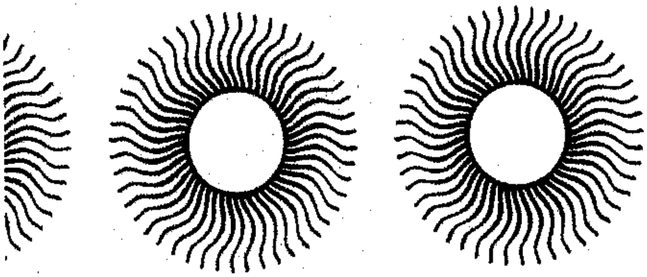

Exploration and Drilling for Geothermal Heat in the Capital District, New York

New York State Energy
Research and Development
Authority

The **New York State Energy Research and Development Authority (ERDA)** is a public benefit corporation chartered by the New York State Legislature. It is governed by a 13-member Board of Directors appointed by the Governor with the consent of the Senate. State Energy Commissioner James L. Larocca is Chairman of the Board and the Chief Executive Officer. A President manages the Authority's RD&D programs, staff, and facilities.

As expressed in its enabling legislation, the underlying rationale for establishing the Authority is:

> *. . . that accelerated development and use within the State of new energy technologies to supplement energy derived from existing sources will promote the State's economic growth, protect its environmental values and be in the best interests of the health and welfare of the State's population . . .*

The legislation further outlines the Authority's mission as:

> *. . . the development and utilization of safe, dependable, renewable and economic energy sources and the conservation of energy and energy resources.*

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State of New York

James L. Larocca
Chairman
New York State Energy
Research & Development
Authority

EXPLORATION AND DRILLING FOR GEOTHERMAL HEAT IN THE CAPITAL DISTRICT, NEW YORK

Final Report

Prepared for

NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

Project Manager
Dr. Burton Krakow

and

U.S. DEPARTMENT OF ENERGY

Project Manager
Dr. David B. Lombard

Prepared by

DUNN GEOSCIENCE CORPORATION
Latham, New York

Project Geologist
Margaret R. Sneeringer

Assistant Project Geologist
W. Konrad Crist

Project Advisor
Dr. James R. Dunn

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NOTICE

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ABSTRACT

The Capital District area of New York was explored to determine the nature of a hydrothermal geothermal system. The chemistry of subsurface water and gas, the variation in gravity, magnetism, seismicity, and temperature gradients were determined. Water and gas analyses and temperature gradient measurements indicate the existence of a geothermal system located under an area from Ballston Spa, southward to Altamont, and eastward toward Albany. Gravimetric and magnetic surveys provided little useful data but microseismic activity in the Altamont area may be significant. Eight wells about 400 feet deep, one 600 feet and one 2232 feet were drilled and tested for geothermal potential. The highest temperature gradients, most unusual water chemistries, and greatest carbon dioxide exhalations were observed in the vicinity of the Saratoga and McGregor faults between Saratoga Springs and Schenectady, New York, suggesting some fault control over the geothermal system. Depths to the warm fluids within the system range from 500 meters (Ballston Spa) to 2 kilometers (Albany).

ACKNOWLEDGEMENTS

Dunn Geoscience Corporation would like to express appreciation to all the landowners who allowed DGC personnel to collect water samples and make gradient measurements in their wells. We are particularly grateful to the following for allowing us to drill water wells on properties in their control:

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Mr. Frederick C. Myers

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Ballston Lake Fire Department

The late Mayor Erastus Corning 2nd and the City of Albany

Supervisor John F. Kirvin and the Town of Rotterdam

City Engineer's Office and the City of Schenectady

Mr. Graham Thompson and personnel of the Rotterdam Industrial Park

General Services Administration and personnel of the Scotia Naval Depot

Dr. Richard O'Rourke and the Burnt Hills-Ballston Lake Central School District

We would particularly like to acknowledge the outstanding cooperation provided by Mr. Thomas Quinn and his staff at Steven's Elementary School in the town of Ballston Lake both while drilling was under way during the site restoration.

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SUMMARY

Exploration for geothermal energy in the Capital District of New York has defined an area of anomalous natural geothermal heat which encompasses much of the Capital District. A minimum 20°C/km temperature gradient goes as far south as Altamont and a broader 20°C/km or greater gradient extends north of the Mohawk River to Ballston Spa. Temperature gradients may be as high as 42°C/km with a heat flow as high as 2.35 Heat Flow Units. The anomalous heat is mostly within a much larger area of carbon dioxide-rich brines which extends from the Albany-Schenectady area northward to Glens Falls. The brines contain about 20,000 ppm (parts per million) total dissolved solids, largely sodium chloride, in the Albany-Schenectady area (as compared to less than 5000 ppm to the immediate south). Toward Saratoga Springs the total dissolved solids concentration lessens, probably in response to pumping of these fluids for commercial uses. North of Saratoga Springs the carbon dioxide brines become depleted in chlorine and enriched in potassium and bicarbonate to become sodium-potassum bicarbonate brines. Heat appears to move with the carbon dioxide and largely along fault zones and within permeable zones in the Galway and Little Falls dolomites. The location of the source of the carbon dioxide, heat, and sodium chloride is not known, but evidence points to the western Albany or Westmere area as most likely.

An exploration well drilled in the town of Ballston Lake has a measured temperature of 25.3°C at 711 meters (2332 feet). Samples of the water contained about 16,000 to 17,000 ppm total dissolved solids and were highly carbonated. Because of its high salinity, such water, once heat is extracted, should be returned to the aquifer in a reinjection well, i.e., development of the thermal resource should require at least two wells.

Large quantities of shallow heat which are not related to the natural geothermal system have been observed under the urban areas of the Capital District. Such heat is manifested in ground-water with temperatures that are as much as 5°C

to 11°C higher than the normal 9°C for rural areas. The heat buildup extends as much as 130 meters deep and is a probable result of the insulating and heating effect of buildings. This heat, which has been called the "urban effect," is available in the Capital District as well as many other urban areas. Further investigation into the extent and use of this resource is indicated.

Section 1

INTRODUCTION

INTRODUCTORY STATEMENT

This report is written to complete the requirements for the third phase of exploration for geothermal resources in the Capital District of New York. It follows the second phase report submitted by Dunn Geoscience Corporation (DGC) to New York State Energy Research and Development Authority (ERDA) and the United States Department of Energy (DOE) dated September 4, 1980, in which the results of expanded geochemical sampling, thermal gradient measurement, and geophysical exploration programs were discussed. Phase II concluded that direct evidence of a geothermal system was indicated by an area of thermal gradients ranging from two to four times a background value of approximately 10° C/km. Geochemical and geophysical data produced during the project provided additional supportive indirect evidence. The Phase III contract between DGC and ERDA is titled "Exploration and Drilling for Geothermal Heat in the Capital District, New York," and dated May 15, 1982. ERDA entered into a contract with DOE, and funding was provided through these agencies. A similarly funded related research contract to conduct seismic studies was negotiated with the New York State Geological Survey.

PERSONNEL

The project geologist for this program was Margaret R. Sneeringer, who was responsible for organization, coordination, and operation of the field program, data reduction, and report preparation. Dr. James R. Dunn was Senior Project Advisor, and helped in data interpretation and modeling. George M. Banino was the Financial Advisor, and William E. Cutcliffe was the Senior Technical Advisor for the project. Staff Geologist W. Konrad Crist was the primary field and computer geologist, and the Acting Project Geologist toward the end of the project. Several other DGC geologists were involved in the field program, but in particular, Gretchen R. Rich, Richard L. Mead, and Daniel P. Fenno should be noted for their participation in the program. Michael Maksymik, part of the Technical Staff, was responsible for coordination and implementation of the site restoration program.

Geochemical analyses of water samples were performed by Health Research, Inc., a division of the New York State Department of Health, under the direction of Robert Weinbloom. Electric logging of the 2322 foot well was conducted by James Nakao of the Syosset, New York, office of the United States Geological Survey. Conductivity measurements of chip and core samples from wells drilled during this project were performed under the direction of Dr. Dennis Hodge at the State University of New York at Buffalo. Electric well log interpretation was done primarily by Mr. Boyd Brown, an Associate Geologic Consultant to DGC.

PURPOSE

This work has been the third phase of an exploration program evaluating the geothermal potential of the Capital District of New York. It was intended to further define the shallow thermal characteristics of the system by continuing the geochemical and thermal gradient measurement programs and by a shallow to intermediate depth drilling program. This work was intended to provide sufficient information to select a site and drill an approximately 2000-foot exploration well at a potential use site. The purposes of the 2000-foot well were to:

- test the data derived from the shallow drilling project;
- determine the variations in geothermal gradient;
- determine the existence and location of the geothermal aquifer;
- help determine the viability of the geothermal system as an energy source for the Capital District.

SCOPE

This phase of the exploration program has included an expanded water sampling program for silica, pH, and temperature determinations on water from active domestic wells, and a continuation of the thermal gradient measurements in abandoned water wells. All geologic, geochemical, and geophysical data were combined to provide a sound basis for the selection of shallow (400 to 500 feet) well sites to fill in holes in data and to confirm existing data. Information gathered from the shallow drilling program, and from previous work was used to select a site for a 2000-foot well, which was then drilled and evaluated through water samples, a variety of well logs, and modeling to provide insight into the geothermal system as a potential energy source at a variety of locations, depths, and conditions.

Section 2

GEOLOGIC SETTING

STRUCTURE

The area of geothermal interest lies on the flank of a major basinal structure that extends far to .the south and west and becomes the Appalachian Basin. Shelf-type sediments lap onto the structurally complex igneous and metamorphic rocks of the Adirondack Mountains to the north, and rapidly thicken to the south and west. The basinal rocks are undeformed except by faulting west of the Capital District, but are both folded and faulted east of the central Capital District largely because of the westward thrusting of the metamorphosed lower Paleozoic rocks of the Taconic Mountains. The Taconic front, or thrust edge, passes approximately north-south just east of the Hudson River. Faults in the basin trend from north-south to northeast-southwest with the major faults fading out to the south. A particular fault system, including the MacGregor, Saratoga, and Ballston Lake faults, cuts through the area of geothermal interest, and appears to control the deep movement of geothermal fluids (see Figure 2-1).

STRATIGRAPHY

Following is a very brief review of the stratigraphic units observed in the basin:

Precambrian - A precambrian basement consisting of metamorphic rocks one to two billion years old underlies the sedimentary basin of the central Hudson Valley. Where exposed in the Adirondacks to the immediate northwest, the Precambrian consists of calcitic and dolomitic marbles, quartzites and various metaclastics, as well as granitic and syenitic gneisses. Anorthosites and gabbros form the core of the Adirondacks.

Cambrian - The lowest sedimentary unit is the Cambrian Potsdam sandstone and basal conglomerate which unconformably overlies the basement rocks. The Potsdam may be up to 100-feet thick, but is extremely variable because it was deposited on a hilly erosion surface. The Potsdam is overlain by the Cambrian Theresa

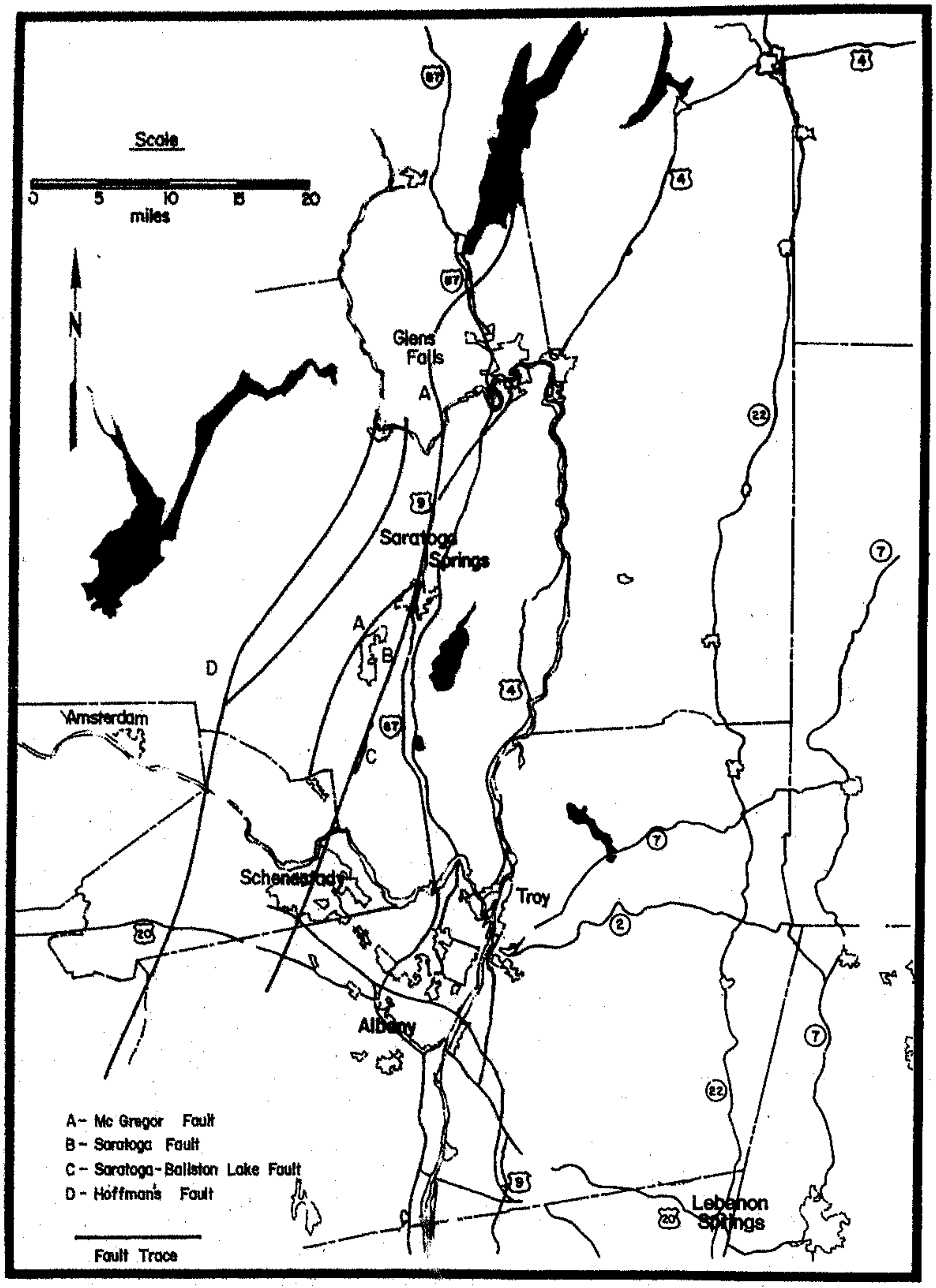


Figure 2-1. Major Faults Within The Capital District

Formation (equivalent to Galway Formation), an intermixed sandstone and dolomite sequence.

Cambro-Ordovician to Ordovician - The Beekmantown Group, an irregular thickness of dolomites interfingered with limestones and sandstones, overlies the Theresa Formation. The Beekmantown formations in this area are, from the bottom up, the Little Falls, the Tribes Hill, and the Chuctanunda Creek which are largely dolomites. The thickness of the Beekmantown is variable because of erosion at the regional Knox Unconformity surface which forms its upper contact and because it wedges out against the Adirondacks. The thickness varies from 0' to the north to 766' at the 2300-foot well drilled in this program.

Middle to Late Ordovician - Above the Knox Unconformity lie the Black River-Trenton limestones, which are more than 100 feet thick at the Glens Falls area. The limestones are overlain by the thick series of shales, siltstones, and minor sandstones of the Canajoharie/Utica and Snake Hill Formations. The Snake Hill Formation consists of the Schenectady, Normanskill, and Austin Glenn members. This sequence is poorly understood because of glacial cover, the depositionally transitional nature of the units, and the complicating factor of being largely covered by older rocks of the Taconic thrust fault sheet or allocthon. The shales are known to have a possible maximum thickness of 3500 feet in this area.

Early Devonian - The Helderberg Group, a series of limestones and cherty units seen as a prominent cliff face known as the Helderberg Escarpment, overlie the Ordovician shales above the Helderberg Group. The overlying sandstones and shales of the Devonian Catskill Delta Complex occur to the south and southwest of the Albany area. The early Devonian occurs at the southern edge of the Capital District study area.

Very little deep drilling has been conducted in the Capital District area, and, therefore, the actual stratigraphy is poorly known. Stratigraphic information was obtained for two holes (Smith and Julick) drilled to basement by NL Industries, and used in estimating stratigraphic thicknesses for the drilling program. Also available was deep stratigraphic information for a gas exploration well drilled in the early 1930's in Altamont, which did not reach basement but did penetrate the carbonate rocks. The stratigraphy of these wells is listed in Table 2-1.

TABLE 2-1

STRATIGRAPHY FOR THREE CAPITAL DISTRICT WELLS

Smith Well*

Depth	Formation
0 - 35'	Overburden
35 - 1065'	Canajoharie/Utica Shale
1065 - 1144'	Trenton Limestone
1144 - 1317'	Chuctanunda Creek Dolomite
1317 - 1648'	Tribes Hill Dolomite
1648 - 1894'	Little Falls Dolomite
1894 - 2062'	Galway Dolomite
2062 - 2086'	Potsdam Sandstone
2086 - 2094'	Basement

Total Depth - 2094'

Julick Well*

Depth	Formation
0 - 19'	Overburden
19 - 233'	Chuctanunda Creek Dolomite
233 - 489'	Tribes Hill Dolomite
489 - 740'	Little Falls Dolomite
740 - 927'	Galway Dolomite
927 - 989'	Potsdam Sandstone
989 - 996	Basement

Total Depth - 996'

Devenpeck Well*

Depth	Formation
0 - 2956'	Canajoharie/Schenectady Shale
2956 - 3012'	Tribes Hill Dolomite
3012'	Little Falls Dolomite

Total Depth - 3012'

*Smith Well located just south of Ballston Spa

*Julick Well located just west of Saratoga Springs
(Personal communication - Jon Broderick)

*Devenpeck Well located in Altamont
(N.Y.S. Geological Survey Bulletin #295)

The locations of these wells are shown on the location map (Figure 2-2), and a sketch cross-section (Figure 2-3) shows the estimated subsurface geology from north to south based on the data from these wells.

During the lower Paleozoic, a deep sedimentary basin existed to the east of Albany in what is now the Hudson Valley. These sediments are different from those in the Saratoga-Altamont area. Faulting and folding also occurred during and after deposition of these sediments causing the depositional sequence to be made more complex. The Taconic overthrust faulting later carried older rock from the east over the younger Hudson Valley rock further complicating the present sequence east of Albany. Recent seismic work and possible future drilling for gas may yield much needed information of the rocks found in the Hudson Valley. Clearly, considerable caution should be employed when using the above stratigraphic information beyond the geographic location of each well.

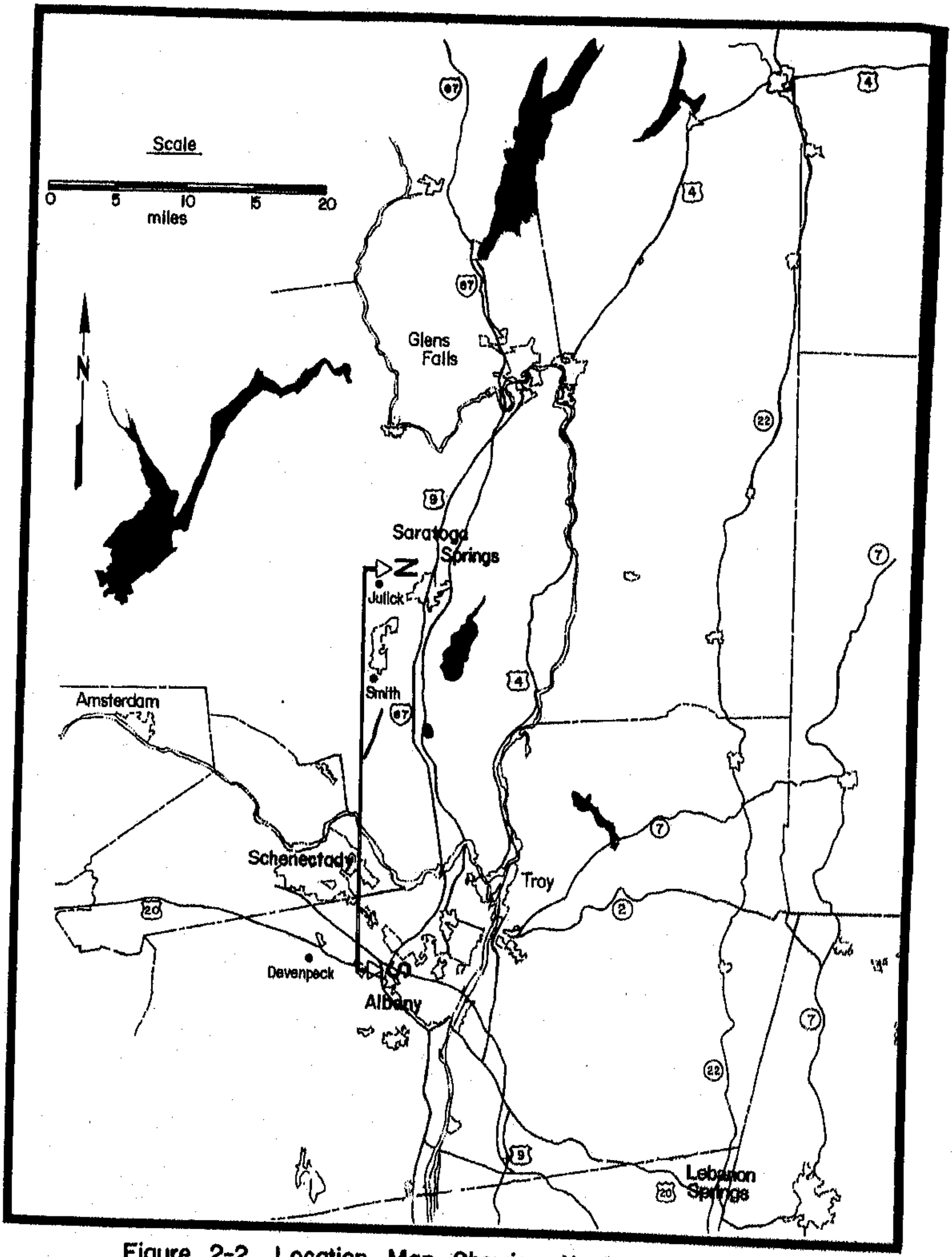
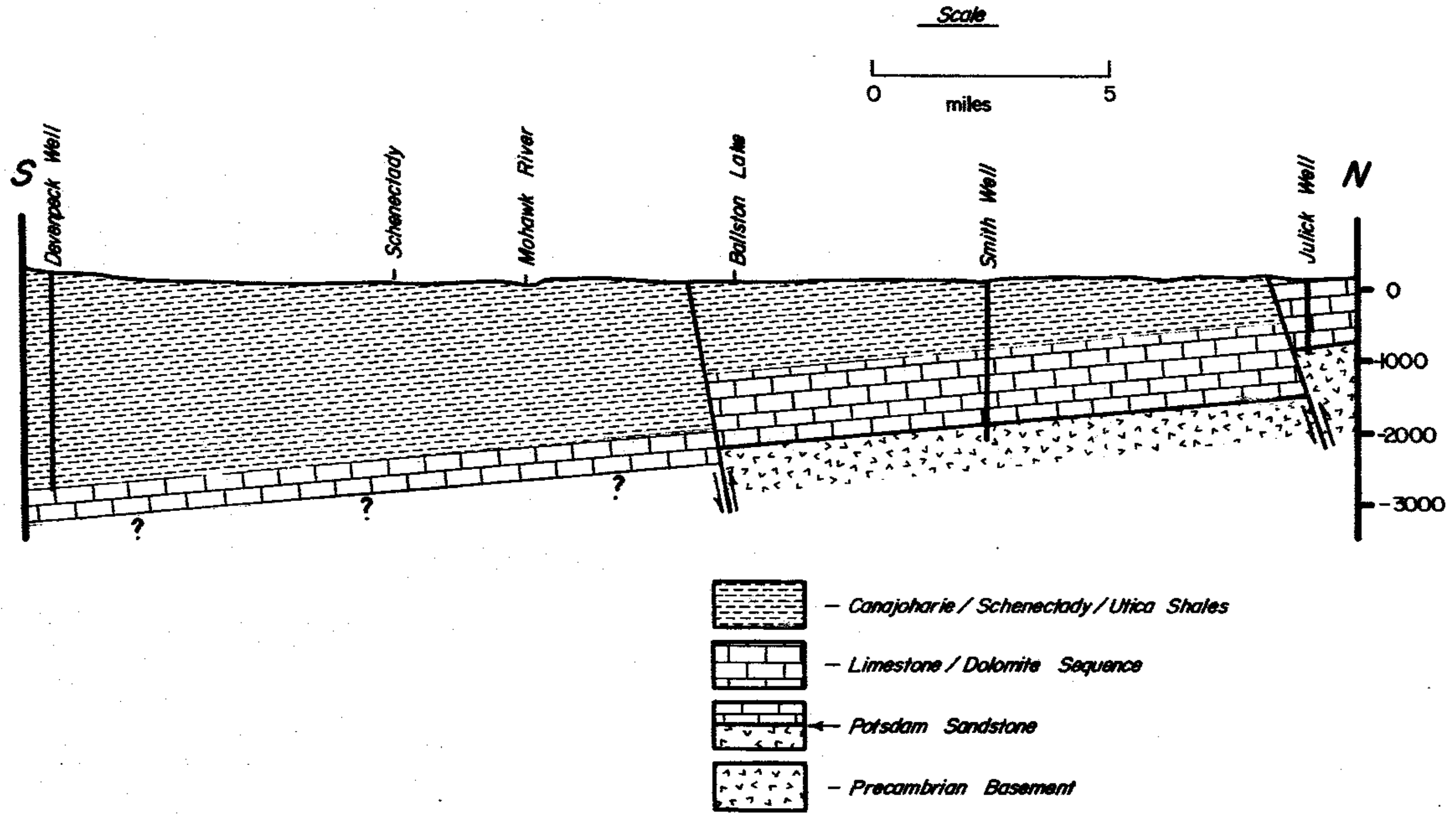


Figure 2-2. Location Map Showing N-S Section Line

Figure 2-3. Structure Cross Section From Saratoga Springs To Altamont, New York



Section 3

GEOCHEMICAL ANALYSES

INTRODUCTION

Initial interest in the possibility of a geothermal system in the Capital District area was sparked by the unusual chemistry of the carbonated waters at Saratoga Springs coupled with the presence of low temperature warm springs at Lebanon Springs. The earliest investigators who considered the origin of Saratoga waters thought that the carbon dioxide had a thermal origin. However, the absence of a source of heat was an obstacle to acceptance of this origin, because such waters throughout the world are generally associated with igneous or metamorphic activity. No other explanation has been suggested and the waters have remained as an enigmatic scientific curiosity. The initial phases of the current geothermal exploration began with an investigation into the chemistry of the system to determine whether clues to the origin of the waters could be found by first applying modern geochemical analysis and interpretation.

PHASE I, REVIEW OF GEOCHEMICAL STUDIES

Water samples from 38 springs and wells in the vicinity of Saratoga Springs were analyzed for a large suite of elements (see Appendix A) to determine the macro- and micro-chemical character of the system and the extent of the carbonated saline waters. The different waters were grouped according to chemical similarity and spatial relationship, and five basic types were defined. These groups included the highly carbonated saline waters typical of Saratoga Springs, a sodium bicarbonate water occurring to the north, essentially uncarbonated saline water occurring to the south, sulfate-bearing water, and relatively pure ground waters. The thermal spring water at Lebanon Springs was also analyzed, and found to be essentially normal ground water that apparently had circulated to great depth from a ground-water recharge zone at a higher elevation to a discharge area at a lower elevation. Geologic conditions as well as the geochemical nature of the water at Lebanon Springs indicated that a different process was at work and that the two systems are probably independent of each other.

A fairly large amount of effort was expended in characterizing the different water types in an attempt to determine the source of the waters. In addition to the extremely large volumes of CO_2 exsolving from the Saratoga area water indicating a possible heat source, the geochemical analyses picked up anomalous concentrations of silica (SiO_2) in several of the samples. Silica is a well recognized geothermal indicator since only two variables govern its concentration in solution; high pH (>11) and high temperatures. As the waters with silica anomalies were neutral to acid, it seemed that high temperature at depth could be the controlling factor for getting silica into solution.

Several other types of analyses were performed on select samples including hydrogen, oxygen, and carbon isotope analyses. The analyses were performed by Ivan Barnes and V.R. O'Neil at the U.S. Geological Survey in Menlo Park, California. The hydrogen and oxygen data, summarized below, indicate that the water in the Saratoga system is largely of meteoric origin although it may be fairly old. Hydrogen and oxygen data also suggest that the saline component of the water is connate (or of the formation) in nature, rather than derived from sea water as dissolved evaporitic salts. The carbon isotope data indicated a thermal origin for the carbon dioxide, but the exact source, i.e., metamorphic or igneous, is uncertain.

TABLE 3-1

ISOTOPE ANALYSIS

Sample	δD	$\delta^{18}O$	Carbonate ppt.	CO_2 gas
Hathorn #3	-64.2	- 9.22	+ .57	-5.03
Orenda	-63.6	-10.39	+ .60	-5.15
Big Red	-65.9	-10.36	-3.92	-6.84
Bennett Well	-79.0	-12.10	-4.35	-7.55
Martin Well	-90.4	-13.26	-4.91	ND

δ = isotope fractionation ratio in <u>sample</u>; expressed in parts per thousand (per mil) difference relation to the standard

D = deuterium isotope of hydrogen

^{18}O = oxygen isotope mass 18

Gas analyses were also performed by Dr. Barnes. These analyses confirmed that carbon dioxide (CO_2) is the dominant gas exsolving from the waters at Saratoga Springs. Anomalous helium was observed in two samples. Although it is recognized as a common radioactive decay product, the source of the helium is unknown.

Radon ^{226} analyses were also performed, and the high radon contents, some over 350 pci/l, were found to be restricted to the Saratoga-type water. Radon, like helium, is also a radioactive decay product. Both radon and helium may be present as a result of a leaching process in which carbonated water extracts the decay products from rocks over a large area and concentrates them in solution.

All these geochemical analyses provided indirect evidence of thermal activity, and a second phase of exploration was initiated to further test the hypothesis.

PHASE II, REVIEW OF GEOCHEMICAL DATA

Geochemical analyses were continued in Phase II; additionally, more direct methods of determining whether or not a geothermal anomaly existed were employed. Complete chemical analyses were performed on 29 new wells, and repeated on six (see Appendix A and Figure 3-1). The waters could all be classified within the same five categories previously identified, and the area of known CO_2 - bearing saline waters was extended to Rotterdam Junction west of Schenectady, and east to Melrose on the east side of the Hudson River, north of Troy. South of the Schenectady-Albany area, saline waters contained less than 5000 ppm total dissolved solids and no CO_2 was observed. As the size of the data base has increased, the classification scheme has become less precise because of dilutions and combinations of water types, along with modifications by wall rock reactions. Gas samples were collected at the time of water sampling, and the results are shown in Table 3-2. Atmospheric contamination proved to be a serious problem, but again CO_2 was shown to be the dominant gas in saline waters.

A regional silica sampling program was begun to try to better define the high silica area observed in the Saratoga Springs vicinity. Water samples were collected from domestic wells penetrating rock and analyzed for SiO_2 (see Appendix B). The results were hand-plotted and contoured, and a definite,

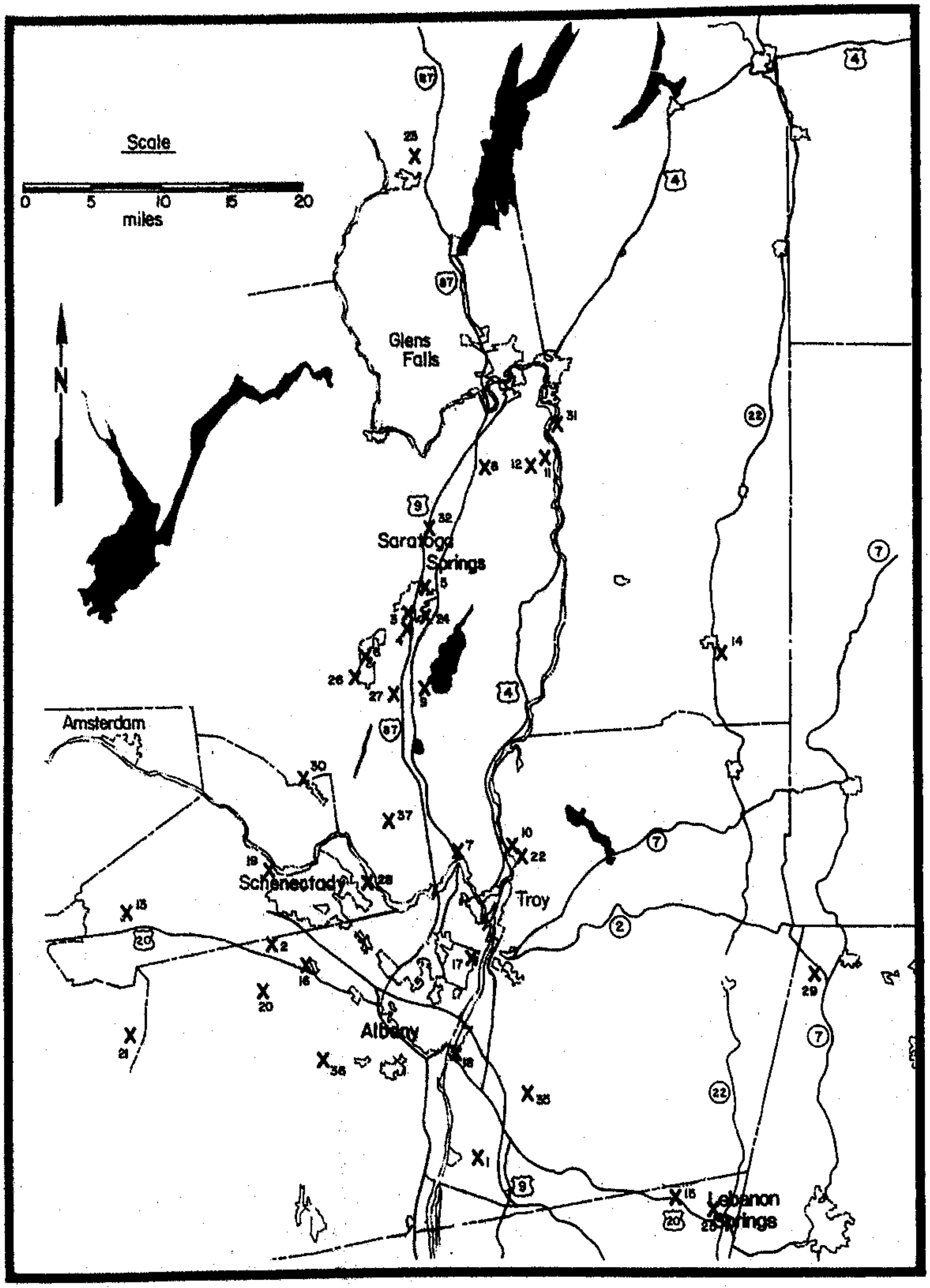


Figure 3-1. Location Map For Standard Geochemical Samples

TABLE 3-2

FREE GAS SAMPLE COMPOSITION

Sample* Number	Oxygen + Argon	Nitrogen	Carbon Dioxide	Helium	Methane	Ethane	Propane	Total
15003**	21.6%	78.0%	0.11%	4.90 ppm	26 ppm	-	-	99.71%
15004**	21.4%	76.7%	0.08%	3.50 ppm	30 ppm	-	-	98.18%
15005**	21.7%	77.5%	0.08%	5.18 ppm	25 ppm	-	-	99.28%
15006	0.41%	9.69%	62.7%	5.20 ppm	21.0%	-	-	93.8%
15007	0.42%	8.37%	0.23%	5.20 ppm	88.0%	360 ppm	1 ppm	97.02%
15008	2.41%	28.3%	0.29%	392.0 ppm	61.0%	142 ppm	-	92.04%
15009	3.09%	13.9%	0.4%	5.80 ppm	72.2%	144 ppm	-	89.59%
15011	0.93%	46.2%	40.8%	1894. ppm	41.9%	268 ppm	1 ppm	100.00%
15015	5.02%	46.8%	0.42%	4303. ppm	40.9%	183 ppm	-	93.57%
15016	0.21%	8.17%	0.38%	34.77 ppm	84.3%	-	1 ppm	93.06%
15017	21.7%	78.1%	0.08%	351.4 ppm	10 ppm	-	-	100.00%
15019	0.05%	1.59%	84.1%	3.86 ppm	7.37%	-	15 ppm	93.11%
15025**	22.2%	76.7%	0.13%	805.90 ppm	12 ppm	-	1 ppm	99.11%
15026**	21.3%	76.1%	2.25%	5.20 ppm	21 ppm	-	-	99.65%
15031	20.9%	75.9%	2.36%	1590.90 ppm	24 ppm	-	-	99.32%

* Last two digits of sample number represents sample numbers on Figure 3-1.

**Contaminated samples where air apparently leaked into containers which failed to seal.

though slight, anomaly could be seen in the Saratoga Springs vicinity and to the southwest.

The continued positive geochemical indicators combined with the more direct thermal gradient indicators led to the third phase of exploration.

PHASE III, GEOCHEMICAL ANALYSES

No further geochemical sampling was done in the third phase of exploration except for determining the water quality for wells drilled during this project. There was, however, some further evaluation of existing data to attempt to identify end members of the complex mixing scheme within the basin, and thereby identify the most likely composition of the assumed geothermal fluid. One end member was identified as a non-carbonate saline water. Using the Phase II geochemical well water data listed in Appendix A, some mixing calculations were attempted. Three water types were used in the calculations (see Table 3-3): saline water (Type I, identified in sample wells 13, 16, and 21 on ternary diagrams), groundwater (Type II, averaged compositions of water from sample wells 14, 18, 32, and 35), and carbonated saline (Type III, average of three samples from sample well 19). Varying proportions of the saline waters and an average ground-water composition were mixed to determine whether any actual well compositions could be approximated from simple mixing of the three "end-members."

