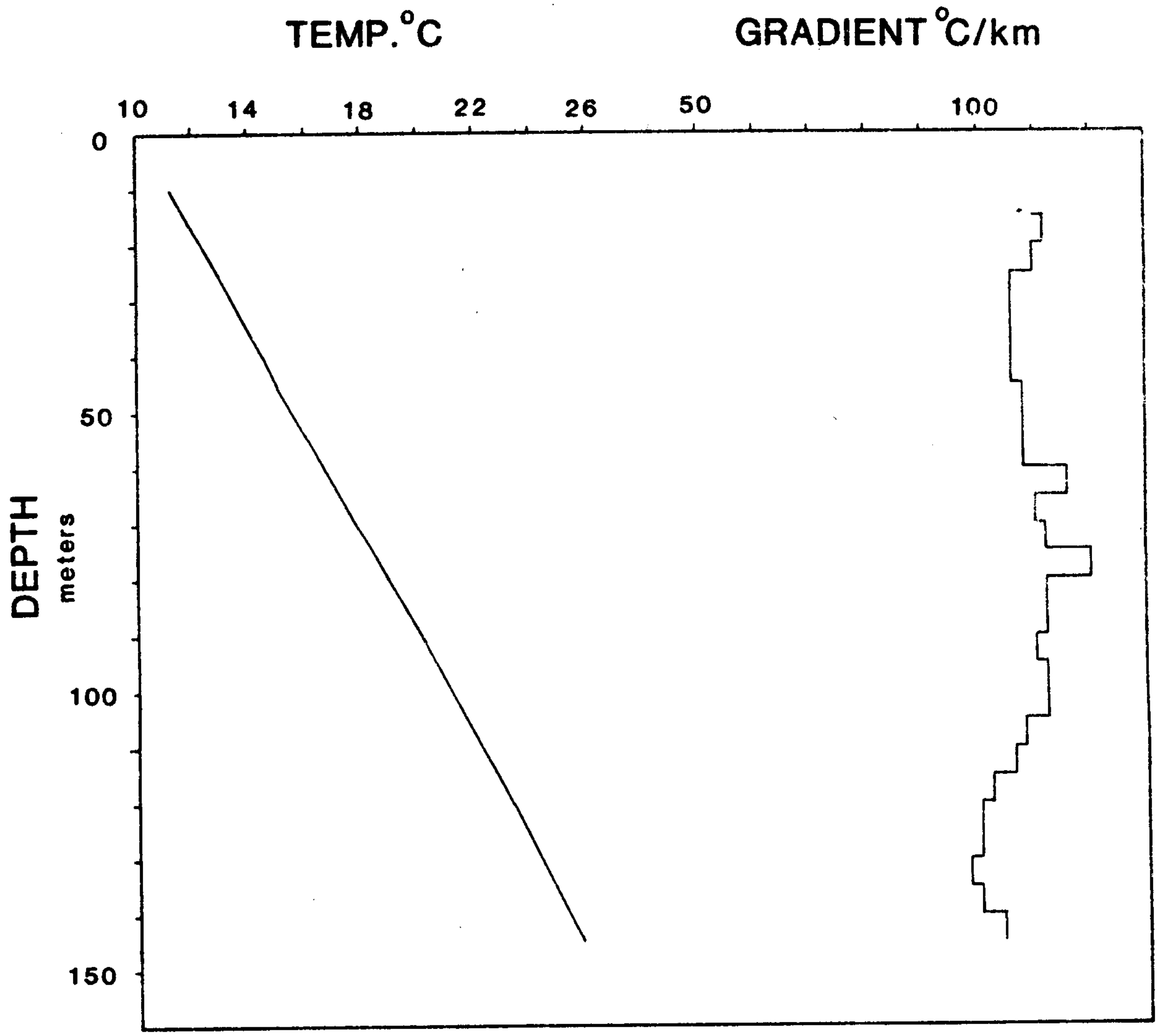
T30N/R42W/SEC 1 BCC

1GT-80



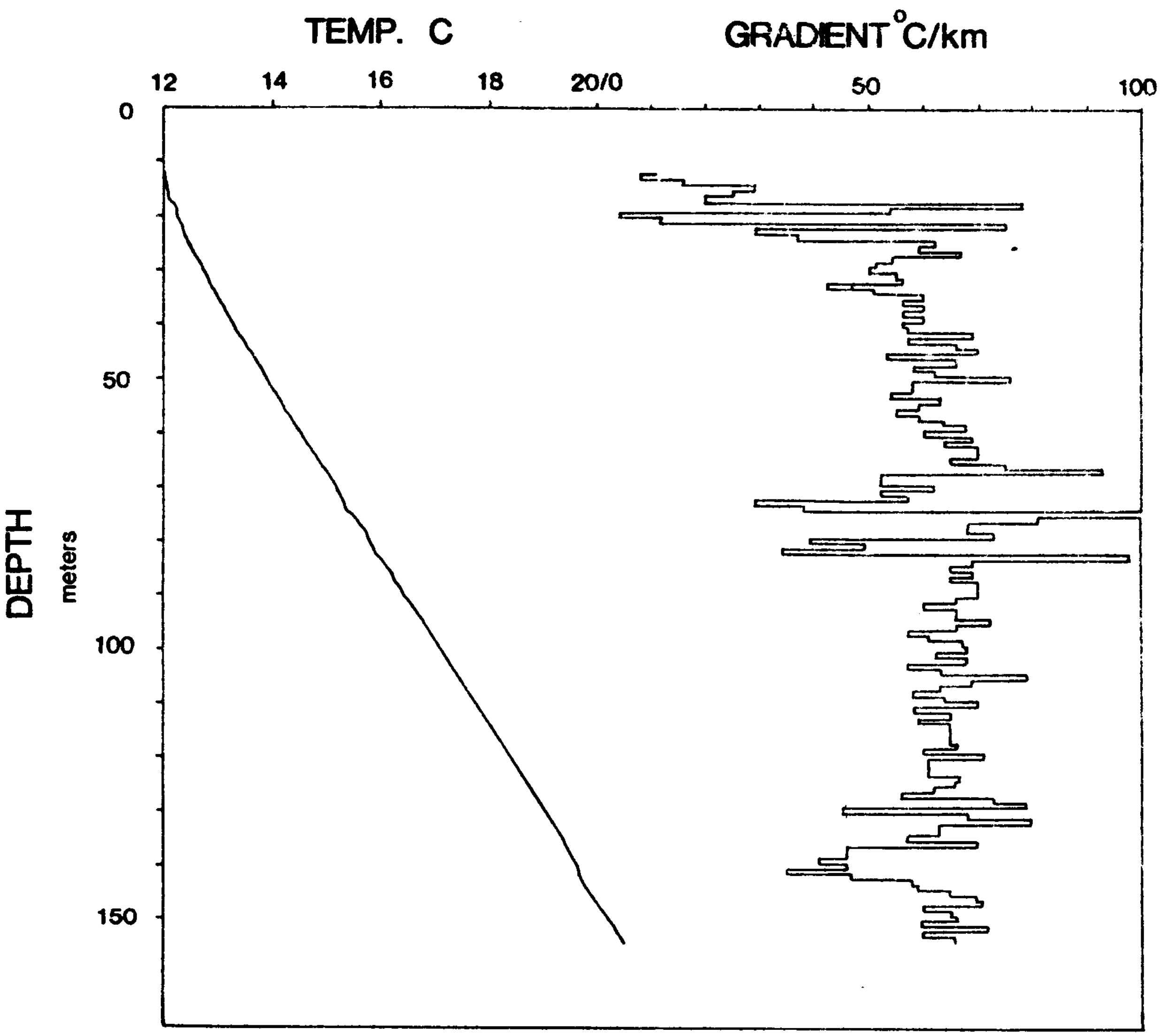
TEMP. °C
GRADIENT °C/km
10
14
18
22
26
30
50
100
0
50
100
150
200
DEPTH
meters
NAPER
T35N/R15W
SEC 24 DCD