These average compositions were then mixed in the following proportions:

50% I, 50% II; 50% II, 50% III; 50% I, 25% II, 25% III; and 25% I, 50% II and 25% III. Of these simple mixes, the results of which are tabulated in Table 3-4, mixing 50% II and 50% III fairly closely resembled the composition of well number 4, and the mixture of 25% I, 50% II, and 25% III, somewhat resembled the composition of well number 5. These calculations indicate that the mixing of subsurface waters involves at least three members, and although the carbonated-saline member can be approximated by the composition of well number 19, it is still apparent from actual concentrations of compounds and elements in the water, that it also is a mixed water.

Wall rock reactions may also affect water composition to varying degrees. It is well known that dissolved CO_2 attacks feldspar and releases sodium

TABLE 3-3

AVERAGED COMPOSITIONS FOR ASSUMED END-MEMBER WATER TYPES USED IN MIXING CALCULATIONS

	Type I Saline Water	Type II Ground-Water	Type III Carbonated-Saline Water
Alkalinity	390.000	205.500	4615.000
SO_4	8.100	89.000	7.000
Cl	5000.000	21.250	6300.000
Na	2933.330	32.550	4733.330
K	31.330	26.330	71.670
Ca	88.300	24.380	583.330
Mg	31.330	0.360	333.330
Fe	3.270	0.550	29.670
PO_4	0.015	0.013	0.035
F	2.400	0.730	0.107
Br	89.330	---	166.670
I	22.330	0.310	10.330
B	0.753	0.350	3.070
Al	0.061	0.160	0.070
Li	12.330	0.080	25.670
SiO_2	4.870	10.830	13.670
Sr	56.000	0.100	143.330
Ba	13.300	0.650	43.600
Ts	9742.000	394.000	19300.000

Results for solids in mg/l

The results of these calculations are tabulated in Table 3-4.

TABLE 3-4

RESULTS OF CALCULATED MIXING OF ASSUMED END-MEMBER WATER TYPES

	50% I 50% II	50% II 50% III	50% I 25% II 25% III	25% I 50% II 25% III
Alkalinity	297.750	2410.250	1400.130	1354.000
SO_4	48.570	48.000	28.070	48.280
Cl	2510.600	3160.600	4080.300	2835.600
Na	1483.000	2382.900	2658.100	1932.900
K	28.800	49.000	24.500	38.900
Ca	56.340	303.850	196.080	180.100
Mg	15.850	106.840	99.010	91.340
Fe	1.920	15.120	9.200	8.520
PO_4	0.014	0.024	0.020	0.014
F	1.560	0.420	1.410	1.810
Br	44.660	83.340	86.330	64.000
I	11.330	5.320	13.830	8.320
B	0.560	1.720	1.240	1.070
Al	0.111	0.115	0.089	0.113
Li	6.200	12.880	12.600	9.540
SiO_2	7.860	12.260	8.570	10.060
Sr	28.050	71.710	63.860	49.880
Ba	6.680	21.830	28.480	14.250
TS	5068.000	9847.000	9794.000	7359.000

Solids are in mg/l.

(Na^+), and potassium (K^+). The high Na^+, K^+ and low chlorine (Cl^-) found in carbonated waters north of Saratoga Springs could result from (1) dilution of saline water causing a reduced total salt content, and (2) addition of K^+, and Na^+ from feldspars increasing the ratio of Na^+ and K^+ to CL^-. Feldspars are locally abundant in the carbonate rocks where the carbonated saline waters primarily occur.

SILICA SAMPLING

The Phase II silica data indicated a rough correlation of higher silica content of the regional groundwater with major faults, and to some degree water temperature. The silica sampling program was expanded to improve coverage in the area from Saratoga Springs to Schenectady and Albany, and to join the data sets from the Saratoga vicinity and the Lebanon Springs vicinity. Analyses were performed by Health Research, Inc., the State Health laboratory, under the direction of Robert Weinbloom.

Temperature measurements were made in the field, and pH measured in the laboratory upon submission of the water samples. The silica data obtained from this program are included in Appendix B. Also included are water temperature, pH, silica geotemperature calculated for quartz, and calculated heat flow based on quartz geotemperatures. The formulas by which the silica geotemperatures are calculated are, for chalcedony as the equilibrium phase...

$$T^{o}C = \frac{1032}{4.69 - \log C} - 273.15 \qquad (3\text{-}1)$$

and for quartz as the equilibrium phase...

$$T^{o}C = \frac{1309}{5.19 - \log C} - 273.15 \qquad (3\text{-}2)$$

where C = silica concentration in mg/l. These temperatures represent the last temperature at which the water was in equilibrium with the given silica phase. It was noted that temperatures calculated assuming equilibrium with chalcedony were extremely low, and in many cases negative. It is assumed, therefore, that the equilibrium phase with which we are dealing, is most likely to be quartz. Individual heat flow values were then calculated using the quartz geotemperatures and the relationship $T/sil_2 = mq + b$, developed by Chandler and Swanberg, 1978, where T/sil_2 is the silica geotemperature in ^oC, m and b are constants determined to be $0.67^{o}C\ m^{2}\ mW^{-1}$ and $13.2^{o}C$ respectively, and q is the heat flow in mWm^{-2}.

The previously collected data was hand-contoured in order to evaluate the spatial variation in silica content and to determine whether a real pattern existed or whether the results were random over the area in question. This rough contouring did indicate a positive correlation between slightly elevated silica contents of groundwaters in the area and the major Saratoga-McGregor Fault System. In the present research, the computer system at Rensselaer Polytechnic Institute was used to generate the contour maps for silica data using a program called Surface II developed at the Kansas Geological Survey. Appendix C has a more complete description of computer techniques.

Contouring of the silica concentrations involved the entire data set including both this year's and last year's results. In order to avoid unnecessary distortion of the contours, the sites producing carbonated saline waters with notably higher silica contents (>25 ppm) were removed from the data set, and only normal groundwaters (non-carbonated, non-saline) were used in the regional evaluation.

Sampling points for silica data are shown on Figure 3-3, and results of the Surface II analyses of silica concentrations are shown in Figure 3-2.

Even with the removal of the highest values in Saratoga Springs a strong anomaly remains there. A slight northeast-southwest trend can be seen in the contours, which is generally consistent with the major fault pattern for the area, although the features do not exactly overlie the faults. The effects may represent regional groundwater flow and associated mixing in subsurface aquifers, and might be reflecting fracture zones not observed at the surface.

The geochemical data collected, although apparently supportive for a geothermal system, are not considered conclusive.

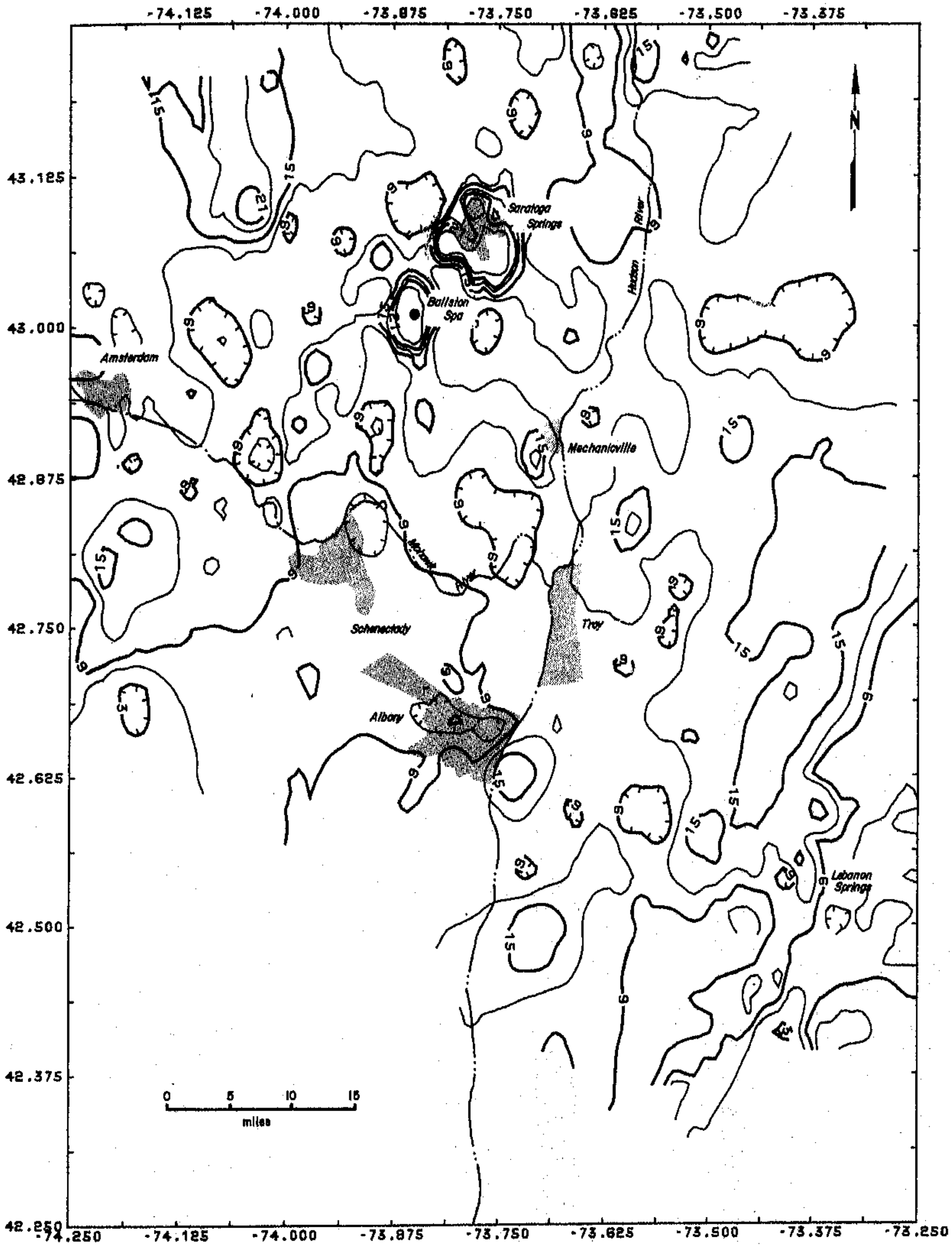


Figure 3.2 Silica Contour Map
(Contour Interval = 3 ppm)

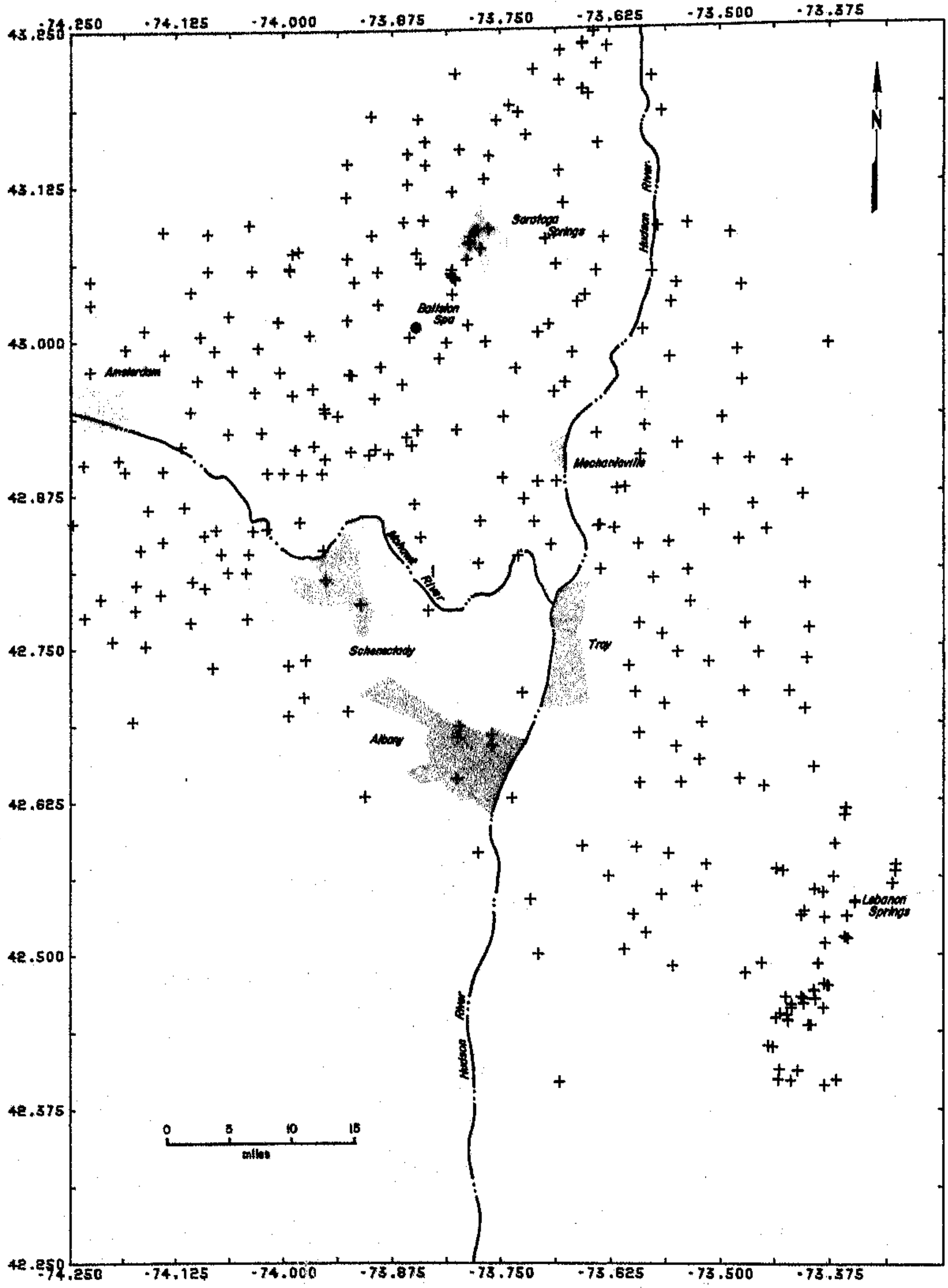


Figure 3-3. Silica & Chemistry Sample Locations

SECTION 4

THERMAL GRADIENT MEASUREMENTS IN ABANDONED WATER WELLS

METHOD

Geothermal gradient measurements throughout the Capital District area were made in abandoned water wells which generally exceeded 90 meters (300 feet) in depth. During the second phase of the project, the gradient measurement program was initiated using a hand-constructed direct-reading temperature meter connected with a thermistor probe through 640 meters (2100 feet) of cable. An apparently random electrical problem developed with this equipment, necessitating its replacement with a Yellow Springs instruments thermistor thermometer and thermistor probe with 610 meters (2000 feet) of cable.

For both sets of equipment, measurements were made by manually lowering and raising the probe and cable assembly in the well, stopping at five meter intervals, and making temperature readings. Both instruments were readable to $\pm 0.05^{\circ}$C. Temperature readings were made while lowering the probe to minimize disturbance of the thermal regime within the base, and the meter was calibrated at the beginning of each run.

The temperature and depth data recorded for each well were graphed to determine the depth to which climatic conditions affected the thermal characteristics of that well. From the point where a continuous linear increase in temperature was observed, temperature and depth data were entered into a least squares linear regression program from which the gradient and coefficient of determination (degree of fit) were calculated. These calculations were performed on a Hewlett-Packard HP-25 programable calculator for Phase II, and on a Radio Shack TRS-80 computer for Phase III.

GRADIENT MONITORING

Gradients were successfully measured in a total of 80 wells around the Capital District area. A number of these wells were selected for remeasurement to check suspect data collected when problems were experienced with the first temperature meter. Others were selected for monitoring during the course of project work to determine the reproducibility of the results and to determine if there were any significant variations in gradient during the year. This monitoring program indicated no distinct seasonal variation, and a reproducibility of 1° C/km for most wells. Some of the variation in calculated gradients may be the result of human error, either in initial data collection, or in selection of the point from which the gradients were to be calculated each time.

GRADIENT DATA

The temperature gradient data collected over both Phases II and III for abandoned wells are listed in Appendix D. Appendix E contains temperature gradient data as used in the computer modeling. For each well this table gives the reference number, name, latitude, longitude, well depth, calculated gradient, and coefficient of determination for each site. Gradients ranged from a low of 3.63° C/km to a high of 44.33° C/km, and the apparent background value is approximately 10° C/km for the area. Graphic representations of measured data are in Appendix D. The well number, graphed data, calculated gradient, date and degree of fit (0 = no fit; 1 =perfect fit) are included on each graph. The sample number can be cross-listed with Appendix D and E. The calculated gradients were handled using the Surface II computer contouring program to produce a contour map of the data (Figure 4-1). The lines shown on the map represent equal gradient values, and can therefore delineate areas showing thermal anomalies. The small crosses show the locations of the points listed in Appendix E where gradients measured are listed. For points where multiple gradients were measured, the average gradient value for that site was used in contouring.

A large positive thermal anomaly exceeding twice background can be seen on the map in the area to the southwest of Saratoga Springs, including Schenectady, and extending into the vicinity of Altamont. The northeast-southwest elongation of the anomaly is fairly well constrained by actual data points, however, the northwest elongation between Amsterdam and Ballston Spa is not supported by sufficient data points to be regarded without caution as representing actual gradients for that area.

The general location of this thermal anomaly corresponds closely with the area of interest as designated by geochemical data, and with the presumed fluid

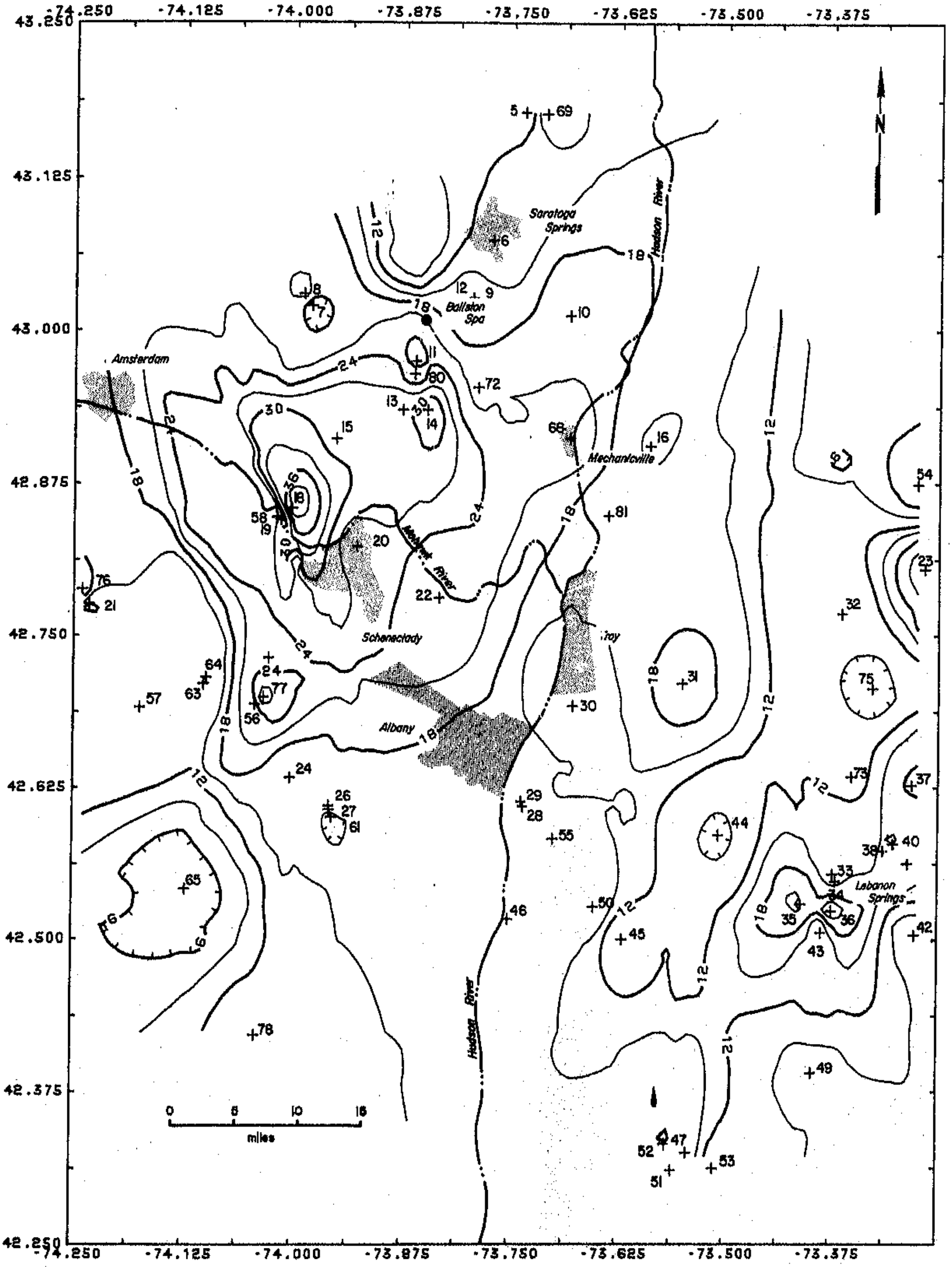


Figure 4-1. Geothermal Temperature Gradient Contour Map Using Only Abandoned Well Data (C.I.=3 °C /km)

transport zone along the Saratoga and Ballston Lake Faults. Other features seen on this map include a fairly large area of lower gradients (less than 18°C/km) that essentially correspond to the Hudson River Valley. The area to the east of the Hudson River has generally lower gradients with a few small positive anomalies. The graphical representation of thermal gradients (see Appendix D) was useful, not only for making gradient calculations, but also for observing several natural phenomena. Seasonal temperature variations and natural solar heating affect the temperature of the outermost portion of the earth's surface, and the near-surface ground waters. This action involving surface warming was exhibited on many graphs of well temperature data. The natural thermal gradient at any given site would be expected to have its lowest temperature at zero depth, the earth's surface, and would continually increase with increasing depth, if nothing were to interfere with the normal flow of heat from the earth's interior. When surface warming takes place, there can actually be either no change or a decrease in temperature with depth, to a point where the surface heat source (warm summer air and/or solar heat) no longer exerts any influence and the normal geothermal gradient resumes. The depth of this inflection point is of importance when calculating the geothermal gradient since a great deal of error can be introduced when trying to fit a straight line through a V- or U-shaped curve, and an inaccurate representation of the gradient will result.

Another natural phenomenon was observed in wells bearing carbonated or "gassy" water. At depth, the gases are held in solution partially by hydrostatic pressure, but when the gas-bearing water is exposed to atmospheric pressure in an environment such as a well base, the gases will exsolve. The exsolution of gases is an endothermic reaction, and the necessary heat in this case is taken from the solvent water. Therefore, as the gases bubble out, the water cools, and a sharp decrease in temperature can be seen for the exsolution zone near the top of the well. The size and depth of the exsolution zone would seem to depend on several things: the quantity of gas involved, the chemistry of the water, and depth of the water table.

SECTION 5

SHALLOW WELL DRILLING PROGRAM

GOALS OF DRILLING

Geochemical and thermal gradient data gathered during Phases I and II of the exploration program provided evidence that a potentially usable geothermal system existed in the Saratoga Springs-Capital District area. The available data, however, left some large informational gaps, and in order to adequately assess and evaluate the geothermal system, it became important to obtain additional information. A drilling program was designed in which a series of shallow (400-600 feet) water wells would be drilled to provide thermal gradient information between data points. This program was designed to determine the limits of the high gradient area, and to provide geologic and thermal information for the placement of an intermediate (2000 feet) depth well.

SELECTION PROCESS

The well sites were initially selected by Dr. James R. Dunn and Margaret R. Sneeringer on the basis of all geological, geochemical and geophysical data available. The sites were disussed with other DGC technical personnel in order to take advantage of collective experience on drill site locating and geologic experience. The site-selection process and drill-site locations were then reviewed with outside experts including Henry Bailey of the New York State Geological Survey and Dr. Gerald Brophy of Amherst College and Dr. Burton Krakow of ERDA. Mr. Bailey, a Petroleum Geologist, has considerable experience in local geology, exploration rationales, and the drill site selection process. Dr. Brophy has been involved with geothermal exploration and drilling throughout the eastern United States and headed the geothermal exploration program for the USDOE for the United States. Finalization of the drilling locations was made with the approval of Dr. Burton Krakow of ERDA in a meeting at DGC offices.

EQUIPMENT AND PROCEDURE

Formal requests for drilling estimates were sent to six local firms. W. Gordon Goold, Inc. submitted the lowest estimate and was awarded the contract.

The equipment used was a Portadrill Model TLS rotary rig with a 2000- foot depth capability. Nine wells ranging in depth from 405 feet to 600 feet were drilled. The holes were drilled as standard water wells, six inches in diameter. Casing was set to a minimum of fifty feet with at least ten feet cased into competent rock. Samples of the drill cuttings were collected for ten-foot intervals, and a record of drilling time kept. A small amount of the drill cuttings were washed and logged in the field, and a representative sample of each ten-foot interval was then bagged and returned to the DGC laboratory where it was washed, dried, and split, and set aside for more detailed examination.

SELECTED SITE DESCRIPTIONS

Based on all geologic, geochemical, and geophysical data, nine drill sites were selected for thermal gradient holes. The general locations are shown on Figure 5-1.

Well 1 is on the Frederick C. Myers farm on the Sacandaga Road in the Harding-Hutchinson crossing area. This site is approximately one mile east of the highest gradient measured thus far, and lies along a northeast-southwest linear feature that may be a fault, although no field evidence for faulting was seen. This site is close to Scotia, a potential user area.

Well 2, also in the Scotia area, is on the south side of Sunnyside Road on property owned by Mrs. Ida Piotrowski. This site is between a major fault and a linear that may be a fault, and was selected to help determine whether the areas between assumed conduits (faults) are also being warmed, or whether the thermal features will be restricted to the conduit areas.

Well 3, at the Ballston Lake Fireman's Grove, is located on or very close to the Ballston Lake fault, an extension of the Saratoga-McGregor fault system. It is about two miles south of an area exhibiting 29 to 31 ^{0}C/km wells on opposite sides of the fault, and where the fault is apparently acting as a conduit for warm fluid.

Well 4 is located in Tivoli Park adjacent to Livingston Junior High School in Albany. This location is at the approximate extension of a linear segment of the Mohawk River, over the Albany gravity high, and close to the southeastern most occurrence of CO_2. It was selected because there is virtually no

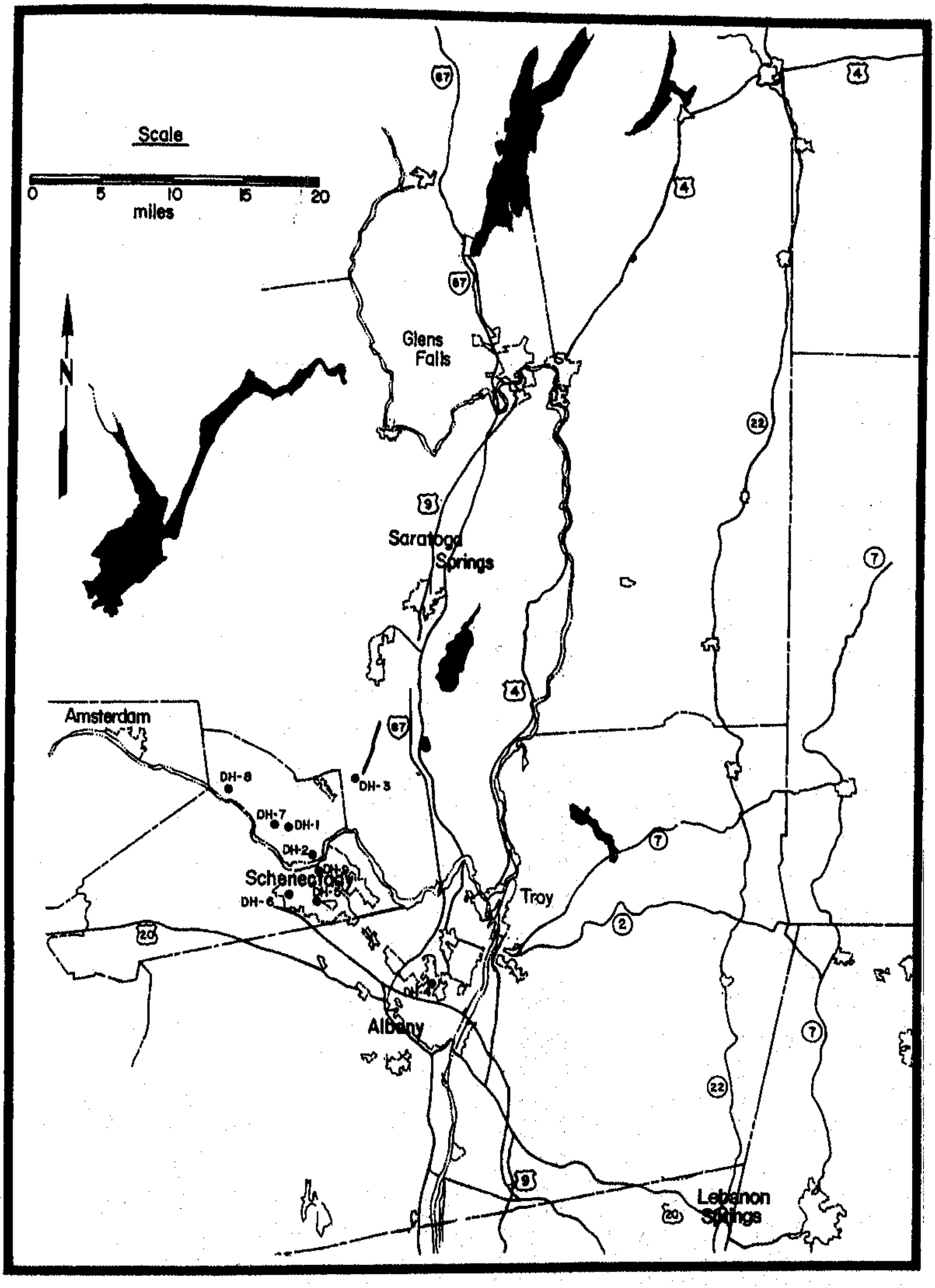


Figure 5-1. Location Map Of Shallow Test Wells

thermal or chemical data for this area at the present time. This site is in a good potential user area.

Well 5 is located at the Westside Landfill off Wedgewood Avenue in the Hungry Hill area of Rotterdam. This site is located at the intersection of the extension of a linear segment of the Mohawk River, the trace of the Ballston Lake Fault, and the edge of a slightly lower gravity anomaly near Schenectady (Sneeringer and Dunn, 1981). The intersection of all these features may represent a major conduit area. This is in a good potential user area.

Well 6 is located at the Rotterdam Industrial Park on Route 7. This site is near the southernmost extension of any faulting and also provides a measure of the southernmost limits of the thermal anomaly. The industrial park tenants are potential users.

Well 7 is located at the Scotia Naval Base just west of Scotia on Route 5. This site is located along a fault and fracture system and is in potential user area.

Well 8 is located at Clark and Brown Furniture several miles west of the Scotia Naval Base well site. It was intended to provide a measure of the thermal gradient west of the known fault/fracture systems around Scotia and should indicate the westward limit of the Scotia area thermal anomaly.

Well 9 is located at the Schenectady Solid Waste Transfer site on Weaver Street in Schenectady. This area is adjacent to a major cross-lineation indicated by the right angle bends in the Mohawk River and near a fault zone. This is also a potential user area.

DRILLING RESULTS

Each well was drilled into shale and graywacke, the carbonate sequence being much deeper. Lithologic analysis of the rock cuttings from each well was performed by Dunn Geoscience Corporation. These analyses, including water shows and drilling rate times, may be reviewed in Appendix F. Generally water production in each well was estimated at less than two gallons per minute (g.p.m.) except for the Tivoli Park well where in excess of 30 to 40 gpm was estimated.

Temperature gradients were measured using the Yellow Springs thermistor thermometer instrument and probe. Measurements were taken every five meters in water using the same procedure as for the abandoned water wells. Resulting temperature profiles were graphed via the computer and are included in Appendix G. Measurements were begun several days after drilling of each hole and repeated periodically until October, 1982. Table 5-1 is a condensation of values which are felt to be representative for each well. Figure 5-2 is a temperature gradient contour map of the Capital District including the data from the shallow test wells. A comparison with earlier abandoned well data can be made from Figure 4-1.

TABLE 5-1

SHALLOW WELL GRADIENT DATA

Well	Gradient*	R^2**	Depth***
Myers Farm	24.10	.995	121.
Piotrowski Farm	36.60	.996	122.
Fireman's Park	31.03	.999	121.
Tivoli Park	17.66	.970	183.
Westside Landfill	21.16	.997	155.
Rotterdam Industrial Park	19.06	.996	139.
Scotia Naval Base	28.22	.997	141.
Clark & Brown Furniture	20.44	.994	139.
Schenectady Solid Waste Transfer	21.05	.995	138.

* Gradient = ° Celsius per kilometer.

** R^2 = coefficient of determination, or degree of fit to a straight line. R^2 = 1 would be a perfect fit.

*** Depths = meters.

WATER SAMPLES AND CHEMISTRY

Water samples were collected from seven of the nine shallow wells drilled using a Kemmerer down-hole water sampler. Field measurements of pH,

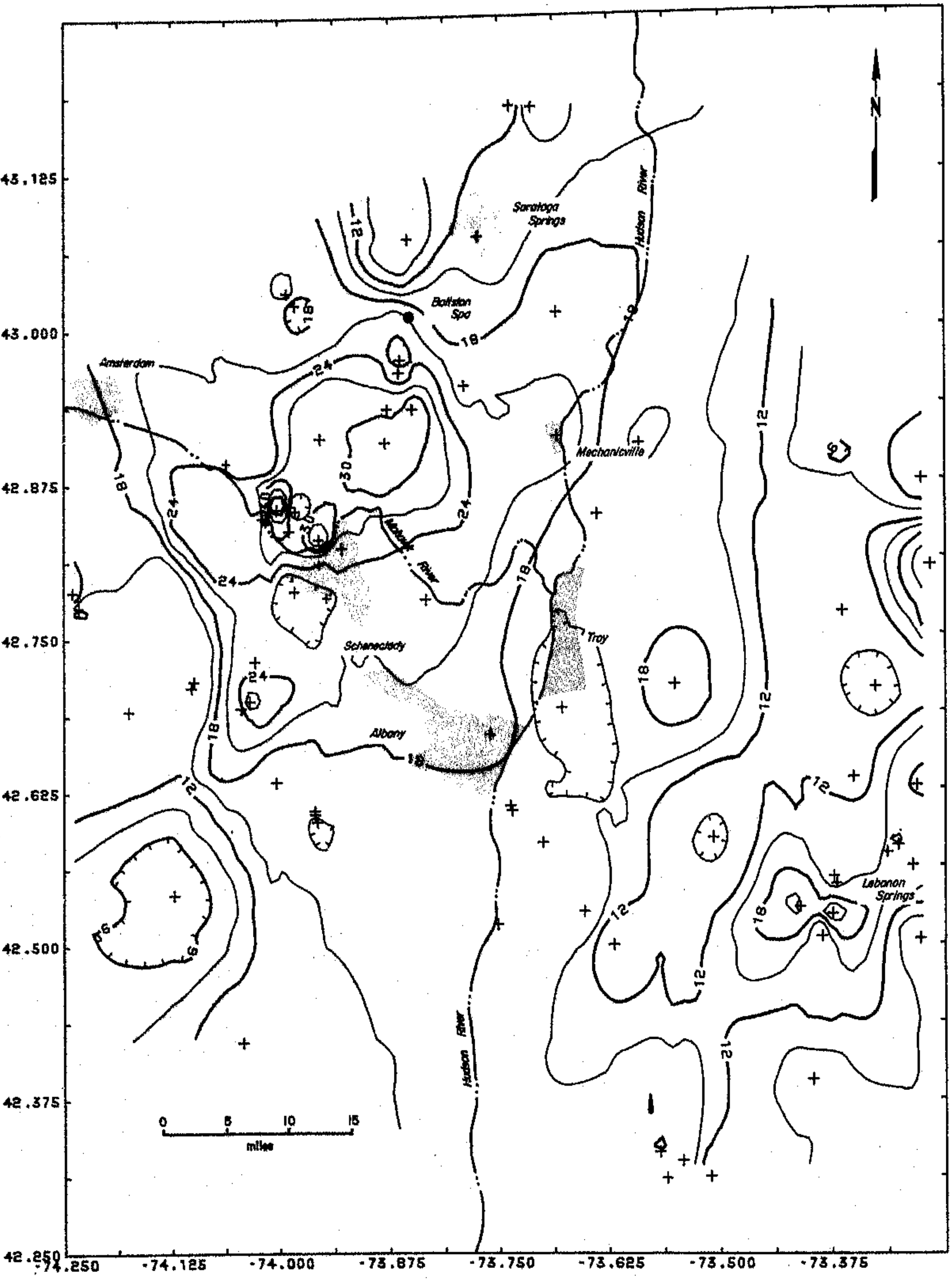


Figure 5-2. Geothermal Temperature Gradient Contour Map
(Contour Interval = 3° C / km)

temperature, and titrated alkalinity were made prior to transporting the samples to Health Research, Inc. where basic water chemistry was analayzed. Samples were not collected from two of the drilled wells because they did not produce enough water to be sampled. Partial analyses were performed, with analyses for sulfate as SO_4, chloride, sodium, calcium, magnesium, silica as SiO_2, and total solids, and the results all shown below in Table 5-2. All wells produced normal groundwaters except the Fireman's Park well which contained slightly carbonated water.