2GT-80



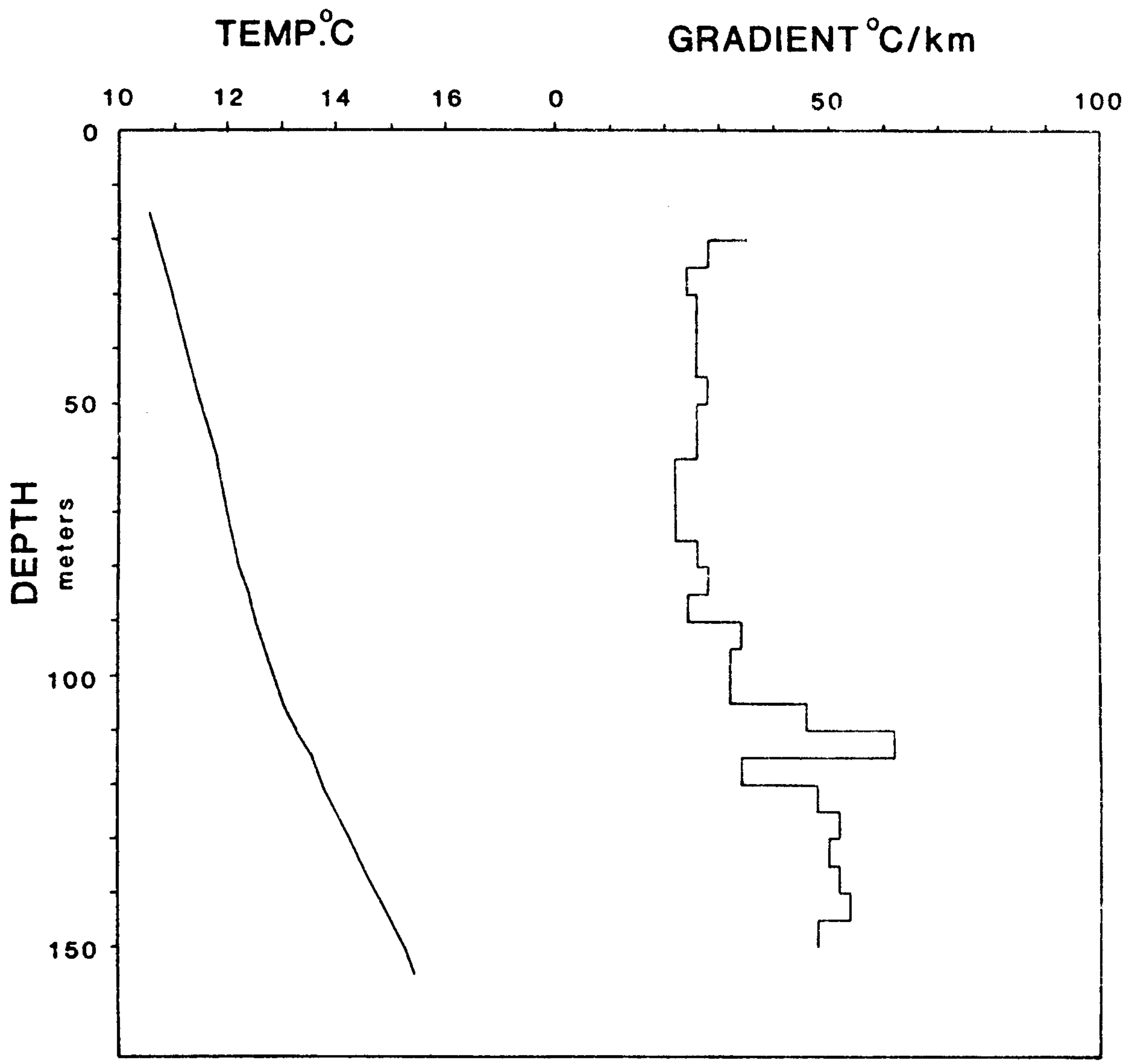
SPRINGVIEW
T35N/R20W/SEC 32 BCC

3GT-80



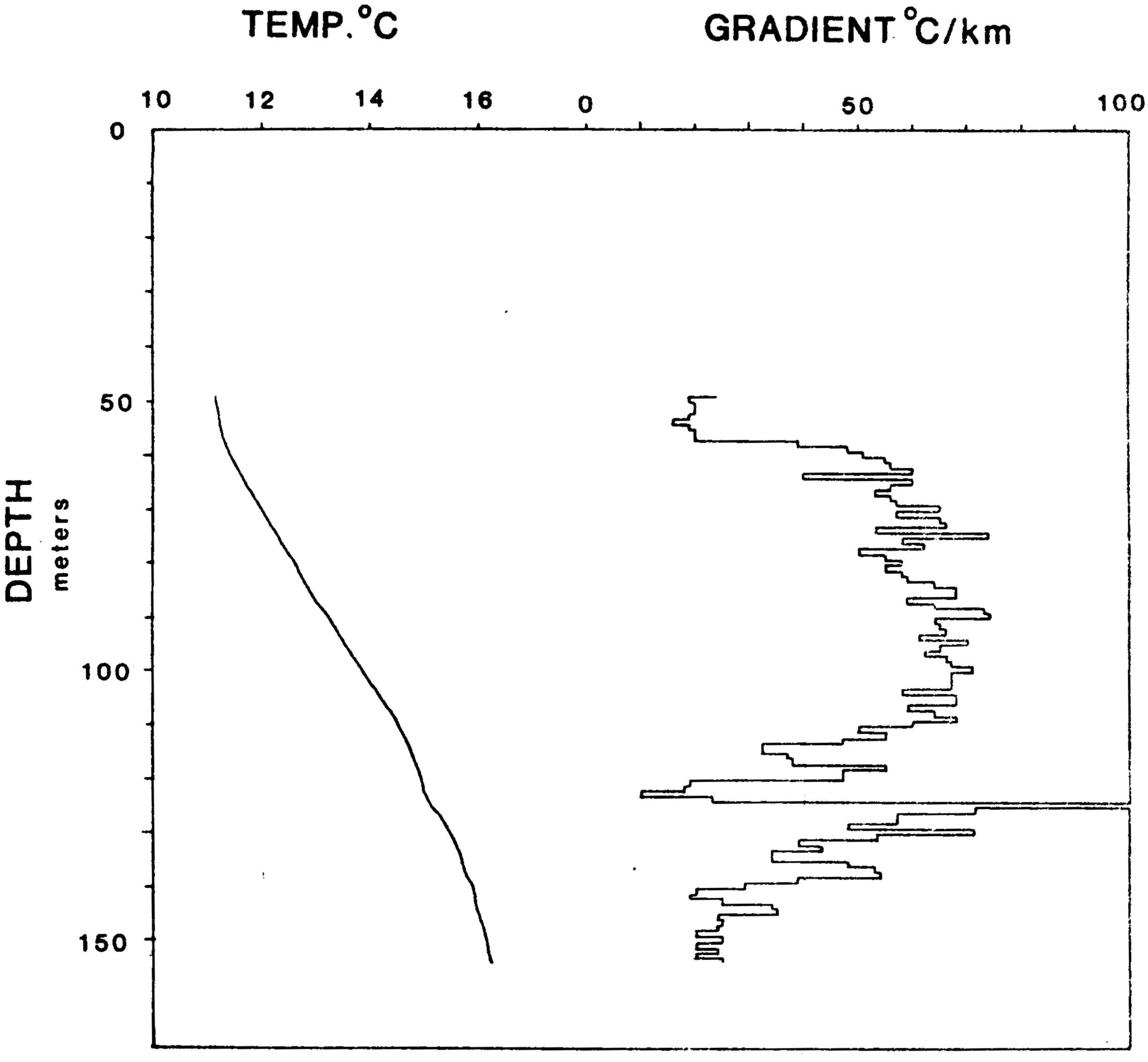
VALENTINE
T34N/R27W/SEC 28

4GT-80



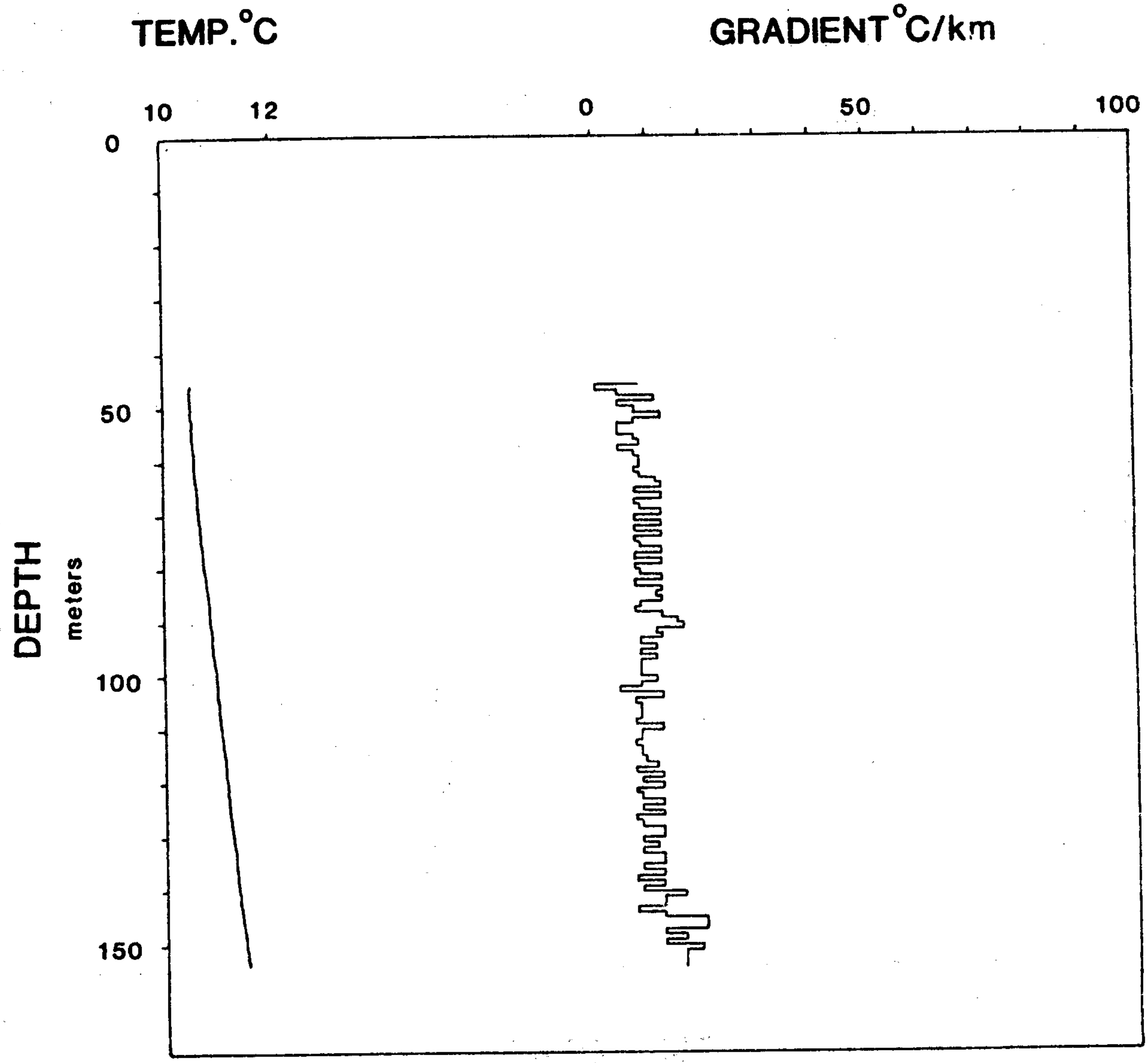
O'NEIL
T28N/R11W/SEC 6 BBBB

5GT-80



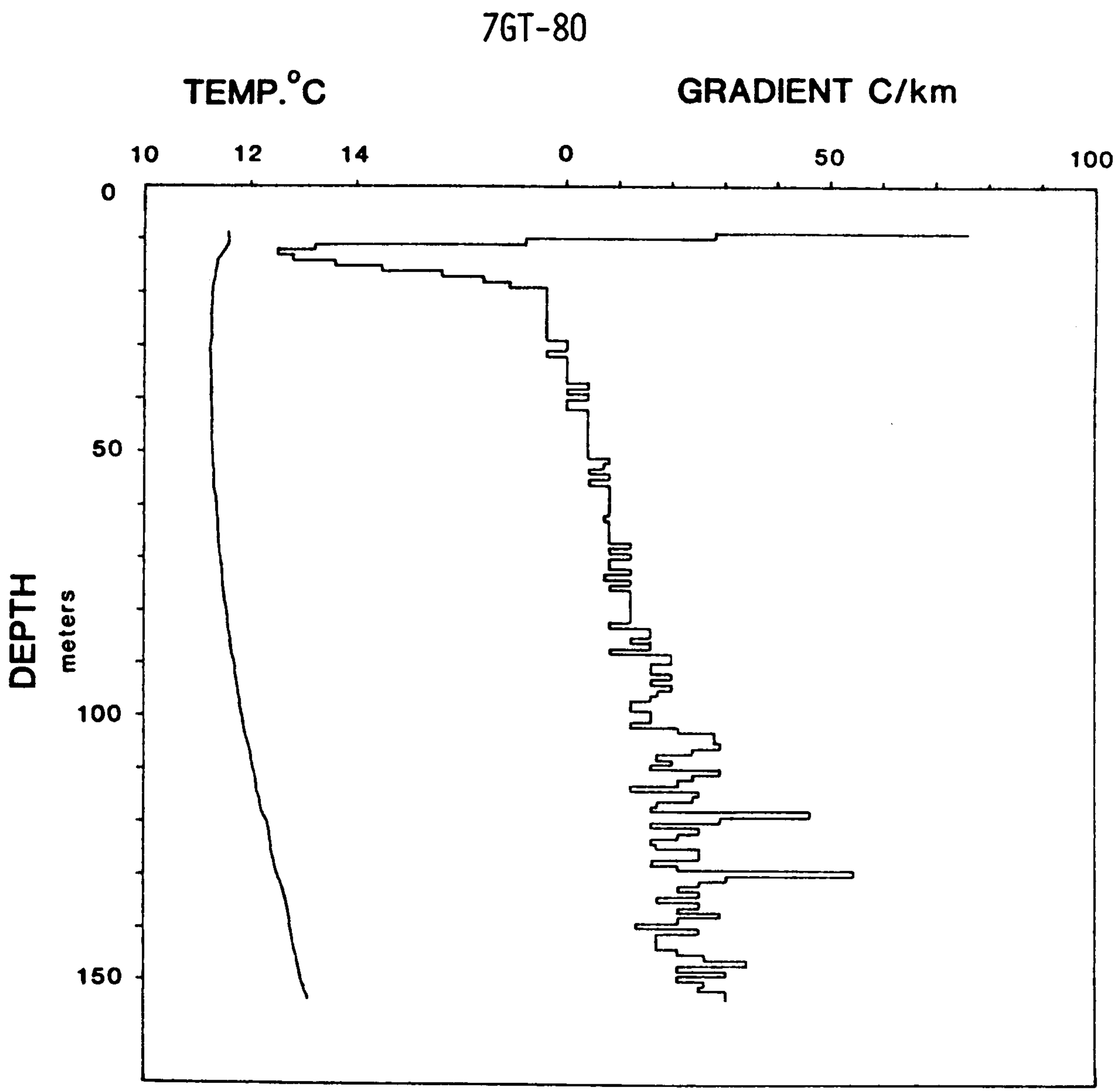
WAYNE

T26N/R3E/SEC 14



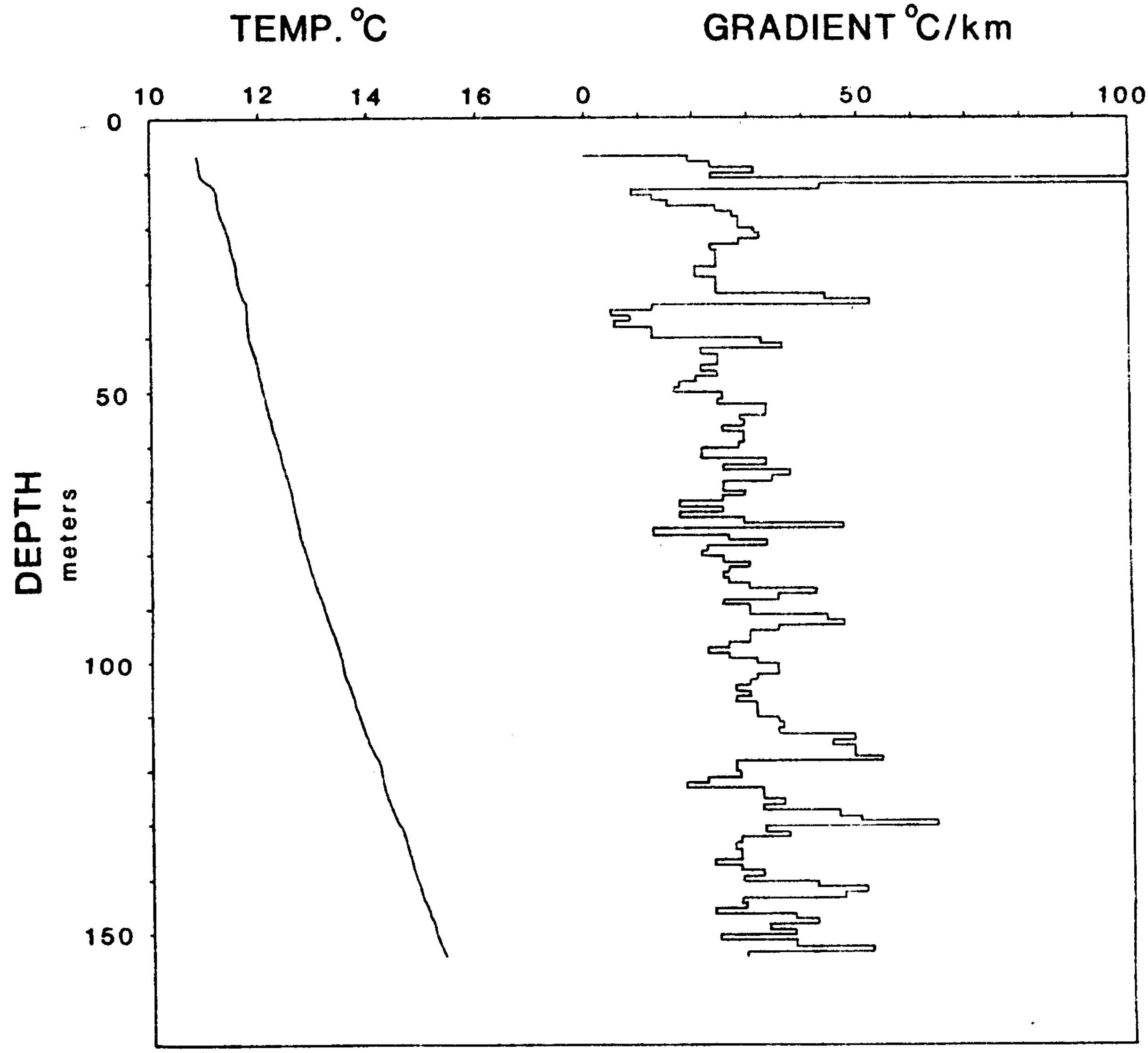
OAKLAND

T21N/ R9E/SEC 6



FREMONT

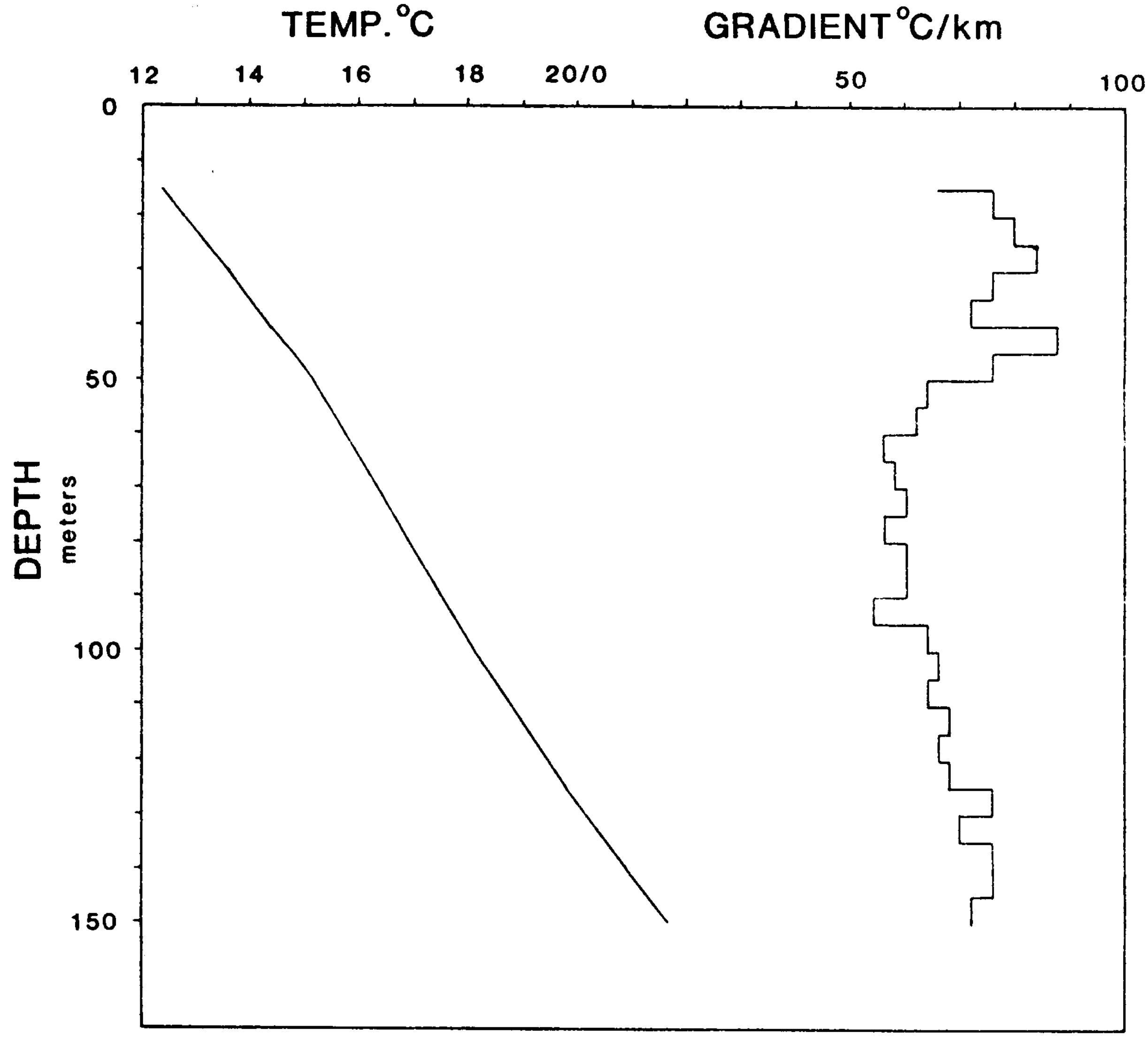
T18N/R8E/SEC 32



BENNET

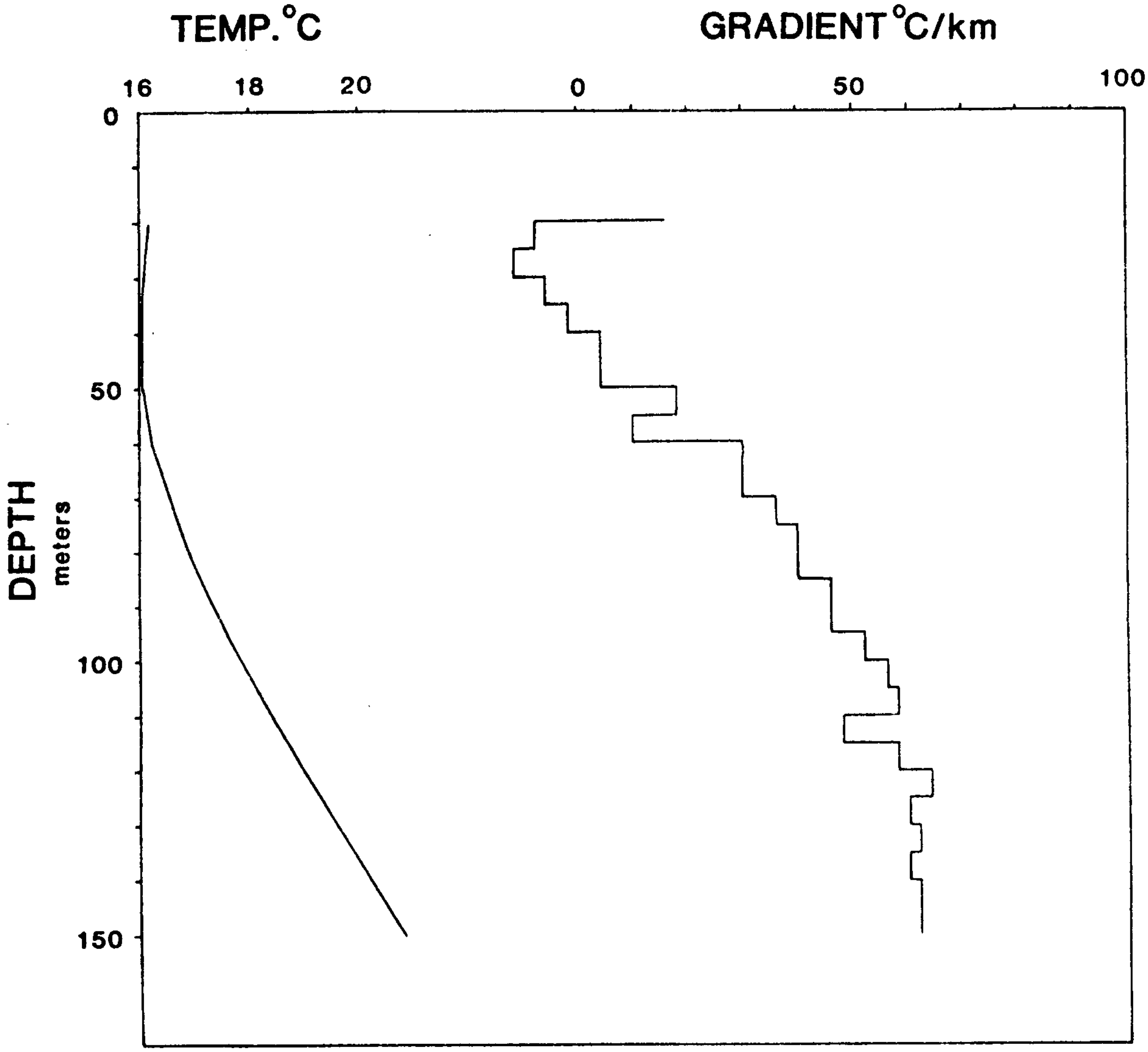
T8N/R8E/SEC 22

9GT-80



WHITNEY
T32N/R51W/SEC 2 DDD

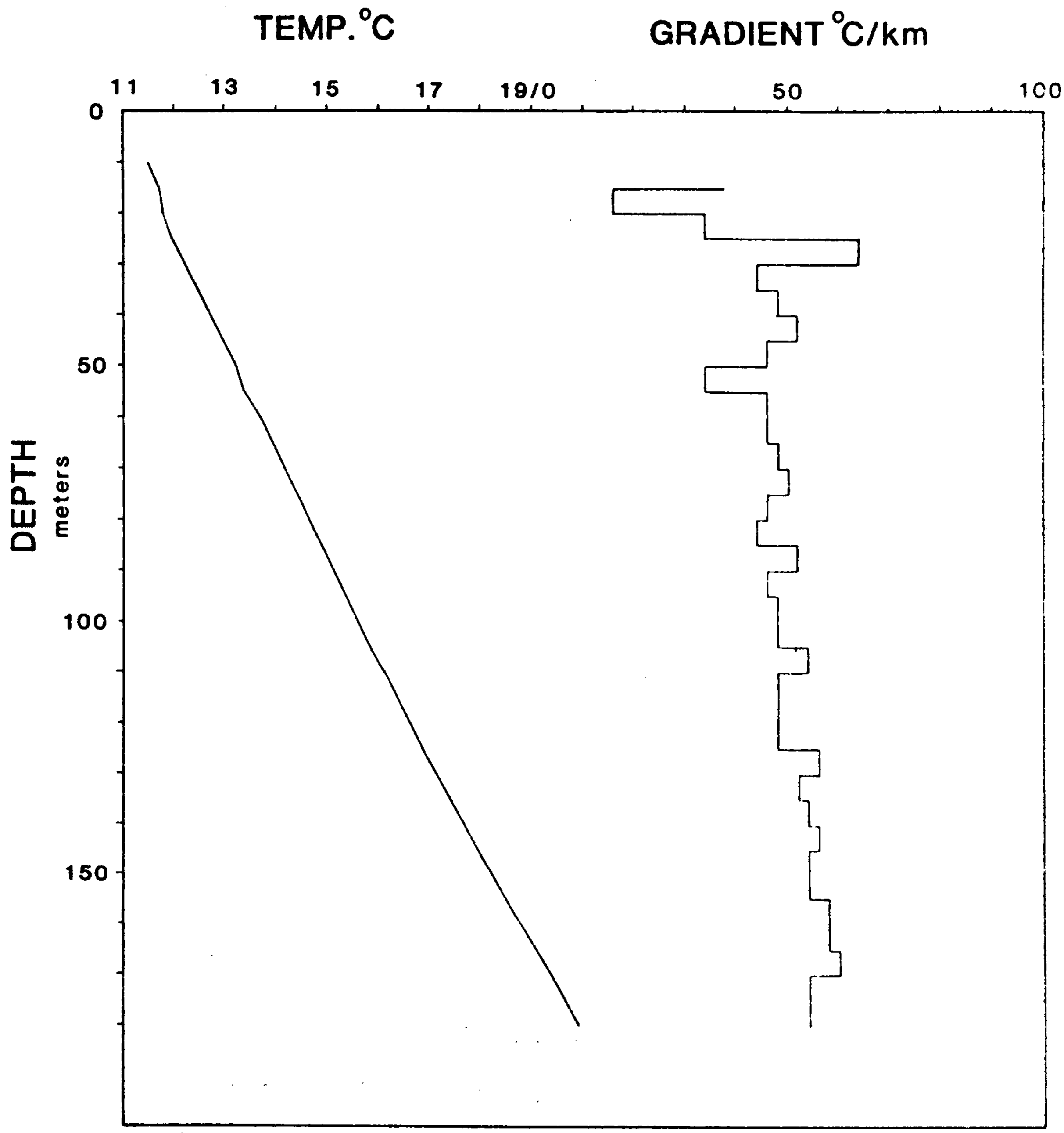
10GT-80



BAYARD

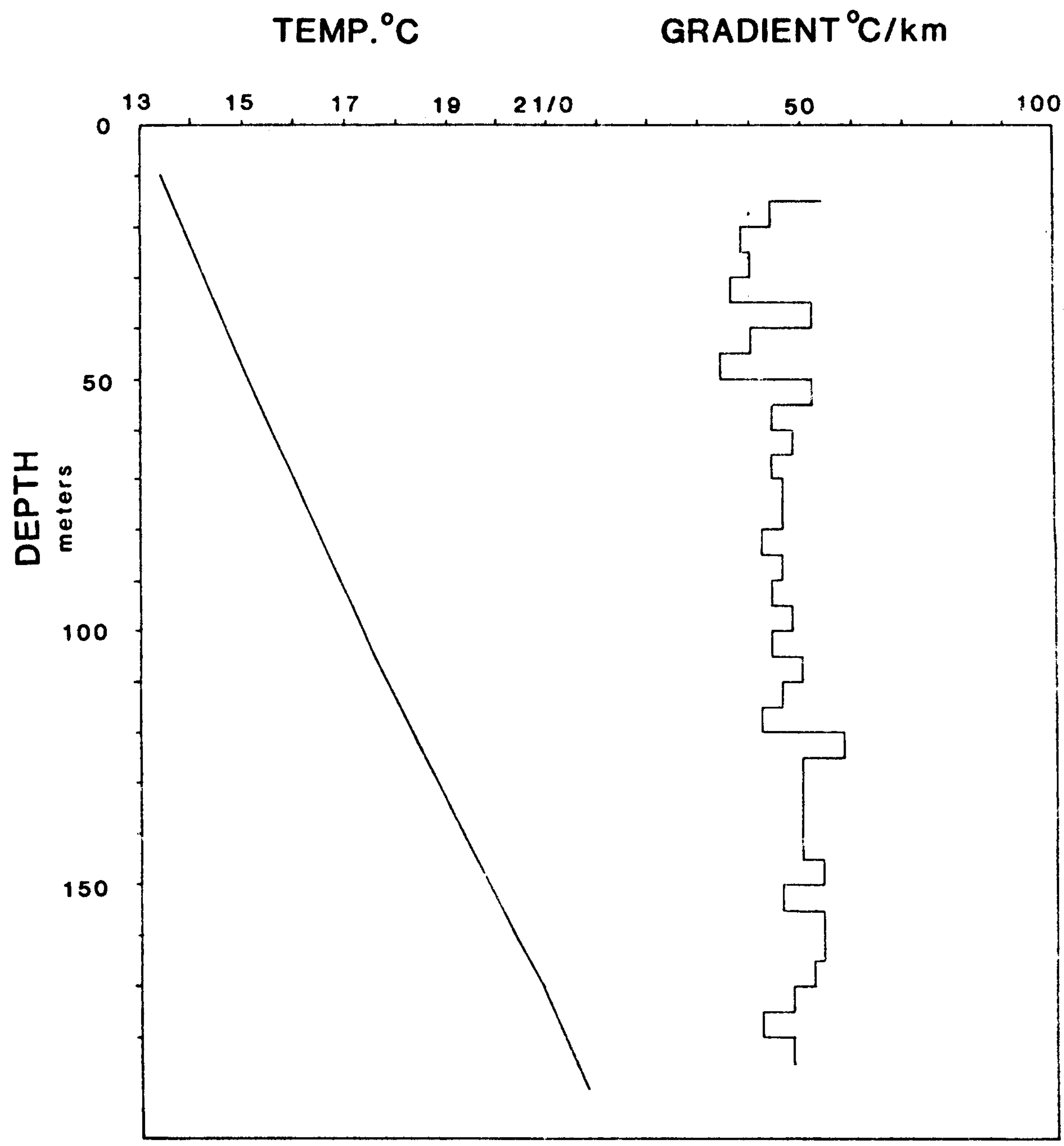