TABLE 5-2

SHALLOW TEST WELL WATER CHEMISTRY DATA

	Tivoli Park	Fireman's Park	SSWTS*	Westside Landfill
Temperature °C	10.800	10.000	10.600	10.200
pH	7.560	7.600	9.460	8.300
Alkalinity (field)	227.000	2340.000	282.000	130.000
Sulfate as SO_4	70.000	25.000	4.100	7.500
Chloride	46.000	370.000	320.000	2.300
Sodium	29.000	1300.000	330.000	48.000
Potassium	3.700	14.000	3.500	1.900
Calcium	54.000	8.400	3.100	9.500
Magnesium	22.000	4.700	1.800	1.900
Silica, react. as SiO_2	3.700	9.000	3.200	8.500
Total Solids	401.000	2970.000	1020.000	183.000

Results for solids and alkalinity in mg/l

	Piotrowski	Myers	Clark & Brown
Temperature °C	8.500	10.400	10.700
pH	9.790	9.140	9.128
Alkaliniy (field)	305.000	594.000	970.000
Sulfate as SO_4	18.000	13.000	6.800
Chloride	80.000	230.000	54.000
Sodium	240.000	400.000	1100.000
Potassum	2.700	3.600	6.000
Calcium	0.900	3.200	3.900
Magnesium	0.600	4.700	1.188
Silica, react. as SiO_2	3.600	6.000	3.200
Total Solids	530.000	1570.000	1170.000

Results for solids and alkalinity in mg/l

*Schenectady Solid Waste Transfer Station

SECTION 6

NEAR-SURFACE GRADIENT CORRECTIONS

At elevations of generally less than 600 feet above sea level, a normal temperature gradient profile may show a temperature decrease for 10 to 35 meters (usually starting at 9°-10°C), then the natural geothermal temperature gradient takes effect and the temperature increases with depth (see Figure 6-1). This basic relationship involving a thermal inflection point can be found in most rural water wells measured in the Capital District. Temperature gradients measured at higher than about 600 feet above sea level tend to be coldest at the top of the water and tend to have no inflection point.

Linear regression is used on all temperature and depth readings only after the geothermal temperature gradient begins. The temperature change in °C per 1000m for this deeper part of wells is the geothermal temperature gradient used in this work.

In urbanized or built-over areas, the temperature gradients have a different character. The inflection point occurs at greater depths; the near-surface temperatures are higher; and the transition from surface effects to the natural geothermal gradient occurs over a greater depth range.

For example, a well under a building in Albany had a temperature of 19.4°C at 5 meters below the well head, with an inflection point at 135 meters at 14.1°C. The near-surface temperature is over 9°C above normal and the inflection point over 100 meters deeper than normal (see Figure 6-2). The United Plating well in Schenectady had a near-surface temperature of 13.8°C and an inflection depth of 60 meters and a temperature of 11.17°C. The well at the Shrine at Auriesville had a surface temperature of 17°C, an inflection point at 85 meters at 10.2°C. The abandoned Saratoga Board plant at Mechanicville had an S-shaped curve, with the deep inflection point at 105 meters with a temperature of 12.2°C. The curve reversed near the surface apparently in response to a ground temperature decrease because the plant was closed and, hence, no longer adding heat to the ground. A shallow well in the

Figure 6-1. Example Normal Geothermal Gradient

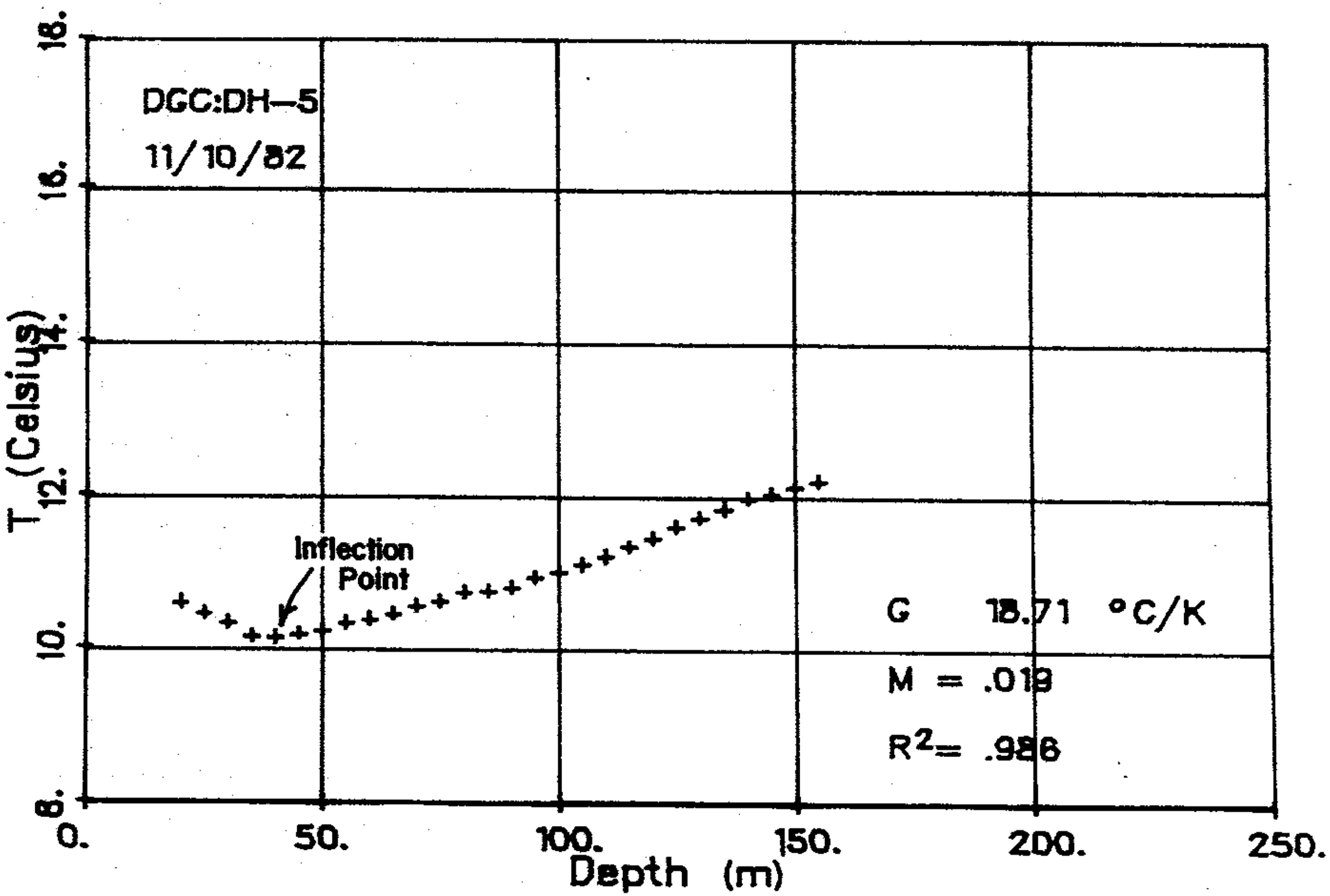
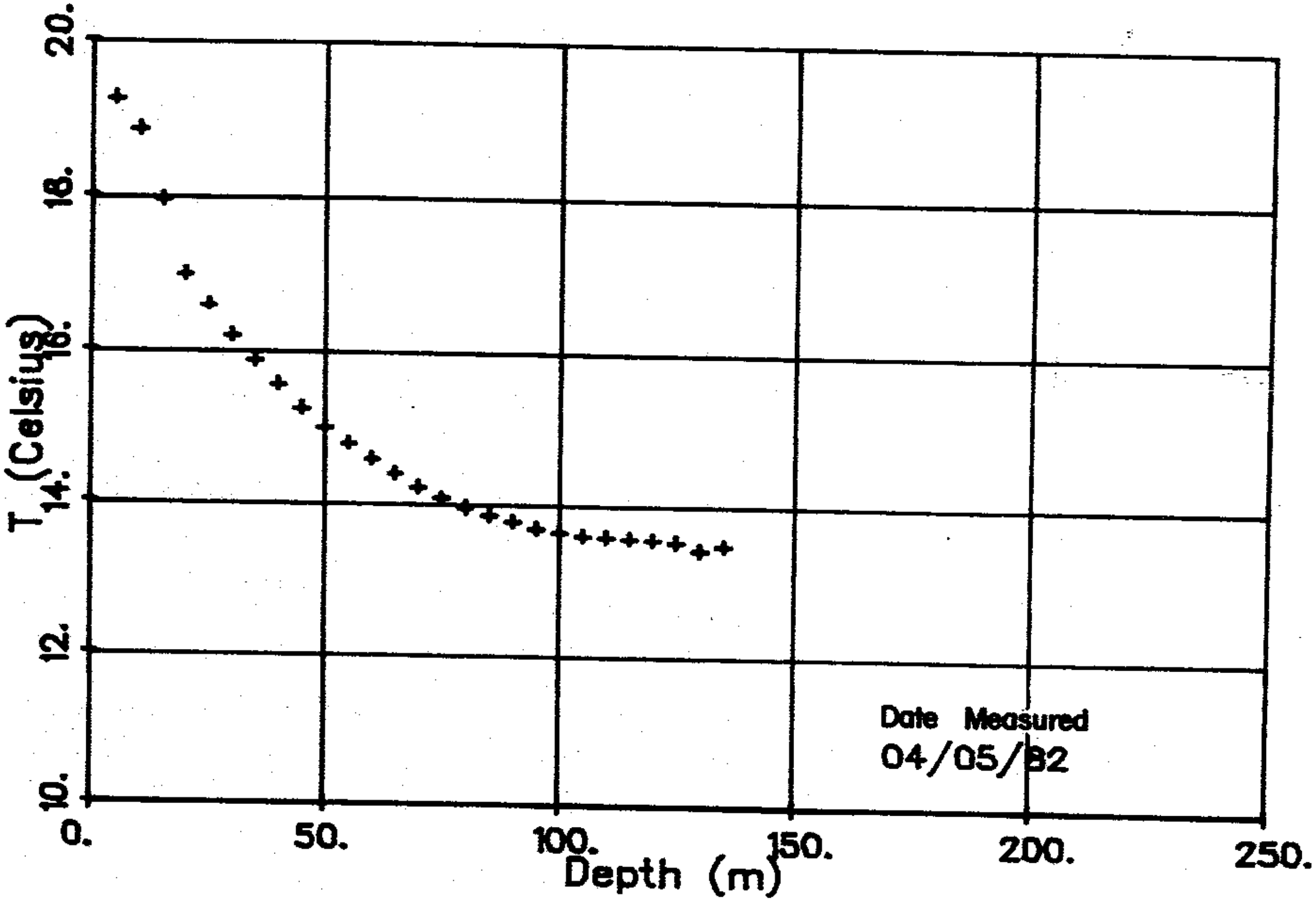


Figure 6-2. Temperature Gradient Profile For Albany Well



Date Measured
04/05/82

basement of the Tuff-Lite Plastics plant in Ballston Spa produced water with an increasing temperature with pumping from 16.1 °C to 22.2 °C during a test pumping. The temperature apparently increased as the warmer, upper water was drawn down by the pumping.

This so-called "urban effect" causes the transition zone around the inflection point to be much broader. The inflection point represents a balance between heat input from the surface and at depth. Selection of a depth at or just below the inflection point for gradient calculations is felt to be in error for such wells, and usually produces too low a geothermal gradient. Deviations from the normal geothermal gradient were not eliminated until about twice the depth of the inflection point. In essence, the surface heat influx obscures the normal gradient at depth and depresses the inflection point. Using a depth nearer to the inflection point decreases the calculated geothermal gradient, since the surface heat influx "raises" one end of the curve causing a smaller slope to the regression line.

The urban heating effect causes the measured gradient to be depressed by raising the temperature at the near-surface. Gradient measurements having "urban effect" were recalculated after selecting a depth twice the inflection point as described above. Recalculated temperature gradients generally showed a less than 1 °C/km to nearly 5 °C/km gradient increase but did not appreciably affect the overall gradient contour map since the urban areas geographically are small with respect to the entire Capital District. Figure 6-3 shows the corrected gradient contour map which can be compared with Figure 5-2.

Somewhat similarly, an anomalously low surface temperature could cause an apparently high geothermal gradient. The Widmer well with a surface temperature of only 6.86 °C had the highest observed geothermal gradient of over 42 °C/km. This high gradient is, therefore, suspect and possibly is caused by some unexplained anomalously cold water circulation at the top of the well.

The significant conclusions which are related to the urban effect (which has apparently not been observed until this research, see Sneeringer and Dunn, 1982) are:

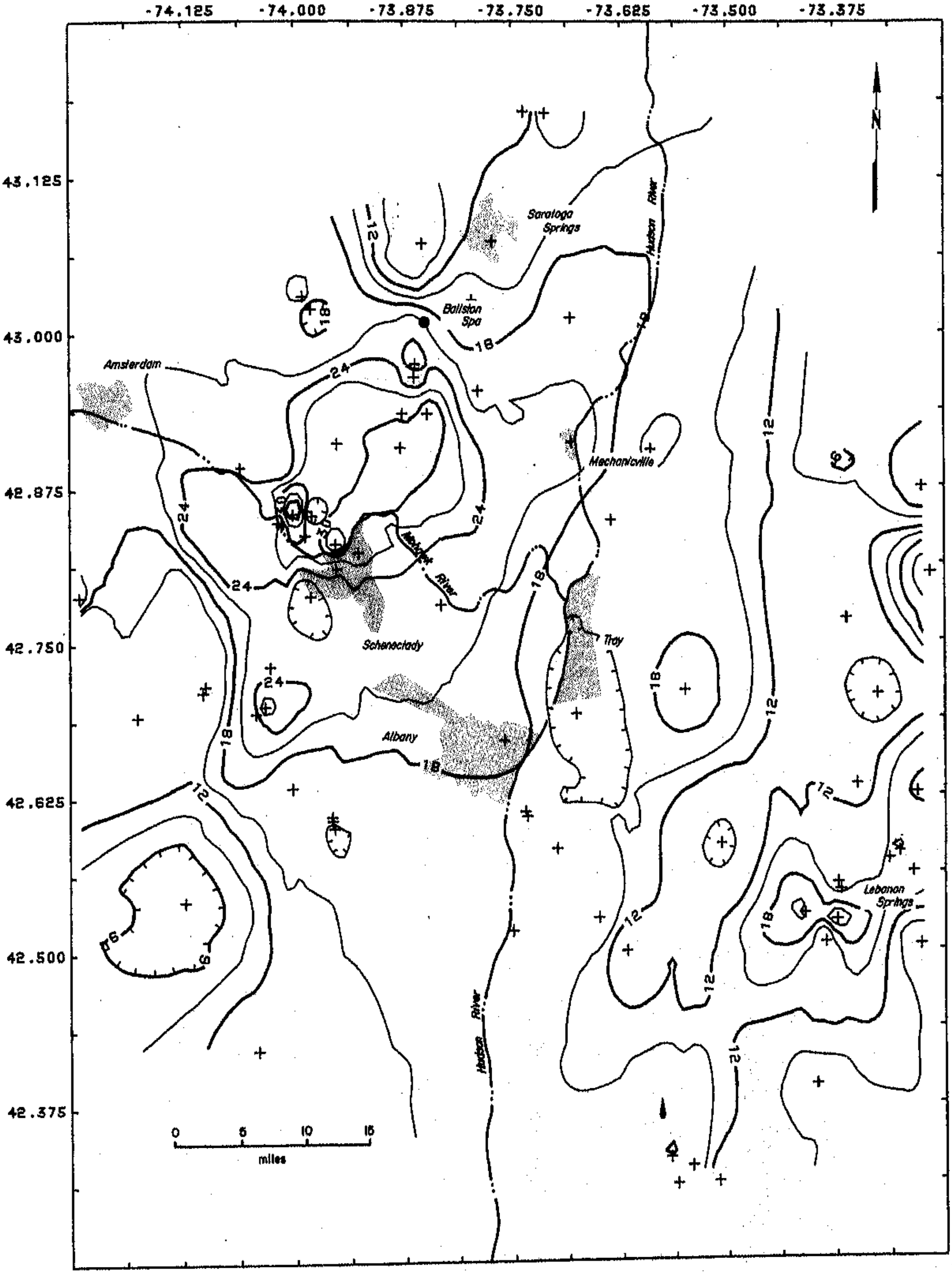


Figure 6-3. Geothermal Temperature Gradient Contour Map Using Corrected Gradient Values (C.I.=3°C/km)

- In urban areas geothermal gradient measurement wells should probably be between 200 and 400 meters deep to get below the surface effects.
- The shallow wells drilled in the current program should have been deeper in the metropolitan areas, i.e., 200 or more meters, instead of the maximum of 155 meters which was drilled.
- The urban effects in the Albany-Schenectady area probably mask the true geothermal gradients.
- Presumably the urban effect is greater under older areas of cities or under older plant sites.
- Vast quantities of heat are probably stored under most urban areas and are economically available for ground-water heat pump systems.

SECTION 7

2300-FOOT WELL

PURPOSE

The 2300-foot well was drilled to further define the physical characteristics of the geothermal aquifer. Better definition was sought for the:

- depth and occurence of deep geothermal aquifer(s);
- temperature gradient variations for various sedimentary units;
- water chemistry of geothermal aquifer(s);
- occurrence and description of lithologic units;
- general aquifer characteristics such as fracture, porosity and permeability.

Results of previous temperature gradient measurements collected throughout the Capital District indicated an area of promising temperature gradients along the Saratoga-McGregor faults between Saratoga Springs and Scotia, New York. This fault system may provide a "conduit" for geothermal fluids to mix nearer the surface with ground water such as at Saratoga Springs.

SITE SELECTION

Site selection was determined cooperatively between Dunn Geoscience Corporation and New York State ERDA personnel. The major site criteria were as noted above with a potential user and a well defined temperature gradient nearby. Budgetary restraints limited the maximum drilling depth to about 2300 feet. Choice of a site was therefore limited to where basement was within 2300 feet of the surface.

The basement depth increases southward from outcrops in the southernmost Adirondack Mountains. The area of geothermal interest ranged from just north of Ballston Lake to the Scotia-Glenville area with basement depths ranging from an estimated 2000 feet to 3500 feet north-to-south. The area around Ballston Lake was chosen for the deep well drill site, since basement depths could be estimated at about 2200-2300 feet.

Previously the Fireman's Park shallow test well (DGC:DH-3) drilled in Ballston Lake had a measured temperature gradient of about 31 °C/km. Given this known value,a site near this well was desirable. The F.L. Stevens Elementary School, located on Lake Hill Road in Ballston Lake near the Fireman's Park well, was felt to be a potential site (see Figure 7-1).

Dr. Richard O'Rourke, Superintendent of the Burnt Hills-Ballston Lake School System, was approached with the idea of drilling at the Stevens Elementary School. He suggested that Dunn Geoscience Corporation should present this proposal to the school board at the April 27, 1982, public meeting. James R. Dunn and George M. Banino represented Dunn Geoscience Corporation for the discussion of the proposal. The school board decided favorably and an agreement was reached between Dunn Geoscience Corporation and the school system to proceed with drilling at the school. The site agreed upon was in some scrub woods on the west side of the playground behind the school's old garage building. It was felt that this would minimize any potential disruption of school activities and would keep land rehabilitation problems to a minimum.

DRILLING

The drilling was awarded to New Jersey Drilling Company of Netcong, New Jersey, which started drilling on May 20, 1982. Equipment used was an Ingersoll-Rand T5-DH Drillmaster. This is a top-head drive mobile rig with a maximum 5000-foot depth capability and using 30-foot long, 4-1/2-inch drill rods and a 7-1/4-inch drill bit. Condition of the equipment was excellent.

The well was drilled as a standard water well. To ensure that no near-surface water would enter the hole or vice versa, a 12-1/4-inch hole was drilled several feet into bedrock to a total depth of 32 feet. An 8-1/4-inch hole was drilled 20 feet further into bedrock to a total depth of 52 feet. Twelve-inch casing supported the larger hole while 8-inch casing was set into the smaller hole. Cement grout was injected to fill the space between the casings. The 12-inch casing was removed by the drill rig, and the cement allowed to harden and seal the 8-inch casing with the bedrock to ensure a water-tight fit.

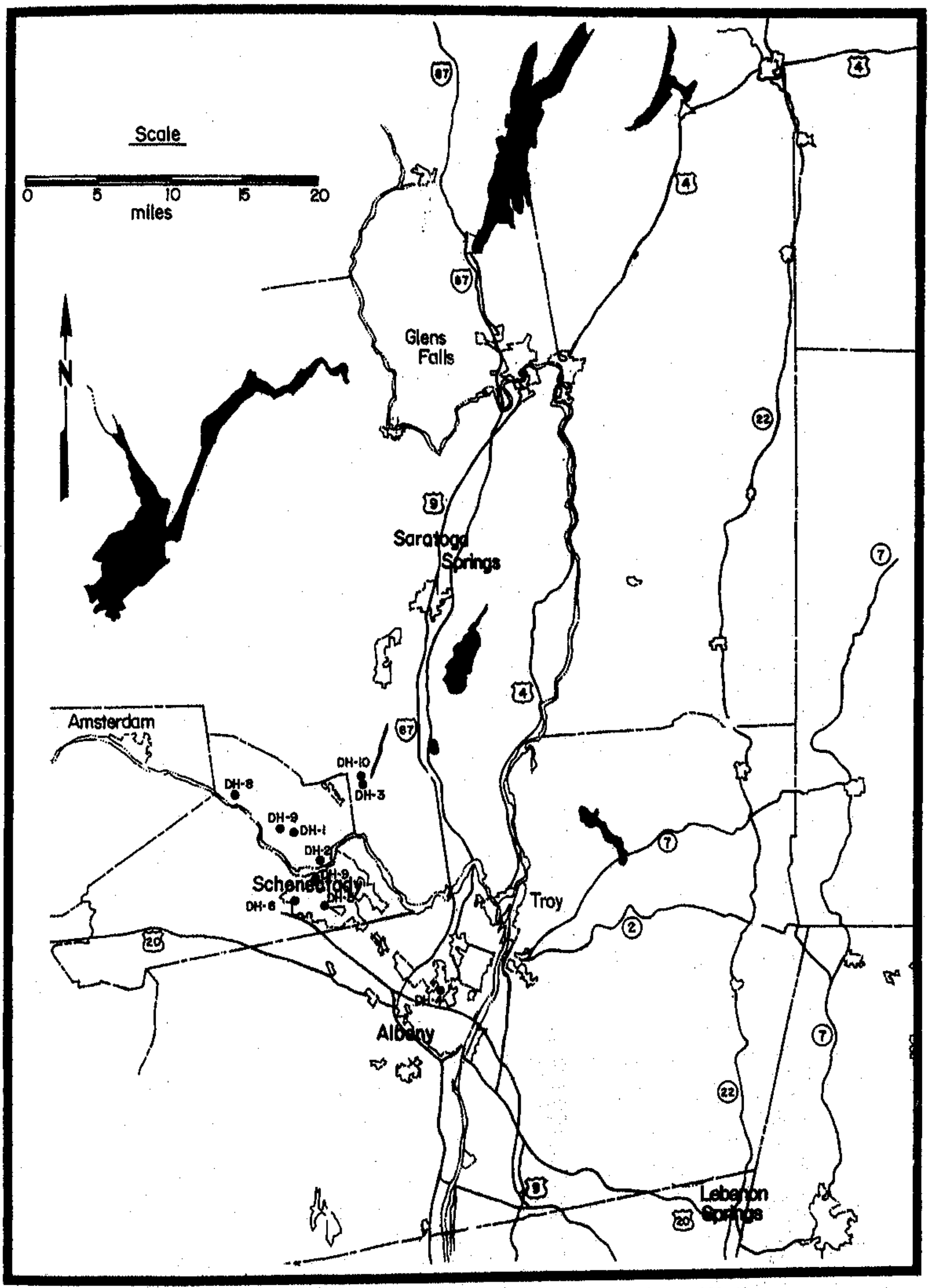


Figure 7-1. Location Map Of Shallow Test Wells With Deep Test Well Added

A 12-inch roller-cone bit was used for the upper cased part of the hole. Drilling was then with an 8-inch percussion bit down to 230 feet where an 8-inch roller cone bit was mounted and used for the rest of the drilling. Rock coring was unsuccessfully attempted at 1930 feet using NX-size core. Apparently jointed, cored rock wedged in the core barrel resulting in only 1/2- inch recovery in a 10-foot run.

SAMPLE COLLECTION

Rock cuttings were collected every 20 feet in the upper shale and graywacke formations. Upon contact with the Trenton limestone, sampling was increased to every 10 feet. Samples were collected from the drill rig spillpipe and stored in sample bags for transport to the DGC laboratory.

The on-site geologist was responsible for sample collection as well as noting any observable faults, fractures or water zones, plus the general rate of drilling. Other responsibilities included on-site coordination with the drill crew, school district representatives, and the media.

STRATIGRAPHY

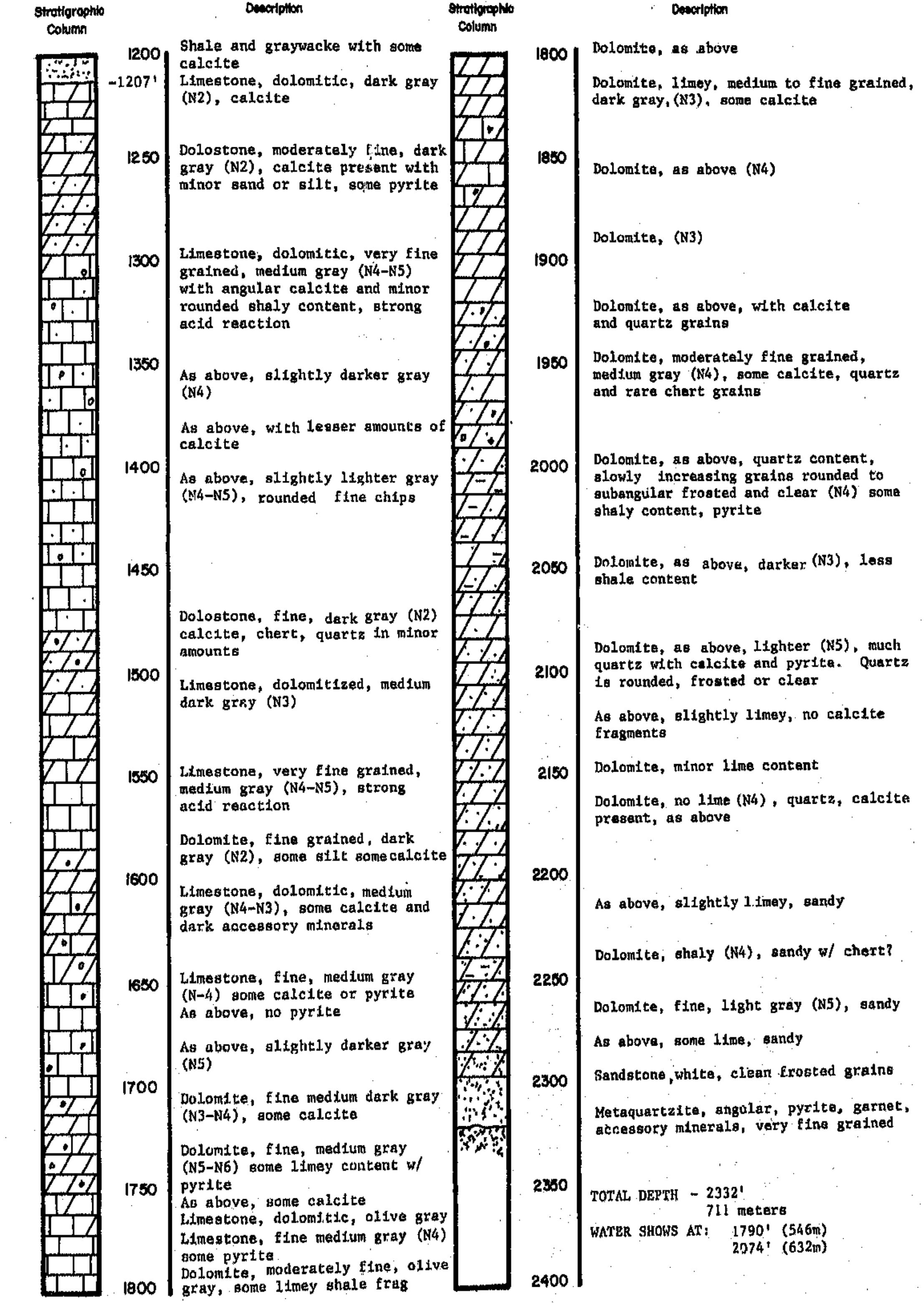
A lithologic description of the drill cuttings was completed in which all samples collected were examined in hand specimen and by microscope for lithology, color, grain size, matrix and accessory minerals. Rock cuttings from the shale/graywacke section were generally 1-15mm flat chips, whereas the limestone/dolomite/sandstone chips were much finer (sand-sized). Figure 7-2 is a compilation in log form of the lithology of the 2332-foot well.

Original (before drilling) estimates of the stratigraphy projected a hypothetical column listed in Table 7-1.

This column was derived from the Smith and Julick wells mentioned earlier and with structural and stratigraphic information from the New York State Museum and Science Service Map and Chart Series Number 18. Assuming a regional slope to the basement and relatively uniform thicknesses to the sedimentary cover, the hypothetical column could be constructed by projecting from the Smith well southward to the drill site.

During drilling no great deviations from the hypothetical column were recorded

GEOTHERMAL DRILLING PROGRAM
HOLE *DH-10*
LOCATION *Stevens Elementary School, Ballston Lake*
DATE DRILLED *May 21-June 15, 1982*



Shale and graywacke with some calcite

Limestone, dolomitic, dark gray (N2), calcite

Dolostone, moderately fine, dark gray (N2), calcite present with minor sand or silt, some pyrite

Limestone, dolomitic, very fine grained, medium gray (N4-N5) with angular calcite and minor rounded shaly content, strong acid reaction

As above, slightly darker gray (N4)

As above, with lesser amounts of calcite

As above, slightly lighter gray (N4-N5), rounded fine chips

Dolostone, fine, dark gray (N2) calcite, chert, quartz in minor amounts

Limestone, dolomitized, medium dark gray (N3)

Limestone, very fine grained, medium gray (N4-N5), strong acid reaction

Dolomite, fine grained, dark gray (N2), some silt somecalcite

Limestone, dolomitic, medium gray (N4-N3), some calcite and dark accessory minerals

Limestone, fine, medium gray (N-4) some calcite or pyrite
As above, no pyrite

As above, slightly darker gray (N5)

Dolomite, fine medium dark gray (N3-N4), some calcite

Dolomite, fine, medium gray (N5-N6) some limey content w/ pyrite
As above, some calcite
Limestone, dolomitic, olive gray
Limestone, fine medium gray (N4) some pyrite
Dolomite, moderately fine, olive gray, some limey shale frag

Dolomite, as above

Dolomite, limey, medium to fine grained, dark gray, (N3), some calcite

Dolomite, as above (N4)

Dolomite, (N3)

Dolomite, as above, with calcite and quartz grains

Dolomite, moderately fine grained, medium gray (N4), some calcite, quartz and rare chert grains

Dolomite, as above, quartz content, slowly increasing grains rounded to subangular frosted and clear (N4) some shaly content, pyrite

Dolomite, as above, darker (N3), less shale content

Dolomite, as above, lighter (N5), much quartz with calcite and pyrite. Quartz is rounded, frosted or clear

As above, slightly limey, no calcite fragments

Dolomite, minor lime content

Dolomite, no lime (N4), quartz, calcite present, as above

As above, slightly limey, sandy

Dolomite, shaly (N4), sandy w/ chert?

Dolomite, fine, light gray (N5), sandy

As above, some lime, sandy

Sandstone, white, clean frosted grains

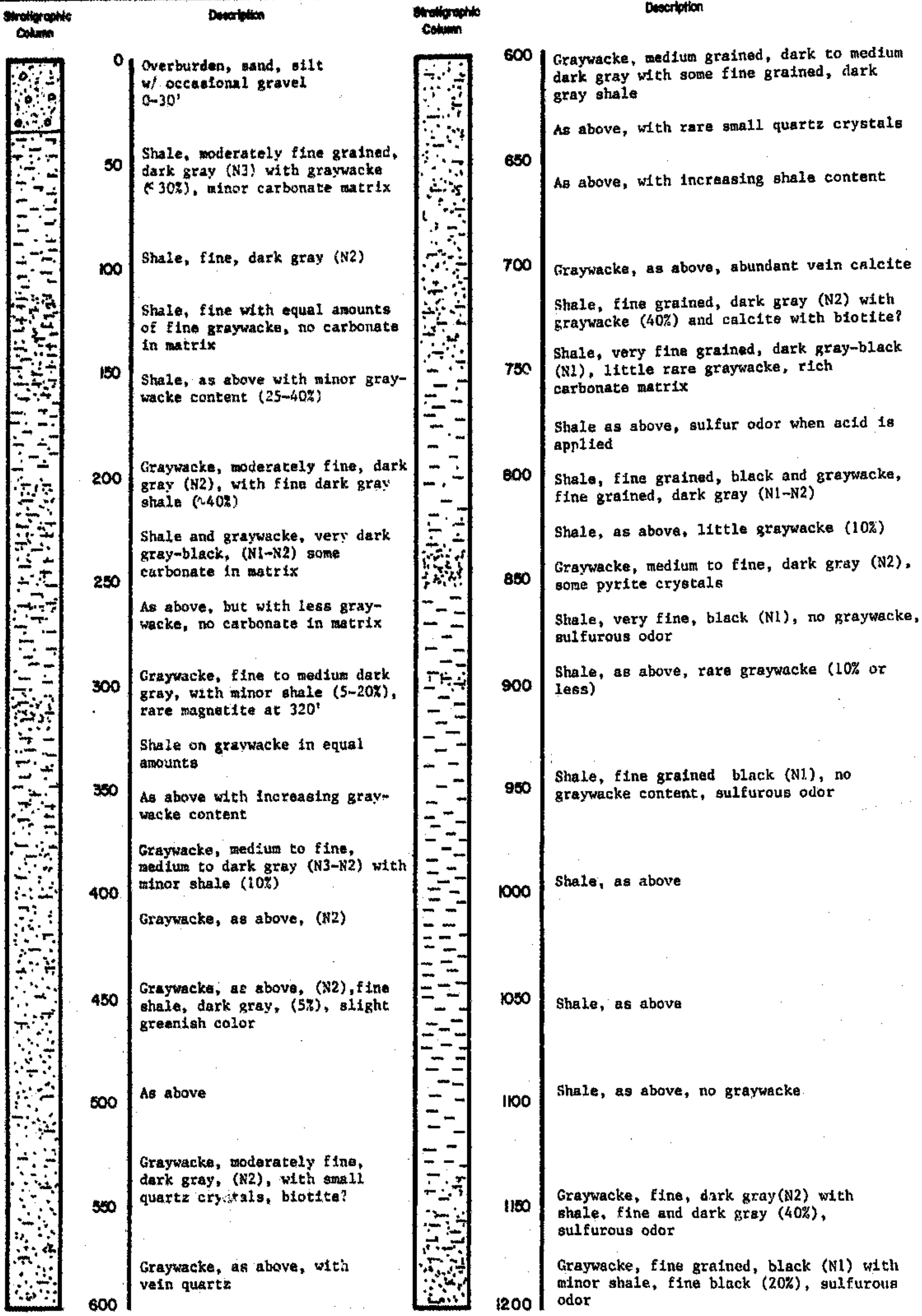
Metaquartzite, angular, pyrite, garnet, accessory minerals, very fine grained

TOTAL DEPTH - 2332'
711 meters

WATER SHOWS AT: 1790' (546m)
2074' (632m)

Figure 7-2. Lithologic Log For DH-10

GEOTHERMAL DRILLING PROGRAM
HOLE DH-10
LOCATION Stevens Elementary School, Ballston Lake
DATE DRILLED May 21-June 15, 1982



0 Overburden, sand, silt w/ occasional gravel 0-30'

50 Shale, moderately fine grained, dark gray (N3) with graywacke (≤30%), minor carbonate matrix

100 Shale, fine, dark gray (N2)

Shale, fine with equal amounts of fine graywacke, no carbonate in matrix

150 Shale, as above with minor graywacke content (25-40%)

200 Graywacke, moderately fine, dark gray (N2), with fine dark gray shale (~40%)

Shale and graywacke, very dark gray-black, (N1-N2) some carbonate in matrix

250 As above, but with less graywacke, no carbonate in matrix

300 Graywacke, fine to medium dark gray, with minor shale (5-20%), rare magnetite at 320'

Shale on graywacke in equal amounts

350 As above with increasing graywacke content

Graywacke, medium to fine, medium to dark gray (N3-N2) with minor shale (10%)

400 Graywacke, as above, (N2)

450 Graywacke, as above, (N2), fine shale, dark gray, (5%), slight greenish color

500 As above

550 Graywacke, moderately fine, dark gray, (N2), with small quartz crystals, biotite?

Graywacke, as above, with vein quartz

600

600 Graywacke, medium grained, dark to medium dark gray with some fine grained, dark gray shale

As above, with rare small quartz crystals

650 As above, with increasing shale content

700 Graywacke, as above, abundant vein calcite

Shale, fine grained, dark gray (N2) with graywacke (40%) and calcite with biotite?