T21N/R51W/SEC 6 BBBC

11GT-80



SIDNEY
T14N/R49W/SEC 33 DDD

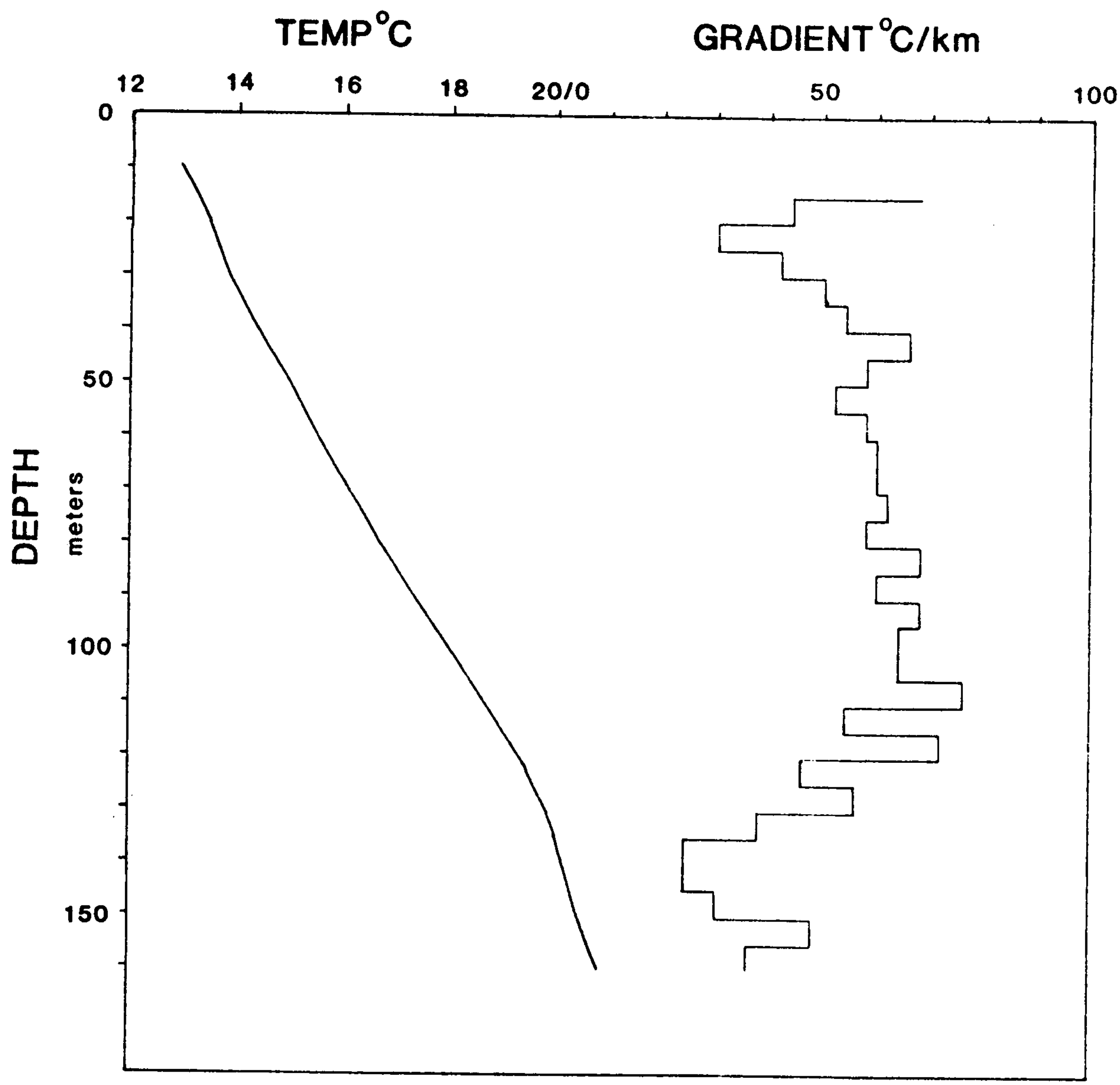
12GT-80



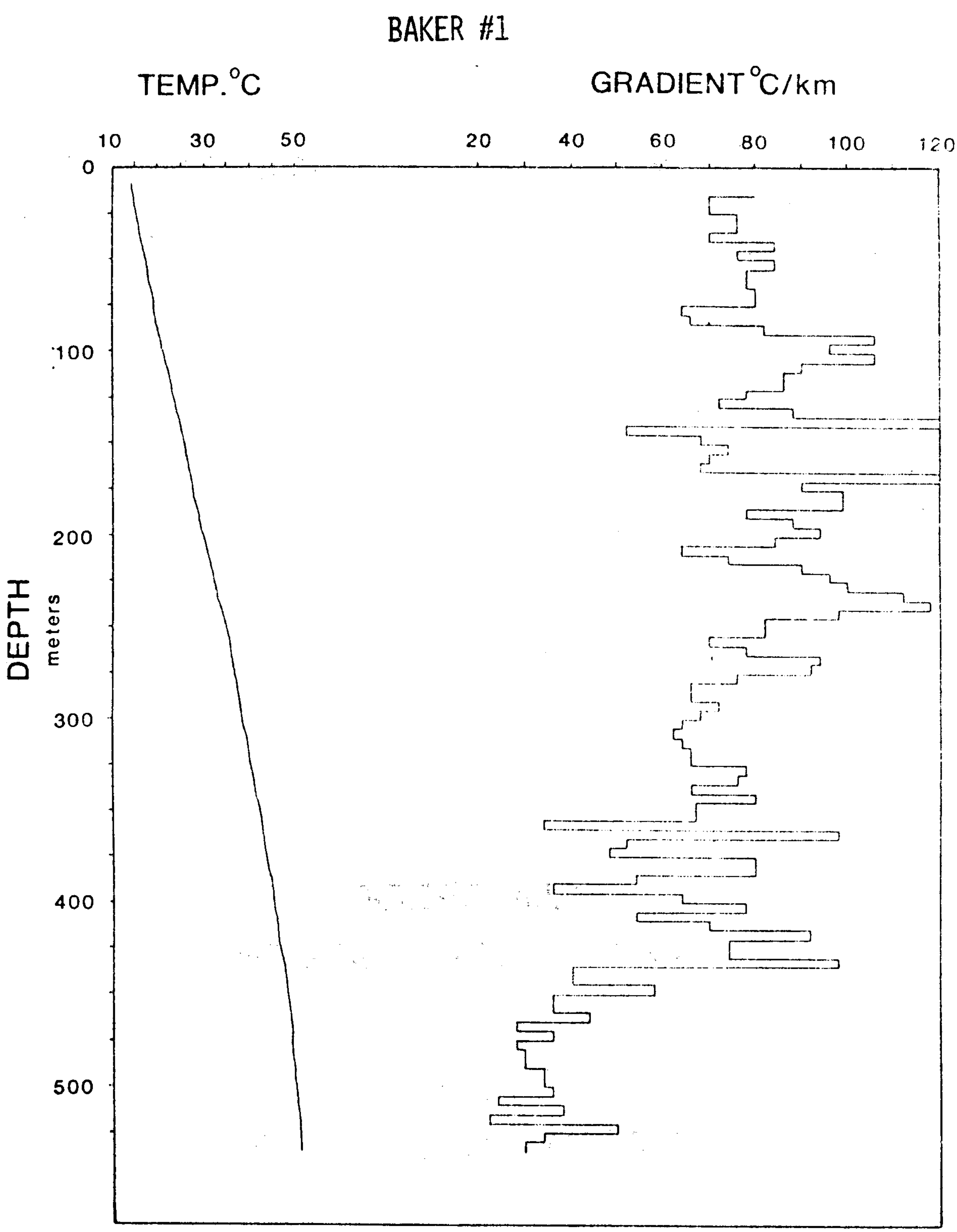
LISCO

T17N/R45W/SEC 26 BCB

13GT-80



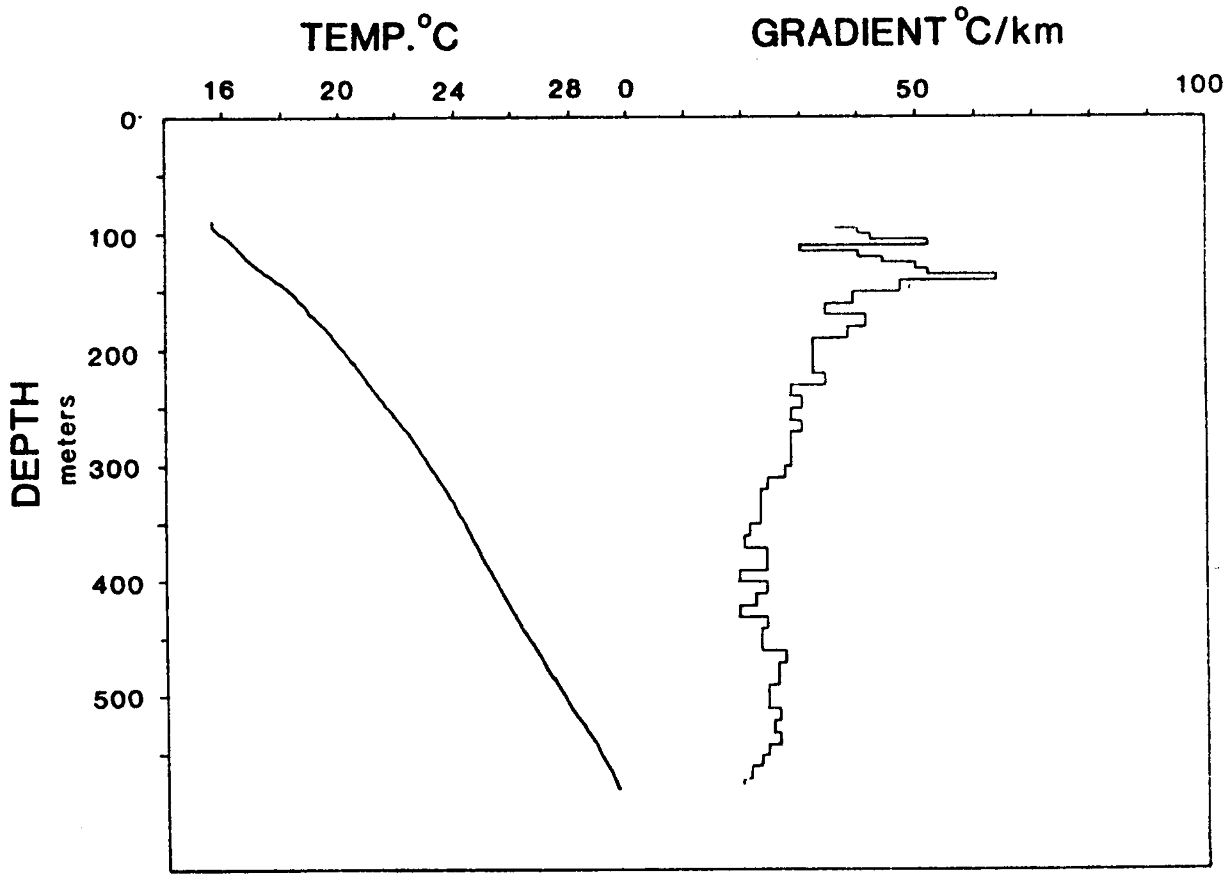
BIG SPRINGS
T13N/R42W/SEC 26 DBAA



BURTON

T34N/R19W/SEC 8 AC

EC #1



ELK CREEK

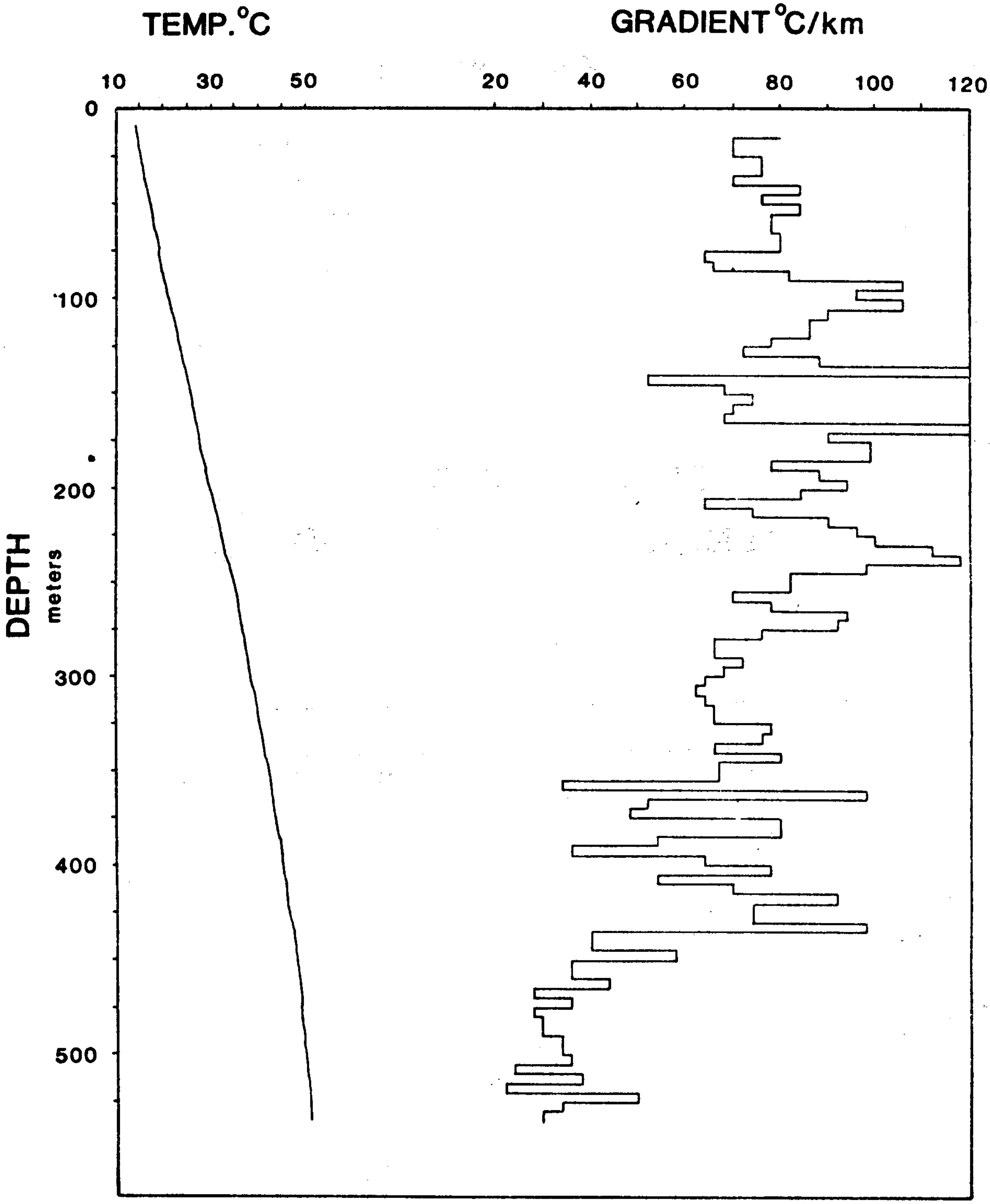
T4N/R11E/SEC 33 CCB

Appendix 2-5

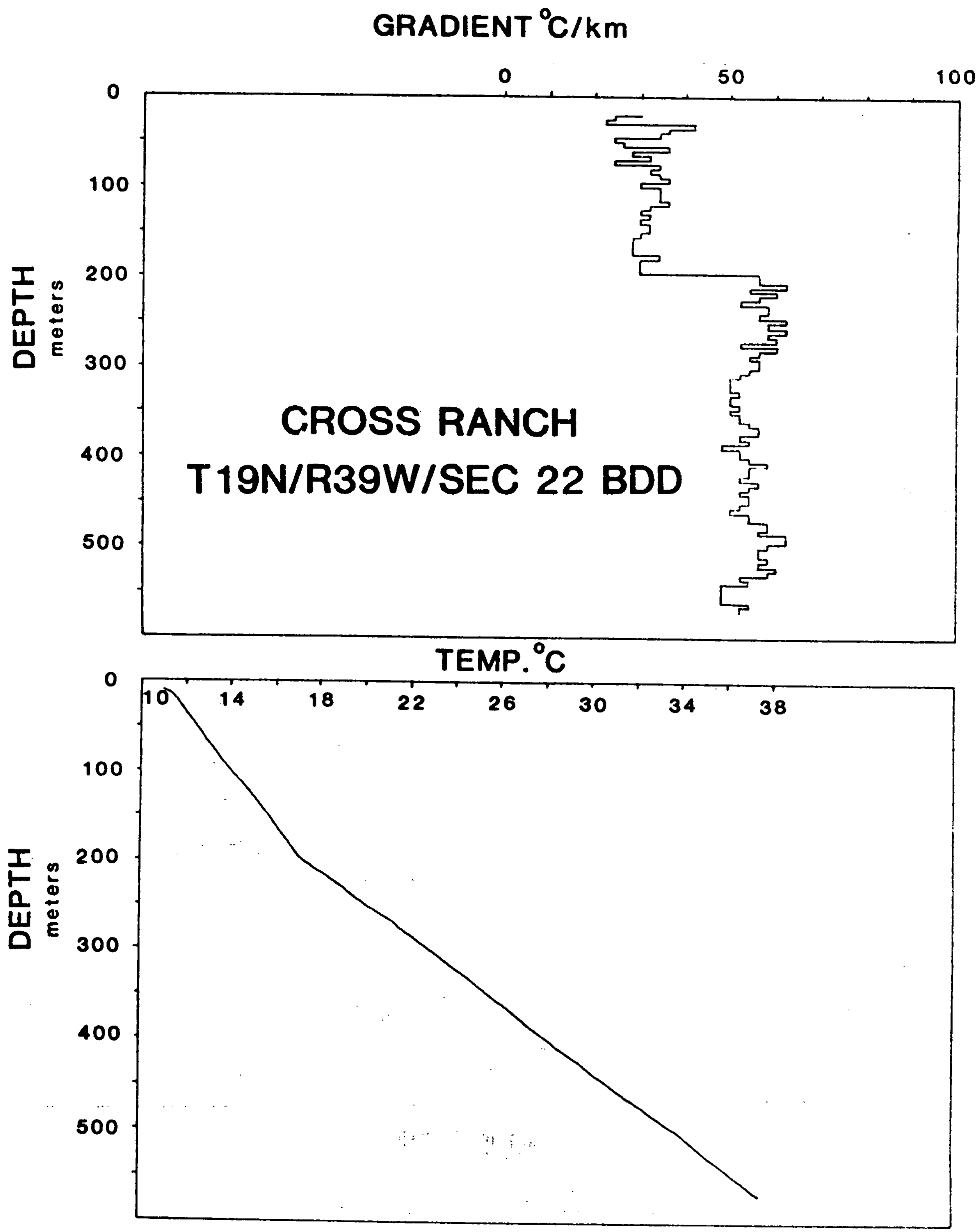
Thermal Gradient - Deep Holes

THERMAL GRADIENT - DEEP HOLES

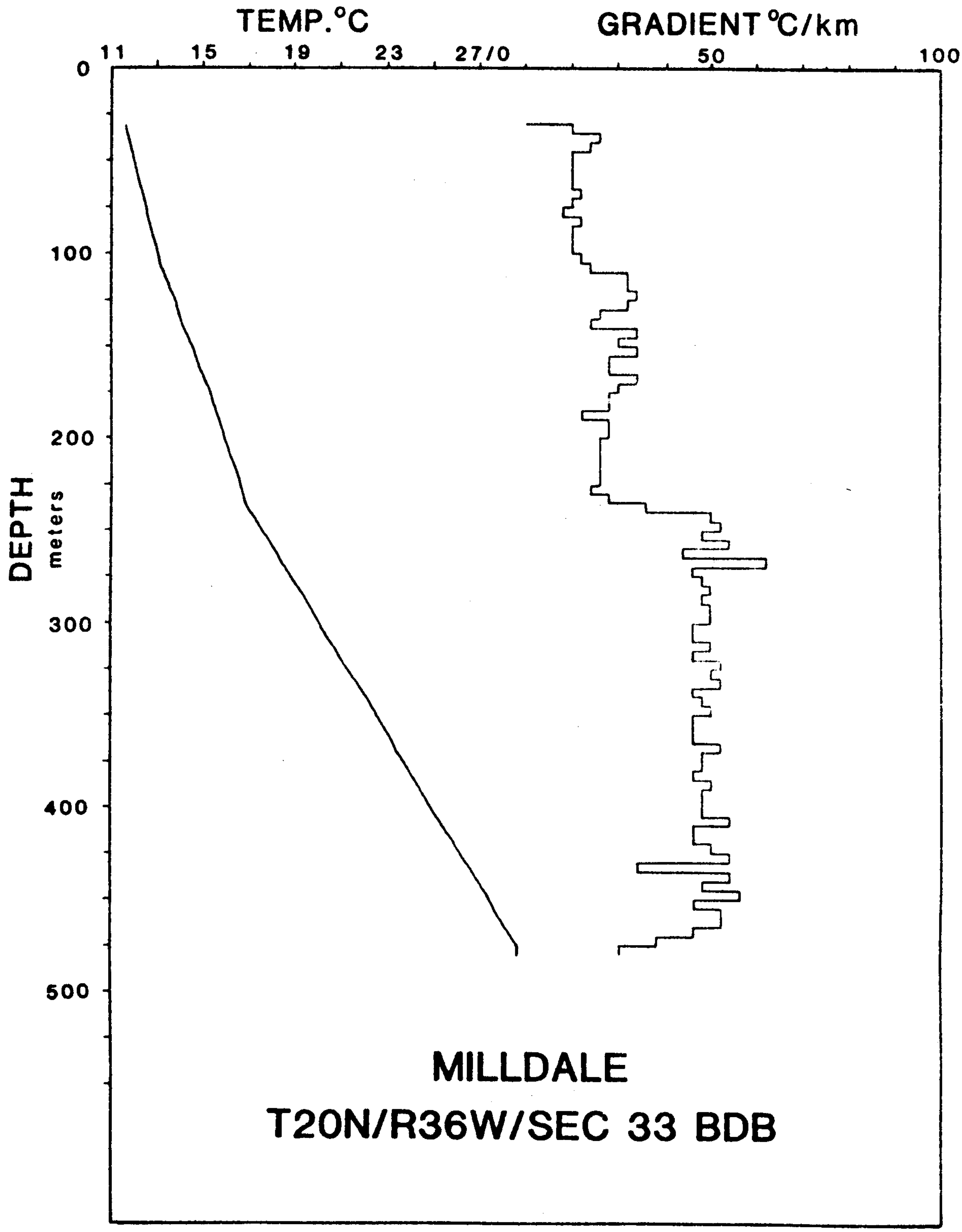
Burton	Keya Paha	SW, NE, Sec. 8, 34N, 19W
Cross Ranch	Arthur	SE, SE, NW, Sec. 22, 19N, 39W