750 Shale, very fine grained, dark gray-black (N1), little rare graywacke, rich carbonate matrix

Shale as above, sulfur odor when acid is applied

800 Shale, fine grained, black and graywacke, fine grained, dark gray (N1-N2)

Shale, as above, little graywacke (10%)

850 Graywacke, medium to fine, dark gray (N2), some pyrite crystals

Shale, very fine, black (N1), no graywacke, sulfurous odor

900 Shale, as above, rare graywacke (10% or less)

950 Shale, fine grained black (N1), no graywacke content, sulfurous odor

1000 Shale, as above

1050 Shale, as above

1100 Shale, as above, no graywacke

1150 Graywacke, fine, dark gray(N2) with shale, fine and dark gray (40%), sulfurous odor

Graywacke, fine grained, black (N1) with minor shale, fine black (20%), sulfurous odor

1200

Figure 7-2. continued

TABLE 7-1

HYPOTHETICAL 2300-FOOT WELL STRATIGRAPHY

Depth (Feet)	Formation
0 - 1220	Shale/Graywacke
1220 - 1300	Trenton Limestone
1300 - 1475	Chuctanunda Creek Dolomite
1475 - 1515	Wolf Hollow Member - Tribes Hill Formation
1515 - 1590	Pallatine Bridge Member - Tribes Hill Formation
1590 - 1810	Fort Johnson Member - Tribes Hill Formation
1810 - 2055	Little Falls Dolomite
2055 - 2065	Mosherville Sandstone
2065 - 2230	Galway Dolomite
2230 - 2270	Potsdam Sandstone
2270-	Precambrian Basement

and the on-site geologist was generally able to anticipate and recognize noticeable lithologic changes in the drill cuttings. The stratigraphic column based on sample cuttings is listed in Table 7-2

A short description of each lithology is as follows:

Schenectady/Utica Shale - black, fissile shales with interbedded fine-grained, medium gray graywacke. The stratigraphy of the shale/graywacke sequence is poorly understood.

Trenton Limestone - alternating dark gray limestone with dark gray to black calcareous shale interbeds.

Chuctanunda Creek Dolomite - medium gray dolomite. The upper part is generally more siliceous. Black interstitial carbonaceous material, some quartz, silt and sand is also present.

Wolf Hollow Member - massive, dark gray to black dolomitic limestone, some calcite.

Pallatine Bridge Member - gray dolomite with large amounts of interbedded shale and persistent, thin-bedded, fine-grained, arenaceous limestone.

Fort Johnson Member - massively bedded, dark gray to black, fine grained, dolomitic limestone.

Little Falls Dolomite - thick series of dolomites variable in color and grain size, mixed with varying amounts of rounded quartz sand frequent light gray to white chert nodules.

Galway Dolomite - generally thin-bedded, fine-grained, sandy dolomite with increasingly greater amounts of rounded quartz grains. Some layers of quartz sandstone and dolomitic quartz sandstone and chert are present in the upper part of the section. Remainder of formation is a medium-to-light gray, massive, fine-to-medium grained sandy dolomite.

Potsdam Sandstone - well-sorted, clean (white), rounded, frosted quartz sand grains. Basal layer, if present, may be an argillaceous (dirty) conglomerate resting on the Precambrian basement.

Basement - highly variable, metamorphosed rock. At the drill site it appears to be a metaquartzite with some accessory minerals and is extremely hard.

WELL LOGGING

Introduction

To further define the characteristics of the geothermal aquifer, a series of geophysical logs were run of the deep well. These logs included multipoint electric resistivity (including self-potential [also called SP or spontaneous potential], short-normal and long-normal electrical logs) and gamma-ray logs. Also run were conductivity, caliper and, most important, temperature logs. The U.S. Geological Survey logging truck from Syosset, New York, with a 4000-foot logging capability was used. James Nakao of the U.S. Geological Survey was the equipment operator. Logging was performed during the week of June 14, 1982. All logging was successful except conductvity and temperature. The conductivity equipment was unable to function because of the high salinity of the well fluids. The temperature log was successfully re-run on July 19, 1982, after the temperature tool and electronics which had been causing abnormally high temperature readings were replaced.

These logs were used to provide general lithostratigraphic correlation and information on the type of aquifer providing the geothermal fluids. The most important measure for the test well was a verification of the geothermal gradient data derived from the shallow and abandoned well gradient measurements. This verification allows better temperature predictability at the depths of occurrence for the geothermal aquifer elsewhere within the Capital District.

Method

In each case the logging tool in use was lowered via an electric winch into the hole. Actual logging was done while retrieving the tool from the bottom of the hole. This allowed for cable stretch to be accounted for during calibration since the hole depth was already known. Only temperature was logged while moving down the hole so that the tool would not mix the well fluids by its passage after being lowered. Measurements were recorded on a strip chart in the logging truck.

Log Description

Gamma ray logging measures the natural radioactivity of the rock. Shales read higher in radioactivity while limestones and sandstones are lower. This log is generally used to record lithology and the "cleanliness" of the rock. Shales contain finer, clay-like material and are generally organic-rich ("dirtier"). Limestones and sandstones tend to be more mono-lithologic (of one mineral type) and contain less organic material.

Electric resistivity logs provide a measure of the fluid saturation of the rock. They also can provide a measure of the porosity of the rock. Dry rock has a higher resistivity. Saturated rock is lower in resistivity. Salinity of the fluid also lowers the resistivity. More porous or fractured rock also has greater opportunity to be more fluid-saturated with a lower resistivity than a "tight," non-porous rock.

Caliper logs are a physical measure of the diameter of the drill hole. Areas of weakness (fractures, fault zones, mud zones, etc.) will generally widen the hole due to the mechanical action of the drill. These zones can be used to indicate possible water-bearing zones which may coincide with zones of weak or broken rock.

Temperature logs are used to provide a direct measure of the geothermal gradient and the temperature at any depth in the hole. When correlated against lithology, a change in heat flow values can be roughly documented by the change in temperature gradient per lithologic type.

Results

A general correlation of gamma-ray and electric logs versus lithology can be seen in Figure 7-3. A graph of the temperature log is in Figure 7-4. A separate temperature log using the Dunn Geoscience Corporation temperature probe can be found in Figure 7-5. The two temperature logs provide a measure of control on the accuracy of each measurement.

Boyd R. Brown, an associate geologic consultant to Dunn Geoscience Corporation, analyzed the logs and provided these conclusions:

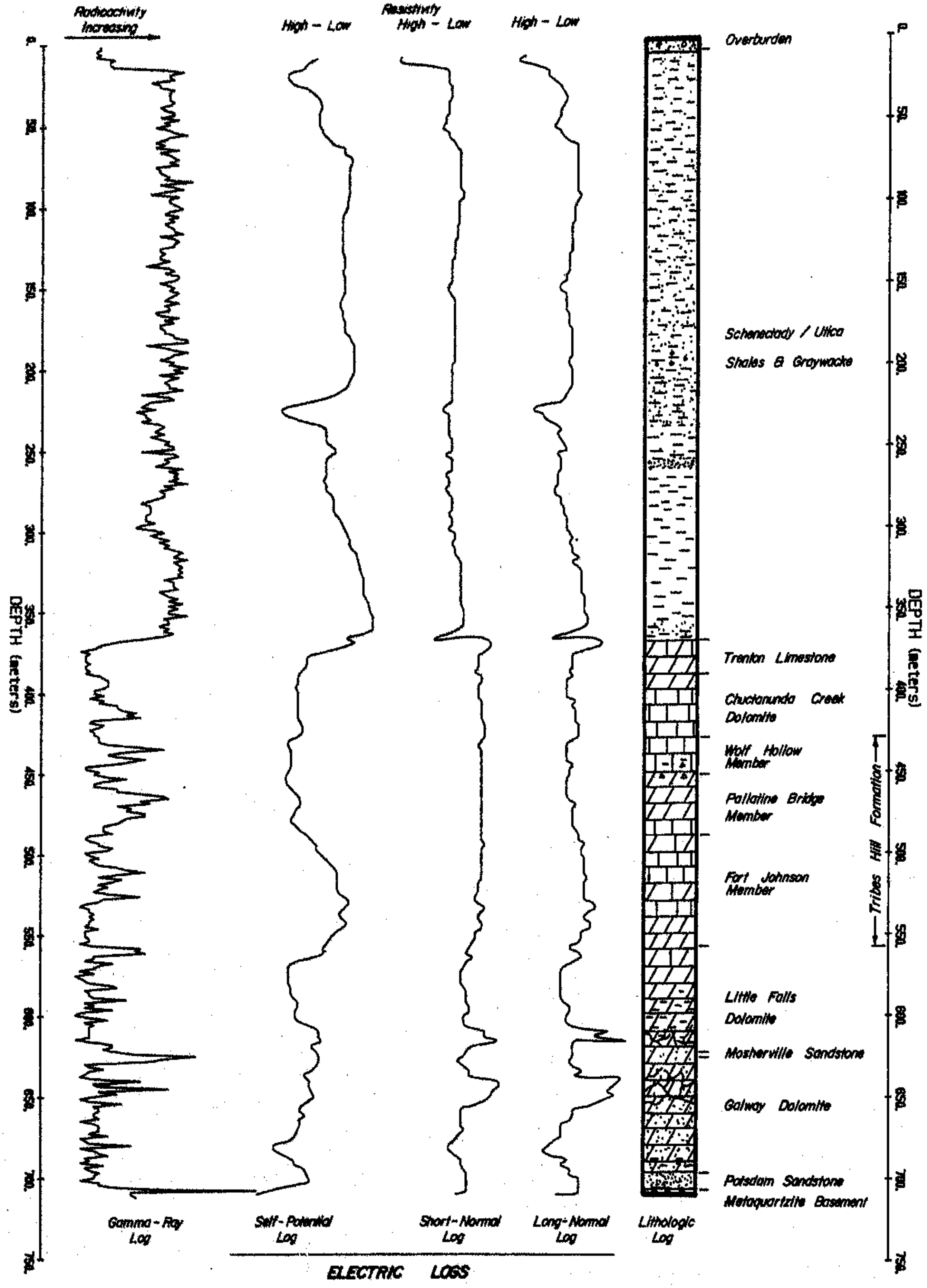


Figure 7-3. Gamma & Electric Log Comparison With Lithology of Deep Well

Figure 7-4. Temperature Log For DH-10 (U.S.G.S)

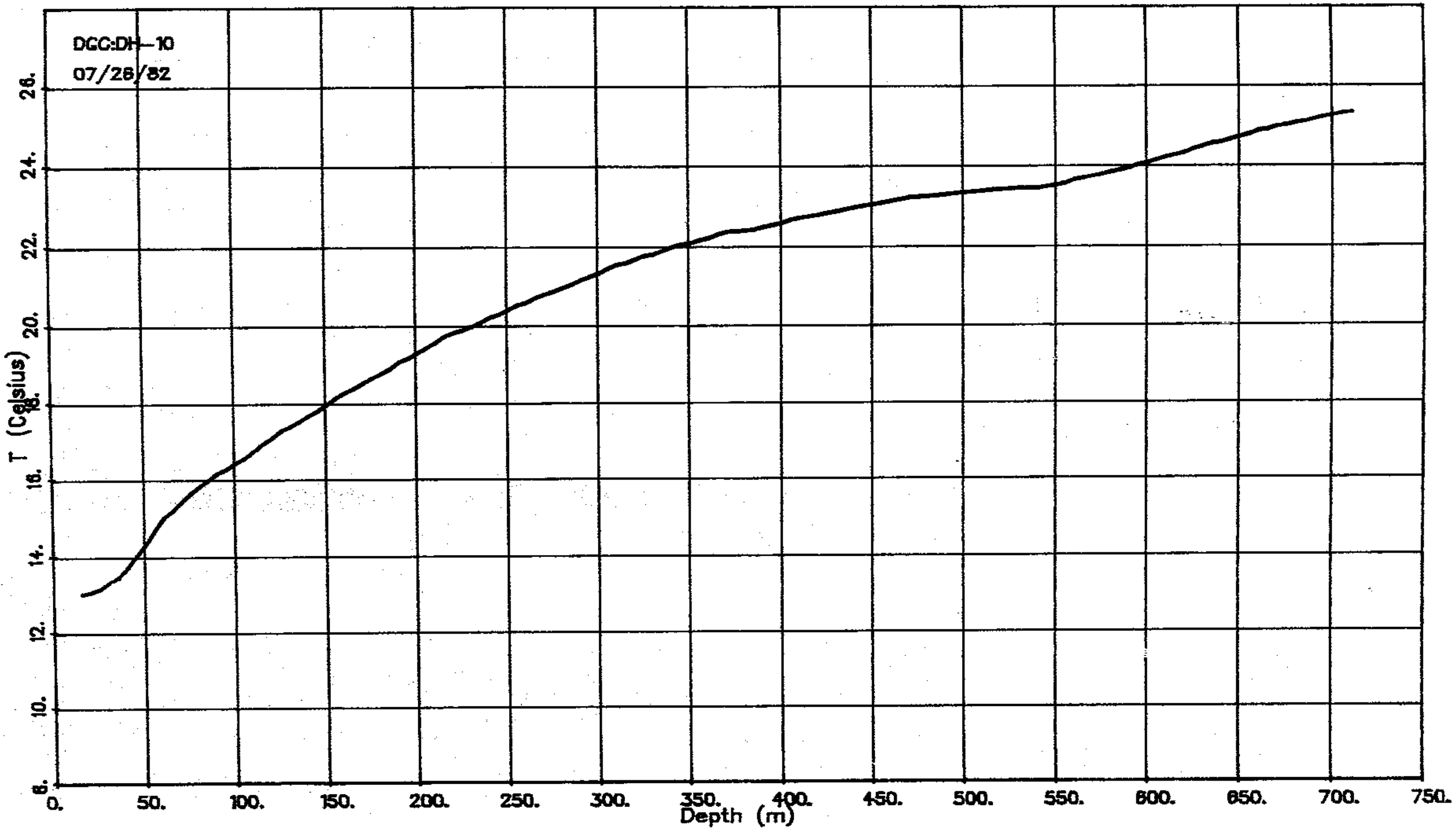
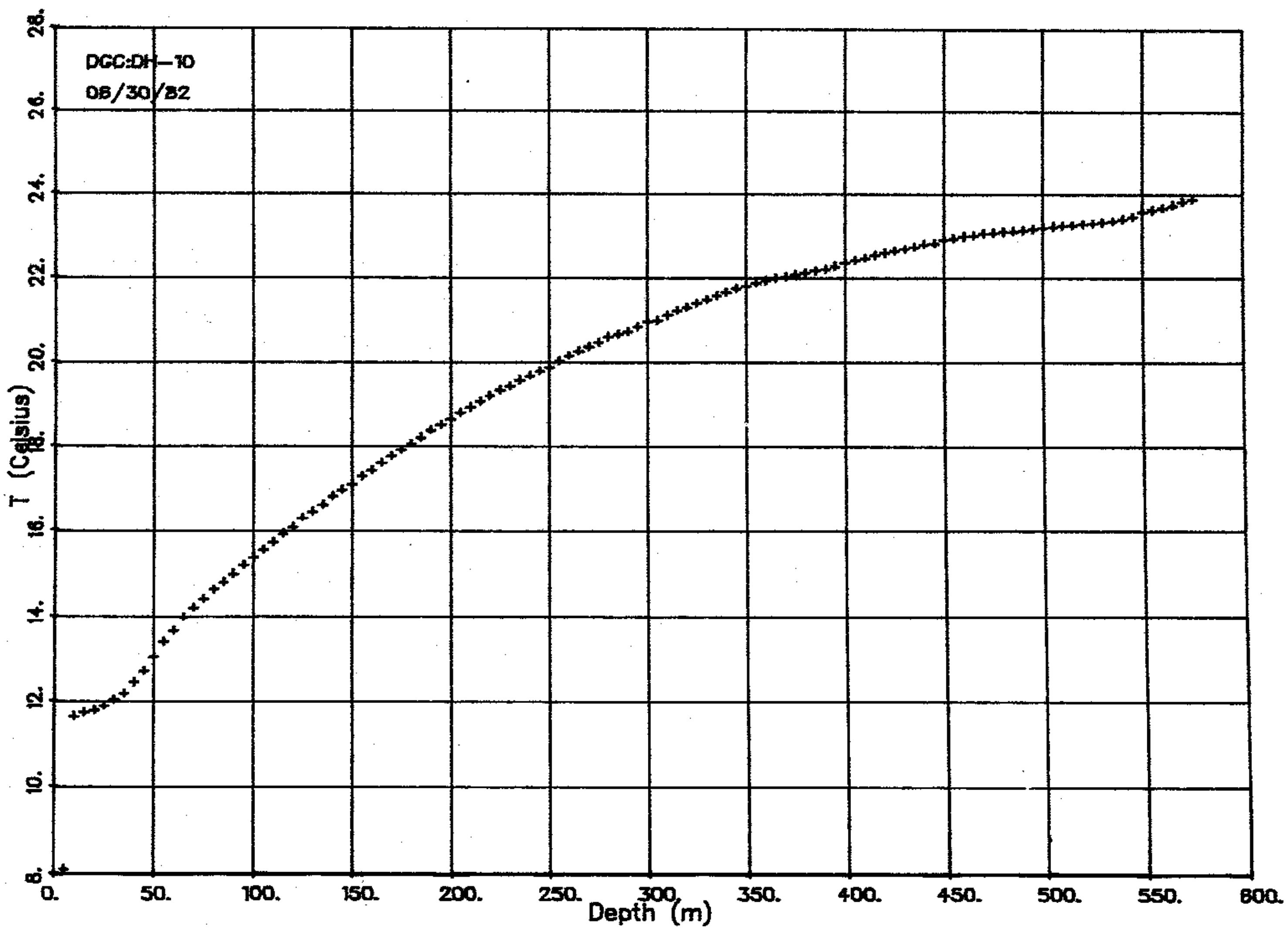


Figure 7-5. Temperature Log For DH - 10 (Dunn Geoscience Temperature Probe)



- Caliper log:

    fluid sensitive or gas pressure zone at 720' (220 m)

    possible permeability(?) at: 1740' (530 m)
    2074' (632 m)
    2168' (661 m)
    2190' (668 m) (?)

- Gamma Ray/Electric Logs:

    natural permeability is producing water at 1790' (564 m), but is interpreted to be fed by a fracture system at 2074' (632 m). These water zones are delineated by lower resistivity "kicks" in the long-normal and short-normal electric logs over that depth interval. Fractures and natural permeability of the rock are believed to be responsible for communication between these two water-producing zones.

    fracture system is probably the true reservoir source with the upper permeable zone of secondary importance.

    fracture system is probably steep-angle and close to the general area of the well (i.e., fault related).

Gamma ray logs were used to provide cross-correlation with respect to the drill cuttings and the lithologic analysis. Table 7-3 has the depths to the top of each formation using each logging method and the lithologic analysis.

Temperature log - general instability of the fluid due to the extremely high CO_2 content of the fluid prevented a measure of normal geothermal gradient. Fluid would semi-periodically flow from the well producing an upward movement of geothermal fluids. This upward flow of warmer fluid disrupted the normal geothermal gradient which requires a static water flow. Using the gradient measurement for the shallow well at Fireman's Park of 30.5° C/km a temperature gradient for the deeper lithologies in the well could be calculated (see Table 7-4).

The temperature log measured an aquifer temperature of 23.5° C and a bottom hole temperature of 25.3° C. This was within the calculated bottom temperature range of 24 to 29° C estimated prior to the actual drilling using the shallow well temperature data. This result was felt to vindicate the use of shallow temperature gradient data as long as adequate subsurface lithologic information is available. This is necessary so that the overall temperature gradient and temperature-at-depth may be estimated in various rock types at other areas within the Capital District.

TABLE 7-3

CORRELATION COMPARISON BY LOGGING
LOG TYPE
(DEPTHS - FEET/METERS)

	Lithologic	Gamma	SP
Trenton	1205/367	1205/367	1205/367
Chucktanunda Creek	1278/390	1278/390	1288/393
Tribes Hill			
Wolf Hollow	1418/451	- - -	1418/432(?)
Palatine Bridge	1480/451	1504/459	1514/462
Fort Johnson	1588/484	1596/487	1602/489
Little Falls	1795/547	1826/557	1832/559
Mosherville(?)	- - -	2044/623	2034/620
Galway	2044/623	2060/628	2056/627
Potsdam	2316/706	2316/706	2308/704

TABLE 7-4

TEMPERATURE GRADIENT BY LITHOLOGY

Lithology	Gradient (° C/km)
Shale	30.5
Carbonate (above aquifer)	19.45
Carbonate (within and below aquifer)	10.7

(Average gradient = 22.96 ° C/km)

CONDUCTIVITY MEASUREMENTS AND HEAT FLOW CALCULATIONS

Method

Heat flow is a measure of the heat flowing out of the earth by conduction, and can be calculated using the equation:

- $q = K\,(\Delta T/\Delta Z)$, where: (7-1)
- q = heat flow in milliwatts per square meter (mW/m^2),
- K = rock thermal conductivity (units are W/M^oC)
- and $(\Delta T/\Delta Z)$ = change ($^oC/km$) in temperature with depth, or the geothermal gradient.

Four samples collected from the shaley drill cuttings and dolomitic core taken at the deep well site, and two samples of dolomitic core from the Pallette quarry west of Saratoga Springs were sent to Dr. Dennis Hodge at Technological Systems Research, Inc., near Buffalo for rock conductivity measurements. These samples were chosen to represent the major lithologies in the well. Chip samples were prepared from the material sent and saturated with water for the measurements. Measurements were made using the needle-probe method, with a precision reported by Hodge (personal communication) of 9% of values determined using divided-bar method. However, according to Sass, et.al., in "Physical Properties of Rocks and Minerals," problems with sampling and the uncertainty involved with the in-situ three-dimensional conductivity structure of the rock, the accuracy of conductivity measurements can be limited to as much as 20% when drill cuttings are used and porosities are uncertain.

Results

The conductivity results determined by Hodge for samples from the Stevens Elementary School well (DGC:DH-10) and Pallette quarry are given in Table 7-5. Samples 1 and 2 were the dolomites from the Pallette quarry, samples 3, 4 and 5 were shale chip samples from the Steven's well, and sample 6 was a piece of dolomitic core collected in the Stevens well. Samples 1 and 2 are located in the Little Falls and Galway Formations respectively.

For the purpose of calculating heat flow for this site, and for estimating heat flow nearby, the average of the three shale values will be used for shale conductivity ($2.27\ W/m^oC$) and the average of the three dolomite values will be used for dolomite conductivity ($3.47\ W/m^oC$).

TABLE 7-5

HEAT FLOW RESULTS OF SELECTED SAMPLES

Sample No.	Identification	Depth	Rock Type	Thermal Conductivity
1	Pallette #7/B.15	250'	Micritic Limestone (Hoyt Formation)	K=2.79 W/m°C
2	Pallette #7/B.22	437'	Med. crystalline silicous dolomite (Galway Formation)	K=3.66 W/m°C
3	DGC:DH-10	180-200'	Fine graywacke/shale (Schenectady Formation)	K=2.36 W/m°C
4	DGC:DH-10	400-420'	Fine black shale (Schenectady Formation)	K=2.23 W/m°C
5	DGC:DH-10	640-660'	Fine black Shale (Schenectady Formation)	K=2.22 W/m°C
6	DGC:DH-10	1930'	Very coarse dolomite with calcite clasts (Little Falls Formation)	K=3.96 W/m°C

In calculating the heat flow at the Stevens Elementary School site, the gradients measured within the specific rock types are also required. Since the heat flow at a given site must be the same for all rock types encountered, it is expected that lower conductivity rocks would have higher gradients, and similarly, high conductivity rocks would have lower gradients. The gradient within the shale was determined to be 30.5 ^{0}C/km, and within the dolomite section, it was found to be 19.4 ^{0}C/km. Using these gradients, the average conductivities and the equation $q=k \cdot T/\Delta Z$, the heat flow, q, for the shale is 69.2 mW/m^{2} or 1.66 HFU (1HFU = 41.8 mW/m^{2}), and q calculated for the dolomite sequence is 67.3 mW/m^{2} or 1.61 HFU which is within experimental error for the measurement technique used for heat flow determination.

Only one other published heat flow value is available for this area of New York, and that was measured in Glens Falls at 43.47 mW/m^{2} or 1.04 HFU. Costain, in "Heat Flow From the Crust of the United States in Physical Properties of Rocks and Minerals," also states that normal heat flow values for this area are in the range of 36 to 48 mW/m^{2} or 0.9 to 1.1 HFU, significantly less than that calculated for the Steven's School site. The area of high gradients can, therefore, be considered to be an area of relatively high heat flow.

By using the average conductivity of shale at the Ballston Lake site, it is possible to estimate the heat flow at other locations where gradients were measured in shale wells. Of particular interest are the two wells having the highest gradients, since they will give an indication of the highest heat flow for the geothermal area. The Widmer well, having an average "apparent gradient" of 43.2 ^{0}C/km, would yield a heat flow of 98.1 mW/m^{2} or 2.35 HFU (Note: for reasons discussed in the Near-Surface Gradient Corrections this gradient may not be valid). The Piotrowski well, drilled for this project and having the second highest gradient, averaging 36.6 ^{0}C/km, yields a heat-flow of 83.0 mW/m^{2} or 1.99 HFU. Both these values are much greater than expected for this part of the country. They appear to indicate that a local high heat flow anomaly coincides with the area of high gradients.

WATER SAMPLES AND CHEMISTRY

Three water samples were collected from the 2300-foot well and chemically analyzed. The samples were collected at depths of 200 feet, 1800 feet and 2230 feet. These depths were chosen to supply information on the near-surface water, the water from the deep water-producing zone, and from below the producing zone. An electrically-operated, piston-chamber collection device provided by the U.S. Geological Survey was used to collect these samples.

The water is extremely gassy (predominantly CO_2), so much so that the exsolution of gas in the casing made the water appear to boil rapidly. Enough gas was exsolving at depth, to lift a column of water 40 to 60 feet in the air in a thrice daily geyser of short duration. The chemical analyses for these samples are shown in Table 7-6. The water from the three depths was essentially the same due to the gas instability, and the total solids were approximately 16,700 mg/l or somewhat less than the most saline of the carbonated waters which were sampled. The highest total solids value is within the aquifer zone and indicates the saline water apparently originates from or travels within the aquifer. Silica concentrations were rather low, but the samples were otherwise chemically similar to the Saratoga-type carbonated saline water.

TABLE 7-6

CHEMICAL ANALYSIS - 2300-FOOT WELL

	200 ft.	1800 ft.	2230 ft.
pH	6.410	6.560	6.460
Sulfate as SO_4	33.000	36.000	29.000
Chloride	8,100.000	7,200.000	8,100.000
Sodium	4,600.000	4,600.000	4,800.000
Potassium	440.000	450.000	460.000
Calcium	700.000	700.000	500.000
Magnesium	280.000	320.000	290.000
Iron	2.600	2.400	2.100
Nitrogen, nitrite*	11.000	5.000	20.000
Nitrogen, nitrate and nitrite	0.050	0.920	0.060
Nitrogen, ammonia	9.000	7.000	11.000
Nitrogen, total lyeldahl	10.000	9.200	14.000
Carbon, organic (TOC)	5.000	10.000	6.000
Phosphate, total as P	0.056	0.030	0.054
Floride, free	0.300	0.400	0.400
Bromide	100.000	140.000	170.000
Iodide	4.300	3.900	4.400
Boron	6.500	6.400	6.800
Aluminum*	130.000	50.000	50.000
Lithium	17.000	17.000	17.000
Silica, react. as SiO_2	2.800	2.400	2.700
Strontium	18.000	18.000	27.000
Barium	28.000	29.000	19.000
Mercury, total*	0.400 LT	0.400 LT	0.400
LT			
Zinc	1.300	1.100	1.600
Hardness, total as $CaCO_3$	4,020.000	4,200.000	3,810.000
Hardness, calcium as $CaCO_3$	3,370.000	2,710.000	2,330.000
Total solids	16,400.000	17,100.000	16,600.000

Results for solids in mg/l.

SECTION 8

GEO-HYDROLOGIC MODEL

INTRODUCTION

For any demonstrated thermal anomaly in the geothermal gradient for an area, a source of abnormal heat is indicated. Within the Capital District two demonstrated areas of geothermal interest are now known: the warm springs at Lebanon Springs and the thermal anomaly associated with the fault system running through Saratoga Springs. The lack of extensive geo-hydrologic information for the deep subsurface in the Capital District is a limiting factor in determining an absolute heat source for the thermal anomalies. The following is a discussion of the alternative hypotheses which may explain the thermal waters.

DEEP CIRCULATION-LEBANON SPRINGS AREA

Areas of normal geothermal gradients may have warm springs if a deep system of faults and fractures is present. These faults or fractures provide a conduit where surface fluids may circulate easily to great depths, become warm, and return to the surface. Such systems are believed to operate for a number of warm springs located along the structural front of the central and southern Appalachian Mountains in the eastern United States. A complex fracture system along which water may circulate appears to be responsible for these springs.

Lebanon Springs probably has a deep circulation system similar to those postulated at other warm springs along the Appalachian Mountains. The water chemistry is similar to surface and near-surface groundwaters. A complex fracture system associated with reverse faulting in the area probably acts as a conduit whereby deeply circulating groundwater becomes heated at depth. Probable groundwater recharge areas are in the mountainous areas to the north and northeast where exposed aquifers of dolomitic rock in contact with the reverse fault provide an access zone for water to begin deep circulation. Temperature gradients in the Lebanon Springs area are considerably lower than those of the Saratoga-Scotia area.

Given the normal 10 to 15° C/km regional temperature gradient, measured gradients (18° C/km) in the Lebanon Springs area are not much greater than normal for the entire region. If deep circulation is responsible for the thermal waters of Lebanon Springs, an elevated temperature gradient would not be required to account for the warm waters.

ALTAMONT-SCHENECTADY-SARATOGA-HIGH HEAT FLOW AREA

An area of high heat flow is demonstrated for the greater Capital District. Deep circulation would not explain the CO_2-rich and saline character of the Saratoga-type waters. Previous isotope analyses of dissolved CO_2 and other gases for Saratoga-type waters have suggested that a deep thermal source is responsible for the presence of CO_2 (see Figure 8-1). Deep circulation within an area of normal geothermal gradient is considered to be very improbable for the greater Capital District. Several geologic mechanisms may be responsible for producing this anomaly. These are discussed below.

Deep Magmatic Source

A hot, magmatic body intruding upward into an area will warm the surrounding area, creating an increased geothermal gradient. High temperatures associated with an intrusive body would metamorphose surrounding non-intrusive "country" rock which, if in contact with carbonate-rich rock, could release large quantities of CO_2 as in the Saratoga-type waters. A magmatic source may also contribute CO_2 plus magmatic fluids and salts altering the water chemistry. The suddenly increased salinity found in the deep aquifer waters in the Schenectady-to-Albany area could be affected by magmatic additions. Saline waters of the deep aquifer are probably connate, but magmatic additions cannot be completely ruled out due to the complex chemistry of these waters. The magmatic body should have a relatively high percentage of radioactive elements available for solution in the thermal fluids to account for the measured radioactive component of the thermal fluids.

A fault/fracture system intersecting the magmatic source at depth would produce a path for transporting the thermal fluids and heat directly to the aquifer and to the surface. Presumably the igneous mass would be at considerable depth (at least 10 km) and at the last stages of crystallization during which gases are most commonly released. The great depth of burial would

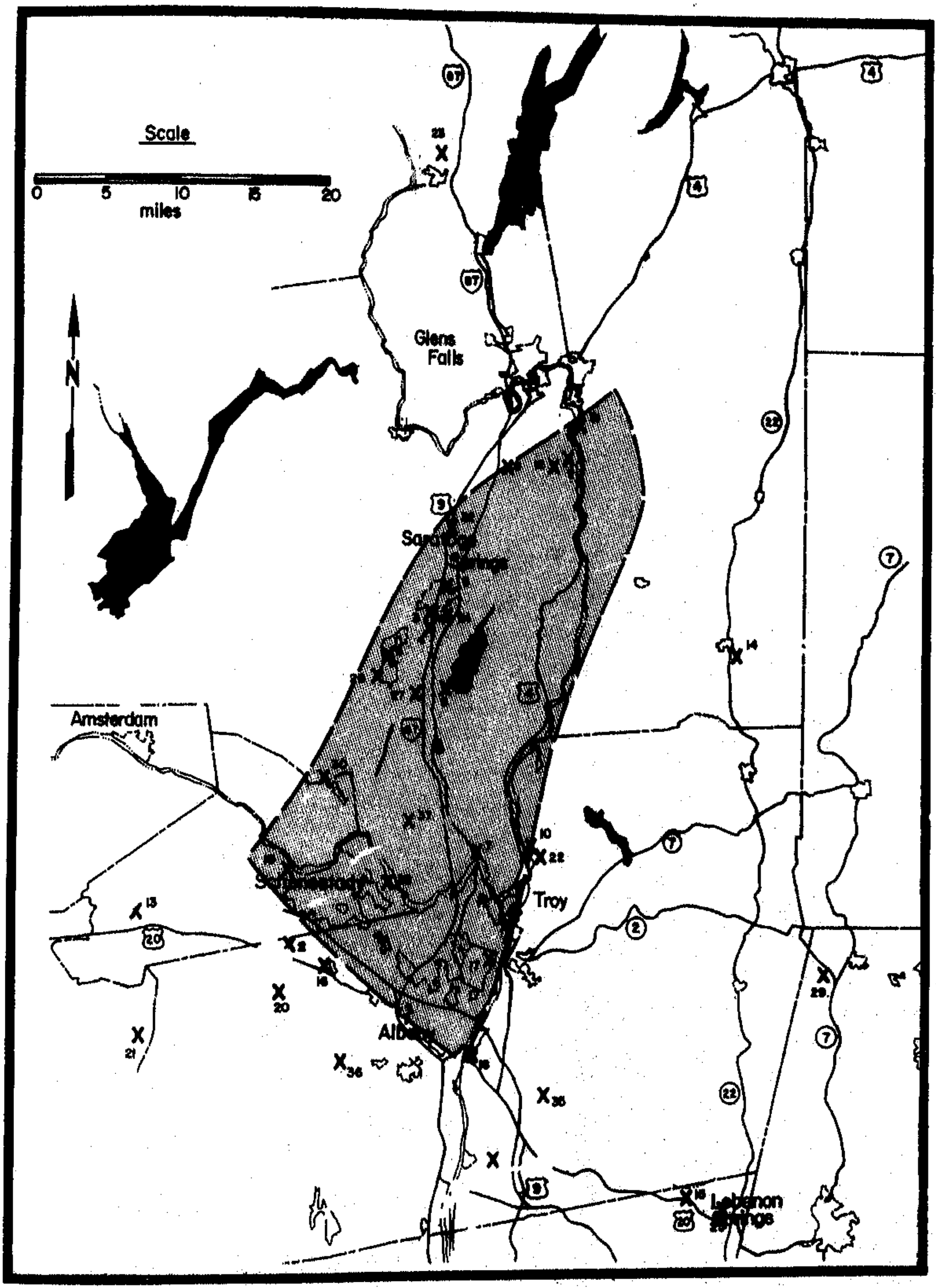


Figure 8-1. Area Enclosing Known CO_2 - Bearing Wells. Geochemical Sample Locations Included For Comparison

obscure any obvious surface temperature anomaly, but at the same time requires deep faulting or fracturing to reach the heat source and bring thermal fluids to the surface. The thermal mass of a magmatic body must be small or the heat flow would be expected to be greater than that measured for the Capital District.

Measurements of gravity and magnetics do not give positive evidence that such a body does exist. This area is generally geologically stable and does not have any evidence of major recent tectonic or magmatic activity. A magmatic intrusive body would be expected to produce some earth tremors as it cools and shrinks. The tremors observed, particularly in the Thompson Lake area, could be related to such intrusive activity. A small mass of several square kilometers of surface area in the last stages of crystallization may not necessarily be associated with much measureable seismic activity.

Radioactive Heating From Buried Pluton

Some granitic igneous rocks occurring in the Precambrian Adirondacks to the north and in the rocks of the same age in northern New Jersey and southern New York contain appreciable concentrations of radioactive elements -- enough in some areas to be considered as economic sources of radioactive elements (Zen, et al, Chapter 33). Precambrian age rocks underlie the sedimentary rocks of the Capital District and some may contain concentrations of radioactive elements. The heat emitted as a by-product of radioactive decay could cause areas of high heat flow. Such heat is considered to be a probable source of several of the geothermal anomalies in the eastern United States. Nearby granitic bodies in New Hampshire have a demonstrated high heat flow due to natural radioactivity. Given a sufficient insulating cap of rock over a pluton, high temperatures can result.

Geophysical evidence of a buried radioactive mass is equivocal. Such masses are often associated with magnetic minerals and, therefore, might be associated with a magnetic anomaly. No such anomaly has been observed on the magnetic maps of this area. However, an igneous mass heated beyond the Curie point for magnetite ($575^{o}C$) would not be magnetic. Such a mass would have to be over 10 km deep to be consistent with known temperature gradients.

If such a radioactive body were in contact with the sedimentary carbonate rocks of the Capital District and sufficiently hot, it could cause chemical reactions between carbonate minerals and silica to create Ca-Mg-Fe silicates and release carbon dioxide in the process. However, the temperature would have to be from 350° to 400°C for such reactions to occur and there is no evidence that such temperatures occur anywhere in the Capital District at the relatively shallow depth of the sedimentary carbonate rocks. The deeper carbonate rocks in the Precambrian have already been metamorphosed and most available SiO_2 already combined with carbonates to form Fe, Mg and Ca silicates. However, a calcitic marble containing quartz could exist, i.e., may not have previously reached the very high temperatures required to combine $CaCO_3$ and SiO_2. Radioactive heat could now be great enough to combine SiO_2 and $CaCO_3$ to produce CO_2. Marbles of Grenville age everywhere observed in New York State have already undergone metamorphism of amphibolite grade. This means that silica has probably already combined with carbonates and been used up. Diopside is pretty much ubiquitous in such marbles. Its equation for formation is:

$$CaMg(CO_3) + SiO_2 = CaMgSi_2O_6 + 2CO_2 \qquad (8\text{-}1)$$

Such reactions have mostly consumed free silica so that heating Grenville marbles should not usually result in release of more CO_2. However, some Grenville calcitic marbles contain quartz indicating the temperatures were too low to combine quartz and calcite to produce wollastonite ($CaSiO_2$) plus carbon dioxide. If such a marble occurred at great depth and the temperatures were very high (400°+ C), wollastonite could form. If this is the case, the radioactive mass may well be heating up and could intrude sometime in the future. The remetamorphism of metamorphosed Grenville rocks does not readily explain the increased NaCl content of the waters associated with the heat, because both the radioactive mass and the marbles would be very low in NaCl.

A deeply buried pluton within the geologic environment of the Capital District would be consistent with the observed high radon, radium and helium present in the geothermal fluid, with the fault system being conduits for these fluids. The contact metamorphism associated with a deeply buried pluton would explain the dissolved CO_2 found in the thermal fluid, but would not explain the increased salt content observed in the thermal fluids.

Decomposition of Organic Matter

Another process of producing heat at depth is exothermic decomposition of organic material trapped within the rock. The production of oil and natural gas (hydrocarbon) from organic material results in a net heat output (exothermic). This process is known, for example, to be producing appreciable quantities of heat at depth in recent sediments in the Gulf of Mexico, an important source of petroleum and natural gas (methane).

The Capital District is located on the edges of two structurally complex areas: the Appalachian basin to the south and southwest; and the Taconic Overthrust belt to the northeast, east and southeast. The Appalachian basin has produced quantities of oil and gas while the Taconic Overthrust belt is currently being investigated for gas. The decomposition of organic materials is exothermic (heat producing) and with sufficient insulating overburden, appreciable temperatures can be attained within the rock.

Exothermic decomposition of organic materials has been suggested to account for the geothermal anomaly in the Capital District. This hypothesis has several problems limiting its acceptance as a viable model:

- The heat source for the geothermal anomaly is associated with deep faulting and fracturing, apparently bringing heat up from great depth. The heat source is apparently below the carbonate geothermal aquifer which transmits the warm fluids. The aquifer cannot be a source of heat by decomposition of organic matter, because of the carbonate rock's low organic content. There are no known hydrocarbon source rocks stratigraphically below the aquifer.

- Due to the great age of the carbonate and related rocks in this area, the exothermic decomposition of organic material in any hydrocarbon source rocks in the Appalachian basin and the Taconic Overthrust probably occurred hundreds of millions of years ago, and the heat has long been dissipated. The known age of faults in this area that could deeply bury younger source rock is old enough that exothermic decomposition would also have ceased in the younger rocks and the heat would no longer be present.

- The temperature gradients measured to the south (Catskill Mountains) and the Taconic Overthrust belt are too low to indicate that any active heat source is present. This finding corroborates the inference that exothermic processes are largely inactive for the areas near the Capital District.

Exothermic decomposition of organic material has also been postulated as the source of CO_2 found in the geothermal fluids. Carbon dioxide is produced by exothermic decomposition, especially in the presence of oxygen (oxygen is rarely found at depth). Isotope analysis of carbonated water from wells in the Saratoga Springs area indicated that the CO_2 could be from a variety of sources including exothermic decomposition. While equivocal, the carbon isotope data for Saratoga suggested a mixture of CO_2 derived from deep, possibly thermal sources and carbon derived from dissolution of known surficial rocks. The chemically reduced nature of the aquifer waters, the mass proportions of measured gases, and carbon isotope ratios do not suggest oxidation of organic material as a major source of CO_2 (see Section 3 of this report and Young and Dunn, 1979). More testing of the dissolved gases is required for a more definite answer.

It should be noted that the dissolution of carbonate rock to produce carbon dioxide is not heat producing. As noted some of the CO_2 dissolved in the geothermal fluids may have this source, but no heat would be produced. Magmatic (deep), thermal sources for warm and hot springs throughout the world do produce great amounts of CO_2 (White, 1957).

In general, the model of exothermic decomposition of organic materials as a heat source for the geothermal anomaly is not supported by

- the extreme age of the rock,
- the structure and stratigraphy of the rocks, and,
- the known thermal gradient measurements.

The past activity of this process may account for the presence of methane within rocks in and surrounding the Capital District. Exothermic decomposition probably contributes to the CO_2 found in the geothermal fluids. Present evidence, while equivocal, suggests that this process is not a major contributor.

Summary Neither the magmatic nor the radioactive model is totally satisfactory as an explanation of the observed phenomena. However, because no other alternatives are reasonable, one of these possibilities probably accounts for the geothermal anomaly. Exothermic decomposition of organic material is not considered a probable mechanism for heat production within the Capital District. Carbon dioxide is most easily explained as being derived from a deep thermal source and moving in the carbonate aquifer up-dip from the south to north towards Saratoga Springs. While flow from the east is not impossible, the structure of the subsurface to the east with the known series of multiple thrust and normal faults should restrict flow of any CO_2 from this direction. These faults place shale beds in contact with carbonate beds which should effectively block the movement of gases from the east to the west towards the Capital District. Current exploration for hydrocarbons under the Taconic Overthrust is largely justified because the structural relationship of the faulted beds should prevent the migration and escape of gases such as CO_2 and methane.

HYDROLOGIC MODEL

As observed in the 2300-foot Stevens Elementary School well, the major aquifer which transports geothermal fluids may be in the lower third of the carbonate section probably in the Little Falls and Galway Formations. The thermal fluid is saline- and CO_2-rich and may be moving northward towards the surface around Saratoga Springs. As this fluid moves northward, mixing with meteoric and groundwater reduces its salinity and contributes to cooling of the fluid. The extensive pumping over the past century from wells in the Saratoga area undoubtedly has contributed markedly to the dilution and accounts for the wells becoming less saline through the years.

The Saratoga-MacGregor-Ballston Lake fault system extends into the carbonate section and probably downwards into the basement. These faults encourage the migration of the thermal fluid and appear to localize the geothermal gradient anomaly in the area. The associated fractures in the area probably facilitate movement of thermal fluids east and west of the faults. The fracture system is complex enough that thermal fluids, but not necessarily heat, migrate over a wide area and can be recognized in well samples far removed from the known faults often even when the wells do not penetrate the carbonate section.

Interpretation of evidence by Boyd Brown from the Stevens Elementary School test well indicates an upper porosity zone aquifer is being fed by a lower fracture zone aquifer. Temperature gradient measurements indicate a nearly zero temperature increase from the top of the first aquifer to the bottom of the second aquifer. These aquifers occur over a thickness of about 150 to 170 feet in the Ballston Lake area. Below this the gradient is normal or below normal for the general region. Above the aquifer the gradient is greater than that for the general region. The aquifers appear to be conduits carrying deep thermal fluids northward from somewhere to the south to the surface near Saratoga Springs. Otherwise the temperature gradient would not decrease below the aquifers. Most -- perhaps all -- gradients measured in the Albany-Schenectady-Ballston Spa areas may, in a sense, be "perched gradients," i.e., the gradients are above a flowing thermal fluid and probably do not persist below the zones in which that fluid travels.

Water flow rates for wells penetrating the geothermal aquifer in the carbonate rocks are not known except in the Saratoga Springs area where the geothermal aquifer is less than 700 feet below the ground surface. Many of these wells which were drilled by the Saratoga Springs Authority for the commercial mineral baths are capable of producing a sustainable flow of 30 to 50 gallons per minute (Carl Edwards, personal communication). Groundwater studies for Saratoga County list yields as high as 150 gallons per minute for several wells (100 gpm for Lincoln Spring #12 well and 150 gpm for an unnamed well; Heath et.al., 1963). Detailed records are unavailable, and the reliability of these measurements is unknown. Conversely, a number of other wells produce less than 30 gallons per minute. Water flows from wells in Saratoga Springs are probably not as great as could be produced from a properly developed geothermal well especially if standard techniques for increasing flows as for oil and gas wells are employed.

A well drilled into the carbonate geothermal aquifer in the southern Capital District area near the probable geothermal source area should produce a greater water flow than Saratoga Springs wells if drilled as a geothermal well. Additionally, the association of faulting and fracturing with the Saratoga Springs "Vichy" wells is clearly established. Several large and numerous small faults and fracture zones cross the Capital District. Water flow should be greatest in or near zones of faulting and fracturing with possible flow rates of several hundred gallons per minute not unlikely. The locations of zones of maximum fracturing along faults where high flow might occur are difficult to predict.

An area with a higher probability for well-developed fracture permeability is the Scotia area where the southern extensions of the faults present in the Saratoga Springs area are located along with possible fracture zones along the Mohawk River lineament. The Albany area is also highly fractured and faulted due to the nearness of the large Taconic Overthrust faults to the east. Fracturing and faulting may extend to great depths as a result of the more intense deformation of the rocks to the east.

SECTION 9

DISCUSSION AND CONCLUSIONS

The research on the geothermal potential of the greater Capital District has disclosed the presence of two unrelated geothermal systems:

- the Lebanon Springs system which is in an area of relatively low geothermal gradients. Apparently normal groundwater circulating to great depth along zones of secondary permeability is released to the surface via a discharge zone along a high angle reverse fault in an area of relatively low geothermal gradients; and,

- the Albany-Schenectady-Saratoga area which is underlain by a geothermal system of higher temperature gradients and heat flow. This latter system is the primary subject of the present research.

THE ALBANY-SCHENECTADY-SARATOGA GEOTHERMAL MODEL

The system is manifested as an area of relatively high temperature gradients and heat flows and is associated with CO_2- and salt-rich waters of the Saratoga Springs type. The origin of the CO_2, the increased salts and the heat is not known with certainty. The best explanation for the chemical, thermal and structural data appears to be that an igneous mass in the last stages of crystallization (a fluid-release phase) at a depth of 10 to 20 km, occurs somewhere under the Capital District. This mass could also be relatively high in natural radioactivity.

An alternative hypothesis to account for the heat and the CO_2 is that a radioactive granitic rock is in contact with quartzose or cherty marbles and the heat is sufficient to cause recrystallization of new silicates. This could most likely occur if metamorphism of the Grenville-age carbonates had not previously reached a high enough grade to combine all of the free silica. If this is the case, the radioactive mass is heating and could be melting and intruding upward some time in the future. The location of such a mass could be around the Westmere area.

Because CO_2 must move from high pressure at great depth to be released at low pressure at shallow depth, the most reasonable source area appears to be the southern edge of the geothermal area where the layered rocks are deepest. Carbon dioxide has been recorded in the Albany area, and although the highest temperature gradients were observed in the Scotia area, forcing CO_2 back 29 km to Albany against the implied pressure gradient into deeper rocks is difficult to visualize. The faults in the Scotia area act as conduits allowing a greater heatflow to the surface and thus, a higher temperature gradient measurement. The area where such a source might most logically occur is at the western edge of Albany where temperature gradients would presumably be higher. A smaller related mass could possibly account for the southward thermal projection to the Altamont area. Study of seismic activity along with temperature gradient measurements in the Capital District have not provided a clear answer to the question of the source of the geothermal anomaly.

Information from the microseismic network indicates that no magmatic masses of the types which occur in western geothermal areas of the United States exist under the Capital District. The extent to which a modest-sized largely crystalline mass could be hidden is not known. Microseismic activity which occurred at Thompson Lake on February 8, 1982, may be related to the southern spur of the 20^0 gradient line in some unknown way (Altamont and Thompson Lake are on the southernmost projection of the Saratoga fault.) The only microseismic activity which was detected near the area of the most probable heat source occurred at Elsmere, just south of Albany, about six miles southeast of Westmere.

The evidence indicates that heated CO_2 is generated in or about the heated mass and moves upward from depth first along zones of permeability created by faults then,once it reaches the bedded Paleozoic rocks, tends to move along zones of secondary permeability and also through porous zones in the Little Falls and Galway dolomites and, possibly the Potsdam sandstone.

The entry zone appears to be somewhere along a line starting at the Hudson River at central Albany passing north of Westmere and then to Rotterdam Junction to the west. No CO_2 was found in saline wells south of this line. In addition, saline wells south of the line are relatively low in total dissolved solids -- less than 5000 ppm - whereas the salinity north of the line rises suddenly to about 20,000 ppm.

The CO_2 migrates largely in the carbonate rocks, under covering rocks of low permeability, northward past Saratoga approximately to the Glens Falls area. The CO_2 must be naturally vented into the meteoric groundwater and into the air where the Paleozoic carbonate rocks outcrop west, north and northeast of Saratoga. Figure 8-1 shows the distribution of the known CO_2-bearing waters.

South of Saratoga Springs the CO_2-rich waters are associated with NaCl brines not appreciably different than sea water, but more dilute. North of Saratoga the total solids drop off and change to high-potash sodium-carbonate brines. This is interpreted as being the result of dilution of the brines by normal groundwater from the north combined with decomposition of alkalic feldspars causing release of Na and K thus radically increasing the ratio of the alkali metal ions to chloride ions. (Simple dilution would leave Na:Cl molecularly about 1:1.)

Presumably in this system CO_2 moves from high pressure to the south and east northward through a stationary or relatively slowly northward-moving brine. Any salts or water introduced with the CO_2 move very slowly or may even be essentially stationary. The warm areas coincide closely with the CO_2-bearing waters and hence it appears that this fluid carries much of the heat. The sharp drop in geothermal gradient which was observed below the permeable zone in the Little Falls and Galway dolomites in the Stevens Elementary School well (DGC:DH-10) is consistent with the heat moving with the fluids, not with its being transmitted by conductivity upward from deeper in the earth below that area.

PREDICTING AQUA-THERMAL RESULTS FROM DRILLING

Any well drilled through the overlying shales and sandstones into the Paleozoic carbonate rocks within the CO_2-rich area should encounter CO_2-bearing saline waters in the Paleozoic carbonate rocks. Wells drilled only into the upper shale-sandstone sequence should usually encounter normal groundwater -- varying from fairly pure meteoric water to sulfate-rich and/or carbonate-rich water with occasional H_2S and/or SO_2 concentrations. A few shallow wells have encountered CO_2-bearing NaCl brines. Such waters are presumably rare leakages upward along zones of permeability such as faults.

In most areas within that part of the thermal anomaly from Altamont north past Saratoga and as far east as the Saratoga Fault, the depth to the observed water-bearing zone and the temperature of the thermal water can be anticipated fairly well. The depth to the aquifer can be estimated from the geology. The temperature of the water in this zone can be estimated by using the temperature gradient in the shales for a given geographic area and by assuming that the gradient in the underlying carbonate rocks is about 0.6 that of the shales, i.e., assuming the same proportionality as observed in the Stevens Elementary School well.

An area with relatively high probability for well-developed fracture permeability is the Scotia area where the southern extensions of the faults present in the Saratoga Springs area are located along with possible fracture zones along the Mohawk River lineament. The Albany area is also highly fractured and faulted due to the nearness of the large Taconic Overthrust faults to the east. Fracturing and faulting may extend to great depths as a result of the more intense deformation of the rocks to the east. If a properly designed well is drilled into a faulted and fractured zone within the carbonate section containing the geothermal aquifer, a flow rate in excess of 150 gallons per minute may be obtained based on maximum yields for non-geothermal type wells in the Saratoga Springs area.

East of the Saratoga Fault, the geology rapidly becomes complex and much less predictable because the carbonate rocks are deeper, and because a series of eastward-dipping thrust faults double up the rock layers. The depth of the aquifer should lie within 200-500 feet above the Precambrian basement (see Figure 9-1). An approximate temperature of the aquifer can also be estimated from known temperature gradients, geology and the assumed depth of the aquifer (approximately 200 feet above the basement) for the Capital District west of the Hudson River (see Figure 9-2). Complexities increase from the Hudson River eastward, because complex sedimentation processes operated during deposition in a long, narrow trough of the ocean along the Hudson River during the lower Paleozoic. The rock units were further complicated by early allocthon block faulting, followed by thrust faulting, with the entire mass being covered by an overthrust plate coming from the east, greatly reducing the ability to predict the geology at depth. Presumably, possible gas exploration drilling in eastern New York coupled with their deep seismic exploration backup will help some in understanding the Hudson Valley geology around Albany. Because of the very

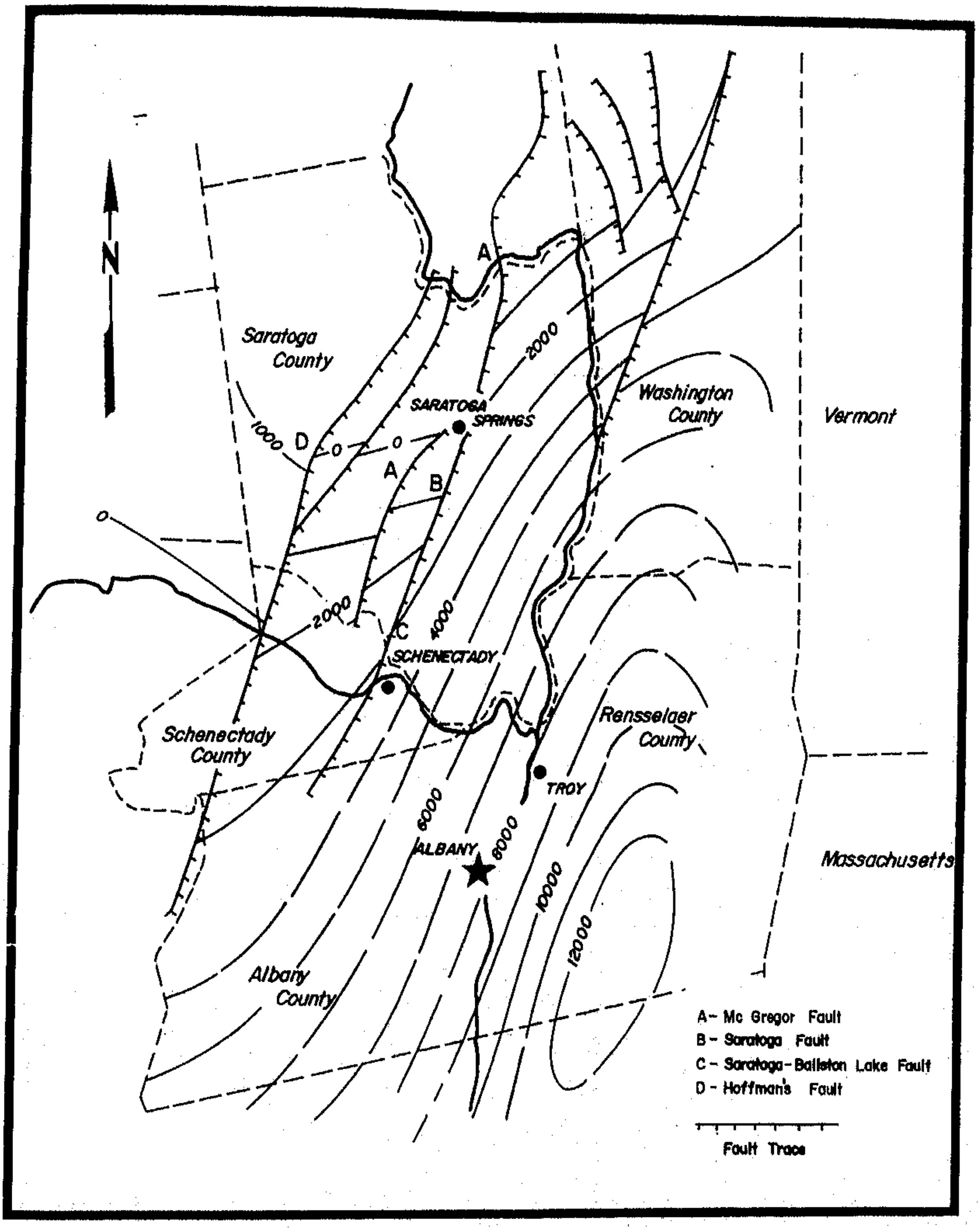


Figure 9-1. Depth (feet) Of Precambrian Basement
(Adapted From N.Y.S. Museum & Science, Map & Chart Series - 18)

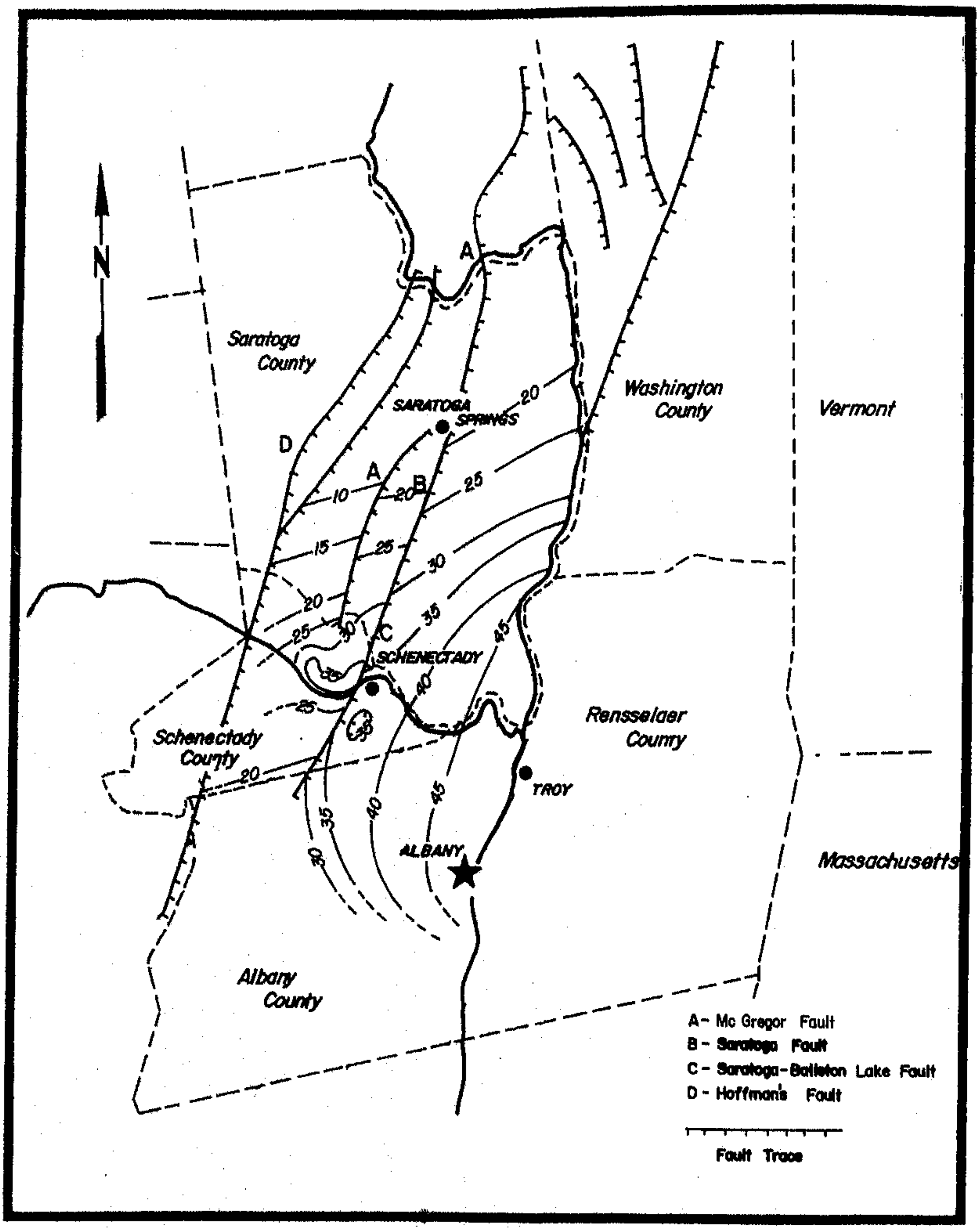


Figure 9-2. Approximate Temperature Of Geothermal Fluids At Depth Contour Map (C.I. = 5°C)

complex geology east of the Hudson River, prediction of the occurrence, depth and temperature of a geothermal aquifer in that area is currently not possible. Most significantly, so far as the exploration for geothermal energy is concerned, drilling east of the Hudson River based on the data available appears to have little probability of success because the temperature gradients are discouraging and because the probability of hitting an aquifer at a predictable depth is very low.

The discovery in this program that relatively near-surface water under urban areas can be as much as 10° to 15°C warmer than under rural areas at comparable elevations and latitude is of potentially major importance. According to research by American Water Well Association and DGC (1978), normal-temperature rural ground water is now economic for ground-water heat pump use over most of New York State. Tapping the stored heat under urban areas could greatly improve the energy efficiency of the ground-water heat pump as compared to heat pump usage with normal ground-water temperatures.

SECTION 10

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APPENDIX A

CHEMICAL DATA

INTRODUCTION

Phase I, Geochemical Data

The foldout represents values for chemical data from wells sampled during Fall, 1978. This chart contains representative chemical values for the sampled wells. Additional sampling data is contained within the Phase I report, "Geothermal Resources Evaluation: Eastern New York State," NYSERDA 79-6. The great majority of these samples are from the Saratoga Springs "Vichy" wells, or were duplicated by later sampling in the Phase II study.

Phase II, Geochemical Data

The table following the foldouts is a compilation of Phase II geochemical sampling. Additional analysis of geochemical data with respect to the geothermal system is contained in the Phase II report, "Exploration for Geothermal Resources in the Capital District of New York." A location map for these chemistry samples can be found as Figure 3-1. The last two digits of the sample number represent the posting number for well locations in Figure 3-1.

Southern Brine Waters						Surface Water Control Wells						Vichy France	
ZZI	FIGLIOMENI	TUDOR PINES	GORMAN	PATTERSON-VILLE (duplicated)	PATTERSON-VILLE	POMPA	Y.K. GREENE	BLOODGOOD	SARATOGA VETERINARY HOSPITAL	WILSON	MIDDLETOWN SPRINGS	CELESTINS	HÔPITAL
09/20	10/09/03	10/20/12	10/20/10	10/19/10	10/19/10	10/6/10	10/16/13	10/06/23	10/06/11	10/19/17	10/26/09	07/14/10	07/14/09
4.2	13.1	10.8	10.6	12.5	12.5	10.8	11.3	15.5	11.5	13.1	10.7	19.3	34.4
3.4	7.7	8.5	7.2	7.8	7.8	7.5	8.6	9.2	8.5	7.3	7.6	6.7	6.8
00	170	750	2880	650	530	17	5	3 LT	3	20	5	240	350
2	9	2 LT	2	60	54	110	5	2	3	160	15	170	220
76	1516	284	194	330	330	296	370	116	216	270	59	3385	3690
70	640	500	1800	290	300	3.1	98	36	70	43	3.9	700	720
9.7	7.5	6.6	20	3.8	3.9	3.8	2.4	.8	2.8	5.1	2.3	84	35
16	6.9	6.9	75	140	200	130	4.7	2.1	10	57	24	LA	LA
5.5	1.7	2.2	19	45	47	41	4.1	.44	4.7	32	3.3	9.1	11
.22	.22	1.7	.50	.31	.37	.16	.12	.05	.12	.31	.05	.05 LT	.14
LT	.2	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	1.5	.4	.2 LT
LT	5 LT	5 LT	5 LT	5 LT	5 LT	5 LT	5 LT	5 LT	5LT	5 LT	.5	5	12
.5	2.3	3.4	13	.29	.24	.20	2.4	.30	1.7	1.0	.005	.005	.17
5.3	3.0	5.3	17	LA	.5	.2 LT	2.6	.6	1.9	2.0	.2	.1	.6
4.2	3.8	2.4	1.0 LT	1.0 LT	1.0 LT	1.2	1.0 LT	1.0	2.8	1.8	1.0	10	10
020	.017	.005	.007	.005	.007	.002	.014	.059	.009	.005 LT	.2	.095	.18
2.3	1.6	.1 LT	.19	.18	.20	.26	1.60	.78	1.7	.23	.1	4.7	6.4
5	10	20	130	3.3	3.3	1.3	6.3	.56	1.5	4.4	.68	8.6	13
.7	1.1	.89	3.5	.028	.027	.010	.45	.006	.098	.060	.003	.007	.049
59	1.0	.96	1.0	.29	.50	.20 LT	.84	.2 LT	.50	.39	.20	1.3	1.8
05	.22	.05	.05 LT	.05 LT	.05 LT	.05 LT	.05	.05 LT	.05 LT	.05 LT	.05	.5 LT	.05 LT
.5	2.6	2.0	8.7	.06	.06	.01	.25	.02	.19	.10	.01	3.6	5.0
1	12	10	10	11	11	12	11	11	11	15	5	37	44
.4	2.0	1.6	34	.9	1.0	1.3	.9	.1	1.3	4.6	.05	.9	1.6
2.4	.9	.5	12	.5 LT	.7	.5 LT	.5	.5	.5	.5 LT	.5	0.5 LT	0.5 LT
LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05	1.0 LT	1.0 LT
004	.005	.006	.002 LT	.002 LT	.003	.002 LT	.002 LT	.005	.004	.002 LT	.002	NA	NA
3 LT	.025	.003 LT	.003 LT	.003 LT	.003 LT	.004	.017	.003	.010	.003 LT	.003	NA	NA
35	2070	1910	6550	1420	1480	436	290	140	230	454	102	3411	4566

ANALYTICAL DATA

FALL 1978 SAMPLING

						North Central Carbonated Waters					Sulfate Waters						
NGRESS (licated)	HATHORN no. 1	BIG RED	PEERLESS	RED	GURN	QUAKER	BENNET	MARTIN	DOSTER	MC NEIL	VITA SPRING	DAVIS	PITCHER	SHARON SPRINGS	SHARON SPRINGS (duplicated)	CONELY	AUGUST BOHL.
/12 /12	10/10/13	10/10/11	10/10/10	10/10/11	10/5/02	10/11/12	10/18/11	10/12/10	10/12/11	10/11/10	10/17/12	10/16/12	10/09/12	10/19/15	10/19/15	10/11/02	10/20/15
2.1	11.0	10.0	10.5	13.6	10.6	11.6	12.5	11.2	15.8	11.8	9.9	10.2	12.5	8.9	8.9	12.5	13.8
6.3	6.0	5.9	5.8	6.1	6.4	6.2	6.4	6.7	5.8 SU	6.8	6.7	7.4	7.2	7.8	7.8	7.4	7.7
390	1600	2500	980	650	750	700	450	190	600	260	230	16	230	51	43	2100	1000
54	INTERF.	9	4	4	5	INTERF.	40	INTERF.	INTERF.	INTERF.	INTERF.	INTERF.	2400	1800	1800	INTERF.	2 LT
970	2240	2660	1960	1340	1672	1550	1930	2340	2250	810	1220	640	380	290	260	220	339
550	950	1100	740	470	600	880	500	570	910	240	510	170	88	15	12	950	530
39	130	100	90	36	72	12	47	15	18	29	46	7.3	11	1.6	2.1	23	6.2
40	410	330	420	290	330	56	200	110	100	170	350	340	130	400	400	140	20
63	160	280	120	90	110	18	65	69	28	41	130	560	450	73	90	55	10
2.4	1.6	81	1.7	6.0	29	.47	1.9	1.5	.44	1.0	1.7	.05 LT	.21	.05	.05 LT	.8	.27
2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2	.2 LT	.2	.2	.2 LT
5 LT	5 LT	5 LT	7	5 LT	5 LT	5 LT	5 LT	5	5 LT	5 LT	5 LT	5	5 LT	5 LT	5 LT	84	5
1.5	6.5	8.0	3.5	3.6	3.0	3.3	8.0	6.0	9.5	.59	5.5	3.4	1.1	.23	.25	7.5	.80
2.0	6.4	10	4.9	3.8	LA	3.5	10	7.2	LA	1.3	5.9	4	1.0	.5	LA	LA	64
1.0	6.0	88	8.0	1.0 LT	22	3.4	1.0 LT	20	1.4	1.0	2.4	6	1.0 LT	1.0 LT	1.0 LT	1.0	1.0 LT
014	.027	.056	.032	.034	.15	.027	.031	.022	.014	.008	.008	.043	.002 LT	.005 LT	.005 LT	.002	.041
.50	.59	.23	.54	.58	.43	.34	.29	.20	.58	.20	.19	.11	.14	1.18	1.15	.11	.1 LT
6.0	29	41	22	15	15	13	18	25	27	7.2	8.3	5.5	1.3	.71	1.3	29	14
.16	.78	.62	.45	.42	.15	.37	.16	.17	.60	.094	.040	.005 LT	.011	.009	.008	.27	1.3
.65	1.4	1.5	.96	.58	1.0	1.1	2.0	2.0	2.8	.68	1.2	.28	.37	.20	.26	.40	.57
05 LT	.22	.05 LT	.16	.08	.32	.06	.16	.05 LT	.05 LT	.05 LT	.22	.05 LT	.05 LT	.05 LT	.05 LT	.05	.05 LT
7.9	3.8	4.8	2.6	1.2	2.0	3.0	1.9	1.1	6.9	.52	.83	.17	.18	.02	.03	2.0	2.4
16	13	70	16	46	55	15	17	16	13	22	22	18	15	16	17	10	17
1.6	5.0	11	3.3	4.8	2.5	8.8	8.6	7.7	11	2.1	12	11	8.6	11	9.3	21	3.6
.5	5.3	8.7	3.8	3.4	7.4	2.6	2.8	7.9	16	3.0	.5 LT	.5 LT	.5 LT	.5	.5 LT	9.1	2.8
05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	INTERF.	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT
004	.006	.002 LT	.008	.004	.007	.004	.005	.002 LT	.004	.007	.005	.002 LT	.012	.002 LT	.003	.003	.002 LT
009	.120	.016	.090	.016	.003 LT	.066	.228	.210	.170	.009	.050	.003 LT	.003 LT	.003 LT	.003 LT	.003 LT	.003 LT
740	5080	6460	3820	2430	3230	2650	2730	2600	3230	1270	3720	5460	4180	2400	2520	4300	2030

SU = Suspect
LT = Less Than
LA = Lab Accident
NA = Not Available
INTERF. = Interference

Thermal Waters ***Saratoga Springs Are***

	LEBANON SPRINGS	FRED GEORGE	OLD IRON	BISCHOFF	HATHORN no. 3	POLARIS	ORENDA	GEYSER	LINCOLN no. 12	ROSEMARY	CONGRESS
Date and Time of Sampling	10/25/08	10/25/10	10/10/02	10/16/10	10/12/12	10/13/10	10/13/09	10/13/12	10/18/10	10/5/12	10/12/12
Water Temperature °C	22.5	22.1	10.5	9.9	10.2	13.5	10.2	14.5	10.8	11.9	12.1
pH (Field)	8.1	8.2	6.2	6.4	6.0	5.5	6.1	5.9	6.5	6.0	6.3
Chloride	7	3	750	6900	6900	1400	4100	1300	1200	560	450
Sulfate (SO_4)	28	9	INTERF.	INTERF.	INTERF.	INTERF.	INTERF.	INTERF.	INTERF.	19	INTERF.
Alkalinity Electron pH 4.5	126	92	1280	4340	4270	1050SU	3280	2100	2090	1960	960
Sodium	7.8	2.0	520	4400	3100	770	2300	640	740	590	340
Potassium	1.6	1.0	34	300	320	100	230	110	110	87	39
Calcium	34	20	320	950	950	400	750	320	340	270	200
Magnesium	15	12	79	470	410	160	300	150	190	190	64
Iron	.05	.05 LT	10	.07	.08	1.6	2.3	2.7	6.2	6.2	2.3
Nitrate and Nitrite	.2	.2 LT	.2 LT	.2	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT	.2 LT
Nitrite	5 LT	5 LT	12	5	5	5	15	8	7	5 LT	5 LT
Ammonia	.007	.007	3.2	3.2	16	4.3	12	4.3	4.5	4.1	.78
Nitrogen Total	3.8	.2 LT	3.6	26	21	6.1	LA	5.8	6.1	43	2.1
Carbon Organic (TOC)	3.8	1.8	1.0	1.0	1.8	9.0	28	1.0	1.0 LT	34	10
Phosphate	.006	.010	.052	.018	.014	.019	.035	.014	.036	.10	.035
Fluoride (Free)	.25	.1 LT	.45	.1 LT	.34	.74	.58	.52	.60	.32	.50
Bromide	.95	.44	18	130	110	24	74	26	34	19	10
Iodide	.006	.004	.49	4.2	4.3	.54	2.6	.43	.87	.45	.19
Boron	.20 LT	.20 LT	.86	3.2	3.5	1.1	1.6	.87	1.6	1.2	.79
Aluminum	.05 LT	.05 LT	.05 LT	.06	.05	.05	.26	.05 LT	.05	.09	.05 LT
Lithium	.01 LT	.01 LT	2.0	14	12	2.8	10	2.8	2.7	1.9	.80
Silica	15	16	45	16	12	21	13	45	45	40	15
Strontium	.3	.05 LT	7.8	25	17	4.7	14	5.2	5.1	4.0	1.6
Barium	.5 LT	.5 LT	6.7	34	21	5.1	17	5.1	5.0	3.7	.7
Tin	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT	.05 LT
Yttrium	.003	.002 LT	.003	.002 LT	.002 LT	.002 LT	.010	.002 LT	.007	.002 LT	.002 LT
Zirconium	.003 LT	.003 LT	.010	.123	.025	.100	.237	.053	.048	.045	.015
Total Dissolved Solids	179	117	2610	17500	14610	4420	10780	4320	4240	3000	1710

NOTE:

The units of all values are expressed in mg/l except Nitrogen, Nitrite which is µmg/l.