Milldale	Arthur	NW, SE, NW, Sec. 33, 20N, 36W
Rothwell	Grant	SE, SE, Sec. 23, 21N, 38W
Deuel	Deuel	SW, NE, NE, Sec. 9, 14N, 46W
Sidney	Cheyenne	Sec. 4, 14N, 50W
Drever #1	Cheyenne	Sec. 27, 14N, 52W
Hagstrom	Kimball	Sec. 19, 14N, 55W
Van Pelt	Banner	Sec. 10, 17N, 56W
Court House Rock	Morrill	Sec. 17, 18N, 50W
Bridgeport	Morrill	Sec. 12, 18N, 51W
Scottsbluff	Scottsbluff	Sec. 28, 21N, 55W

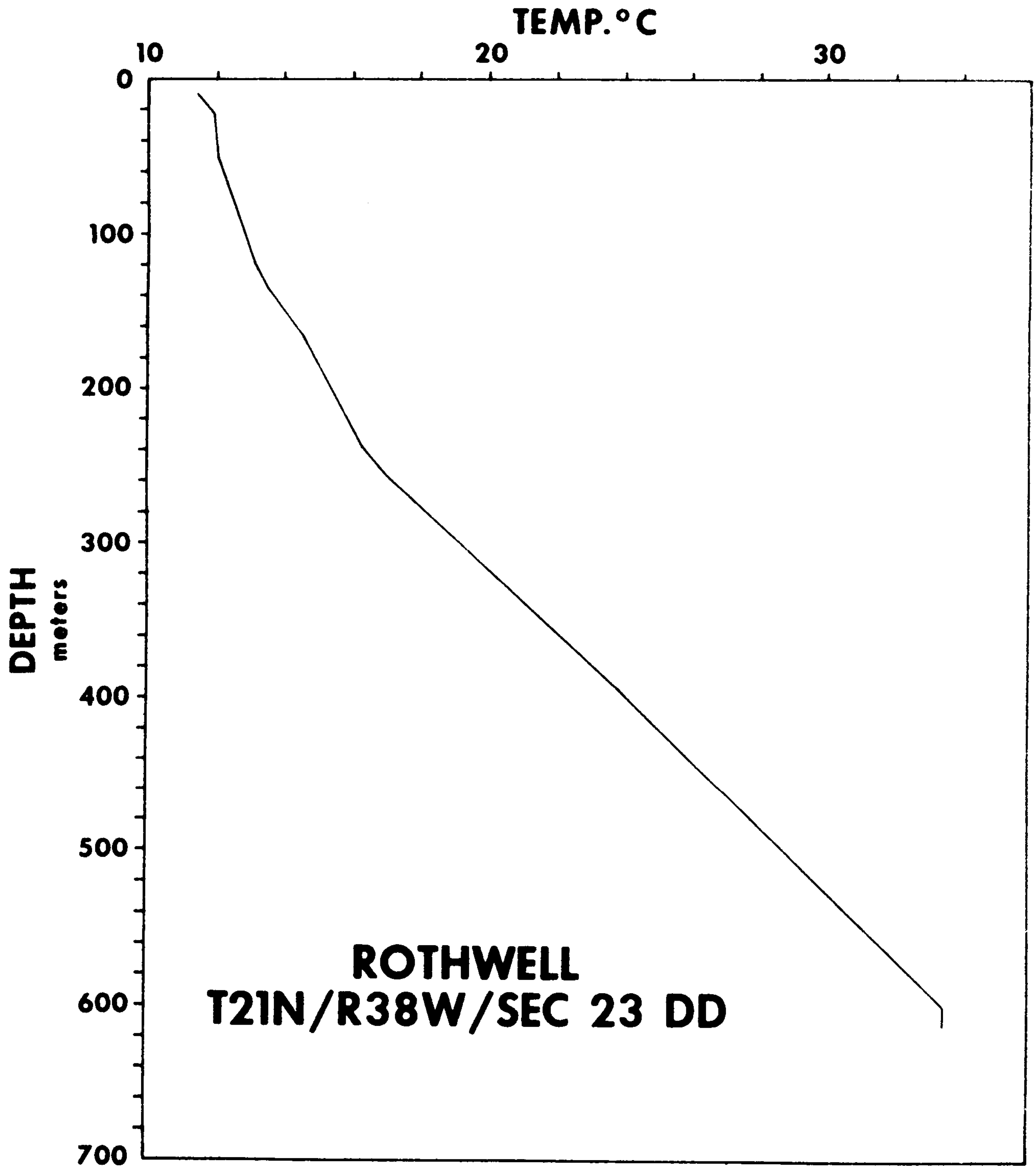


BURTON
T34N/R19W/SEC 8 AC

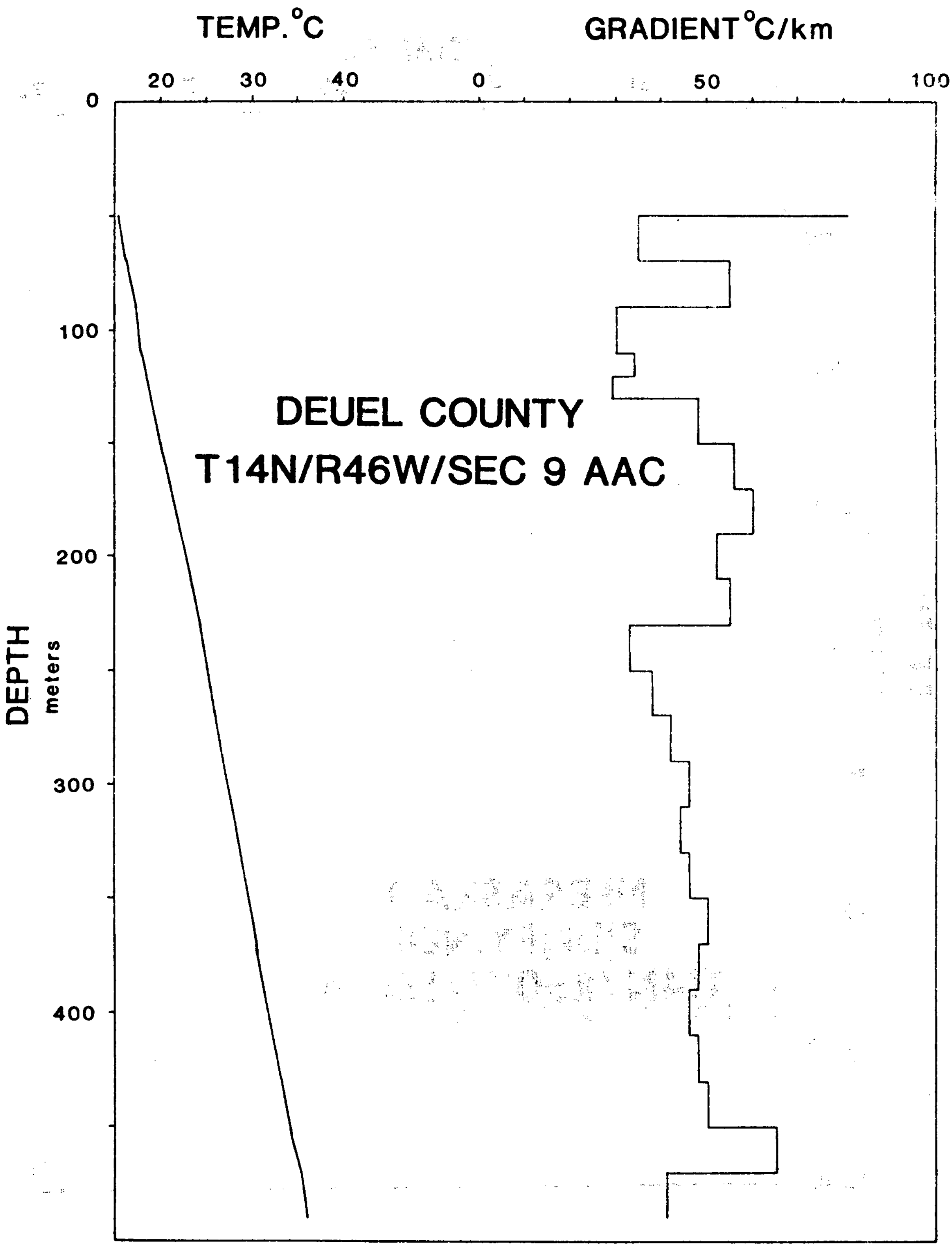


GRADIENT °C/km
0
50
100
0
100
200
300
400
500
DEPTH
meters
CROSS RANCH
T19N/R39W/SEC 22 BDD
TEMP. °C
10
14
18
22
26
30
34
38
0
100
200
300
400
500
DEPTH
meters

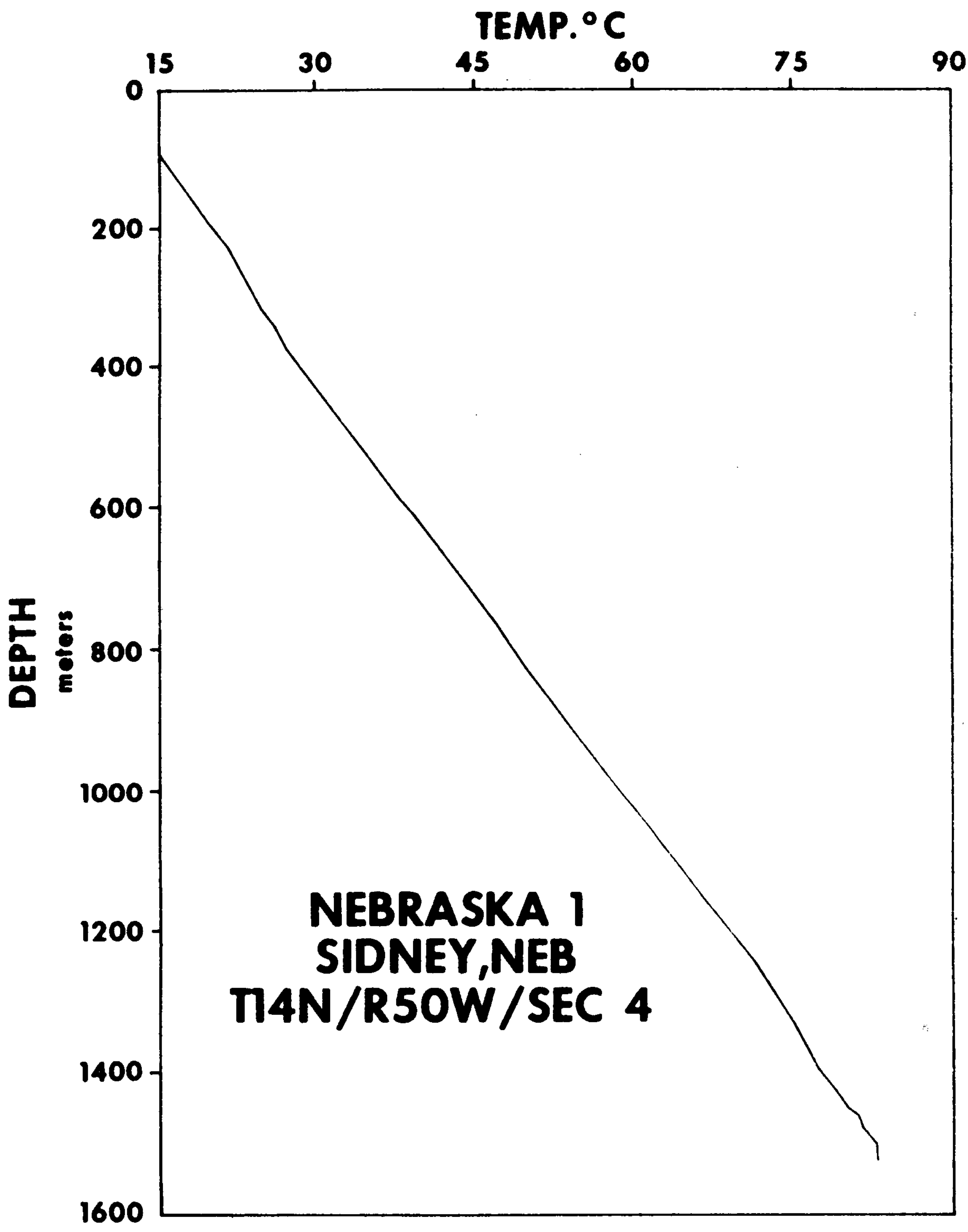

TEMP.°C
GRADIENT °C/km
11
15
19
23
27/0
50
100
0
100
200
300
400
500
DEPTH
meters
MILLDALE
T20N/R36W/SEC 33 BDB

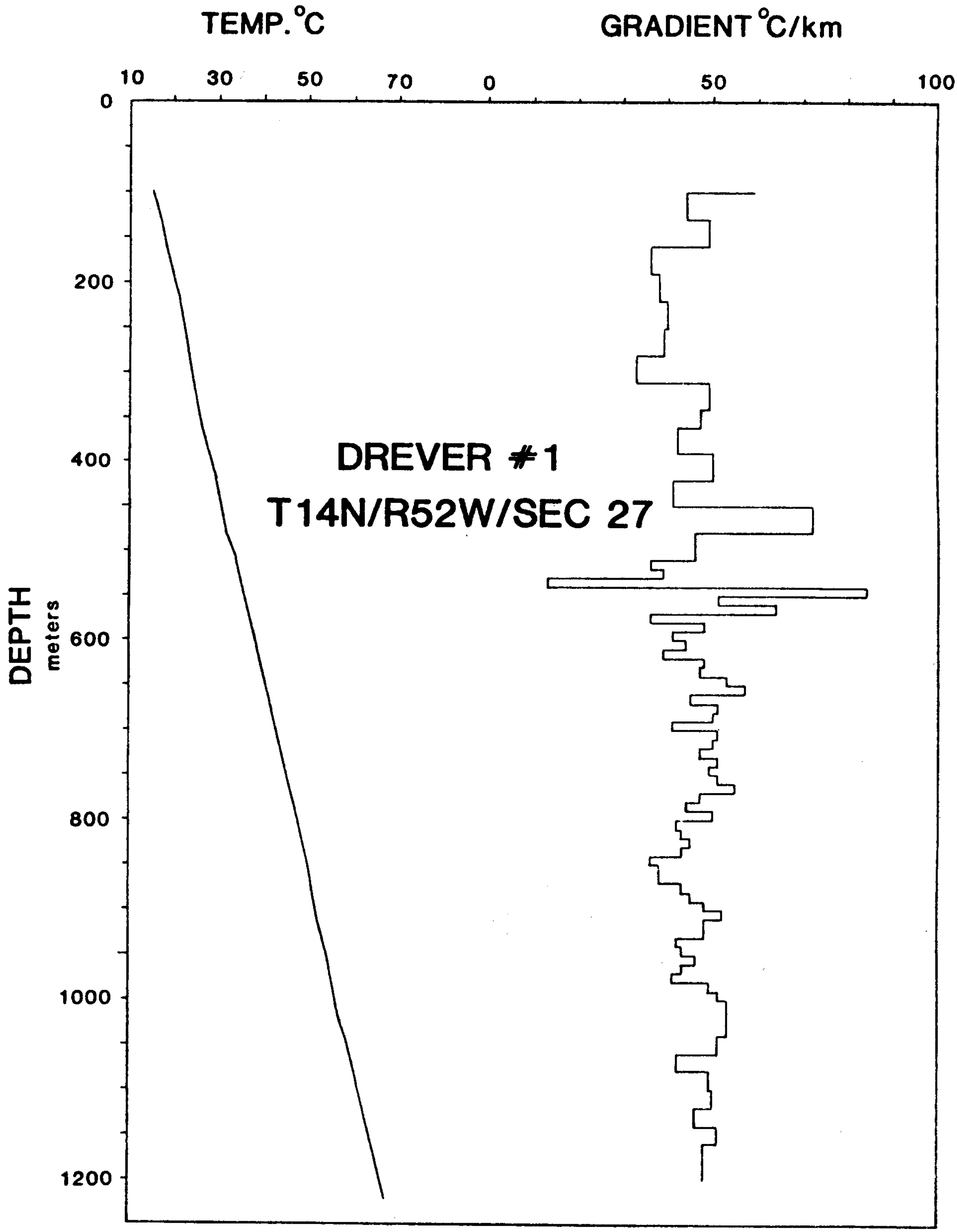


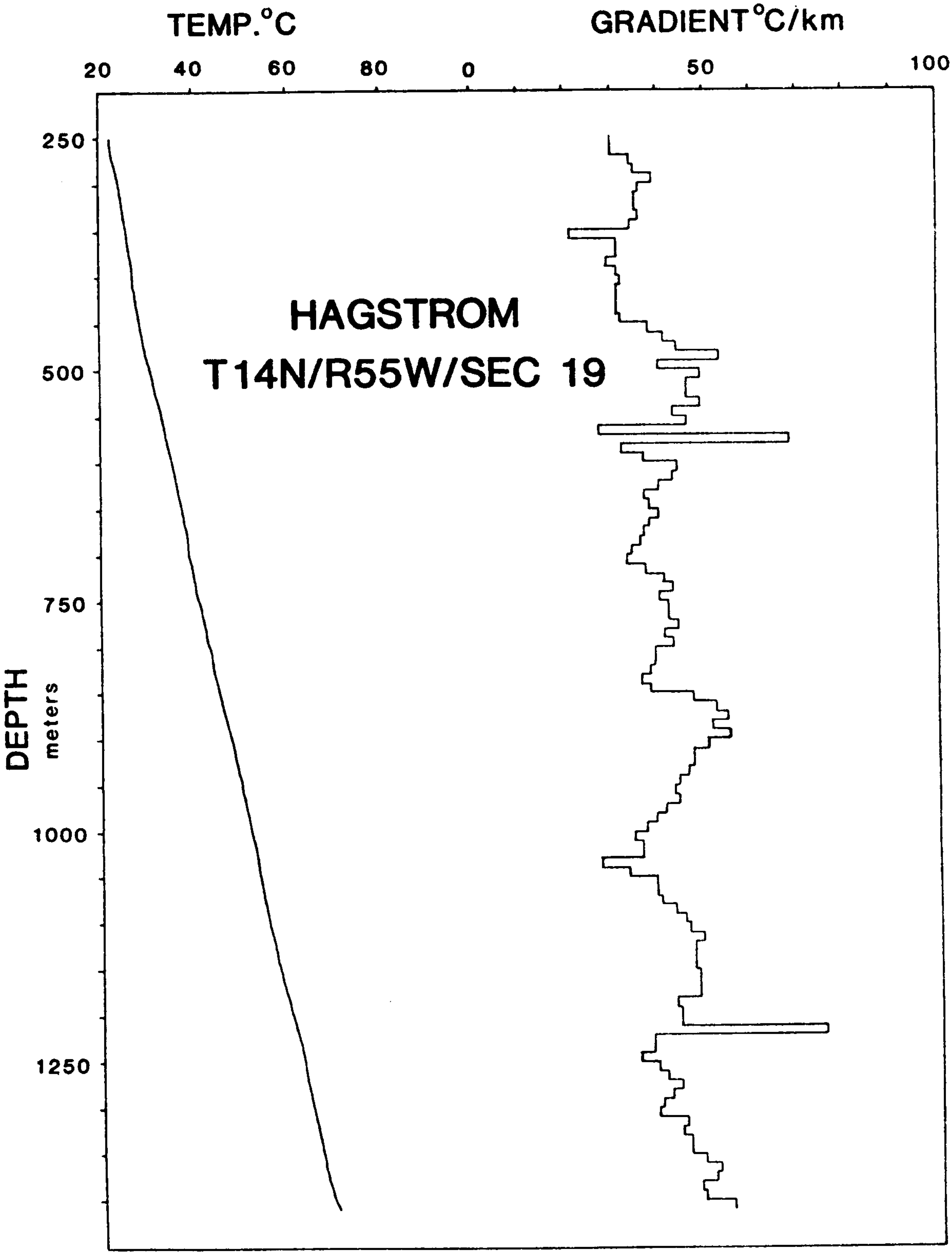
TEMP. °C
10
20
30
0
100
200
300
400
500
600
700
DEPTH
meters
ROTHWELL
T21N/R38W/SEC 23 DD

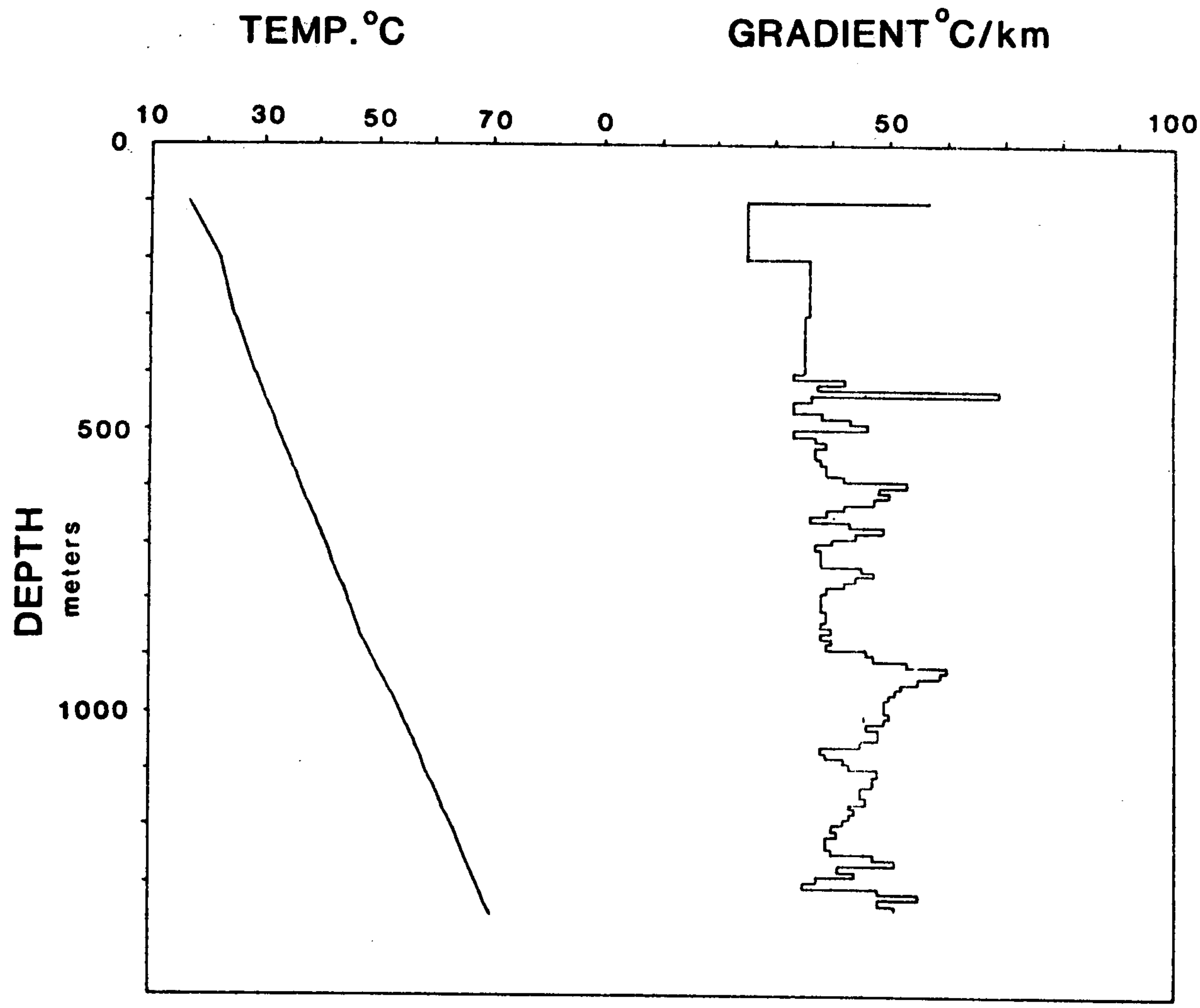


TEMP. °C
GRADIENT °C/km
20
30
40
0
50
100
0
100
200
300
400
DEPTH
meters
DEUEL COUNTY
T14N/R46W/SEC 9 AAC

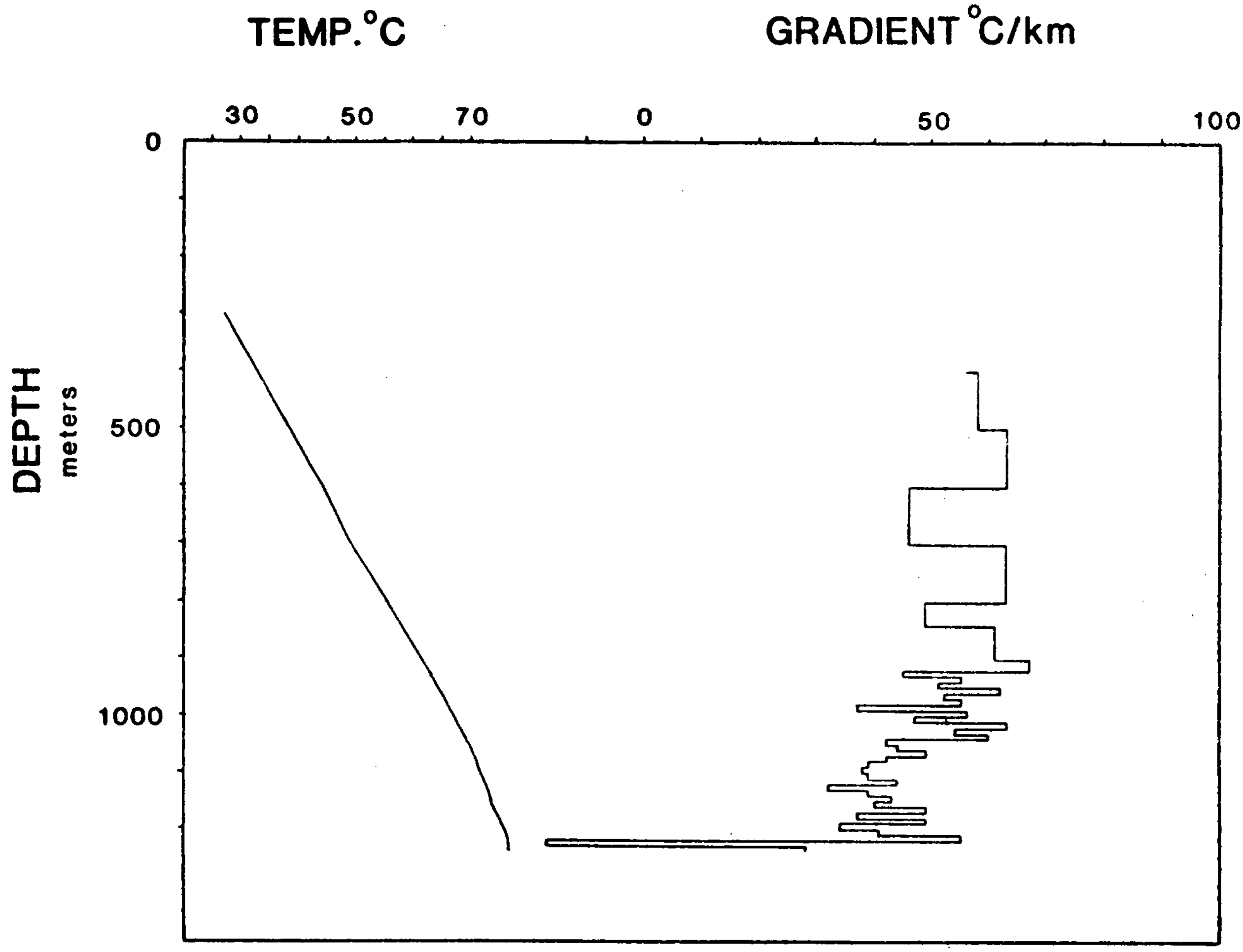

TEMP. °C
15
30
45
60
75
90
0
200
400
600
800
1000
1200
1400
1600
DEPTH
meters
NEBRASKA 1
SIDNEY,NEB
T14N/R50W/SEC 4


TEMP. °C
GRADIENT °C/km
10
30
50
70
0
50
100
0
200
400
600
800
1000
1200
DEPTH
meters
DREVER #1
T14N/R52W/SEC 27