TABLE A-2

SAMPLING SITES - SOURCE DATA

FALL 1978

Sampling Site	Location	Owner
Lebanon Springs	Lebanon Springs	Town of Lebanon Springs
Sand Spring	Williamstown, Massachusetts	Mr. Fred George
Old Iron	Ballston Spa, New York	Town of Ballston Spa
Bischoff	Ballston Spa, New York	Mr. Louis Pastore
Hathorn #3	Saratoga Springs Reservation	State of New York
Polaris	Saratoga Springs Reservation	State of New York
Orenda	Saratoga Springs Reservation	State of New York
Geyser	Saratoga Springs Reservation	State of New York
Lincoln #12	Saratoga Springs Reservation	State of New York
Rosemary	Grand Union Motel Saratoga Springs, New York	Mr. James Benton
Congress #1	Congress Park, Saratoga Springs, New York	City of Saratoga Springs
Hathorn #1	Saratoga Springs, New York	City of Saratoga Springs
Big Red	Saratoga Springs, New York	Saratoga Race Track
Peerless	Saratoga Springs, New York	City of Saratoga Springs
Red	Saratoga Springs, New York	City of Saratoga Springs
Gurn Spring	Gurn Springs, New York	Wilton Medical Center
Quaker	Quaker Springs, New York	Quaker Springs Historical Society
Bennet	Moreau, New York	Mr. Gerald Bennet
Martin	Moreau, New York	Mr. Jeffrey Martin
McNeil	Argyle, New York	Mr. Harold McNeil
Sharon Spring	Sharon Springs, New York	Town of Sharon Springs
Vita Spring	Durkeetown, New York	Ms. Elizabeth Rozelle
Davis	Smith's Basin, New York	Mr. James Davis
Pitcher	Dunnsville, New York	Mr. LeRoy Pitcher
Congly	Melrose, New York	Ms. Dolores Congly
Auguste Bohl	Bethlehem, New York	Auguste Bohl Equipment Corp.
Yezzi	Guilderland, New York	Mr. Daniel Yezzi
Figliomeni	Parkers Corners, New York	Mr. Joseph Figliomeni

(Table A-2 (Continued)

Sampling Site	Location	Owner
Tudor Pines	Central Bridge, New York	Tudor Pines Homes
Gorman	Sloansville, New York	Mr. Gorman
Pattersonville	Pattersonville, New York	N.Y.S. Thruway Authority
Pompa	Milton, New York	Pompa Bros. Quarry
Y.K. Greene	Wilton, New York	Mr. Y. Kittner Greene
Bloodgood	Malta, New York	Judge Bloodgood
Saratoga Veterinary Hospital	Wilton, New York	Saratoga Veterinary Hospital
Wilson	Altamont, New York	Mr. Arthur Wilson
Middletown Springs	Middletown Springs, Vermont	Middletown Springs Historical Society
Celestins	Vichy, France	Unknown
Hopital	Vichy, France	Unknown

APPENDIX A

CHEMICAL DATA FROM STANDARD SAMPLING

Sample No.	15001*	15002	15003	15004	15005	15006
T^{o}C	13.3	11.4	12.6	9.9	10.6	10.4
pH	7.9	8.0	6.1	5.8	6.6	5.8
Alkalinity (field)	194.0	1690.0	2940.0	3360.0	3560.0	1410.0
SO$_4$	4.0	8.0	29.0	15.0	20.0	4.0
Cl	450.0	330.0	350.0	3100.0	2700.0	1700.0
Na	180.0	450.0	350.0	2300.0	2300.0	550.0
K	3.4	8.4	72.0	220.0	36.0	35.0
Ca	55.0	5.4	260.0	720.0	120.0	290.0
Mg	26.0	2.3	190.0	310.0	120.0	80.0
Fe	0.77	0.13	6.6	2.8	7.8	13.0
NO$_2$	.005	.005	.005	.007	.007	.005
NH$_3$	0.49	2.3	2.8	5.2	11.0	3.4
N$_{TOT}$	0.7	3.3	3.7	9.0	13.0	4.4
TOC	5.0LT	11.0	5.0LT	34.0	5.0LT	5.0
PO$_4$	0.008	0.04	0.07	0.053	0.049	0.074
F	0.06	2.0	0.37	0.46	0.44	0.42
Br	6.7	18.0	18.0	82.0	67.0	26.0
I	0.62	2.5	0.10	2.0	1.8	0.35
B	0.29	1.2	1.0	3.4	2.5	0.98
Al	0.05LT	0.05LT	0.05LT	0.59	0.063	0.05LT
Li	0.5	3.2	1.2	7.3	10.0	2.0
SiO$_2$	8.8	7.6	44.0	10.0	15.0	16.0
Sr	3.1	2.8	4.3	13.0	37.0	8.4
Ba	2.2	0.9	2.4	14.0	20.0	7.2
Hg	0.0004LT	0.0004	0.0004	0.0004LT	0.0004LT	0.0004LT
Zn	0.07	0.36	0.05LT	0.05LT	0.05LT	0.05LT
T S	1180.0	2250.0	2429.0	10370.0	7825.0	2567.0

* Last two digits of the sample number represent the posting number for data located in Figure 3-1.

LA = Lab Accident
LT = Less Than
NA = Not Analyzed
INTF = Interference
Results in mg/l.

Appendix A - cont'd.

Sample No.	15007	15008	15009	15010	15011	15012
T°C	12.2	12.1	10.8	10.2	11.0	12.2
pH	8.1	9.3	8.9	6.5	6.3	6.6
Alkalinity (field)	720.0	410.0	690.0	2470.0	2270.0	2260.0
SO_4	5.0	3.0	4.0	7.0	28.0	34.0
Cl	270.0	390.0	350.0	1500.0	120.0	700.0
Na	400.0	350.0	460.0	1500.0	490.0	950.0
K	4.2	NA	3.5	100.0	15.0	17.0
Ca	2.3	0.9	0.9	170.0	73.0	65.0
Mg	0.4	0.6	1.7	83.0	54.0	28.0
Fe	0.29	NA	0.05	8.8	1.7	0.39
NO_2	.005	.005	.006	.013	.005LT	.005
NH_3	0.95	NA	1.6	5.8	5.2	8.5
N_{TOT}	1.2	NA	1.8	7.7	6.3	9.5
TOC	16.0	NA	5.0LT	6.0	32.0	12.0
PO_4	0.047	NA	0.057	0.036	0.013	0.028
F	4.2	NA	3.6	0.18	0.2	0.5
Br	16.0	NA	14.0	42.0	15.0	44.0
I	0.92	NA	1.8	1.4	0.020	0.16
B	1.1	NA	0.88	3.4	2.0	3.7
Al	0.05	NA	0.05LT	0.36	0.05LT	0.05LT
Li	2.0	NA	1.9	3.5	0.9	6.4
SiO_2	8.3	7.2	7.6	12.0	13.0	10.0
Sr	1.0	NA	1.0	18.0	7.6	11.0
Ba	0.5LT	NA	0.5LT	20.0	5.6	11.0
Hg	0.0004LT	NA	0.0004LT	0.0004LT	0.0004LT	0.0004LT
Zn	0.16	NA	0.05	0.05LT	0.05LT	0.05
T S	1136.0	1073.0	1263.0	5458.0	2177.0	3179.0

LA = Lab Accident
LT - Less Than
NA - Not Analyzed
INTF = Interference
Results in Mg/l.

Appendix A - cont'd.

Sample No.	15013	15014	15015	15016	15017	15018
T^{o}C	9.9	9.6	10.8	11.5	12.2	10.9
pH	7.7	7.7	7.7	7.8	9.7	7.3
Alkalinity (field)	280.0	110.0	670.0	640.0	490.0	450.0
SO_4	6.0	22.0	5.0	2.0	11.0	310.0
Cl	4100.0	2.0LT	240.0	4900.0	7.0	66.0
Na	2600.0	2.6	290.0	2700.0	250.0	49.0
K	34.0	0.5	1.8	21.0	2.1	NA
Ca	89.9	35.0	7.1	35.0	0.5LT	39.0
Mg	33.0	3.8	5.7	18.0	0.4	84.0
Fe	3.4	0.96	0.1	0.52	1.5	NA
NO_2	.005	.005LT	.005LT	.005	.010	NA
NH_3	19.0	0.053	0.45	6.4	0.91	NA
N_{TOT}	19.0	NA	1.3	8.5	1.4	NA
TOC	5.0LT	NA	8.0	17.0	5.0LT	NA
PO_4	0.024	NA	0.032	0.010	0.067	NA
F	3.0	0.1LT	2.5	1.8	3.9	NA
Br	82.0	NA	6.5	56.0	5.2	NA
I	14.0	NA	0.035	35.0	0.17	NA
B	0.79	0.2LT	0.28	1.1	1.2	NA
Al	0.052	0.37	0.05LT	0.05	0.35	NA
Li	12.0	0.01LT	0.31	11.0	0.6	NA
SiO_2	6.7	8.7	7.7	5.5	11.0	17.0
Sr	58.0	NA	1.0	19.0	1.0	NA
Ba	16.0	NA	0.5LT	6.9	0.5LT	NA
Hg	0.0006	NA	0.0004LT	0.0004LT	0.0004LT	NA
Zn	0.05LT	NA	0.36	0.84	0.05	NA
T S	9816.0	160.0	1079.0	8810.0	554.0	1010.0

LA = Lab Accident
LT = Less Than
NA = Not Analyzed
INTF = Interference
Results in mg/l.

Appendix A - cont'd.

Sample No.	15019	15020	15021	15022	15023	15024
T^oC	10.5	10.8	8.7	11.0	8.1	8.9
pH	6.3	7.6	6.4	6.3	6.7	6.1
Alkalinity (field)	4430.0	2410.0	250.0	2740.0	70.0	4660.0
SO_4	INTF	180.0	16.4	9.0	8.0	5.0
Cl	5700.0	800.0	6000.0	2800.0	14000.0	1200.0
Na	3800.0	1400.0	3500.0	1200.0	2700.0	1300.0
K	78.0	13.0	39.0	110.0	18.0	110.0
Ca	580.0	12.0	140.0	270.0	5000.0	380.0
Mg	320.0	5.0	43.0	120.0	650.0	230.0
Fe	39.0	0.05LT	5.9	6.3	15.0	240.0
NO_2	.010	.005	.008	.007	.090	.016
NH_3	22.0	3.5	13.5	10.0	0.81	5.4
N_{TOT}	31.0	3.5	13.0	11.0	1.2	LA
TOC	5.0LT	5.0LT	5.0LT	5.0LT	7.0	18.0
PO_4	0.056	0.003	0.012	0.007	0.14	0.084
F	0.12	2.6	2.4	0.2	0.2	0.2
Br	160.0	25.0	130.0	46.0	100.0	40.0
I	12.0	3.0	18.0	0.27	0.27	0.76
B	4.0	1.3	0.37	0.97	0.94	0.55
Al	0.11	0.05LT	0.082	0.066	0.097	0.13
Li	25.0	5.0	14.0	5.0	0.51	4.0
SiO_2	14.0	8.2	2.4	13.0	6.8	55.0
Sr	100.0	3.3	91.0	36.0	2300.0	12.0
Ba	50.0	0.5LT	17.0	36.0	9.1	6.3
Hg	0.0004LT	0.0004	0.0004LT	0.0004LT	0.0004LT	0.0004LT
Zn	0.05	0.05	0.05LT	0.05LT	0.06	0.05
T S	19500.0	4070.0	10600.0	7550.0	29700.0	6070.0

LA = Lab Accident
LT = Less Than
NA = Not Analyzed
INTF = Interference
Results in mg/l.

Appendix A - cont'd.

Sample No.	15025	15026	15027	15028	15029	15030
T^oC	11.2	10.9	11.7	10.9	8.3	10.6
pH	8.7	6.9	9.5	7.2	8.2	9.7
Alkalinity (field)	1680.0	1430.0	320.0	1020.0	310.0	510.0
SO_4	7.0	5.0	2.0	3.0	14.0	6.0
Cl	380.0	120.0	2.0	680.0	32.0	6.0
Na	760.0	310.0	100.0	850.0	10.0	190.0
K	2.1	50.0	0.8	6.0	0.1	1.4
Ca	5.7	99.0	0.5LT	13.0	72.0	0.7
Mg	2.0	32.0	0.1	8.6	16.0	0.2
Fe	0.86	0.39	0.05	3.7	0.05	0.29
NO_2	.005	.005	.005	.007	.005	.005
NH_3	0.37	3.8	1.5	2.6	0.044	1.8
N_{TOT}	0.42	4.2	1.6	2.6	0.040	1.8
TOC	13.0	5.0	27.0	11.0	0.5	5.0
PO_4	0.024	0.011	0.02	0.033	0.003	0.040
F	4.4	0.5	0.9	1.4	0.1LT	2.1
Br	14.0	INTF	INTF	18.0	INTF	15.0
I	0.070	0.044	0.005	0.78	0.005LT	0.15
B	0.46	0.50	0.29	0.41	0.26	1.2
Al	0.05	0.044	0.005	0.42	0.05	0.25
Li	0.3	1.7	0.41	3.4	0.01LT	0.9
SiO_2	4.3	8.8	12.0	5.9	6.6	12.0
Sr	1.0LT	2.8	1.0LT	4.6	1.0LT	1.0LT
Ba	0.5LT	3.4	0.5LT	3.7	0.5LT	0.5LT
Hg	0.0004LT	0.0004LT	0.0004LT	0.0004LT	0.0004LT	0.0004LT
Zn	0.05LT	0.05LT	0.05LT	4.3	0.05LT	0.05LT
T s	2050.0	1640.0	328.0	2110.0	304.0	500.0

LA = Lab Accident
LT - Less Than
NA = Not Analyzed
INTF = Interference
Results in mg/l.

Appendix A - cont'd.

Sample No.	15031	15032	15033	15034*	15035	15036	15037
T^oC	10.2	9.7	9.7	NA	9.0	9.9	9.5
pH	6.8	8.7	6.4	6.2	8.0	7.15	9.5
Alkalinity (field)	3530.0	216.0	4600.0	NA	46.0	940.0	400.0
SO_4	20.0	3.0	5.0	9.0	21.0	4.0	5.0
Cl	700.0	2.0	5100.0	8100.0	15.0	320.0	12.0
Na	1100.0	78.0	5200.0	5200.0	4.6	450.0	160.0
K	26.0	2.2	69.0	68.0	1.0	7.2	2.9
Ca	150.0	7.3	600.0	570.0	24.0	51.0	2.1
Mg	160.0	3.0	330.0	350.0	6.7	17.0	0.8
Fe	2.1	0.06	14.0	36.0	0.05LT	2.7	0.39
NO_2	.051	.050	.010	.014	.005	.005	.005
NH_3	6.1	1.2	12.0	13.0	0.021	1.2	0.95
N_{TOT}	7.8	1.5	29.0	28.0	0.082	1.4	1.2
TOC	5.0	2.0	2.0	3.0	2.0	1.0	1.0LT
PO_4	0.022	0.021	0.036	0.013	0.005	0.019	0.04
F	2.5	2.0	0.1LT	0.1LT	0.1LT	0.46	1.3
Br	25.0	6.8	170.0	170.0	INTF	12.0	INTF
I	.26	0.066	10.0	9.0	0.55	0.55	0.052
B	LA	0.65	2.6	2.6	0.2LT	1.3	0.62
Al	0.05LT	0.05LT	0.05LT	0.05	0.05	0.05	0.31
Li	2.1	0.23	25.0	27.0	0.01LT	1.0	0.51
SiO_2	16.0	8.8	13.0	14.0	8.8	10.0	12.0
Sr	13.0	1.0	160.0	170.0	1.0LT	3.9	1.0LT
Ba	9.7	0.5	6.8	74.8	0.5LT	1.5	0.5LT
Hg	0.0004LT	0.0004LT	0.0004LT	0.0015	0.0004LT	0.0004LT	0.0004LT
Zn	0.05LT	0.05LT	0.05LT	NA	0.15	0.05LT	0.05LT
T S	4380.0	231.0	18900.0	19500.0	175.0	1490.0	435.0

*Duplicate Location For 15033

LA = Lab Accident
LT = Less Than
NA = Not Analyzed
INTF = Interference
Results in mg/l.

APPENDIX B

SILICA CHEMISTRY DATA

INTRODUCTION

Silica sampling data is compiled in tabular form from both the Phase II and Phase III silica sampling surveys. Samples may be located by their latitude and longitude, or by United States Geological Survey 7-1/2-minute quadrangle maps. The great number of points preclude their numbering on a posting of reasonable size. An explanatory legend is located at the end of the table. Additional explanatory information can be found in Section 3 of this report. The temperature quality indicator is a minor indicator of data quality. Analysis of the data set showed that little or no significant variation existed between "suspect" and "good" data. The first two digits of the sample number refer to the year of sampling; the last three digits are the actual sample number.

A key to the quadrangle maps follows:

Abbreviation	Quadrangle Map
ALBNY	Albany
ALTAM	Altamont
AMDAM	Amsterdam
AVLPK	Averill Park
BRDAL	Broadalbin
BRTHL	Burnt Hills
CAMBG	Cambridge
CANAA	Canaan
CORIN	Corinth
DELMR	Delmar
DUANE	Duanesberg
ECHAT	East Chatham
EGLBG	Eagle Bridge
EGRNB	East Greenbush
FTMIL	Fort Miller
GALWY	Galway
GLPVL	Gallupville
GLVRV	Gloversville
GNSVT	Gansevoort
GRFTN	Grafton
HANCK	Hancock
JHNBG	Johnsburg
MDGRV	Middle Grove

MECHV	Mechanicville
NASSA	Nassau
NISKY	Niskayuna
PATVL	Pattersonville
PORTC	Porter Corners
POWNL	Pownal
QKSPR	Quaker Springs
RNDLK	Round Lake
ROJUN	Rotterdam Junction
SARSP	Saratoga Springs
SCOKE	Schaghticoke
SCYVL	Schuylerville
STEPH	Stephentown Center
TABTN	Taborton
TOMHN	Tomhannock
TRBHL	Tribes Hill
TROYN	Troy North
TROYS	Troy South
VRHSH	Voorheesville

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8015101	CANAA	42.4853	-73.4706	187.	0	7.2	-0.0	6.9	27.69	21.63
8015102	CANAA	42.4762	-73.3811	61.	0	8.3	-0.0	5.4	20.51	10.90
8015103	CANAA	42.4565	-73.3820	30.	0	7.8	-0.0	7.5	30.21	25.40
8015104	CANAA	42.4711	-73.3927	37.	0	11.8	-0.0	9.2	36.58	34.90
8015105	MECHV	42.3944	-73.3808	0.	1	10.0	-0.0	4.8	17.17	5.93
8015107	MECHV	42.3987	-73.3674	61.	0	8.3	-0.0	15.0	52.97	59.35
8015110	MECHV	42.3981	-73.4186	30.	0	-0.0	-0.0	6.2	24.51	16.88
8015111	SCOKE	42.9061	-73.5904	50.	0	12.8	-0.0	15.0	52.97	59.35
8015113	MECHV	42.3971	-73.6824	6.	0	10.7	-0.0	8.9	35.53	33.33
8015114	SCOKE	42.9297	-73.5857	24.	0	11.4	-0.0	11.0	42.38	43.55
8015115	STEPH	42.5691	-73.4347	48.	0	12.7	-0.0	15.0	52.97	59.35
8015116	CANAA	42.4642	-73.4038	26.	0	-0.0	-0.0	9.7	38.28	37.43
8015117	CANAA	42.4601	-73.4041	25.	0	-0.0	-0.0	5.9	23.06	14.72
8015118	HANCK	42.5569	-73.3059	53.	0	11.9	-0.0	5.6	21.55	12.46
8015119	MECHV	42.4250	-73.4390	30.	0	-0.0	-0.0	5.2	19.43	9.30
8015120	CANAA	42.4259	-73.4442	85.	0	-0.0	-0.0	13.0	47.99	51.93
8015122	CANAA	42.4461	-73.4215	67.	0	-0.0	-0.0	13.0	47.99	51.93
8015123	CANAA	42.4468	-73.4218	0.	0	-0.0	-0.0	5.0	18.32	7.64
8015124	CANAA	42.4509	-73.4227	83.	0	-0.0	-0.0	14.0	50.55	55.75
8015125	CANAA	42.4565	-73.4177	34.	0	-0.0	-0.0	15.0	52.97	59.35
8015126	CANAA	42.4595	-73.4177	64.	0	-0.0	-0.0	13.0	47.99	51.93
8015127	CANAA	42.4657	-73.4241	119.	0	-0.0	-0.0	12.0	45.28	47.88
8015128	CANAA	42.4519	-73.4305	30.	0	-0.0	-0.0	7.5	30.21	25.40
8015130	CANAA	42.4485	-73.4352	34.	0	-0.0	-0.0	14.0	50.55	55.75
8015131	STEPH	42.5299	-73.3802	85.	0	-0.0	-0.0	14.0	50.55	55.75
8015132	HANCK	42.5722	-73.3022	49.	0	11.8	-0.0	5.7	22.06	13.22
8015133	HANCK	42.5140	-73.3575	49.	0	-0.0	-0.0	6.9	27.69	21.63
8015134	HANCK	42.5127	-73.3546	0.	0	-0.0	-0.0	4.7	16.59	5.05
8015135	STEPH	42.5500	-73.3820	30.	0	14.0	-0.0	16.0	55.26	62.78
8015136	STEPH	42.5523	-73.3916	39.	0	-0.0	-0.0	16.0	55.26	62.78
8015137	STEPH	42.5676	-73.4272	121.	0	14.7	-0.0	12.0	45.28	47.88
8015138	HANCK	42.5310	-73.3555	51.	0	-0.0	-0.0	8.9	35.53	33.33
8015139	STEPH	42.5091	-73.3794	61.	0	-0.0	-0.0	11.0	42.38	43.55
8015140	CANAA	42.4927	-73.3875	30.	0	-0.0	-0.0	10.0	39.26	38.90
8015141	SCOKE	42.9152	-73.5484	27.	0	10.4	-0.0	9.4	37.27	35.93
8015142	SCOKE	42.8799	-73.6081	48.	0	14.0	-0.0	14.0	50.55	55.75
8015143	ECHAT	42.4911	-73.5535	0.	0	11.8	-0.0	7.3	29.39	24.17
8015144	NASSA	42.5179	-73.5841	30.	0	11.9	-0.0	8.1	32.58	28.93
8015145	NASSA	42.5330	-73.5987	17.	0	11.6	-0.0	13.0	47.99	51.93
8015146	NASSA	42.5489	-73.5666	30.	0	12.5	-0.0	12.0	45.28	47.88
8015147	NASSA	42.5553	-73.5263	43.	0	11.5	-0.0	14.0	50.55	55.75
8015148	NASSA	42.5733	-73.5158	46.	0	10.5	-0.0	16.0	55.26	62.78
8015149	NASSA	42.5823	-73.5584	6.	0	9.9	-0.0	7.0	28.12	22.27
8015150	NASSA	42.5874	-73.5952	30.	0	13.0	-0.0	8.4	33.71	30.62
8015151	CANAA	42.4748	-73.3759	30.	0	6.1	-0.0	8.7	34.82	32.26
8015152	CANAA	42.4752	-73.3773	38.	0	6.1	-0.0	5.0	18.32	7.64
8015153	CANAA	42.4657	-73.4064	27.	0	9.4	-0.0	10.0	39.26	38.90
8015154	CANAA	42.4703	-73.3922	5.	0	9.4	-0.0	6.9	27.69	21.63

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8015155	CANAA	42.4638	-73.3910	30.	0	8.3	-0.0	5.7	22.06	13.22
8015156	STEPH	42.5349	-73.4030	73.	0	16.5	-0.0	6.0	23.55	15.45
8015157	EGRNB	42.5640	-73.6265	40.	0	10.4	-0.0	15.0	52.97	59.35
8015158	MECHV	42.3989	-73.4328	0.	0	7.2	-0.0	4.2	13.49	0.43
8015159	MECHV	42.4060	-73.4106	55.	0	6.7	-0.0	2.1	-4.24	-26.03
8015160	MECHV	42.4069	-73.4314	27.	0	5.6	-0.0	3.4	7.84	-8.00
8015161	CANAA	42.4425	-73.3985	58.	0	3.3	-0.0	5.7	22.06	13.22
8015162	CANAA	42.4427	-73.3959	20.	0	-0.0	-0.0	5.0	18.32	7.64
8015163	HANCK	42.5625	-73.3703	0.	0	10.0	-0.0	7.9	31.81	27.78
8015164	HANCK	42.5892	-73.3689	70.	0	6.1	-0.0	16.0	55.26	62.78
8015165	STEPH	42.5318	-73.4065	30.	0	15.5	-0.0	9.2	36.58	34.90
8015166	HANCK	42.6127	-73.3578	32.	0	6.1	-0.0	14.0	50.55	55.75
8015167	HANCK	42.6181	-73.3566	27.	0	6.1	-0.0	5.9	23.06	14.72
8015169	EGRNB	42.5011	-73.7062	30.	0	11.0	-0.0	17.0	57.44	66.03
8015179	NASSA	42.5045	-73.6090	46.	0	9.0	-0.0	10.0	39.26	38.90
8015184	HANCK	42.5670	-73.3027	15.	0	-0.0	-0.0	5.3	19.97	10.11
8015198	HANCK	42.5429	-73.3464	30.	0	12.0	-0.0	6.1	24.03	16.17
8015199	HANCK	42.5415	-73.3469	34.	0	-0.0	-0.0	7.2	28.97	23.54
8015200	QKSPR	43.0058	-73.7065	27.	0	12.0	-0.0	12.0	45.28	47.88
8015202	QKSPR	43.0304	-73.6612	30.	0	12.0	-0.0	10.0	39.26	38.90
8015204	QKSPR	43.0358	-73.6530	30.	0	10.0	-0.0	15.0	52.97	59.35
8015206	QKSPR	43.0554	-73.6403	18.	0	11.0	-0.0	8.2	32.96	29.50
8015208	QKSPR	43.0819	-73.6315	0.	0	10.0	-0.0	6.5	25.91	18.97
8015209	SARSP	43.0970	-73.8382	18.	0	11.0	-0.0	5.4	20.51	10.90
8015210	QKSPR	43.1101	-73.6780	30.	0	9.0	-0.0	8.0	32.20	28.36
8015211	SARSP	43.0957	-73.8612	41.	0	10.8	-0.0	6.0	23.55	15.45
8015212	QKSPR	43.0813	-73.6982	49.	0	11.0	-0.0	11.0	42.38	43.55
8015213	SARSP	43.0705	-73.8465	27.	0	13.0	-0.0	9.5	37.61	36.43
8015214	QKSPR	43.0608	-73.6862	55.	0	9.0	-0.0	11.0	42.38	43.55
8015215	SARSP	43.0621	-73.8418	30.	0	10.5	-0.0	13.0	47.99	51.93
8015216	QKSPR	43.0123	-73.6944	22.	0	10.0	-0.0	14.0	50.55	55.75
8015218	CORIN	43.1263	-73.8568	49.	0	9.0	-0.0	9.6	37.94	36.93
8015219	GNSVT	43.1362	-73.6826	9.	0	11.5	-0.0	12.0	45.28	47.88
8015220	CORIN	43.1509	-73.8565	24.	0	10.0	-0.0	14.0	50.55	55.75
8015221	GNSVT	43.1581	-73.6383	91.	0	8.0	-0.0	8.9	35.53	33.33
8015222	CORIN	43.2147	-73.8021	42.	0	11.0	-0.0	8.8	35.18	32.80
8015223	GNSVT	43.1976	-73.6493	91.	0	10.5	-0.0	8.1	32.58	28.93
8015224	CORIN	43.1200	-73.8056	33.	0	11.5	-0.0	10.0	39.26	38.90
8015225	GNSVT	43.2323	-73.6818	9.	0	13.0	-0.0	15.0	52.97	59.35
8015226	CORIN	43.1787	-73.8447	30.	0	10.5	-0.0	9.3	36.93	35.42
8015227	GNSVT	43.2371	-73.6556	43.	0	11.2	-0.0	6.8	27.25	20.97
8015228	CORIN	43.1606	-73.8365	160.	0	12.0	-0.0	9.0	35.89	33.86
8015229	GNSVT	43.2381	-73.6556	80.	0	13.0	-0.0	8.2	32.96	29.50
8015230	CORIN	43.1416	-73.8361	91.	0	9.5	-0.0	9.4	37.27	35.93
8015231	GNSVT	43.2470	-73.6434	21.	0	12.8	-0.0	6.3	24.98	17.59
8015232	CORIN	43.1772	-73.7541	98.	0	10.5	-0.0	10.0	39.26	38.90
8015233	GNSVT	43.2213	-73.6400	81.	0	12.5	-0.0	4.1	12.83	-0.55
8015234	GNSVT	43.1892	-73.7394	37.	0	9.5	-0.0	11.0	42.38	43.55

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8015235	GNSVT	43.2353	-73.6281	65.	0	11.0	-0.0	7.1	28.55	22.91
8015236	GNSVT	43.2175	-73.7121	101.	0	9.5	-0.0	13.0	47.99	51.93
8015237	GNSVT	43.2086	-73.6823	97.	0	11.0	-0.0	9.6	37.94	36.93
8015238	GNSVT	43.1654	-73.7203	96.	0	11.5	-0.0	8.7	34.82	32.26
8015239	CORIN	43.1485	-73.7630	23.	0	4.5	-0.0	14.0	50.55	55.75
8015240	SARSP	43.0121	-73.7876	60.	0	12.5	-0.0	10.0	39.26	38.90
8015241	RNDLK	42.9042	-73.9515	0.	0	6.0	-0.0	11.0	42.38	43.55
8015242	RNDLK	42.9418	-73.9515	53.	0	10.0	-0.0	9.0	35.89	33.86
8015243	BRTHL	42.9788	-73.8879	55.	0	10.5	-0.0	9.4	37.27	35.93
8015244	BRTHL	42.9721	-73.9204	55.	0	11.0	-0.0	13.0	47.99	51.93
8015245	BRTHL	42.9391	-73.9368	24.	0	9.5	-0.0	14.0	50.55	55.75
8015246	BRTHL	42.9614	-73.9657	37.	0	9.5	-0.0	18.0	59.53	69.15
8015247	BRTHL	42.9530	-73.8952	69.	0	9.5	-0.0	11.0	42.38	43.55
8015248	RNDLK	42.9561	-73.9894	76.	0	12.0	-0.0	11.0	42.38	43.55
8015249	MDGRV	43.0168	-73.9258	45.	0	10.5	-0.0	12.0	45.28	47.88
8015250	RNDLK	42.9072	-73.9012	48.	0	11.8	-0.0	11.0	42.38	43.55
8015251	MDGRV	43.0558	-73.8914	24.	0	11.5	-0.0	17.0	57.44	66.03
8015252	RNDLK	42.9725	-73.9235	9.	0	14.0	-0.0	13.0	47.99	51.93
8015253	MDGRV	43.0853	-73.8982	27.	0	9.0	-0.0	11.0	42.38	43.55
8015254	RNDLK	42.9451	-73.9529	23.	0	21.0	-0.0	11.0	42.38	43.55
8015225	MDGRV	43.1164	-73.9270	18.	0	9.5	-0.0	12.0	45.28	47.88
8015256	BRTHL	42.9101	-73.9218	5.	0	5.8	-0.0	8.9	35.53	33.33
8015257	MDGRV	43.0666	-73.9258	15.	0	9.5	-0.0	7.9	31.81	27.78
8015258	BRTHL	42.8925	-73.9552	3.	0	10.0	-0.0	8.9	35.53	33.33
8015259	MDGRV	43.0478	-73.9180	71.	0	10.0	-0.0	13.0	47.99	51.93
8015260	BRTHL	42.9149	-73.9643	52.	0	15.0	-0.0	14.0	50.55	55.75
8015261	MDGRV	43.0047	-73.9696	46.	0	11.0	-0.0	8.8	35.18	32.80
8015262	BRTHL	42.8919	-73.9783	61.	0	16.1	-0.0	10.0	39.26	38.90
8015263	MDGRV	43.0590	-73.9927	46.	0	10.0	-0.0	11.0	42.38	43.55
8015264	BRTHL	42.8930	-73.9994	27.	0	12.5	-0.0	13.0	47.99	51.93
8015265	MDGRV	43.0575	-73.9921	98.	0	9.0	-0.0	11.0	42.38	43.55
8015266	BRTHL	42.9120	-73.9862	71.	0	12.5	-0.0	16.0	55.26	62.78
8015267	MDGRV	43.0726	-73.9824	23.	0	11.0	-0.0	11.0	42.38	43.55
8015269	MDGRV	43.0709	-73.9891	21.	0	9.5	-0.0	6.6	26.36	19.64
8015273	DUANE	42.7942	-74.1419	30.	0	9.0	-0.0	13.0	47.99	51.93
8015275	DUANE	42.7814	-74.1720	32.	0	11.0	-0.0	13.0	47.99	51.93
8015277	DUANE	42.8020	-74.1714	61.	0	9.5	-0.0	14.0	50.55	55.75
8015279	DUANE	42.7563	-74.1995	32.	0	13.5	-0.0	13.0	47.99	51.93
8015281	DUANE	42.7909	-74.2131	96.	0	12.5	-0.0	16.0	55.26	62.78
8015285	DUANE	42.8631	-74.1568	24.	0	-0.0	-0.0	11.0	42.38	43.55
8015287	DUANE	42.8306	-74.1662	26.	0	8.5	-0.0	16.0	55.26	62.78
8015291	ROJUN	42.8421	-74.0913	57.	0	10.0	-0.0	9.7	38.28	37.43
8015293	ROJUN	42.8271	-74.0396	70.	0	9.5	-0.0	9.5	37.61	36.43
8015295	ROJUN	42.8124	-74.0640	38.	0	12.0	-0.0	12.0	45.28	47.88
8128001	SARSP	43.0500	-73.8026	0.	1	14.8	7.93	10.6	41.16	41.73
8128002	SARSP	43.0506	-73.8038	64.	1	11.8	6.06	17.3	58.08	66.98
8128003	SARSP	43.0513	-73.8060	91.	1	10.6	6.22	10.2	39.90	39.86
8128004	SARSP	43.0537	-73.8074	10[illegible].	1	10.2	6.16	8.9	35.53	33.33

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8128005	SARSP	43.0371	-73.8056	0.	1	13.9	8.00	9.6	37.94	36.93
8128006	SARSP	43.0570	-73.8062	46.	1	14.[illegible]	6.16	49.1	100.97	130.99
8128007	SARSP	43.0487	-73.8020	246.	1	9.[illegible]	6.26	8.9	35.53	33.33
8128008	SARSP	43.0023	-73.8546	197.	1	10.5	5.62	46.2	98.16	126.81
8128010	SARSP	43.0881	-73.7785	130.	1	12.0	5.54	41.2	92.99	119.09
8128011	SARSP	43.0774	-73.7853	30.	1	11.4	4.92	10.3	40.22	40.33
8128013	SARSP	43.0834	-73.7850	84.	1	14.8	5.25	17.1	57.66	66.35
8128015	SARSP	43.0796	-73.7851	306.	1	11.2	5.53	10.1	39.58	39.38
8128016	SARSP	43.0890	-73.7766	76.	1	12.2	6.25	44.4	96.35	124.11
8128017	SARSP	43.0900	-73.7640	0.	1	11.0	6.52	13.9	50.30	55.37
8128020	SARSP	43.0871	-73.7800	0.	1	11.3	6.25	14.4	51.53	57.21
8128022	SARSP	43.0867	-73.7800	76.	1	11.3	6.09	25.5	72.83	89.00
8128023	SARSP	43.0781	-73.7866	91.	1	14.4	6.93	6.1	24.03	16.17
8128025	SARSP	43.0780	-73.7865	30.	1	11.7	6.55	32.3	82.48	103.40
8128027	SARSP	43.0648	-73.7890	91.	1	11.2	6.24	48.4	100.30	130.00
8128029	ROJUN	42.8459	-74.0347	60.	1	11.8	8.96	8.8	35.18	32.80
8128031	ROJUN	42.8468	-74.0776	30.	0	16.3	7.40	12.7	47.20	50.74
8128032	ROJUN	42.8273	-74.0719	55.	1	9.8	7.52	11.0	42.38	43.55
8128033	ROJUN	42.8119	-74.0426	53.	1	13.0	9.16	9.8	38.61	37.92
8128034	ROJUN	42.7995	-74.0907	70.	1	11.5	7.42	12.5	46.66	49.94
8128035	ROJUN	42.8654	-74.1141	30.	1	12.2	7.81	8.7	34.82	32.26
8128037	ROJUN	42.8051	-74.1050	49.	1	12.5	7.87	11.2	42.97	44.44
8128038	ROJUN	42.7715	-74.1071	91.	1	11.3	7.84	8.9	35.53	33.33
8128039	ROJUN	42.7745	-74.0413	18.	1	13.4	7.39	9.4	37.27	35.93
8128041	ALTAM	42.7347	-74.0813	75.	1	10.3	7.13	8.7	34.82	32.26
8128042	DUANE	42.8372	-74.1394	33.	1	11.8	7.94	12.4	46.39	49.53
8128044	DUANE	42.8523	-74.2459	41.	0	13.8	7.70	10.4	40.54	40.80
8128045	DUANE	42.7522	-74.1600	56.	1	13.2	8.30	9.6	37.94	36.93
8128046	PATVL	42.9261	-74.0247	27.	1	11.0	8.99	9.0	35.89	33.86
8128047	PATVL	42.9252	-74.0640	76.	0	16.2	8.91	10.5	40.85	41.27
8128049	PATVL	42.9147	-74.1181	55.	0	16.2	7.46	12.6	46.93	50.34
8128050	PATVL	42.9589	-74.0324	30.	1	12.8	8.04	10.9	42.08	43.10
8128052	PATVL	42.9430	-74.1076	30.	1	10.1	7.72	15.4	53.90	60.74
8128053	PATVL	42.9683	-74.0994	12.	1	10.3	7.63	9.5	37.61	36.43
8128055	PATVL	42.9763	-74.0588	30.	1	12.7	7.54	5.9	23.06	14.72
8128056	PATVL	42.9749	-74.0038	51.	1	13.1	7.07	9.6	37.94	36.93
8128057	PATVL	42.9948	-74.0287	26.	0	14.2	7.37	13.6	49.54	54.25
8128058	GALWY	43.0208	-74.0635	18.	1	10.1	7.80	10.4	40.54	40.80
8128059	GALWY	43.0039	-74.0962	24.	1	12.1	7.56	7.9	31.81	27.78
8128060	PATVL	42.9925	-74.0797	30.	1	9.8	7.23	5.6	21.55	12.46
8128061	GALWY	43.0405	-74.1071	18.	1	10.8	8.00	10.6	41.16	41.73
8128062	GALWY	43.0160	-74.0056	10.	1	9.3	7.29	9.9	38.94	38.41
8128064	GALWY	43.0572	-74.0359	55.	1	12.7	8.05	11.6	44.14	46.18
8128066	GALWY	43.0573	-74.0876	63.	1	12.3	8.08	10.0	39.26	38.90
8128067	GALWY	43.0872	-74.0876	20.	1	12.6	8.61	18.0	59.53	69.15
8128068	GALWY	43.0942	-74.0388	24.	1	13.9	7.45	23.1	68.95	83.21
8128069	NISKY	42.8188	-73.7756	30.	1	11.5	8.15	9.5	37.61	36.43
8128071	NISKY	42.8532	-73.7735	49.	1	11.8	8.99	8.1	32.58	28.93