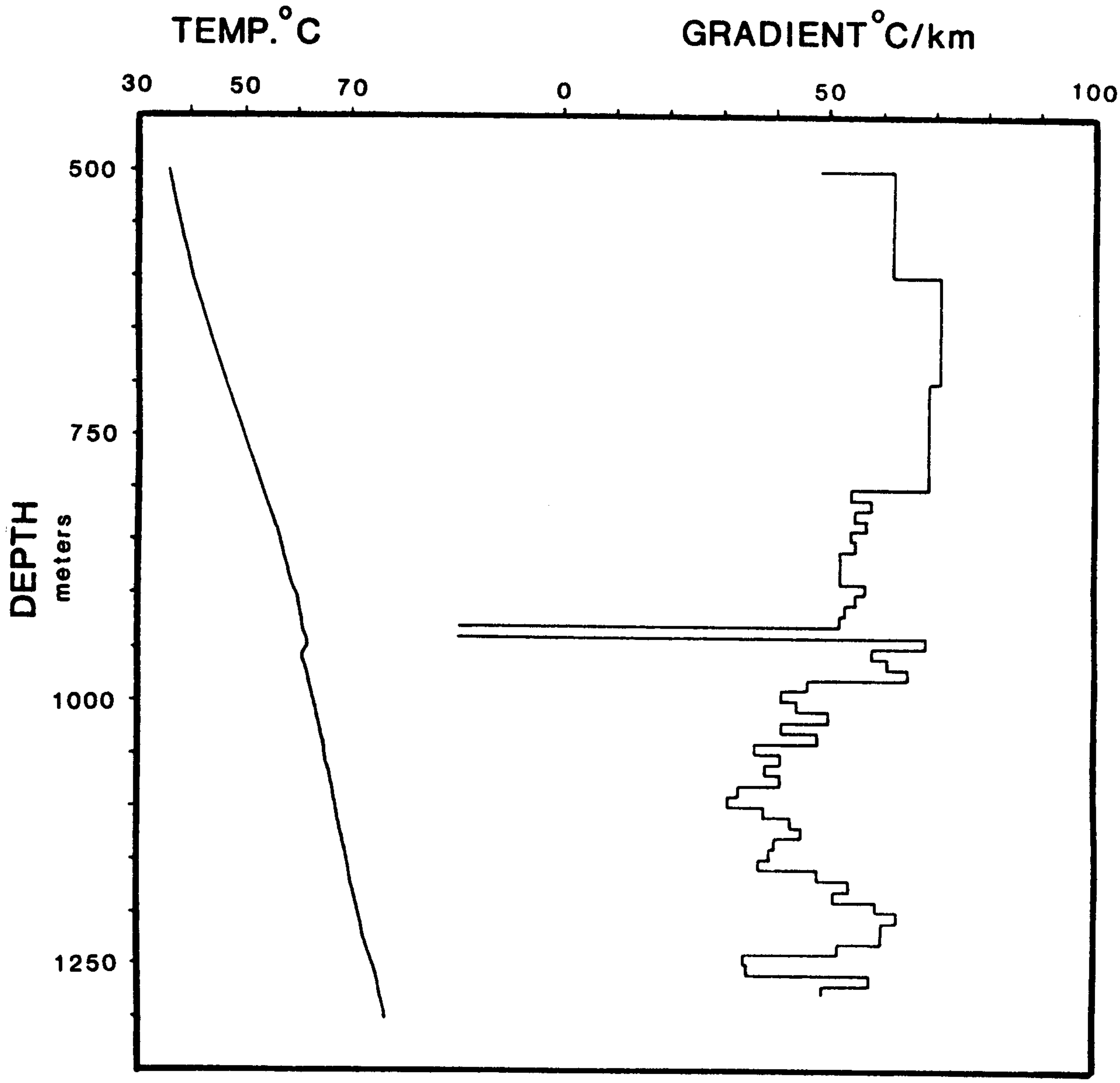

TEMP.°C
GRADIENT °C/km
20
40
60
80
0
50
100
250
500
750
1000
1250
DEPTH
meters
HAGSTROM
T14N/R55W/SEC 19



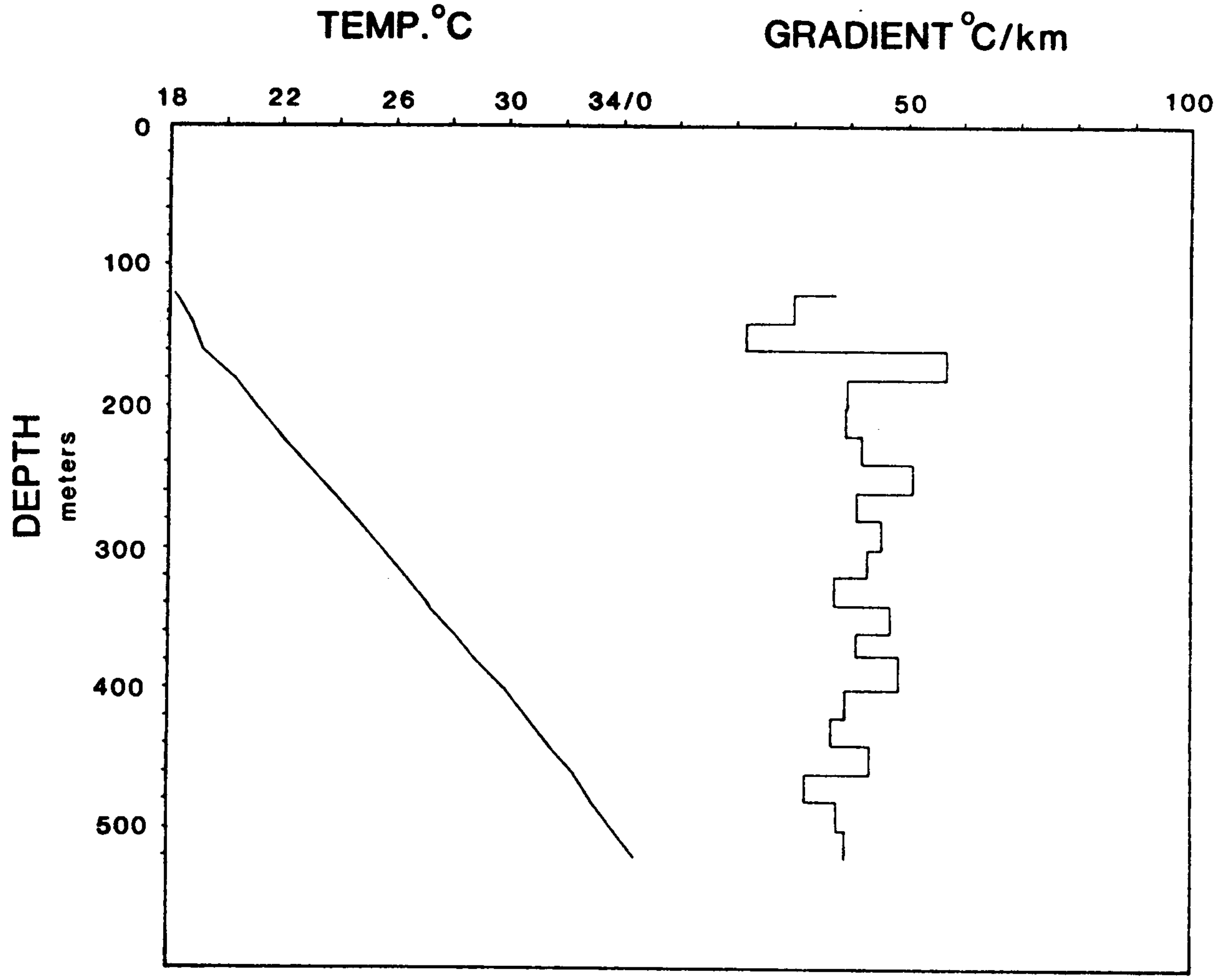
VAN PELT
T17N/R56W/SEC 10



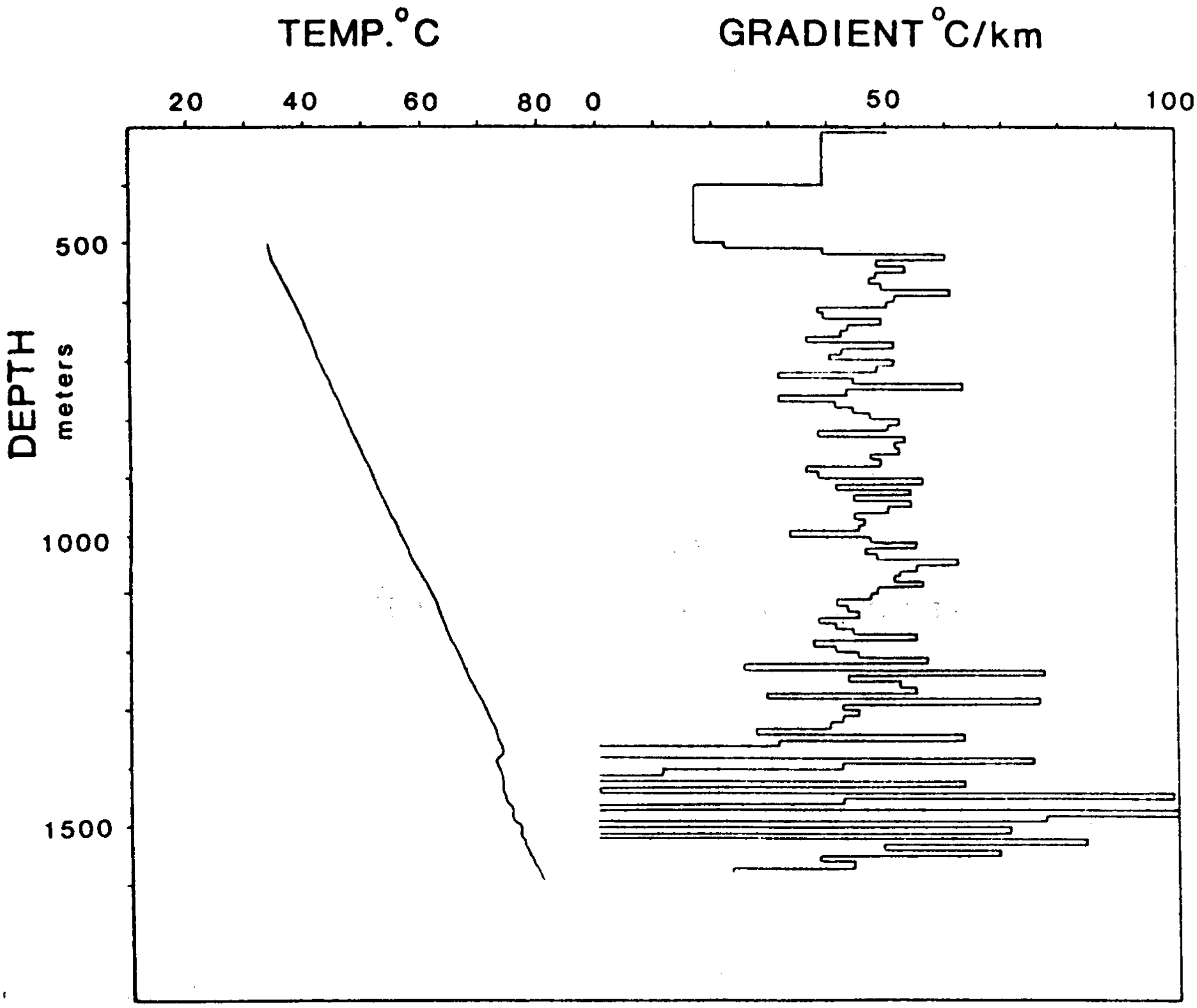
COURT HOUSE ROCK
T18N/R50W/SEC 17/16



BRIDGEPORT
T18N/R51W/SEC 12



SCOTTSBLUFF
T21N/R55W/SEC 28 BD



SCOTTSBLUFF
T21N/R55W/SEC 28

Appendix 2-6

Thermal Gradient Values - Shallow Wells

THERMAL GRADIENT VALUES - SHALLOW WELLS

Number	Name	Location
HFNE1	Riverdale	10N-16W-5DAA
HFNE2	Grant	12N-38W-31CCC
HFNE3	Daykin	4N-1E-31ADD
HFNE4	Plymouth	4N-3E-13DDA
HFNE5	Rising City	15N-1E-27DDD
HFNE6	Dannebrog	14N-11W-22DDD
HFNE7	Merna	18N-22W-24CCC
HFNE8	Alliance	25N-48W-12CCCC
HFNE9	Hemingford	26N-49W-6CCC
HFNE10	Gurley	16N-49W-19BBB
HFNE11	Kimball	15N-55W-7ABB
HFNE12	Grant	9N-39W-2DDD
HFNE13	Imperial	7N-38W-29CBB
HFNE14	Lamar	7N-41W-11DAA
HFNE15	Champion	6N-41W-21CCC
HFNE16	Enders	4N-38W-30BCC
HFNE17	Benkelman	2N-38W-10DDDD
HFNE18	Quick	6N-29W-32CCC
HFNE19	Mayfield	8N-29W-12BBB
HFNE20	Wellfleet	10N-30W-20DDD
HFNE21	Beverly	4N-32W-6BBC
HFNE22	Hayes Center	7N-33W-35DDD
HFNE23	Suttlers Canyon	9N-33W-32DCD
HFNE24	Sutherland	11N-34W-1CCC
HFNE25	Farnam	9N-26W-36ADD
HFNE26	Eustis	6N-24W-23BCB
HFNE27	Ragan	4N-18W-15AD
HFNE28	Minden	6N-15W-34DCC
HFNE29	Elgin	23N-6W-28DC
HFNE30	Brunswick	27N-5W-17AAA

HFNE1
RIVERDALE, NEBRASKA   10N-16W-5DAA   LOGGED 7-23-78

ELEVATION: 687 M
LATITUDE: 40 DEG 51.99 MIN
LONGITUDE: 99 DEG 10.12 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
20.00	11.90	0.00
25.00	12.05	30.00
30.00	11.98	-14.00
35.00	12.16	36.00
40.00	12.67	102.00
45.00	12.73	12.00
50.00	12.82	18.00
55.00	12.96	28.00
60.00	13.05	18.00
65.00	13.18	26.00
70.00	13.64	92.00
74.50	13.31	-73.33

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE2

HFNE2

GRANT, NEBRASKA (NORTH) 12N-38W-31CCCC LOGGED 7-24-78

ELEVATION: 1033 M
LATITUDE: 40 DEG 57.59 MIN
LONGITUDE: 101 DEG 42.36 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	11.58	0.00
20.00	11.63	10.00
25.00	13.30	334.00
30.00	12.41	-178.00
35.00	12.46	10.00
40.00	12.51	10.00
45.00	12.95	88.00
50.00	13.21	52.00
55.00	13.42	42.00
60.00	13.48	12.00
65.00	13.62	28.00
70.00	13.82	40.00
75.00	14.04	44.00
80.00	14.33	58.00
85.00	14.48	30.00
90.00	14.63	30.00
95.00	14.84	42.00
100.00	15.03	38.00
105.00	15.21	36.00
110.00	15.37	32.00
115.00	15.55	36.00
120.00	15.71	32.00
125.00	15.86	30.00
130.00	16.02	32.00
135.00	16.18	32.00
140.00	16.34	32.00
145.00	16.50	32.00
150.00	16.72	44.00
155.00	16.96	48.00
160.00	17.20	48.00
165.00	17.36	32.00
170.00	17.52	32.00
174.00	17.62	25.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

? YES

TYPE IN FIRST DEPTH, LAST DEPTH

? 40,170

HFNE3
DAYKIN, NEBRASKA   4N-1E-31ADD   LOGGED 8-6-78

ELEVATION: 451 M
LATITUDE: 40 DEG 16.35 MIN
LONGITUDE: 97 DEG 21.11 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	11.05	0.00
12.50	11.69	256.00
15.00	11.88	76.00
17.50	11.87	-4.00
20.00	11.96	36.00
22.50	12.05	36.00
25.00	12.11	24.00
27.50	12.06	20.00
30.00	12.10	16.00
32.50	12.14	16.00
35.00	12.18	16.00
37.50	12.21	12.00
40.00	12.25	16.00
42.50	12.28	12.00
45.00	12.32	16.00
47.50	12.34	8.00
50.00	12.38	16.00
52.50	12.40	8.00
55.00	12.43	12.00
57.50	12.46	12.00
58.50	12.49	30.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE4
PLYMOUTH, NEBRASKA   4N-3E-13DDA   LOGGED 8-6-78

ELEVATION: 437 M
LATITUDE: 40 DEG 18.54 MIN
LONGITUDE: 97 DEG 1.98 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
37.50	12.39	0.00
40.00	12.41	8.00
42.50	12.44	12.00
45.00	12.45	4.00
47.50	12.47	8.00
50.00	12.49	8.00
52.50	12.52	12.00
55.00	12.53	4.00
57.50	12.56	12.00
60.00	12.59	12.00
62.50	12.60	4.00
65.00	12.61	4.00
67.50	12.63	8.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE5

RISING CITY, NEBRASKA   15N-1E-27DDD   LOGGED 8-6-78

ELEVATION: 490 M
LATITUDE: 41 DEG 14.21 MIN
LONGITUDE: 97 DEG 17.56 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	11.46	0.00
12.50	11.51	20.00
15.00	11.47	-16.00
17.50	11.16	-124.00
20.00	11.05	-44.00
22.50	11.21	64.00
25.00	11.31	40.00
27.50	11.41	40.00
30.00	11.50	36.00
32.50	11.53	12.00
35.00	11.57	16.00
37.50	11.60	12.00
40.00	11.69	36.00
42.50	11.73	16.00
45.00	11.78	20.00
47.50	11.80	8.00
50.00	11.80	0.00
52.50	11.80	0.00
55.00	11.82	8.00
57.50	11.88	24.00
60.00	12.03	60.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE6
DANNEBROG , NEBRASKA 14N-11W-22DDD LOGGED 8-6-78

ELEVATION: 579 M
LATITUDE: 41 DEG 9.82 MIN
LONGITUDE: 98 DEG 33.46 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
12.50	11.96	0.00
15.00	11.96	0.00
17.50	11.98	8.00
20.00	12.00	8.00
22.50	12.00	0.00
25.00	12.03	12.00
27.50	12.06	12.00
30.00	12.10	16.00
32.50	12.13	12.00
35.00	12.19	24.00
37.50	12.23	16.00
40.00	12.27	16.00
42.50	12.32	20.00
45.00	12.36	16.00
47.50	12.42	24.00
50.00	12.47	20.00
52.50	12.52	20.00
55.00	12.58	24.00
57.50	12.64	24.00
60.00	12.70	24.00
62.50	12.77	28.00
65.00	12.84	28.00
67.50	12.96	48.00
70.00	12.97	4.00
72.50	13.04	28.00
75.00	13.11	28.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE7

MERNA, NEBRASKA   18N-22W-24CCCC   LOGGED 8-7-78

ELEVATION: 804 M
LATITUDE: 41 DEG 30.58 MIN
LONGITUDE: 99 DEG 48.38 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	10.83	0.00
12.50	10.99	64.00
15.00	11.03	16.00
17.50	11.11	32.00
20.00	11.19	32.00
22.50	11.28	36.00
25.00	11.33	20.00
27.50	11.40	28.00
30.00	11.49	36.00
32.50	11.55	24.00
35.00	11.66	44.00
37.50	11.74	32.00
40.00	11.80	24.00
4.50	11.86	24.00
45.00	11.94	32.00
47.50	11.99	20.00
49.50	12.05	30.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE8
ALLIANCE, NEBRASKA 25N-48W-12CCCC LOGGED 8-7-78

ELEVATION: 1213 M
LATITUDE: 42 DEG 9.43 MIN
LONGITUDE: 102 DEG 52.62 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	10.35	0.00
12.50	10.79	176.00
15.00	11.20	164.00
17.50	10.74	-184.00
20.00	10.76	8.00
22.50	10.81	20.00
25.00	10.84	12.00
27.50	10.88	16.00
30.00	10.93	20.00
32.50	11.00	28.00
35.00	11.05	20.00
37.50	11.11	24.00
40.00	11.19	32.00
42.50	11.26	28.00
45.00	11.32	24.00
47.50	11.39	28.00
50.00	11.46	28.00
52.50	11.51	20.00
55.00	11.55	16.00
57.00	11.63	40.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE9

HEMINGFORD, NEBRASKA   26N-49W-6CCC   LOGGED 8-7-78

ELEVATION: 1292 M
LATITUDE: 42 DEG 14.95 MIN
LONGITUDE: 103 DEG 5.43 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	9.82	0.00
12.50	9.97	60.00
15.00	9.95	-8.00
17.50	9.98	12.00
20.00	10.06	32.00
22.50	10.17	44.00
25.00	10.29	48.00
27.50	10.41	48.00
30.00	10.52	44.00
32.50	10.64	48.00
35.00	10.75	44.00
37.50	10.86	44.00
40.00	11.00	56.00
42.50	11.12	48.00
45.00	11.29	68.00
47.50	11.31	8.00
50.00	11.38	28.00
52.50	11.45	28.00
55.00	11.52	28.00
57.50	11.61	36.00
60.00	11.69	32.00
62.50	11.78	36.00
65.00	11.85	28.00
67.50	11.94	36.00
70.00	12.01	28.00
72.50	12.07	24.00
75.00	12.14	28.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE10
GURLEY, NEBRASKA   16N-49W-19BBB   LOGGED 8-8-78

ELEVATION: 1304 M
LATITUDE: 41 DEG 21.05 MIN
LONGITUDE: 102 DEG 59.45 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	10.78	0.00
17.50	10.88	40.00
20.00	11.02	56.00
22.50	11.08	24.00
25.00	11.23	60.00
27.50	11.35	48.00
30.00	11.55	80.00
32.50	11.65	40.00
35.00	11.81	64.00
37.50	11.92	44.00
40.00	12.08	64.00
42.40	12.18	41.67
45.00	12.31	50.00
47.50	12.43	48.00
50.00	12.55	48.00
52.50	12.71	64.00
55.00	12.86	60.00
57.50	12.98	48.00
60.00	13.13	60.00
62.50	13.24	44.00
65.00	13.40	64.00
67.50	13.63	92.00
70.00	13.66	12.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE11
KIMBALL, NEBRASKA 15N-55W-7ABB LOGGED 8-8-78

ELEVATION: 1496 M
LATITUDE: 41 DEG 17.55 MIN
LONGITUDE: 103 DEG 40.25 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	10.84	0.00
17.50	10.92	32.00
20.00	10.94	8.00
22.50	10.90	-16.00
25.00	10.96	24.00
27.50	11.04	32.00
30.00	11.15	44.00
32.50	11.23	32.00
35.00	11.33	40.00
37.50	11.43	40.00
40.00	11.55	48.00
42.50	11.66	44.00
45.00	11.77	44.00
47.50	11.86	36.00
50.00	11.94	32.00
52.50	12.03	36.00
55.00	12.13	40.00
57.50	12.25	48.00
60.00	12.35	40.00
62.50	12.45	40.00
65.00	12.53	32.00
67.50	12.58	20.00
70.00	12.59	4.00
72.50	12.62	12.00
75.00	12.64	8.00
77.50	12.66	8.00
80.00	12.69	12.00
82.50	12.73	16.00
85.00	12.85	48.00
87.50	12.96	44.00
90.00	12.89	-28.00
92.50	12.91	8.00
95.00	13.00	36.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE12
GRANT, NEBRASKA (SOUTH) 9N-39W-2DDD LOGGED 8-9-78

ELEVATION: 1042 M
LATITUDE: 40 DEG 46.31 MIN
LONGITUDE: 101 DEG 43.38 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.77	0.00
17.50	12.81	16.00
20.00	12.78	-12.00
22.50	12.73	-20.00
25.00	12.83	40.00
27.50	12.94	44.00
30.00	13.09	60.00
32.50	13.20	44.00
35.00	13.20	0.00
37.50	13.22	8.00
40.00	13.23	4.00
42.50	13.26	12.00
45.00	13.29	12.00
47.50	13.32	12.00
50.00	13.39	28.00
52.50	13.45	24.00
55.00	13.56	44.00
57.50	13.65	36.00
60.00	13.72	28.00
62.50	13.86	56.00
65.00	13.95	36.00
67.50	13.99	16.00
68.50	14.02	30.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE13
IMPERIAL, NEBRASKA   7N-38W-29CBB   LOGGED 8-9-78

ELEVATION: 1005 M
LATITUDE: 40 DEG 32.65 MIN
LONGITUDE: 101 DEG 39.88 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
27.50	12.80	0.00
30.00	12.83	12.00
32.50	12.89	24.00
35.00	12.96	28.00
37.50	13.08	48.00
40.00	13.19	44.00
42.50	13.29	40.00
45.00	13.38	36.00
47.50	13.47	36.00
50.00	13.58	44.00
52.50	13.67	36.00
55.00	13.78	44.00
57.50	13.85	28.00
60.00	13.96	44.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE14
LAMAR, NEBRASKA   7N-41W-11DAA   LOGGED 8-10-78

ELEVATION: 1066 M
LATITUDE: 40 DEG 35.22 MIN
LONGITUDE: 101 DEG 55.96 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	11.78	0.00
17.50	11.91	52.00
20.00	12.00	36.00
22.50	12.08	32.00
25.00	12.13	20.00
27.50	12.17	16.00
30.00	12.25	32.00
32.50	12.30	20.00
35.00	12.33	12.00
37.50	12.40	28.00
40.00	12.46	24.00
42.50	12.55	36.00
45.00	12.58	12.00
47.50	12.61	12.00
50.00	12.76	60.00
52.50	12.99	92.00
55.00	12.99	0.00
57.50	12.99	0.00
58.00	13.04	100.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE15
CHAMPION, NEBRASKA   6N-41W-21CCC   LOGGED 8-10-78

ELEVATION: 1063 M
LATITUDE: 40 DEG 28.01 MIN
LONGITUDE: 101 DEG 59.01 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
17.50	13.10	0.00
20.00	13.16	24.00
22.50	13.23	28.00
25.00	13.31	32.00
27.50	13.41	40.00
30.00	13.57	64.00
32.50	13.68	44.00
35.00	13.75	28.00
37.50	13.77	8.00
40.00	13.81	16.00
42.50	13.84	12.00
45.00	13.87	12.00
47.50	13.92	20.00
50.00	14.04	48.00
52.50	14.06	8.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE16
ENDERS, NEBRASKA 4N-38W-30BCC LOGGED 8-10-78

ELEVATION: 996 M
LATITUDE: 40 DEG 17.13 MIN
LONGITUDE: 101 DEG 39.58 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.85	0.00
17.50	13.26	164.00
20.00	13.34	32.00
22.50	13.45	44.00
25.00	13.58	52.00
27.50	13.70	48.00
30.00	13.95	100.00
32.50	13.92	-12.00
35.00	14.06	56.00
37.50	14.18	48.00
40.00	14.30	48.00
42.50	14.46	64.00
45.00	14.52	24.00
47.50	14.60	32.00
50.00	14.69	36.00
52.50	14.76	28.00
55.00	14.83	28.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

TYPE IN FIRST DEPTH, LAST DEPTH

LEAST SQUARES GRADIENT BETWEEN 15.0 METERS AND 55.0 METERS IS
46.26 DEG C/KM

STANDARD ERROR OF THE ESTIMATE IS
.08807

IF YOU WANT ANOTHER LEAST SQUARE GRADIENT TYPE YES

TO CONTINUE TYPE IN NEXT CODE, TO STOP TYPE STOP

IATED*

HFNE17
BENKELMAN, NEBRASKA   2N-38W-10DDDD   LOGGED 8-11-78

ELEVATION: 987 M
LATITUDE: 40 DEG 8.95 MIN
LONGITUDE: 101 DEG 35.27 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	13.10	0.00
17.50	12.99	-44.00
20.00	13.31	128.00
22.50	13.45	56.00
25.00	13.64	76.00
27.50	13.82	72.00
30.00	13.85	12.00
32.50	13.90	20.00
35.00	13.92	8.00
37.50	14.03	44.00
40.00	14.09	24.00
42.50	14.15	24.00
45.00	14.18	12.00
46.00	14.26	80.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE18
QUICK, NEBRASKA 6N-29W-32CCC LOGGED 8-11-78

ELEVATION: 859 M
LATITUDE: 40 DEG 26.33 MIN
LONGITUDE: 100 DEG 38.54 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	13.04	0.00
20.00	13.24	40.00
25.00	13.43	38.00
30.00	13.58	30.00
35.00	13.74	32.00
40.00	13.89	30.00
45.00	14.09	40.00
50.00	14.27	36.00
55.00	14.42	30.00
60.00	14.59	34.00
65.00	14.77	36.00
70.00	14.91	28.00
75.00	15.05	28.00
80.00	15.12	14.00
85.00	15.20	16.00
90.00	15.26	12.00
95.00	15.34	16.00
97.50	15.42	32.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE19
MAYFIELD, NEBRASKA   8N-29W-12BBB   LOGGED 8-11-78

ELEVATION: 853 M
LATITUDE: 40 DEG 40.98 MIN
LONGITUDE: 100 DEG 34.17 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.71	0.00
20.00	13.02	62.00
25.00	13.23	42.00
30.00	13.45	44.00
35.00	13.73	56.00
40.00	13.90	34.00
45.00	14.09	38.00
50.00	14.31	44.00
55.00	14.47	32.00
60.00	14.65	36.00
65.00	14.78	26.00
70.00	14.94	32.00
75.00	15.15	42.00
80.00	15.24	18.00
85.00	15.31	14.00
90.00	15.47	32.00
95.00	15.58	22.00
100.00	15.72	28.00
105.00	15.82	20.00
110.00	15.92	20.00
115.00	16.01	18.00
120.00	16.11	20.00
125.00	16.41	60.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE20
·WELLFLEET, NEBRASKA   10N-30W-20DDD   LOGGED 8-11-78

ELEVATION: 908 M
LATITUDE: 40 DEG 48.67 MIN
LONGITUDE: 100 DEG 45.29 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.29	0.00
20.00	12.54	50.00
25.00	12.54	0.00
30.00	12.65	22.00
35.00	12.82	34.00
40.00	12.96	28.00
45.00	13.06	20.00
50.00	13.16	20.00
55.00	13.25	18.00
60.00	13.35	20.00
65.00	13.54	38.00
70.00	13.59	10.00
75.00	13.61	4.00
80.00	13.64	6.00
85.00	13.64	0.00
90.00	13.66	4.00
95.00	13.68	4.00
100.00	13.70	4.00
105.00	13.65	-10.00
110.00	14.16	102.00
115.00	14.19	6.00
120.00	14.14	-10.00
125.00	14.39	50.00
130.00	14.69	60.00
135.00	14.78	18.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE21
BEVERLY, NEBRASKA   4N-32W-6BBC   LOGGED 8-12-78

ELEVATION: 885 M
LATITUDE: 40 DEG 22.31 MIN
LONGITUDE: 100 DEG 59.06 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.35	0.00
20.00	12.80	90.00
25.00	12.84	8.00
30.00	13.12	56.00
35.00	13.29	34.00
40.00	13.58	58.00
45.00	13.76	36.00
50.00	13.94	36.00
55.00	14.17	46.00
60.00	14.41	48.00
65.00	14.54	26.00
70.00	14.61	14.00
75.00	14.83	44.00
80.00	14.84	2.00
85.00	14.84	0.00
90.00	14.84	0.00
95.00	14.92	16.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE22
HAYES CENTER, NEBRASKA 7N-33W-35DDD LOGGED 8-12-78

ELEVATION: 920 M
LATITUDE: 40 DEG 31.34 MIN
LONGITUDE: 101 DEG 1.53 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
10.00	11.90	0.00
15.00	12.12	44.00
20.00	12.26	28.00
25.00	12.71	90.00
30.00	12.98	54.00
35.00	13.21	46.00
40.00	13.42	42.00
45.00	13.68	52.00
50.00	13.92	48.00
55.00	14.10	36.00
60.00	14.28	36.00
65.00	14.38	20.00
70.00	14.48	20.00
75.00	14.59	22.00
80.00	14.66	14.00
85.00	14.75	18.00
90.00	14.84	18.00
95.00	14.98	28.00
100.00	15.06	16.00
105.00	15.11	10.00
110.00	15.15	8.00
115.00	15.23	16.00
120.00	15.22	-2.00
125.00	15.48	52.00
130.00	16.07	118.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE23
SUTTLERS CANYON, NEBRASKA 9N-33W-32DCD LOGGED 8-12-78

ELEVATION: 986 M
LATITUDE: 40 DEG 41.95 MIN
LONGITUDE: 101 DEG 5.87 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.63	0.00
20.00	12.72	18.00
25.00	12.77	10.00
30.00	12.94	34.00
35.00	13.10	32.00
40.00	13.25	30.00
45.00	13.43	36.00
50.00	13.60	34.00
55.00	13.78	36.00
60.00	13.88	20.00
65.00	14.03	30.00
70.00	14.19	32.00
75.00	14.34	30.00
80.00	14.36	4.00
85.00	14.40	8.00
90.00	14.44	8.00
95.00	14.43	-2.00
100.00	14.44	2.00
105.00	14.42	-4.00
110.00	14.50	16.00
115.00	14.54	8.00
120.00	14.53	-2.00
125.00	14.58	10.00
130.00	14.55	-6.00
135.00	14.71	32.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE24

SUTHERLAND, NEBRASKA 11N-34W-1CCC LOGGED 8-12-78

ELEVATION: 975 M
LATITUDE: 40 DEG 56.71 MIN
LONGITUDE: 101 DEG 8.86 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.69	0.00
20.00	12.48	-42.00
25.00	12.71	46.00
30.00	12.85	28.00
35.00	12.92	14.00
40.00	13.07	30.00
45.00	13.16	18.00
50.00	13.26	20.00
55.00	13.34	16.00
60.00	13.38	8.00
65.00	13.53	30.00
70.00	13.53	0.00
75.00	13.60	14.00
80.00	13.59	-2.00
85.00	13.61	4.00
90.00	13.62	2.00
105.00	13.65	2.00
110.00	13.72	14.00
115.00	13.69	-6.00
120.00	13.71	4.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE25
FARNAM, NEBRASKA 9N-26W-36ADD LOGGED 8-13-78

ELEVATION: 847 M
LATITUDE: 40 DEG 42.60 MIN
LONGITUDE: 100 DEG 13.45 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	12.00	0.00
20.00	12.79	158.00
25.00	12.88	18.00
30.00	13.06	36.00
35.00	13.25	38.00
40.00	13.45	40.00
45.00	13.64	38.00
50.00	13.85	42.00
55.00	14.02	34.00
60.00	14.24	44.00
65.00	14.46	44.00
70.00	14.65	38.00
75.00	14.80	30.00
80.00	15.00	40.00
85.00	15.08	16.00
90.00	15.13	10.00
95.00	15.15	4.00
100.00	15.17	4.00
105.00	15.22	10.00
110.00	15.24	4.00
115.00	15.30	12.00
120.00	15.36	12.00
125.00	15.44	16.00
130.00	15.52	16.00
135.00	15.54	4.00
140.00	15.56	4.00
145.00	15.86	60.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE26
EUSTIS, NEBRASKA   6N-24W-23BCB   LOGGED 8-13-78

ELEVATION: 763 M
LATITUDE: 40 DEG 29.55 MIN
LONGITUDE: 100 DEG 1.17 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	13.05	0.00
20.00	13.05	0.00
25.00	13.21	32.00
30.00	13.35	28.00
35.00	13.26	-18.00
40.00	13.67	82.00
45.00	13.79	24.00
50.00	13.92	26.00
55.00	14.03	22.00
60.00	14.08	10.00
65.00	14.12	8.00
70.00	14.29	34.00
75.00	14.40	22.00
80.00	14.53	26.00
85.00	14.74	42.00
90.00	14.81	14.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE27
RAGAN, NEBRASKA 4N-18W-15AD LOGGED 8-13-78

ELEVATION: 691 M
LATITUDE: 40 DEG 18.85 MIN
LONGITUDE: 99 DEG 19.73 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	13.00	0.00
20.00	12.00	-200.00
25.00	12.33	66.00
30.00	12.54	42.00
35.00	12.69	30.00
40.00	12.77	16.00
45.00	12.87	20.00
50.00	12.97	20.00
55.00	13.07	20.00
60.00	13.12	10.00
65.00	13.17	10.00
70.00	13.22	10.00
75.00	13.25	6.00
80.00	13.29	8.00
85.00	13.32	6.00
90.00	13.37	10.00
95.00	13.39	4.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE28
MINDEN, NEBRASKA 6N-15W-34DCC LOGGED 8-13-78

ELEVATION: 664 M
LATITUDE: 40 DEG 26.19 MIN
LONGITUDE: 99 DEG 0.00 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	11.82	0.00
17.50	12.23	164.00
20.00	12.13	-40.00
22.50	12.15	8.00
25.00	12.19	16.00
27.50	12.24	20.00
30.00	12.30	24.00
32.50	12.33	12.00
35.00	12.37	16.00
37.50	12.37	0.00
40.00	12.38	4.00
42.50	12.43	20.00
45.00	12.43	0.00
47.50	12.42	-4.00
50.00	12.43	4.00
52.50	12.44	4.00
55.00	12.45	4.00
60.00	12.46	2.00
62.50	12.49	12.00
64.00	12.49	0.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE29
ELGIN, NEBRASKA   23N-6W-28DC   LOGGED 8-18-78

ELEVATION: 585 M
LATITUDE: 41 DEG 55.73 MIN
LONGITUDE: 98 DEG 1.06 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	11.57	0.00
17.50	11.49	-32.00
20.00	11.50	4.00
22.50	11.53	12.00
25.00	11.55	8.00
27.50	11.62	28.00
30.00	11.68	24.00
32.50	11.72	16.00
35.00	11.74	8.00
37.50	11.82	32.00
40.00	11.85	12.00
42.50	11.90	20.00
45.00	11.95	20.00
47.50	12.00	20.00
50.00	12.06	24.00
52.50	12.11	20.00
55.00	12.17	24.00
57.50	12.22	20.00
60.00	12.28	24.00
62.50	12.34	24.00
65.00	12.40	24.00
66.00	12.41	10.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

HFNE30
BRUNSWICK, NEBRASKA 27N-5W-17AAA LOGGED 8/18/78

ELEVATION: 563 M
LATITUDE: 42 DEG 19.18 MIN
LONGITUDE: 97 DEG 54.83 MIN

DEPTH (METERS)	TEMPERATURE (DEG CELSIUS)	GRADIENT (DEG C/KM)
15.00	11.28	0.00
17.50	11.30	8.00
20.00	11.27	-12.00
22.50	11.30	12.00
25.00	11.31	4.00
27.50	11.36	20.00
30.00	11.35	-4.00
32.50	11.43	32.00
35.00	11.51	32.00
37.50	11.62	44.00
40.00	11.69	28.00
42.50	11.78	36.00
45.00	11.84	24.00
47.50	11.90	24.00
50.00	11.97	28.00
52.50	12.02	20.00
55.00	12.06	16.00
57.50	12.13	28.00

IF YOU WANT A LEAST SQUARES GRADIENT TYPE YES

Appendix 6-1

Dissemination of Geothermal Information

STATE OF NEBRASKA

DISSEMINATION OF GEOTHERMAL INFORMATION PERTINENT TO NEBRASKA STATE-COUPLED PROGRAM

* * PUBLICATIONS * *
6/30/83

Gosnold, W. D., Jr., 1979, Heat Flow and the geothermal regime of Nebraska and the Great Plains [abs.]: The Nebraska Academy of Sciences, 89th Annual Meeting, Proceedings, p. 49-50.

Gosnold, W. D., Jr., 1979, Geothermal studies, Nebraska: Geothermal Energy and the Eastern U.S., Technical Information Interchange Meeting - Minutes, The Johns Hopkins University Applied Physics Laboratory APL/JHU QM-79-261, no. XXIV, p. 1-12.

Becker, Dave, and Gosnold, W. D., Jr., 1980, Use of the finite difference method to predict subsurface temperatures [abs.]: The Nebraska Academy of Sciences, 90th Annual Meeting, Proceedings, p. 31.

Gosnold, W. D., Jr., 1980, Assessment of geothermal resources in Nebraska [abs.]: The Nebraska Academy of Sciences, 90th Annual Meeting, Proceedings, p. 32.

Shoberg, T. P., and Gosnold, W. D., Jr., 1980, A thermal model of the Elk Creek carbonatite [abs.]: The Nebraska Academy of Sciences, 90th Annual Meeting, Proceedings, p. 33.

Gosnold, W. D., Jr., 1980, Nebraska geothermal resources: Geothermal Energy and the Eastern United States, Fifth Technical Information Interchange Meeting - Minutes, The Johns Hopkins University Applied Physics Laboratory, JHU/APL QM-80-185, no. V, p. 1-20.

Gosnold, W. D., Jr., 1980, Preliminary heat flow data from Nebraska: EOS, v. 61, no. 48, p. 1193-1194.

Gosnold, W. D., Jr., and Eversoll, D. A., 1980, Low temperature geothermal resources in Nebraska, report of investigations: 1979-1980: U.S. Department of Energy, Division of Geothermal Energy, Resource Assessment/Commercialization Planning Meeting, Salt Lake City, Utah, p. 112-124.

Gosnold, W. D., Jr., 1980, Preliminary report on the geothermal resource potential of Nebraska: Geothermal Resources Council Transactions, v. 4, p. 45-48.

Gosnold, W. D., Jr., Eversoll, D. A., and Carlson, M. P., 1980, An inventory of geothermal resources in Nebraska: January Progress Summary of the State-Coupled Program Between U.S. Department of Energy and the University of Nebraska, Conservation and Survey Division, University of Nebraska, Lincoln, Nebraska, 29 p.

Eversoll, D. A., 1981, A computer project for subsurface data at Conservation and Survey Division, University of Nebraska-Lincoln [abs.]: The Nebraska Academy of Sciences, 91st Annual Meeting, Proceedings, p 31.

Gosnold, W. D., Jr., Eversoll, D. A., and Carlson, M. P., 1981, Geothermal investigations in Nebraska: methods and results: Geothermal Direct Heat Program, Glenwood Springs Technical Conference Proceedings, University of Utah Research Institute, DOE/ID/12079-39, ESL-59, v. 1, p. 187-204.

Adams, John, 1981, Geothermal energy: in There s energy for the taking (last in a series): Nebraska Farmer, v. 123, no. 19, p. 63.

Gosnold, W. D., Jr., and Eversoll, D. A., 1981, Usefulness of heat flow data in regional assessment of low temperature geothermal resources with special reference to Nebraska: Geothermal Resources Council Transactions, v. 5, p. 79-82.

Gosnold, W. D., Jr., Becker, D. J., and Eversoll, D. A., 1981, New heat flow data from Nebraska: EOS, v. 62, no. 45, p. 1054.

Gosnold, W. D., Jr., and Eversoll, D. A., compilers, 1982, Map showing Geothermal resources of Nebraska, 1982: National Oceanic and Atmospheric Administration for the U. S. Deparment of Energy, scale 1:500,000.

German, K. E., Jr., 1982, Heat production from the Precambrian basement rock of Nebraska [abs.]: The Nebraska Academy of Sciences, 92nd Annual Meeting, Proceedings, p. 47-48.

Carter, Larry, and Bintner, Gayle, 1982, The use of geothermal data for petroleum exploration in Nebraska [abs.]: The Nebraska Academy of Sciences, 92nd Annual Meeting, Proceedings, p. 46.

McCabe, Don, 1982, Geothermal energy: our newest resource: Nebraska Farmer, v. 124, no. 12, p.12.

Burbank, J. A., 1982, Geothermal energy resources in Nebraska: Fact Sheet, Cooperative Extension Service, University of Nebraska, Lincoln, Nebraska.

Gosnold, W. D., Jr., Eversoll, D. A. and Carlson, M. P., 1982, Three years of geothermal research in Nebraska: Geothermal Direct Heat Program, Roundup Technical Conference Proceedings, Salt Lake City Meeting, University of Utah Research Institute, DOE/ID/12079-71, ESL-98, v. 1, p. 141-157.