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8128073	NISKY	42.8674	-73.8491	8.	1	12.2	7.97	12.0	45.28	47.88
8128074	NISKY	42.8400	-73.8418	34.	1	11.2	9.33	9.1	36.24	34.38
8128075	RNDLK	42.9150	-73.8521	61.	1	13.3	8.01	15.0	52.97	59.35
8128077	RNDLK	42.9275	-73.8456	11.	1	16.2	7.68	16.0	55.26	62.78
8128078	RNDLK	42.9218	-73.8582	67.	0	15.5	8.65	10.9	42.08	43.10
8128080	RNDLK	42.9646	-73.8632	15.	0	16.8	8.20	10.9	42.08	43.10
8128081	RNDLK	42.9854	-73.8206	85.	1	12.8	9.41	9.5	37.61	36.43
8128082	RNDLK	42.9276	-73.8009	46.	1	14.6	8.03	12.5	46.66	49.94
8128083	MECHV	42.9378	-73.7462	21.	1	14.3	8.04	13.2	48.52	52.71
8128084	MECHV	42.8882	-73.7471	46.	1	11.7	8.59	9.3	36.93	35.42
8128085	TROYN	42.8524	-73.7112	123.	1	11.5	8.28	7.8	31.42	27.19
8128087	TROYN	42.8712	-73.7229	66.	1	12.4	8.38	9.1	36.24	34.38
8128088	MECHV	42.8852	-73.6859	44.	0	15.6	7.35	10.9	42.08	43.10
8128089	MECHV	42.8850	-73.7071	57.	1	11.2	7.29	20.0	63.44	74.99
8128091	MECHV	42.9575	-73.6885	73.	1	12.7	8.51	9.1	36.24	34.38
8128092	MECHV	42.9769	-73.7321	61.	1	11.9	7.87	10.4	40.54	40.80
8128093	MECHV	42.9893	-73.6679	23.	1	8.5	7.70	15.5	54.13	61.09
8128094	MECHV	42.9650	-73.6759	46.	1	14.2	7.28	11.9	45.00	47.46
8128095	MECHV	42.9239	-73.6400	50.	1	12.4	7.97	8.9	35.53	33.33
8128096	TROYN	42.8335	-73.6921	59.	1	10.5	7.56	9.6	37.94	36.93
8128097	TROYN	42.8489	-73.6371	99.	0	16.7	7.81	9.6	37.94	36.93
8128098	TROYN	42.8490	-73.6360	30.	1	13.3	7.53	11.9	45.00	47.46
8128100	TROYN	42.8132	-73.6356	30.	1	12.5	7.46	13.1	48.26	52.32
8128101	SCOKE	42.8791	-73.6171	27.	1	11.7	7.76	10.3	40.22	40.33
8128102	SCOKE	42.9845	-73.5571	27.	1	11.8	7.49	14.2	51.04	56.48
8128103	SCYVL	43.0292	-73.5556	179.	1	13.4	8.64	13.0	47.99	51.93
8128104	SCYVL	43.0449	-73.5494	55.	1	11.6	8.09	10.3	40.22	40.33
8128105	SCYVL	43.0926	-73.5365	76.	1	11.8	7.89	11.4	43.56	45.32
8128107	TOMHN	42.7604	-73.5660	58.	1	11.7	8.60	11.1	42.68	44.00
8128109	TOMHN	42.7863	-73.5337	58.	1	12.9	8.93	8.3	33.34	30.06
8128111	TOMHN	42.8122	-73.5364	29.	0	14.3	7.80	11.3	43.27	44.88
8128112	TOMHN	42.8059	-73.5760	28.	1	13.3	7.68	11.5	43.85	45.75
8128113	TOMHN	42.8334	-73.5930	21.	1	13.2	7.17	19.3	62.11	-73.00
8128114	TOMHN	42.8349	-73.5580	37.	0	15.5	7.45	13.6	49.54	54.25
8128115	TOMHN	42.7693	-73.5921	30.	1	11.0	7.70	14.9	52.73	59.00
8128116	AVLPK	42.7350	-73.6039	91.	1	11.2	7.95	9.1	36.24	34.38
8128117	AVLPK	42.7458	-73.5483	46.	1	12.5	7.79	7.9	31.81	27.78
8128119	AVLPK	42.7376	-73.5129	46.	1	9.4	7.86	13.8	50.05	55.00
8128121	AVLPK	42.6884	-73.5208	87.	0	15.7	7.56	12.6	46.93	50.34
8128122	AVLPK	42.6585	-73.5234	30.	1	11.2	7.42	15.7	54.58	61.77
8128123	AVLPK	42.6400	-73.5445	38.	0	15.7	7.30	9.3	36.93	35.42
8128124	AVLPK	42.6692	-73.5501	30.	1	11.3	7.12	13.6	49.54	54.25
8128125	AVLPK	42.7040	-73.5635	47.	1	11.6	7.80	11.7	44.43	46.61
8128126	AVLPK	42.7137	-73.5966	50.	1	11.9	8.98	8.6	34.45	31.72
8128127	AVLPK	42.6804	-73.5922	21.	0	16.8	7.76	12.1	45.56	48.29
8128128	AVLPK	42.6400	-73.5916	61.	1	13.6	7.83	9.4	37.27	35.93
8128129	TOMHN	42.8603	-73.5179	36.	1	13.7	6.88	12.2	45.83	48.71
8128131	GRFTN	42.8651	-73.4619	38.	0	15.2	7.03	12.2	45.83	48.71

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO$_2$	Tqtz	Qqtz
8128133	GRFTN	42.8364	-73.4780	49.	1	12.9	7.51	14.1	50.80	56.12
8128134	GRFTN	42.8441	-73.4457	58.	1	11.3	7.52	14.0	50.55	55.75
8128135	EGBRG	42.8992	-73.4227	30.	1	12.3	7.97	12.7	47.20	50.74
8128136	GRFTN	42.8722	-73.4049	25.	1	10.3	7.67	16.3	55.93	63.77
8128137	EGBRG	42.9018	-73.4657	24.	1	12.7	7.55	16.3	55.93	63.77
8128138	SCOKE	42.9012	-73.5023	38.	1	12.4	8.22	14.2	51.04	56.48
8128140	EGLBG	42.9353	-73 4974	43.	1	12.7	7.96	13.5	49.29	53.87
8128141	EGLBG	42.9650	-73.4742	29.	1	11.0	7.89	12.5	46.66	49.94
8128142	EGLBG	42.9900	-73.4800	12.	0	7.7	6.70	5.9	23.06	14.72
8128143	CAMBG	43.0419	-73.4750	87.	1	11.5	6.98	9.9	38.94	38.41
8128144	CAMBG	43.0842	-73.4879	38.	1	13.4	7.79	12.8	47.46	51.14
8128145	SCYVL	43.0904	-73.5704	43.	1	11.8	8.72	8.1	32.58	28.93
8128147	SCYVL	43.0538	-73.5769	38.	1	12.5	7.94	11.6	44.14	46.18
8128148	SCYVL	43.0071	-73.5877	43.	0	16.4	7.60	10.2	39.90	39.86
8128149	SCOKE	42.9556	-73.5889	110.	1	11.4	8.40	8.8	35.18	32.80
8128150	GRFTN	42.7683	-73.4707	20.	0	14.6	8.05	14.0	50.55	55.75
8128152	GRFTN	42.7642	-73.3978	26.	1	9.4	8.16	16.5	56.36	64.42
8128153	GRFTN	42.8004	-73.4025	48.	1	11.4	8.22	17.1	57.66	66.35
8128154	TABTN	42.7448	-73.4552	21.	1	9.7	7.45	17.4	58.29	67.30
8128155	ALBNY	42.6797	-73.7600	30.	1	10.9	7.80	9.6	37.94	36.93
8128156	ALBNY	42.6776	-73.7997	8.	1	11.3	7.22	1.8	-7.89	-31.47
8128157	ALBNY	42.6866	-73.7974	61.	1	14.3	9.22	9.2	36.58	34.90
8128158	DELMR	42.5836	-73.7759	107.	0	20.3	9.08	9.2	36.58	34.90
8128159	TABTN	42.7136	-73.4722	61.	0	16.4	7.87	13.1	48.26	52.32
8128162	TABTN	42.7131	-73.4200	94.	1	8.6	7.53	14.1	50.80	56.12
8128163	TABTN	42.7397	-73.4002	46.	1	9.9	7.73	13.6	49.54	54.25
8128164	TABTN	42.6989	-73.4025	94.	1	9.7	8.11	18.5	60.54	70.65
8128165	TABTN	42.6364	-73.4491	118.	1	12.8	7.89	17.6	58.71	67.92
8128166	TABTN	42.6427	-73.4769	137.	1	12.2	7.90	12.5	46.66	49.94
8128167	TABTN	42.6517	-73.3926	107.	1	12.8	7.86	15.3	53.67	60.40
8128168	PORTC	43.1433	-73.9256	28.	0	15.7	7.42	12.1	45.56	48.29
8128170	PORTC	43.1815	-73.8985	30.	1	13.0	6.76	12.2	45.83	48.71
8128172	FTMIL	43.1541	-73.7974	28.	1	12.4	7.46	11.1	42.68	44.00
8128173	FTMIL	43.1830	-73.5659	36.	0	18.8	7.05	10.8	41.77	42.65
8128174	AMDAM	42.8946	-74.1394	45.	1	14.0	7.30	10.9	42.08	43.10
8128175	AMDAM	42.9035	-74.1921	17.	1	12.4	7.57	13.7	49.80	54.62
8128176	AMDAM	42.8945	-74.1847	122.	0	14.0	7.69	7.7	31.02	26.60
8128177	AMDAM	42.9000	-74.2335	244.	1	10.4	7.33	7.2	28.97	23.54
8128178	TRBHL	42.8866	-74.2921	66.	1	11.7	8.37	6.6	26.36	19.64
8128179	TRBHL	42.9037	-74.3494	28.	0	14.8	7.73	13.7	49.80	54.62
8128180	TRBHL	42.9629	-74.3538	85.	1	10.1	7.21	10.1	39.58	39.38
8128181	TRBHL	42.9821	-74.3015	24.	1	12.4	7.50	20.9	65.11	77.47
8128182	AMDAM	42.9757	-74.2259	30.	1	12.8	7.70	15.8	54.81	62.10
8128184	AMDAM	42.9939	-74.1844	38.	1	10.9	7.65	10.8	41.77	42.65
8128185	AMDAM	42.9896	-74.1376	21.	1	10.3	7.39	12.3	46.11	49.12
8128186	BRDAL	43.0088	-74.1618	17.	0	-0.0	7.84	14.1	50.80	56.12
8128187	BRDAL	43.0890	-74.1394	46.	0	-0.0	8.18	12.9	47.73	51.54
8128188	BRDAL	43.0492	-74.2262	23.	0	-0.0	7.80	12.8	47.46	51.14

Sample	Quad.	Lat.	Long.	D	QI	Temp.	pH	SiO_2	Tqtz	Qqtz
8128189	BRDAL	43.0301	-74.2256	53.	0	-0.0	7.94	11.7	44.43	46.61
8128190	GLVRV	43.0101	-74.3214	30.	0	-0.0	6.80	10.5	40.85	41.27
8128191	GLVRV	43.0318	-74.2894	22.	0	-0.0	7.38	14.1	50.80	56.12
8128192	VRHSV	42.6994	-73.9253	67.	0	12.7	7.51	6.8	27.25	20.97
8128194	VRHSV	42.7106	-73.9762	20.	1	11.5	7.62	9.7	38.28	37.43
8221008	MYERS	42.8530	-73.9810	121.	1	10.4	9.14	6.0	23.55	15.45
8221007	PIOTR	42.8300	-73.9540	122.	1	8.5	9.79	3.6	9.35	-5.75
8221004	FGRVE	42.9080	-73.8790	121.	1	10.0	7.60	9.0	35.89	33.86
8221003	TIVOL	42.6710	-73.7600	122.	0	10.8	7.56	3.7	10.07	-4.67
8221006	WSTLF	42.7860	-73.9110	155.	1	10.2	8.30	8.5	33.10	31.17
8221009	CLARK	42.8930	-74.0180	139.	1	10.7	9.12	3.2	6.26	-10.36
8221005	SSWTS	42.8060	-73.9510	138.	1	10.0	7.60	9.0	35.89	33.86
8221012	STEVE	42.9120	-73.8942	680.	1	-0.0	6.41	2.8	2.84	-15.46
8221001	SBALB	42.6439	-73.8009	135.	1	19.4	7.75	10.0	39.26	38.90
8015001	EGRNB	42.5453	-73.7156	43.	1	13.3	7.90	8.8	35.18	32.80
8015002	VRHSV	42.7410	-73.9741	85.	1	11.4	8.00	7.6	30.62	26.00
8015007	TROYN	42.8247	-73.7295	111.	1	12.2	8.10	8.3	33.34	30.06
8015008	GNSVT	43.1838	-73.7295	122.	1	12.1	9.30	7.2	28.97	23.54
8015009	RNDLK	42.9985	-73.7673	54.	1	10.8	8.90	7.6	30.62	26.00
8015010	TROYN	42.8485	-73.6385	80.	1	10.2	6.50	12.0	45.28	47.88
8015011	FTMLR	43.2647	-73.5945	89.	1	11.0	6.30	13.0	47.99	51.93
8015012	GNSVT	43.2015	-73.6557	61.	1	12.2	6.60	10.0	39.26	38.90
8015013	DUANE	42.7757	-74.2321	100.	1	9.9	7.70	6.7	26.81	20.31
8015014	EGLBG	42.9939	-73.3762	0.	1	9.6	7.70	8.7	34.82	32.26
8015016	VRHSV	42.7364	-73.9940	94.	1	11.5	7.80	5.5	21.03	11.69
8015017	TROYS	42.7136	-73.7248	158.	1	12.2	9.70	11.0	42.38	43.55
8015018	TROYS	42.6280	-73.7365	55.	1	10.9	7.30	17.0	57.44	66.03
8015019	ROJUN	42.8472	-74.0185	10.	1	10.5	6.30	14.0	50.55	55.75
8015020	VRHSV	42.6957	-73.9938	61.	1	10.8	7.60	8.2	32.96	29.50
8015021	GLPVL	42.6912	-74.1752	87.	1	8.7	6.40	2.4	-1.00	-21.19
8015022	TOMHN	42.8466	-73.6200	75.	0	11.0	6.30	13.0	47.99	51.93
8015023	JHNBG	43.6003	-73.9598	74.	1	8.1	6.70	6.8	27.25	20.97
8015024	SARSP	43.0739	-73.7729	305.	1	8.9	6.10	55.0	106.31	138.97
8015025	CANAA	42.4933	-73.4513	183.	1	11.2	8.70	4.3	14.13	1.39
8015026	MDGRV	43.0295	-73.8906	122.	1	10.9	6.90	8.8	35.18	32.80
8015027	RNDLK	42.9980	-73.8122	55.	1	11.7	9.50	12.0	45.28	47.88
8015028	NISKY	42.7809	-73.8331	183.	1	10.5	7.20	5.9	23.06	14.72
8015029	POWNL	42.6804	-73.2474	78.	1	8.3	8.20	6.6	26.36	19.64
8015031	ALTAM	43.2110	-73.5776	93.	1	10.2	6.80	16.0	55.26	62.78
8015032	CORIN	43.1300	-73.7690	61.	1	9.7	8.70	8.8	35.18	32.80
8015035	EGRNB	42.5886	-73.6564	46.	1	9.0	8.00	8.8	35.18	32.80
8015036	VRHSV	42.6295	-73.9059	40.	1	9.9	7.15	10.0	39.26	38.90
8015037	NISKY	42.8127	-73.8279	67.	1	9.5	9.50	12.0	45.28	47.88

Sample = Sample number
Quad. = Topographic quadrangel
Lat. = Latitude
Long. = Longitude
D = Well depth
QI = Temperature quality; 1=good; o=suspect

Temp. = Water temperature
SiO_2 = Silica concentration in mg/l
Tqtz = Quartz geotemperature
Qqtz = Heat flow based on quartz geotemperature
-0.0 = Missing data

APPENDIX C

COMPUTER TECHNIQUES

COMPUTER TECHNIQUES

With the large database developed during this project, computer analysis of the data became useful and necessary. Different sampling locations and corresponding data were used in construction of a modular database of similar format allowing the database to be accessed by a variety of computer programs. Locations were plotted onto topographic maps with the resulting latitude and longitude values used in the database. Accuracy by this method was approximately .001 to .0001 degrees.

The computer system at Rensselaer Polytechnic Institute was used to generate contour maps using a program called Surface II developed at the Kansas Geological Survey. Surface II is a multipurpose contouring package which can generate contour maps from irregularly distributed data points such as well locations. The program first generates a regularly spaced data grid from the irregular X, Y or Z (latitude, longitude and value to be contoured) data array. The regular grid is generated by an interpolation operation from the irregular data points. A complex weighting scheme dependent on the point distribution is used to locate each regular grid point by the interpolation procedure. Sample data were selected by a quadrant search method which require the data chosen for grid point calculation surround the grid point thus reducing extrapolation beyond the data and reducing the effects of clustered sample data.

Contouring is accomplished by determining the location of a contour interval by interpolation as it is drawn between the regular grid coordinates. Once the location of the contour line has been found between or at one of two adjacent grid points, a search routine is initiated to locate the next pair of grid points through which the contour line may be extended. The process is repeated across the grid surface until the contour terminates at the grid edge or with itself.

Care must be exercised so that the sample data points are well distributed spatially. Highly clustered points force the program to extrapolate (estimate) a relatively large amount of the grid surface. These areas of low data density should be viewed with some caution as the fitting routine for estimation may not accurately describe the true surface. For this project, care was taken whenever possible to ensure an evenly distributed sample data set.

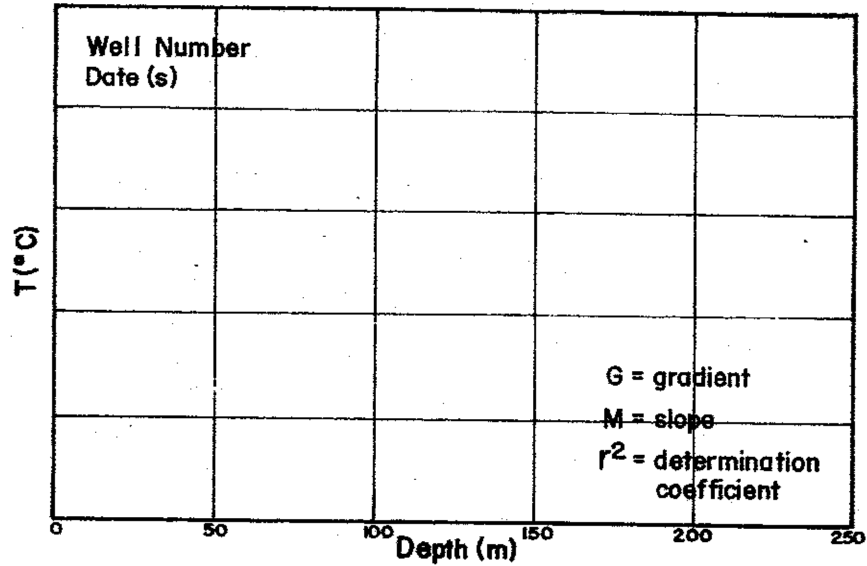
Statistical analysis using the database required the use of Dunn Geoscience Corporation's computer programs for temperature gradient calculations and some univariate statistics. The MIDAS statistics package at Rensselaer Polytechnic Institute was used for regression and cluster analysis of the chemical data. Results were analyzed by Dunn Geoscience Corporation personnel.

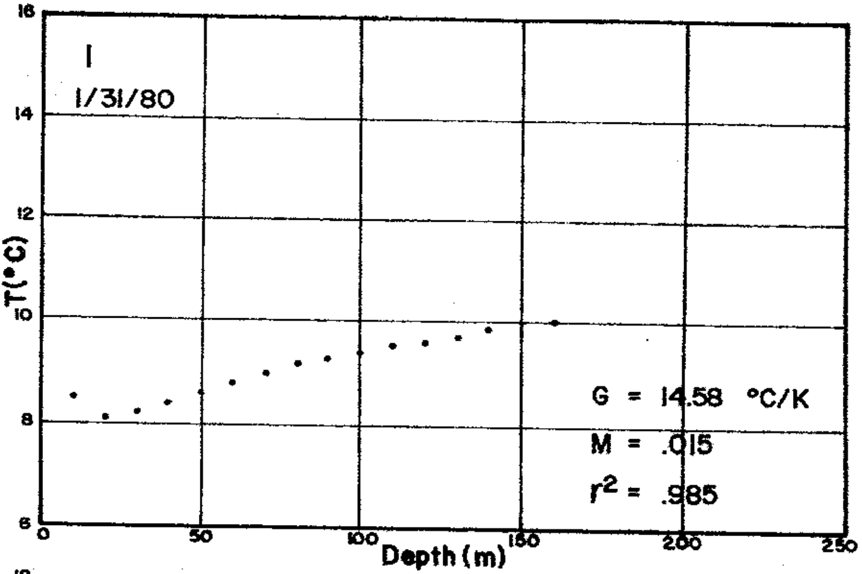
Plotting of data was done through the Plotsys plotting system at Rensselaer Polytechnic Institute using its Calcomp plotter or the Dunn Geoscience Corporation Tektronix 4662 plotter. Plotting programs were either written by W. Konrad Crist of Dunn Geoscience Corporation or were already part of a computer program such as in the case of Surface II. In all cases computer-derived output whether tabular or plotted was reviewed for consistency with the original data and with human interpretation of that data.

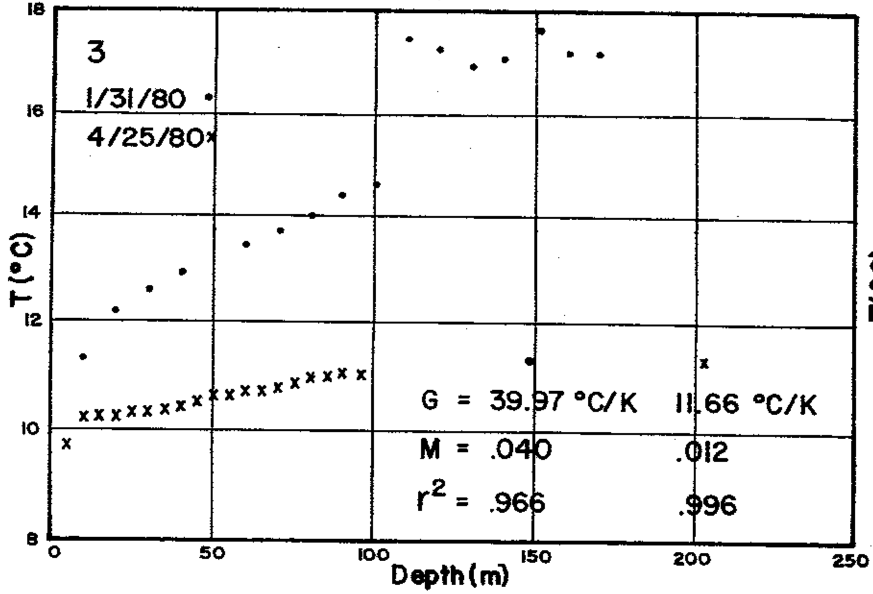
APPENDIX D

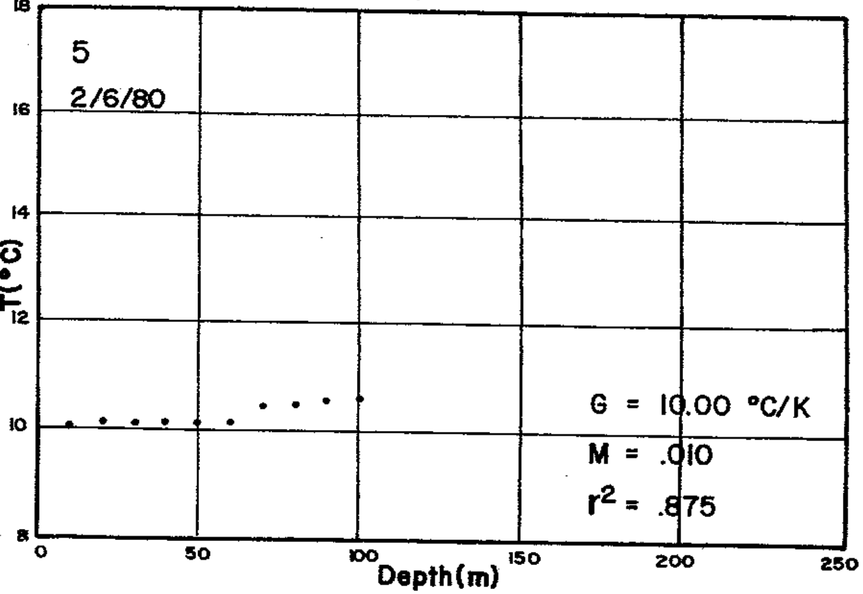
ABANDONED WELL GRADIENT GRAPHS

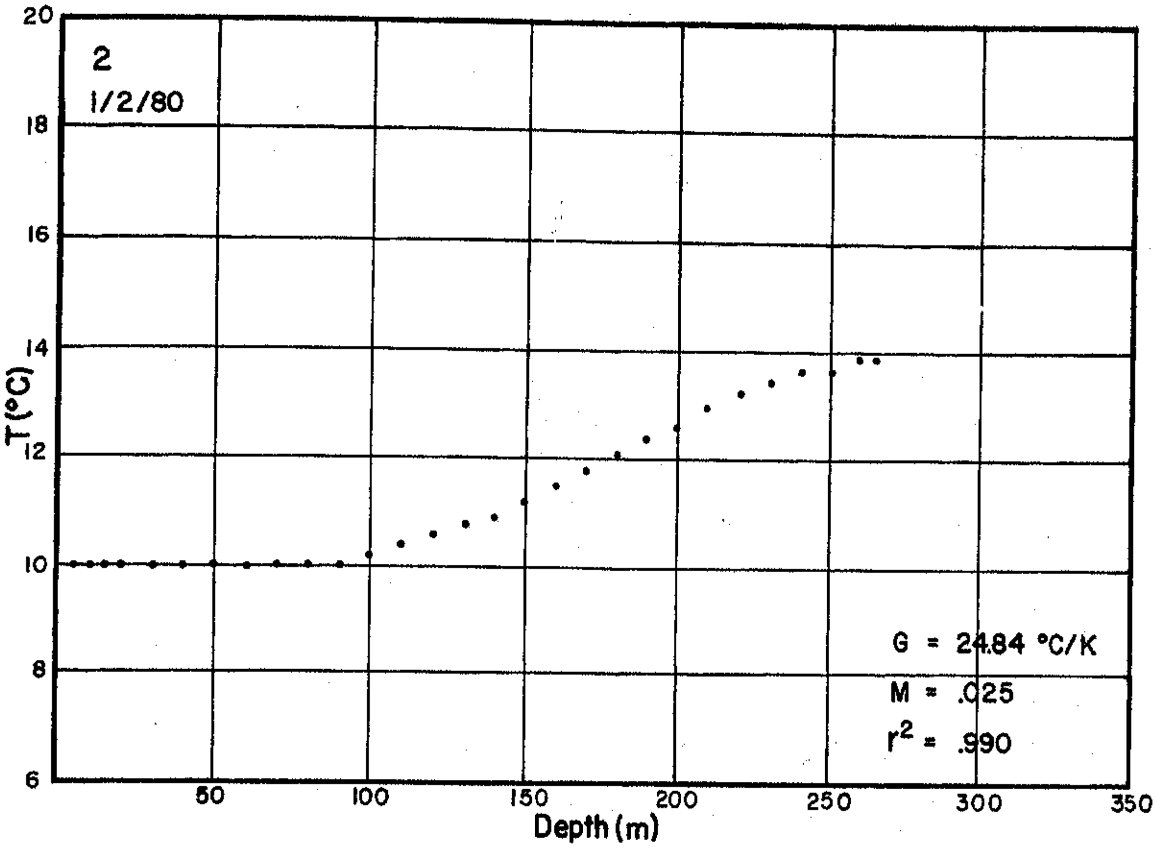
KEY

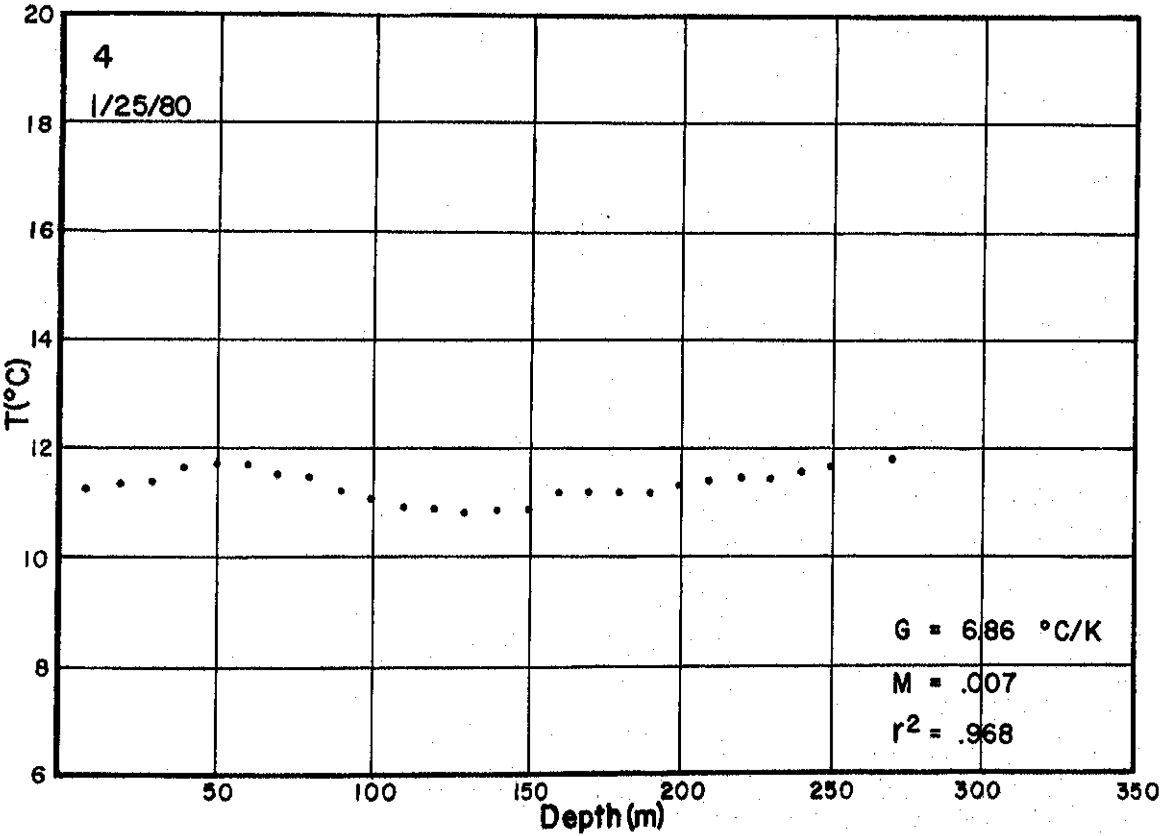

Well Number
Date (s)
T(°C)
G = gradient
M = slope
r^2 = determination coefficient
0
50
100
150
200
250
Depth (m)

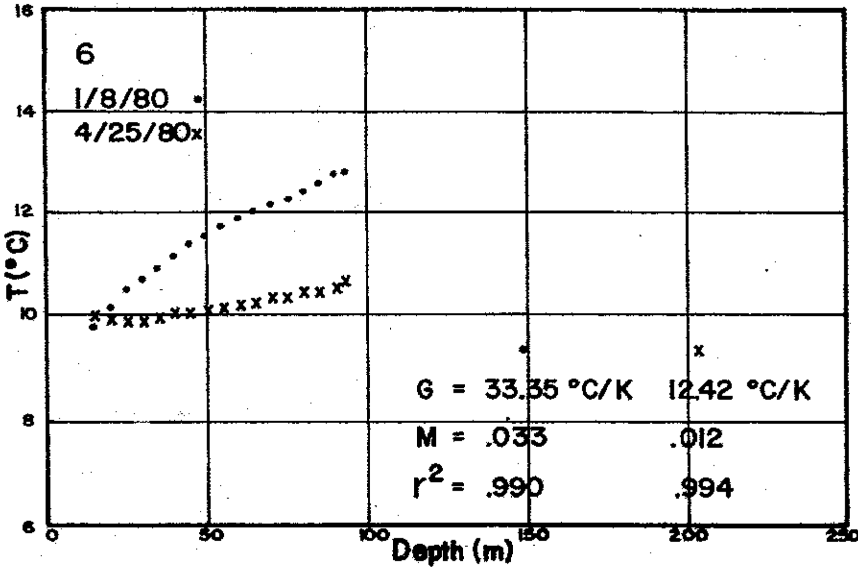

1
1/31/80
16
14
12
10
8
6
T(°C)
G = 14.58 °C/K
M = .015
r^2 = .985
0
50
100
150
200
250
Depth (m)

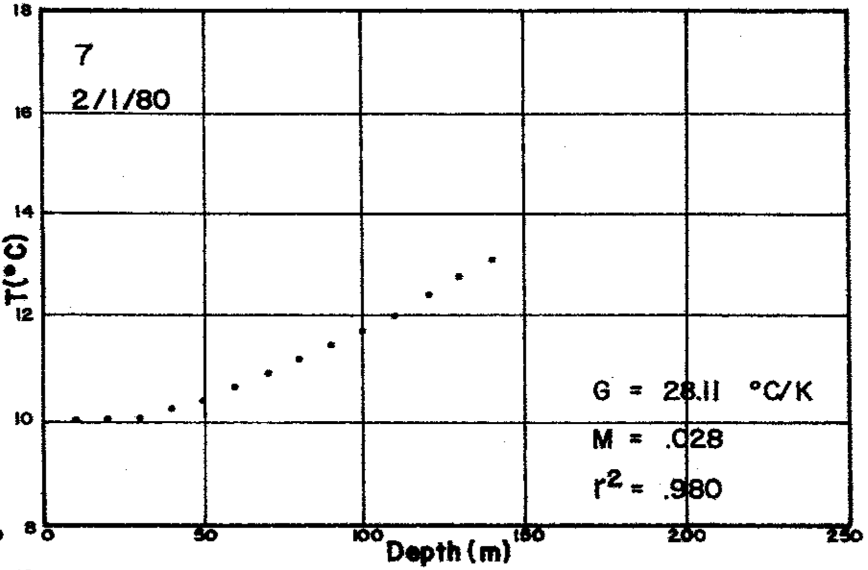

3
1/31/80 •
4/25/80 x
18
16
14
12
10
8
T(°C)
G = 39.97 °C/K
M = .040
r^2 = .966
11.66 °C/K
.012
.996
0
50
100
150
200
250
Depth (m)

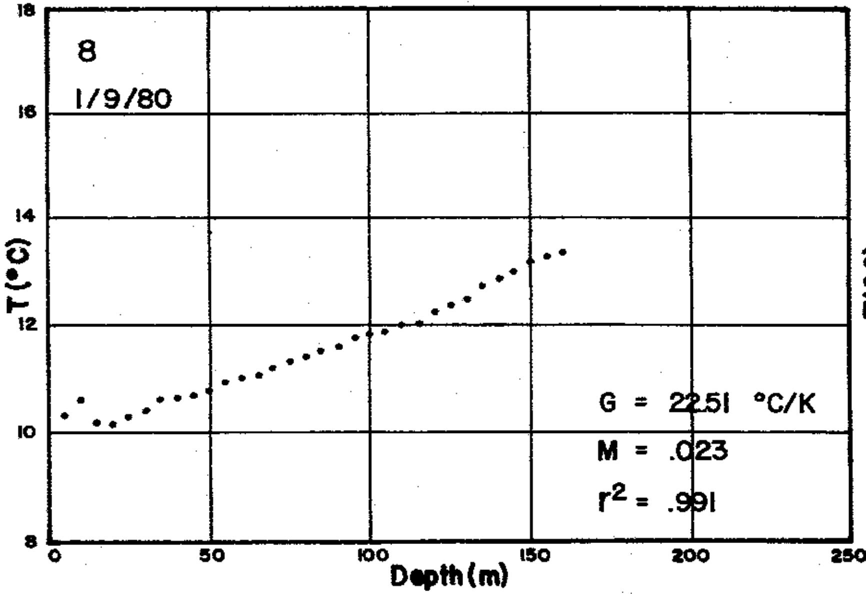

5
2/6/80
18
16
14
12
10
8
T(°C)
G = 10.00 °C/K
M = .010
r^2 = .875
0
50
100
150
200
250
Depth (m)

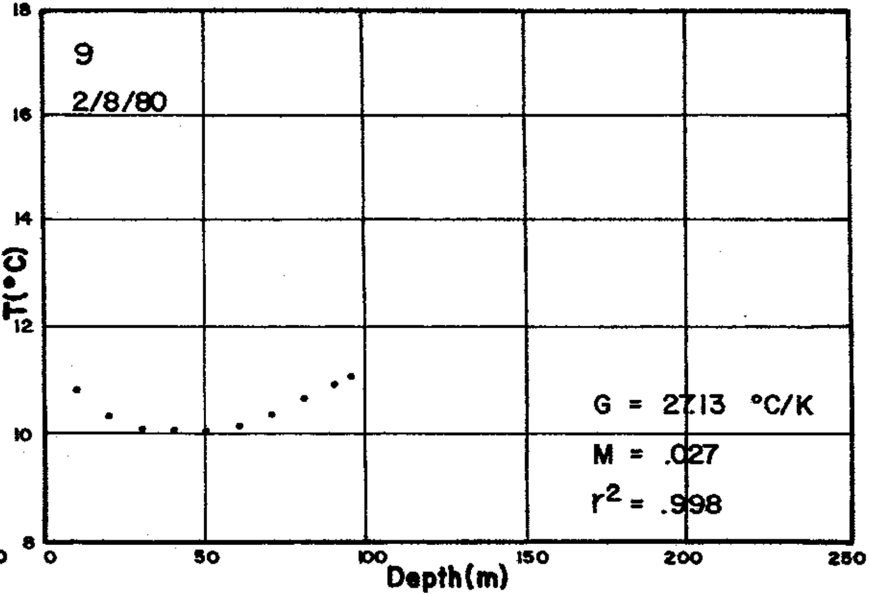

2
1/2/80
T(°C)
20
18
16
14
12
10
8
6
50
100
150
200
250
300
350
Depth (m)
G = 24.84 °C/K
M = .025
r^2 = .990

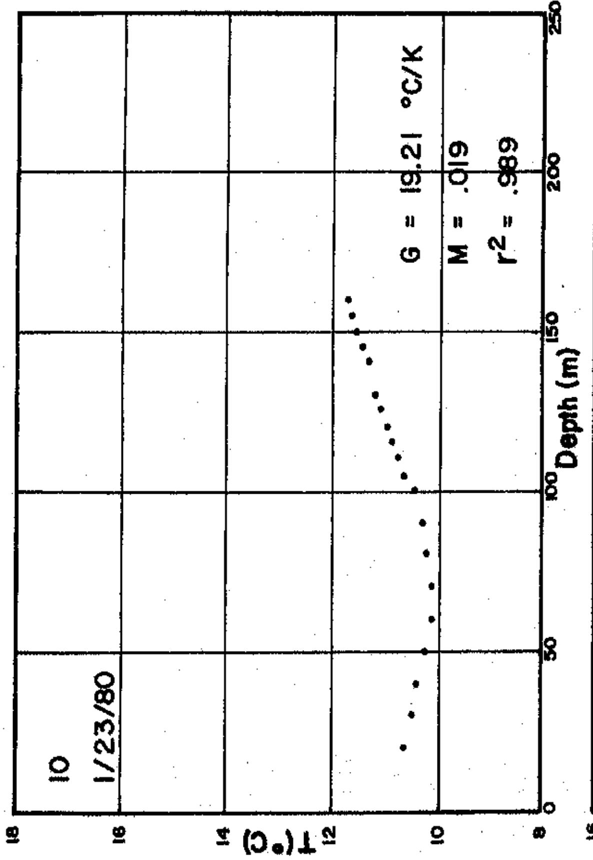

4
1/25/80
T(°C)
20
18
16
14
12
10
8
6
50
100
150
200
250
300
350
Depth (m)
G = 6.86 °C/K
M = .007
r^2 = .968

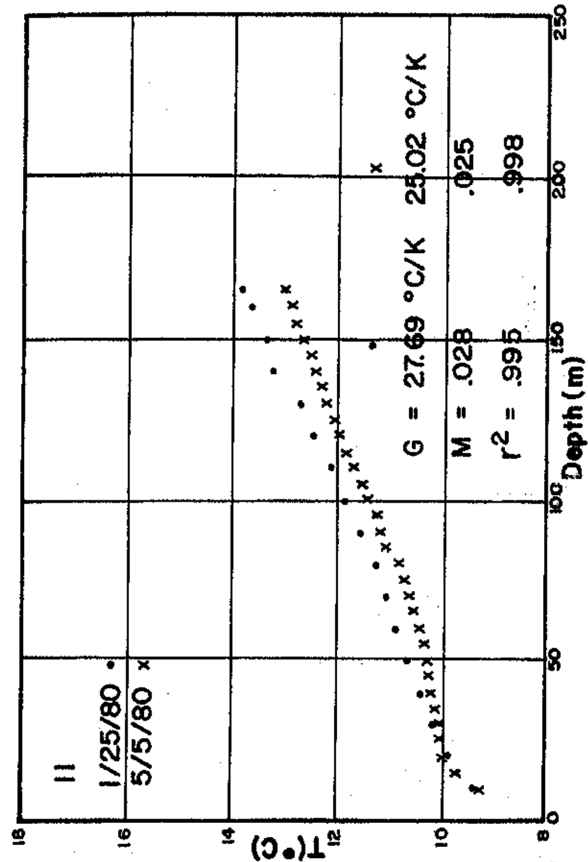

6
1/8/80 •
4/25/80 x
G = 33.35 °C/K 12.42 °C/K
M = .033 .012
r² = .990 .994
T(°C)
16
14
12
10
8
6
Depth (m)
0
50
100
150
200
250

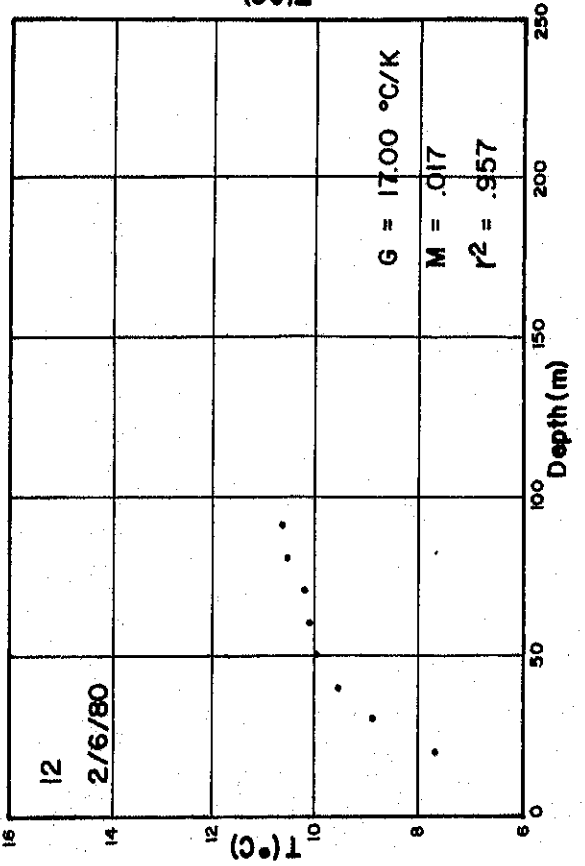

7
2/1/80
G = 28.11 °C/K
M = .028
r² = .980
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

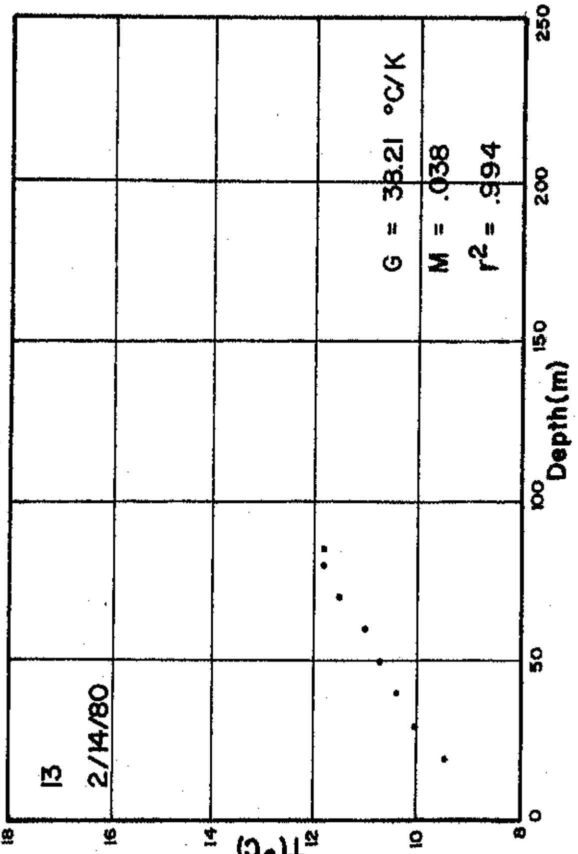

8
1/9/80
G = 22.51 °C/K
M = .023
r² = .991
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

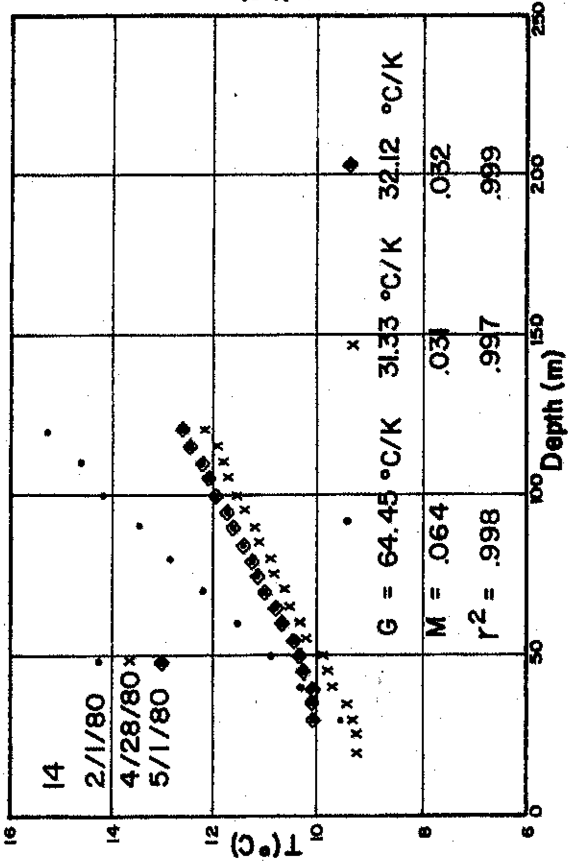

9
2/8/80
G = 27.13 °C/K
M = .027
r² = .998
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

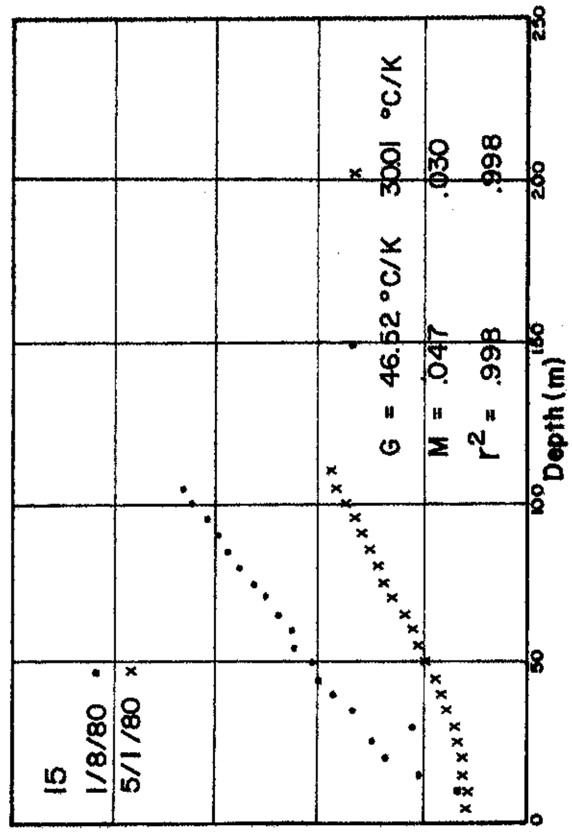

10
1/23/80
G = 19.21 °C/K
M = .019
r^2 = .989
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

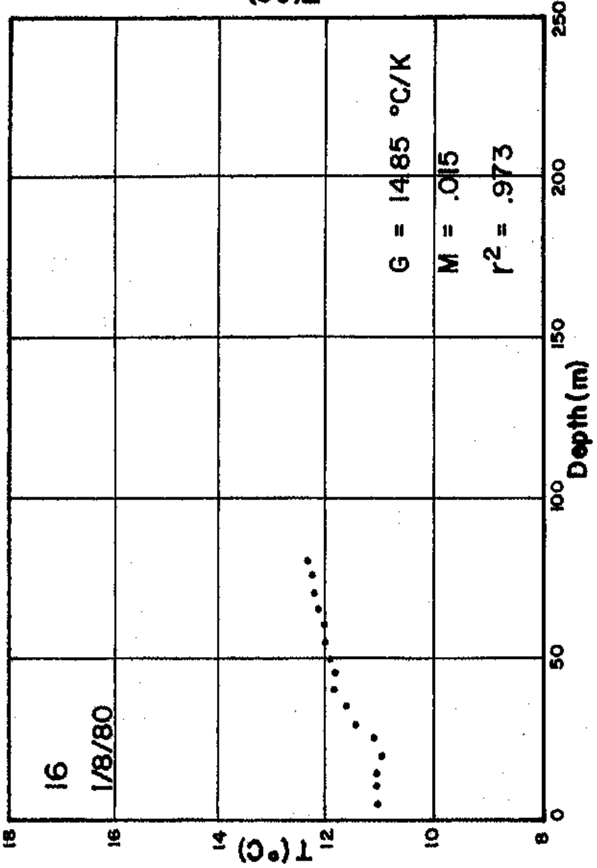

11
1/25/80 •
5/5/80 x
G = 27.69 °C/K 25.02 °C/K
M = .028 .025
r^2 = .995 .998
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

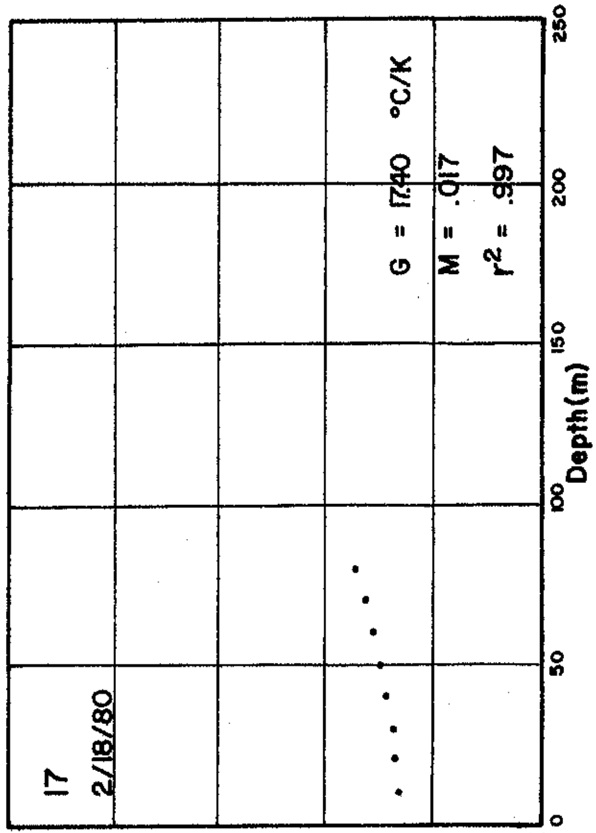

12
2/6/80
G = 17.00 °C/K
M = .017
r^2 = .957
T(°C)
6
8
10
12
14
16
Depth (m)
0
50
100
150
200
250

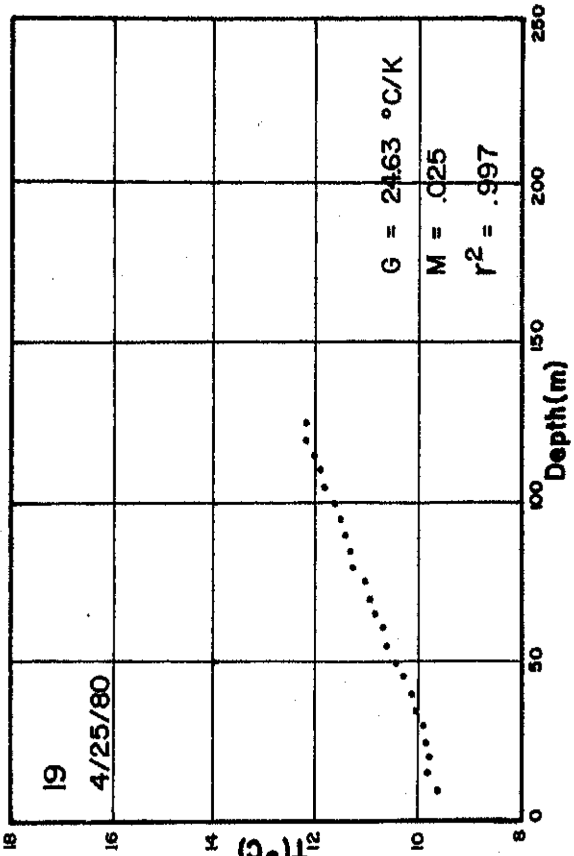

13
2/14/80
G = 38.21 °C/K
M = .038
r^2 = .994
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

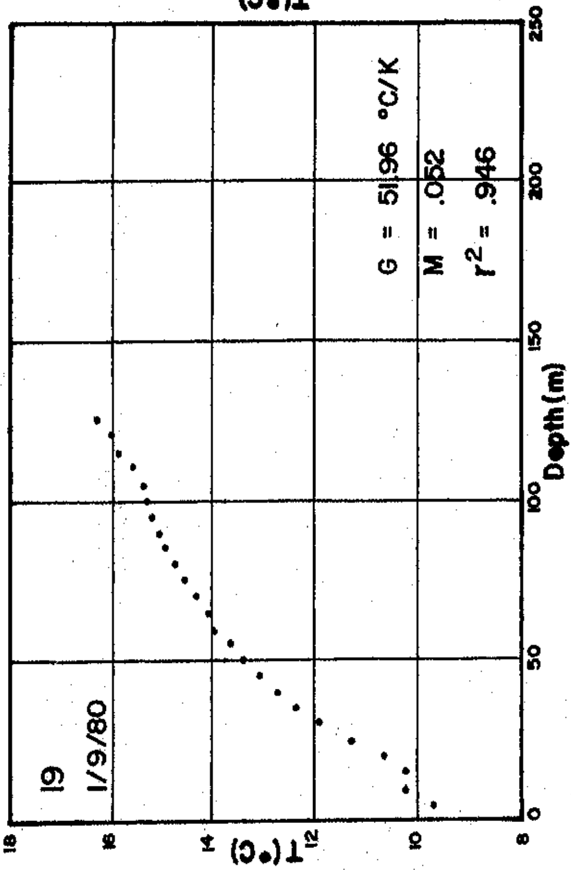

14
2/1/80
4/28/80
5/1/80
G = 64.45 °C/K 31.33 °C/K 32.12 °C/K
M = .064 .031 .032
r^2 = .998 .997 .999
T(°C)
Depth (m)
16
14
12
10
8
6
0
50
100
150
200
250

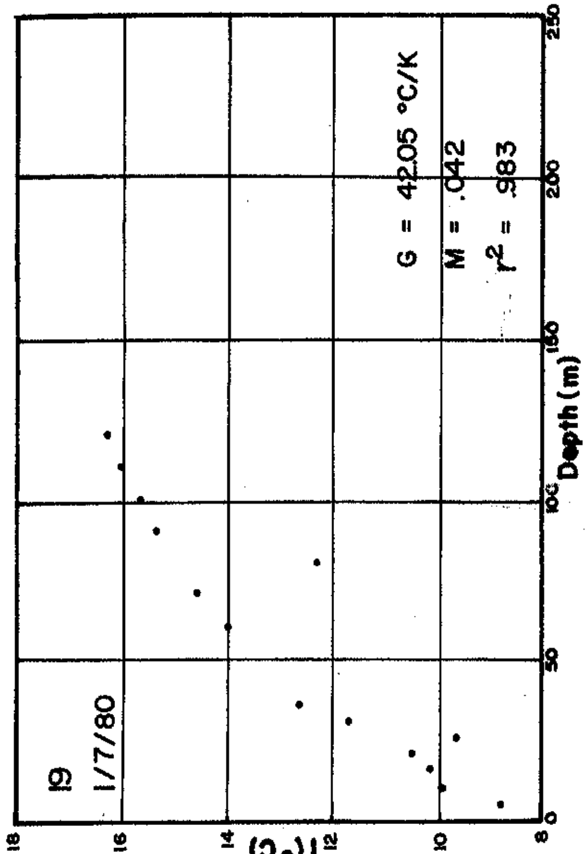

15
1/8/80
5/1/80
G = 46.52 °C/K 30.01 °C/K
M = .047 .030
r^2 = .998 .998
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

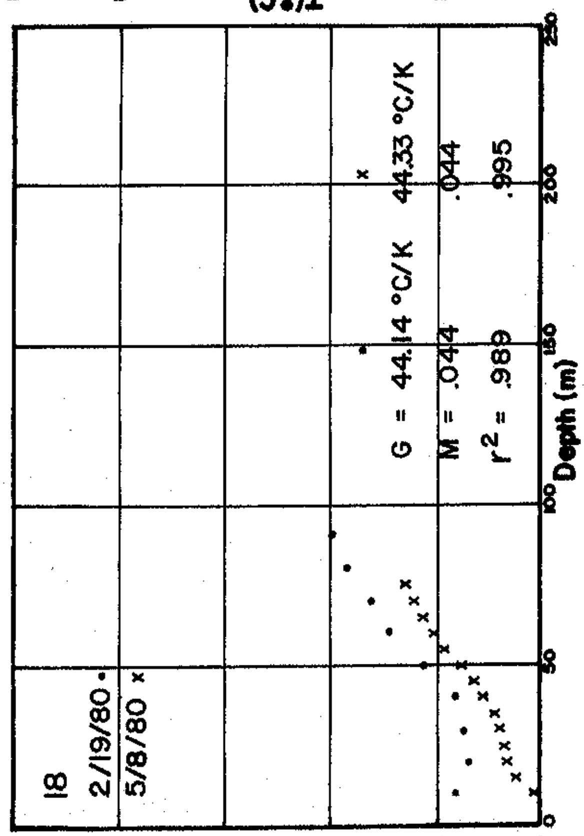

16
1/8/80
G = 14.85 °C/K
M = .015
r^2 = .973
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

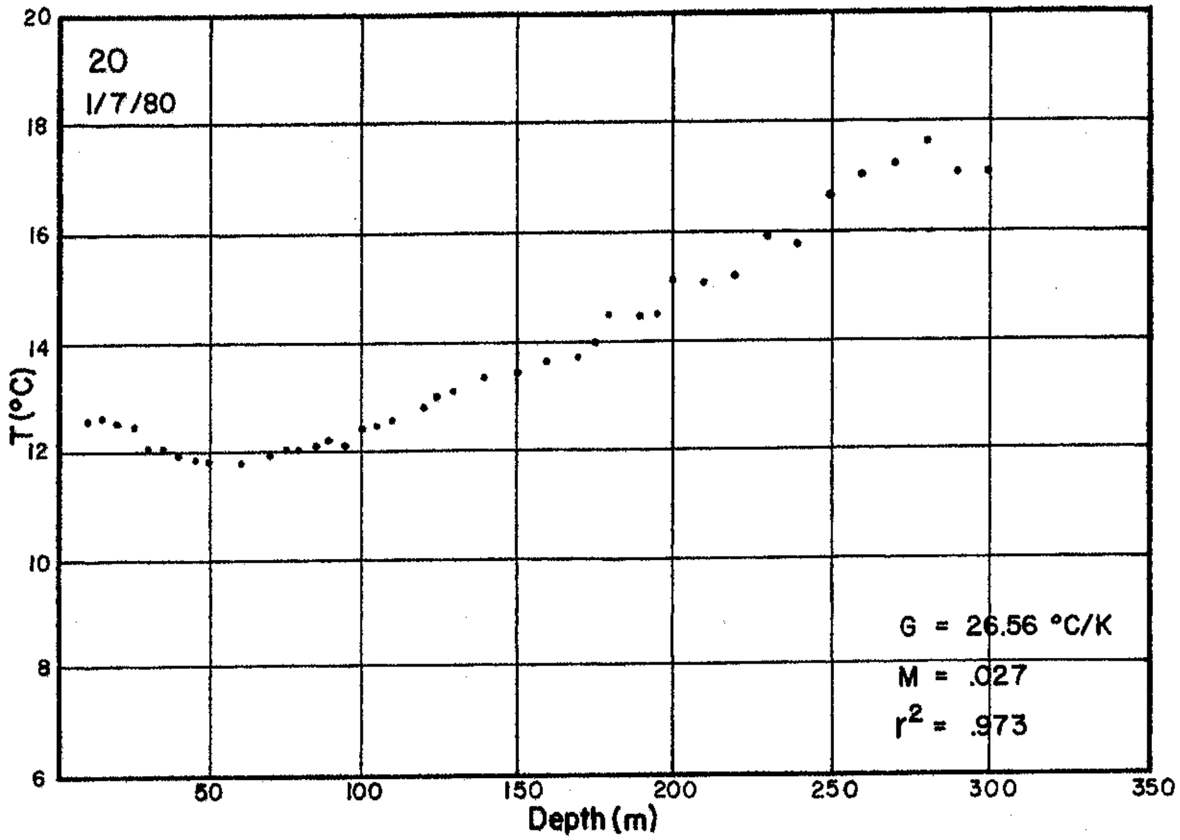

17
2/18/80
G = 17.40 °C/K
M = .017
r^2 = .997
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

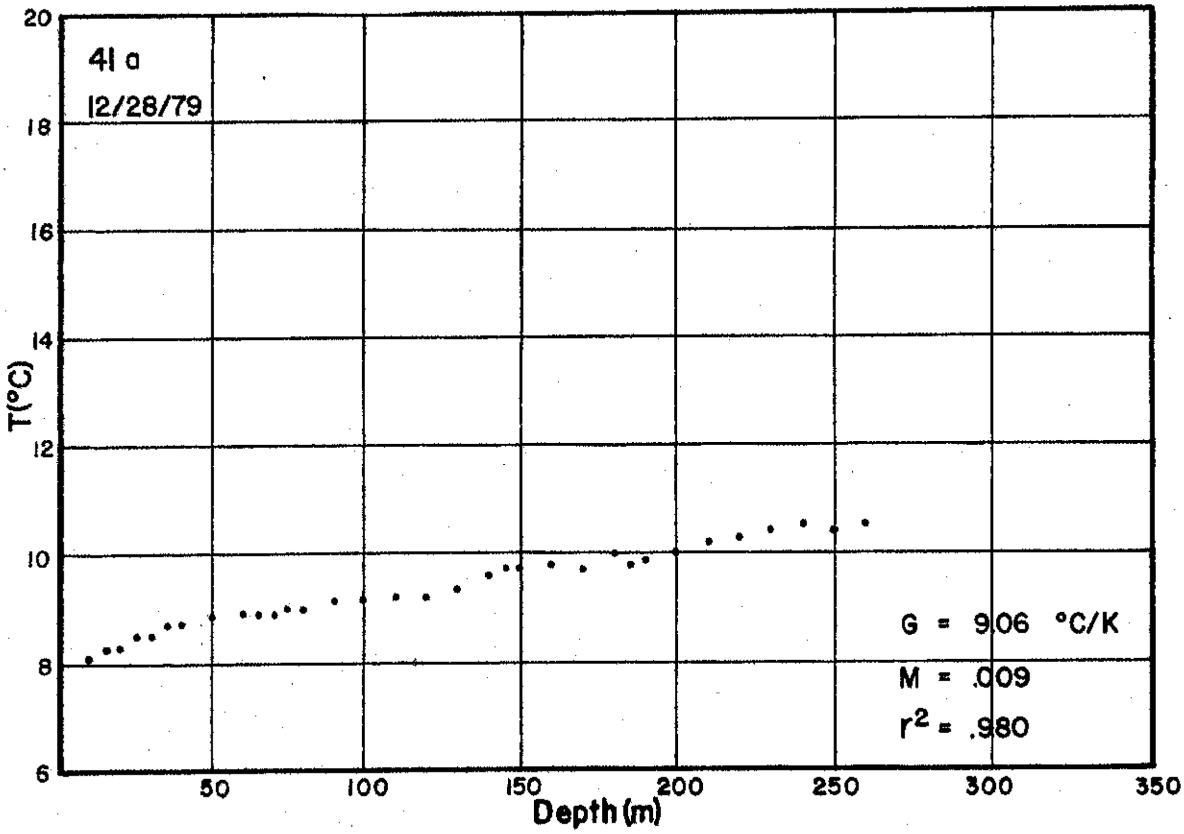

19
4/25/80
G = 24.63 °C/K
M = .025
r^2 = .997
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

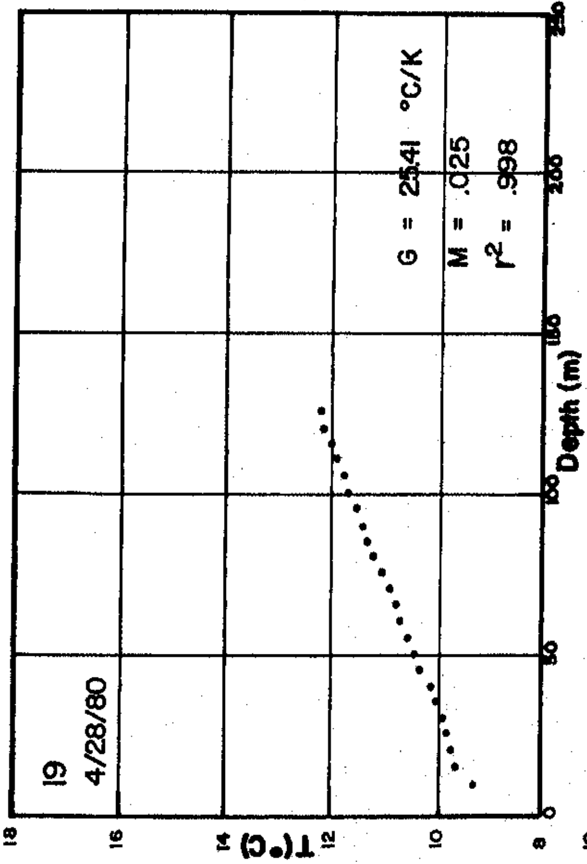

19
1/9/80
G = 51.96 °C/K
M = .052
r^2 = .946
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

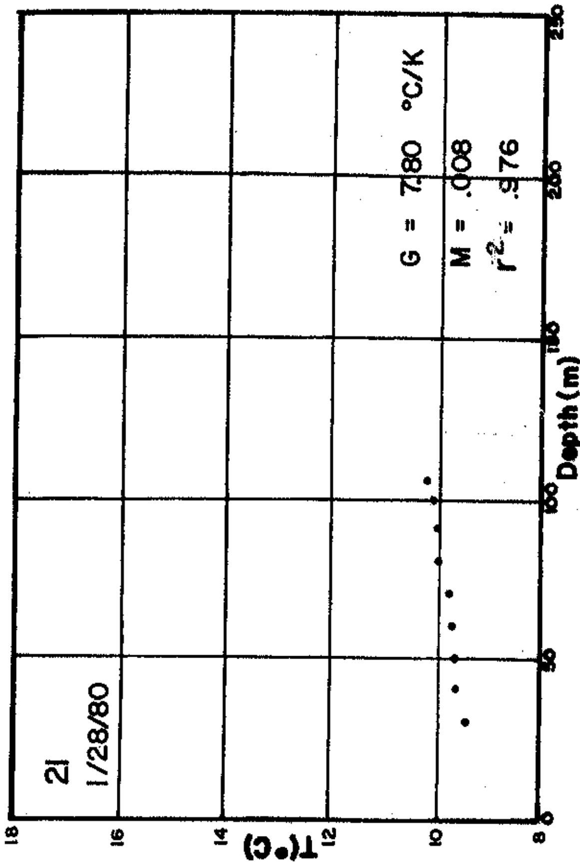

19
1/7/80
G = 42.05 °C/K
M = .042
r^2 = .983
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

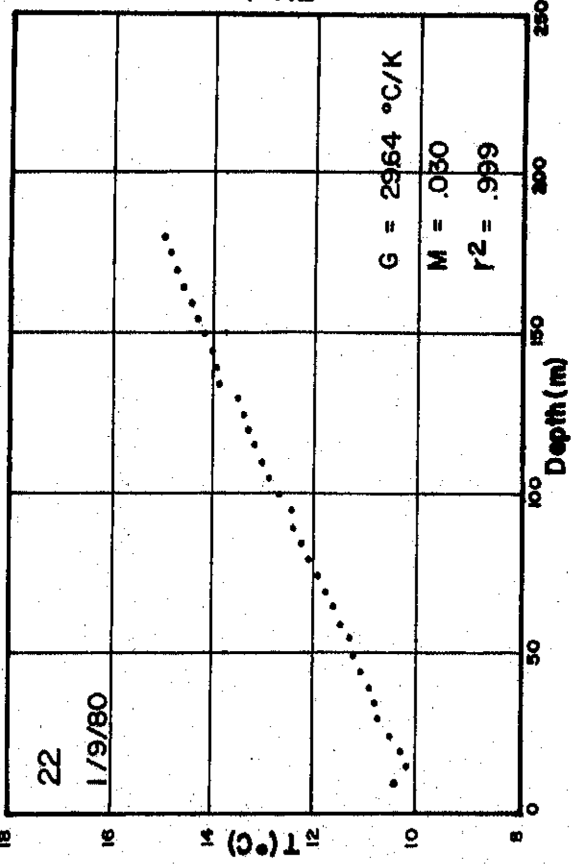

18
2/19/80 •
5/8/80 x
G = 44.14 °C/K
M = .044
r^2 = .989
44.33 °C/K
.044
.995
T(°C)
6
8
10
12
14
16
Depth (m)
0
50
100
150
200
250

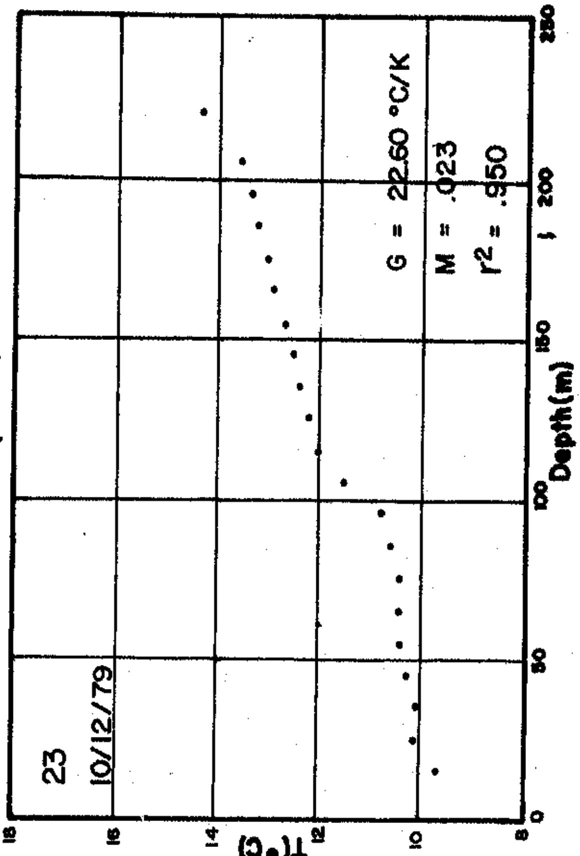

20
1/7/80
G = 26.56 °C/K
M = .027
r^2 = .973
T(°C)
20
18
16
14
12
10
8
6
50
100
150
200
250
300
350
Depth (m)

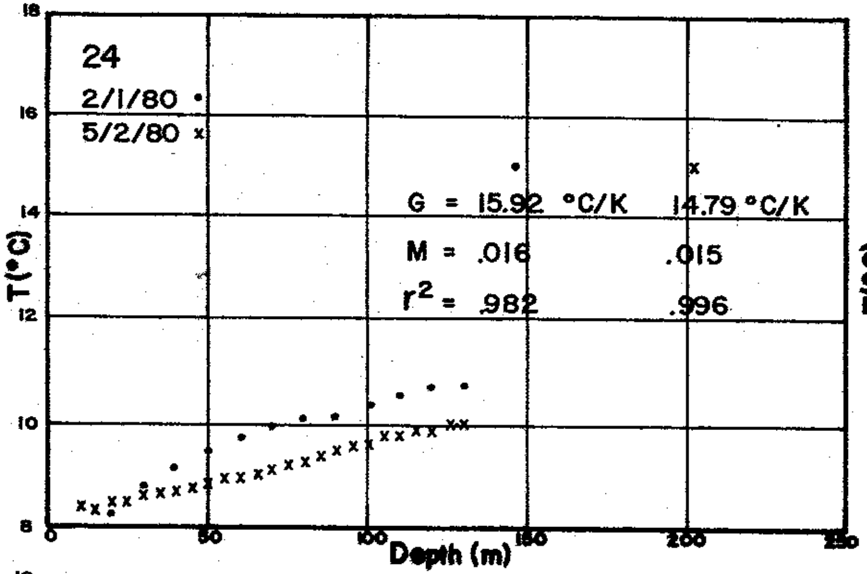

41 a
12/28/79
G = 9.06 °C/K
M = .009
r^2 = .980
T(°C)
20
18
16
14
12
10
8
6
50
100
150
200
250
300
350
Depth (m)

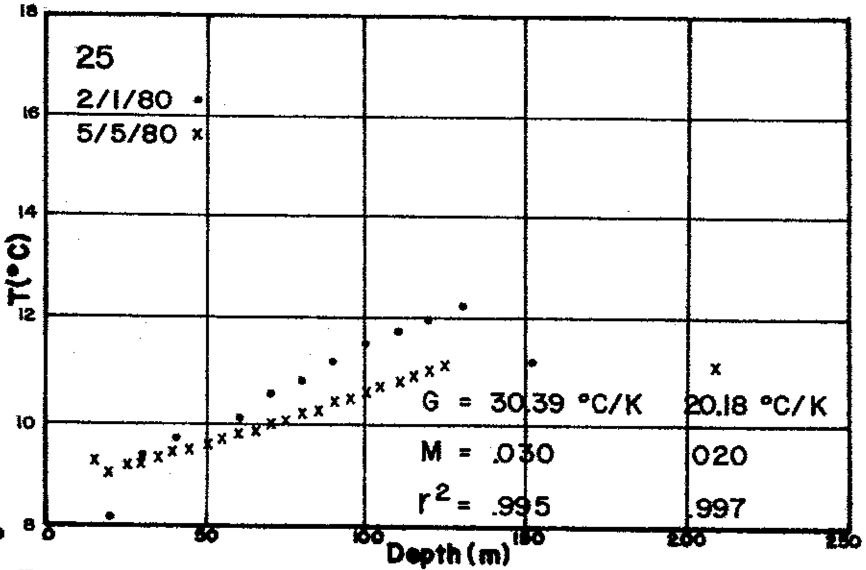

19
4/28/80
G = 25.41 °C/K
M = .025
r^2 = .998
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