Gosnold, W. D., Jr., 1982, Heat flow and water movement in the Dakota Aquifer [abs.]: C. V. Theis Conferences on Geohydrology, Dakota Aquifer Symposium, October 5-6, Lincoln, Nebraska.

Gosnold, W. D., Jr., 1982, Geothermal resource maps and bottom hole temperature surveys: Geothermal Resources Council Transactions, v. 6, p. 23-26.

Gosnold, W. D., Jr., and Eversoll, D. A., 1982, A heat flow anomaly in the Great Plains, EOS, v. 63, no. 45, p. 1091.

* * SUBMITTED PAPERS * *

Gosnold, W. D., Jr., 1983, Heat flow and ground water movement in the central Great Plains: Dakota Aquifer Symposium, National Water Well Association [In Press].

Gosnold, W. D., Jr., 1983, Relation between heat flow and regional ground water flow in the Great Plains of the United States: Submitted to: I.U.G.G., Hamburg, Germany.

STATE OF NEBRASKA

* * PRESENTATIONS * *
6/30/83

Gosnold, W. D., Jr., 1978, Heat flow in the western Great Plains - new data from western Nebraska: presented at Las Cruces, New Mexico Geothermal Energy Symposium - A Focus on New Mexico.

Gosnold, W. D., Jr., 1979, Heat flow and geothermal energy in Nebraska: U.S.G.S Conference on Geothermal Energy, Taos, New Mexico.

Eversoll, D. A., 1980, Nebraska geothermal study: presentation to 50th Annual Nebraska Well Drillers Conference, Lincoln, Nebraska, Feburary, 1980.

Gosnold, W. D., Jr., 1980, The status and potential of geothermal energy: presentation to the Mid-America Alternative Energy Organization, April, 1980.

Gosnold, W. D., Jr., 1980, A summary of the Nebraska geothermal program: presentation to the Physics Department of Creighton University, in: An Inventory of Geothermal Resources in Nebraska, Progress Summary, April, 1980.

Messenger, K. A., 1980, Geothermal energy in Nebraska: presentation to Belmont Elementary school, Lincoln, Nebraska, May 9, 1980.

Gosnold, W. D., Jr., 1980, presentation to the Omaha Nebraska Lions Club, July, 1980.

Carlson, M. P., 1980, Geothermal resources: Energy Education Workshop, Teachers College, University of Nebraska, Lincoln, Nebraska, August 8, 1980.

Gosnold, W. D., Jr., 1980, Taped presentation, Nebraska Educational Television on Nebraska's geothermal resource, October, 1980.

Gosnold, W. D., Jr., 1980, Geothermal exhibit for the 1980 Mid-America Energy Exhibition, Omaha, Nebraska, October, 1980.

Gosnold, W. D., Jr., 1980, Geothermal report to the Nebraska Oil and Gas Commission, Sidney, Nebraska, October, 1980.

Gosnold, W. D., Jr., 1980, Nebraska geothermal resources: Presentation to Geothermal Energy and the Eastern United States, Fifth Technical Information Interchange Meeting, Coolfont Convention Center, Berkeley Springs, Virginia, November, 1980.

Gosnold, W. D., Jr., 1980, Presentation, Geothermal resources in Nebraska: to the Omaha Nebraska Business Men's Association, November, 1980.

Gosnold, W. D., Jr., Eversoll, D. A., and Carlson, M. P., 1980, Production of state geothermal maps generated from geothermal contracts and grants: Information exchange meeting and workshop, Lincoln, Nebraska, November, 1980.

Carlson, M. P., 1980, Report on Nebraska geothermal project to Interstate Oil Compact Commission, Geothermal Resources Committee, Dallas, Texas, December 4, 1980.

Gosnold, W.D. Jr., 1981, Report on Nebraska geothermal project to State-Federal Geothermal Conference, Department of Energy, Geothermal Division, Seattle, Washington, January 26-29, 1981.

Gosnold, W. D., Jr., and Cavanaugh, John, 1981, Geothermal Energy in Nebraska: Taped television presentation in cooperation with Nebraska Public Television, January, 1981.

Gosnold, W. D., Jr., Eversoll, D. A., and Carlson, M. P., 1981, Briefing session for the Nebraska State Energy Office, February, 1981.

Gosnold, W. D., Jr., 1981, Presentation on geothermal resources of Nebraska to Omaha West Rotary Club, Omaha, Nebraska, March, 1981.

Gosnold, W. D., Jr., 1981, Presentation on geothermal resources of Nebraska to the Grain Alcohol Conference, Lincoln, Nebraska, March, 1981.

Gosnold, W. D., Jr., 1981, Presentation on geothermal resources of Nebraska to the Arbor Heights Junior High, Omaha, Nebraska, March, 1981.

Gosnold, W. D., Jr., 1981, "Geothermal Chili": second place prize receipe in the Cornhusker County Chili Cook-off, March, 1981.

Gosnold, W. D., Jr., 1981, Presentation on geothermal energy in Nebraska to the U. S. Energy Plan III hearing in Kansas City, Missouri, April, 1981.

Eversoll, D.A., 1981, A computer project for subsurface data at Conservation and Survey Division, University of Nebraska-Lincoln: Presentation to the Nebraska Academy of Sciences, 91st Annual Meeting, April, 1981.

Gosnold, W. D., Jr., 1981, Presentation on the progress of the state geothermal map of Nebraska to Plains States Geothermal Map Meeting sponsored by the National Oceanic and Atmospheric Administration, Department of Energy, and University of Utah Resources Institute in Boulder, Colorado, August, 1981.

Gosnold, W. D., Jr., 1981, Geothermal resources in Nebraska: presentation to the Institute of Food Technologists, Ak-Sar-Ben section, Omaha, Nebraska, August 26, 1981.

Gosnold, W. D., Jr., 1981, U.S. petroleum supplies and geothermal alternatives, presented to Omaha, Nebraska Sierra Club, Omaha, Nebraska, October, 1981.

Gosnold, W. D., Jr., 1981, Geothermal energy: presented to the Northern Section of the Society of Petroleum Engineers, Omaha, Nebraska, October, 1981.

Gosnold, W.D., Jr., D.J. Becker, and D.A. Eversoll, 1981, New heat flow data from Nebraska: American Geophysical Union Fall Meeting, San Francisco, California, December, 1981.

Carlson, M. P., 1981, Report on Nebraska geothermal project to Interstate Oil Compact Commission, Geothermal Resources Committee, Santa Fe, New Mexico, December, 1981.

Gosnold, W. D., Jr., 1982, "Geothermal Chili": first prize recipe in the Cornhusker County Chili Cook-off, February, 1982.

Carlson, M. P., 1982, Definition and data base for geothermal energy in Nebraska: Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska, Lincoln, Nebraska, May 24, 1982.

Eversoll, D. A., 1982, Geologic framework of geothermal resources in Nebraska: Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska, Lincoln, Nebraska, May 24, 1982.

Gosnold, W. D., Jr., 1982, Indications and potential for geothermal resources in Nebraska: Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska, Lincoln, Nebraska, May 24, 1982.

Roberts, P. R., 1982, Drilling and completion of deep wells in Nebraska: Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska, Lincoln, Nebraska, May 24, 1982.

Carlson, M. P., 1982, Legislative and regulatory status of geothermal energy in Nebraska: Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska, Lincoln, Nebraska, May 24, 1982.

Carlson, M. P., 1982, Report on Nebraska geothermal project to Interstate Oil Compact Commission, Geothermal Resources Committee, Columbus, Ohio, June 14, 1982.

Gosnold, W. D., Jr., 1982, Low temperature geothermal resources in the United States Great Plains: Presentation at the Workshop on Terrestrial Heat Flow Structure and the Structure of the Lithosphere, Liblice, Czechloslovakia.

Gosnold, W. D., Jr., and German, Ken, 1982, Geothermal investigations in Nebraska: Presentation, Symposium on Geothermal Energy, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Carlson, M. P., 1982, Geothermal resources: Energy Education Workshop, Teachers College, University of Nebraska, Lincoln, Nebraska, July 29, 1982.

Gosnold, W. D., Jr., 1982, "Geothermal Chili": participated in the World Champion International Chili Society Cook-off in Los Angeles, California, October, 1982.

Gosnold, W. D., Jr., 1982, A heat flow anomaly in the Great Plains, American Geophysical Union, San Francisco, California, December, 1982.

Carlson, M. P., 1982, Report on Nebraska geothermal project to Interstate Oil Compact Commission, Geothermal Resources Committee, New Orleans, Louisana, December 6, 1982.

Carlson, M. P., 1983, Geothermal resources: Energy Education Workshop, Teachers College, University of Nebraska, Lincoln, Nebraska, May 20, 1983.

Carlson, M. P., 1983, Report on Nebraska geothermal project to Interstate Oil Compact Commission, Geothermal Resources Committee, Tulsa, Oklahoma, June 20, 1983.

Appendix 7-1

Maps:

Geothermal Resources of Nebraska
Location of Oil and Gas Test Holes
with Bottom-Hole Temperature Data

(Maps located in back of report)

STATE OF NEBRASKA

* * MEETINGS ATTENDED AND SPONSORED * *
6/30/83

- - MEETINGS ATTENDED - -

1979-----------------------------------

Geothermal Resources Council meeting on Geothermal Energy and Its Direct Use in the Eastern U.S., Roanoke, Virginia, April 3-5, 1979.
Interstate Oil Compact Commission, Geothermal Resources Committee, Lexington, Kentucky, June 18, 1979.
Second Annual Hot Dry Rock Conference, Santa Fe, New Mexico, September 17-18, 1979.
Geothermal Resources Council Annual Meeting, Reno, Nevada. September 24-27, 1979.
Technical Information Exchange meeting, Berkeley, West Virginia, October 30-31, 1979.
Interstate Oil Compact Commission, Geothermal Resources Committee, Los Angeles, California, December 3, 1979.

1980-----------------------------------

State Coupled Resource Assessment Team Meeting, Salt Lake City, Utah, January 22-24, 1980.
National Ground Water Geothermal Heat Pump Conference and Exposition, Columbus, Ohio, February 11, 1980.
50th Annual Nebraska Well Drillers Conference, Lincoln, Nebraska, February 14, 1980
Interstate Oil Compact Commission, Geothermal Resources Committee, Vail, Colorado, June 16, 1980.
Geothermal Resources Council Annual Meeting, Salt Lake City, Utah, September 9-11, 1980.
State Coupled Resource Assessment Team Meeting, Salt Lake City, Utah, September, 1980 (in conjunction with the above GRC Ann. Mts.)
American Geophysical Union, DeKalb, Illinois, November, 1980
Eastern Geothermal Technical Interchange meeting, Berkeley Springs, West Virginia, November 6-7, 1980
Interstate Oil Compact Commission, Geothermal Resources Committee, Dallas, Texas, December 4, 1980.

1981--------------------------------

Department of Energy, Division of Geothermal Energy State-Federal Geothermal Conference, Seattle, Washington, January 26-29, 1981.
U.S. Energy Plan III Hearing, Kansas City, Missouri, April, 1981.
State Coupled Program Meeting, Glenwood Springs, Colorado, May 4-6, 1981.
Plains States Geothermal Map Meeting, Boulder, Colorado, August 31-September 1, 1981.
Geothermal Resources Council Annual Meeting, Houston, Texas, October 25-29, 1981.
Geothermal Energy, the Institutional Maze and Its Changing Structure, Newport Beach, California, December 1-2, 1981.
American Geophysical Union Meeting, San Francisco, California, December, 1981.
Interstate Oil Compact Commission, Geothermal Resources Committee, Santa Fe, New Mexico, December 7, 1981.

1982--------------------------------

Geothermal State-Coupled Team Conference, Salt Lake City, Utah, April 6-8, 1982.
Geothermal Resources of Nebraska, map workshop, Lincoln, Nebraska, May 24, 1982.
International Conference on Heat Flow and the Structure of the Lithosphere, Liblice, Czechoslovakia, May 30 - June 5, 1982.
Symposium on Geothermal Energy, Los Alamos, New Mexico, June, 1982.
Interstate Oil Compact Commission, Geothermal Resources Committee, Columbus, Ohio, June 14, 1982.
Geothermal Resources Council Annual Meeting, San Diego, California, October 11-14, 1982.
Interstate Oil Compact Commission, Geothermal Resources Committee, New Orleans, Louisana, December 6, 1982.
American Geophysical Union, Fall Meeting, San Francisco, California, December, 1982.

1983--------------------------------

Geothermal Resources Council Workshop on Shallow Geothermal Wells, Reno, Nevada, January 31 - February 1, 1983.
Advisory Committee to Nebraska Energy Office - Review of Geothermal Grant Requests, Lincoln, Nebraska, May 6, 1983.
Interstate Oil Compact Commission, Geothermal Resources Committee, Tulsa, Oklahoma, June 19 - 21, 1983.

- - MEETINGS SPONSORED - -

1980--------------------------------

Meeting with representatives of the Central Great Plains State Coupled Resource Assessment Teams, National Oceanic and Atmospheric Association, and the Earth Science Laboratory-University of Utah Research Institute to define and coordinate data and maps generated from geothermal contracts, Lincoln, Nebraska, November 3, 1980.

Briefing session for the Nebraska State Energy Office, Lincoln, Nebraska, February 6, 1981.

1982--------------------------------

Workshop on the Potential for Low-Temperature Geothermal Resources in Nebraska: Lincoln, Nebraska, May 24, 1982.

Geothermal Resources of Nebraska

1982

Geothermal data compiled by the
University of Nebraska

Map prepared by the
National Geophysical and Solar-Terrestrial Data Center
National Oceanic and Atmospheric Administration
for the
Division of Geothermal Energy
United States Department of Energy

Geothermal data for the map were compiled and interpreted by
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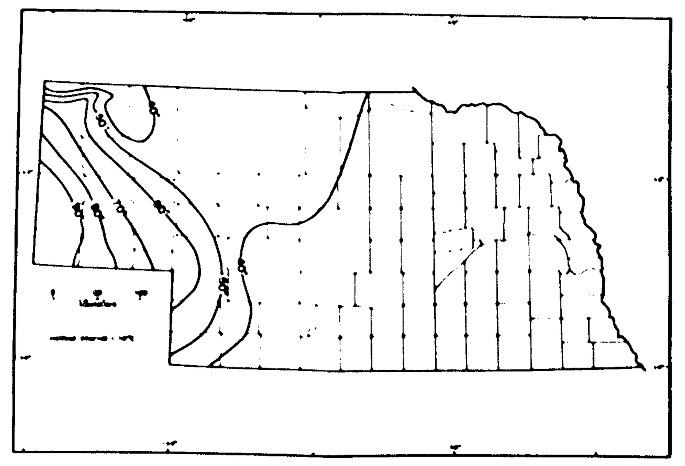
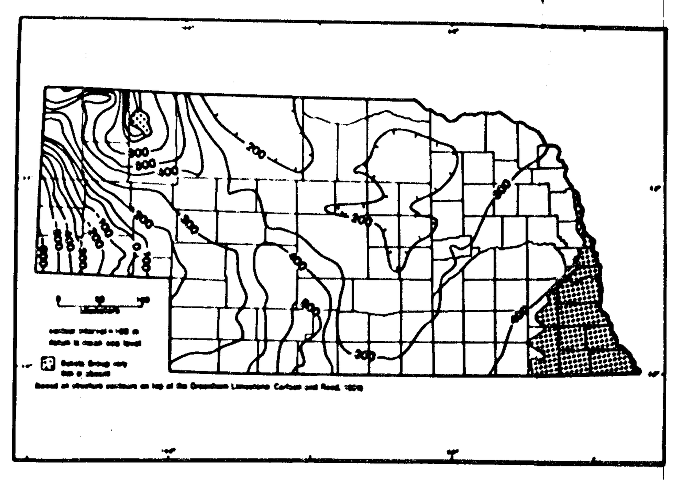
Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln

Scale 1:500,000

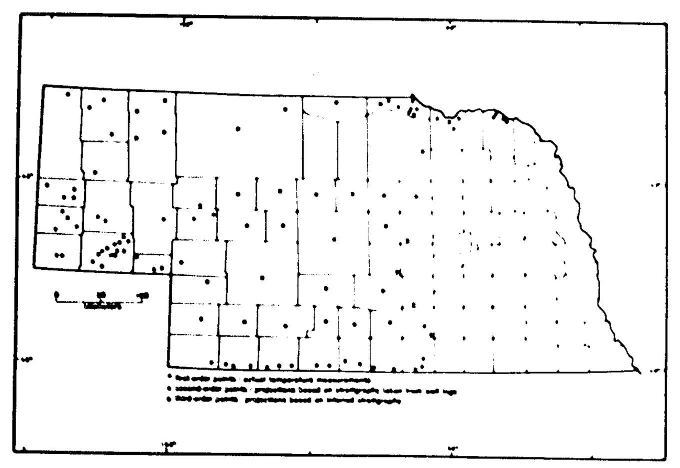
GEOTHERMAL RESOURCES OF NEBRASKA



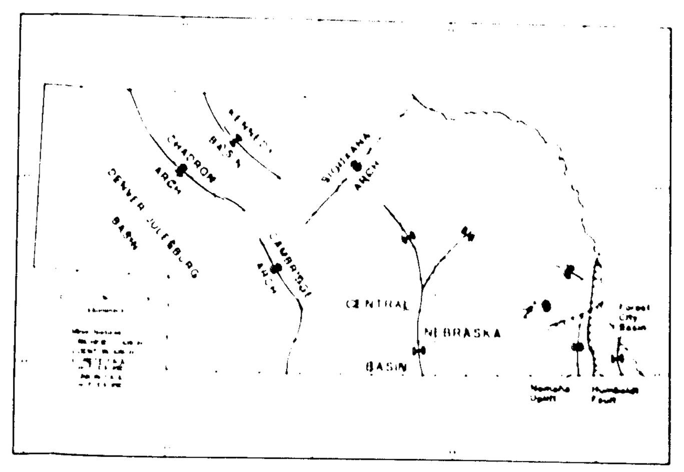
Map 1. Projected temperature contours on top of the Dakota Group (Cretaceous)



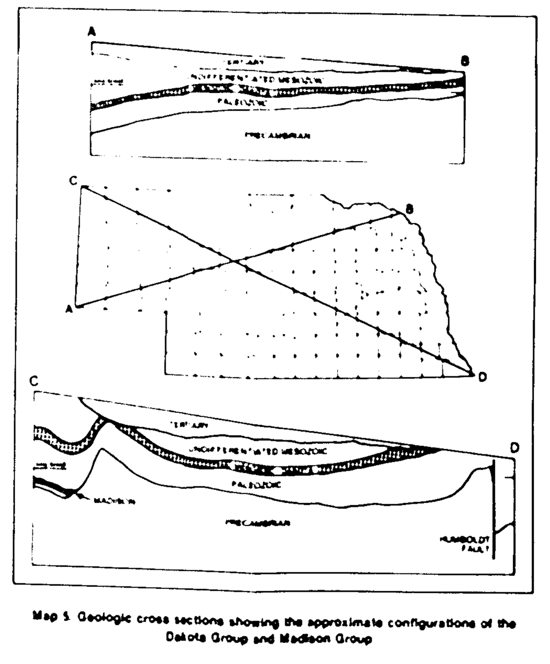
Map 2. Generalized structure contours on top of the Dakota Group (Cretaceous)



Map 3. Locations of control points for subsurface temperature projections



Map 4. Principal structural features



Map 5. Geologic cross sections showing the approximate configurations of the Dakota Group and Madison Group

TECHNICAL REFERENCES

LOCATION OF OIL AND GAS TEST HOLES WITH BOTTOM-HOLE TEMPERATURE DATA

April, 1983

Conservation and Survey Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln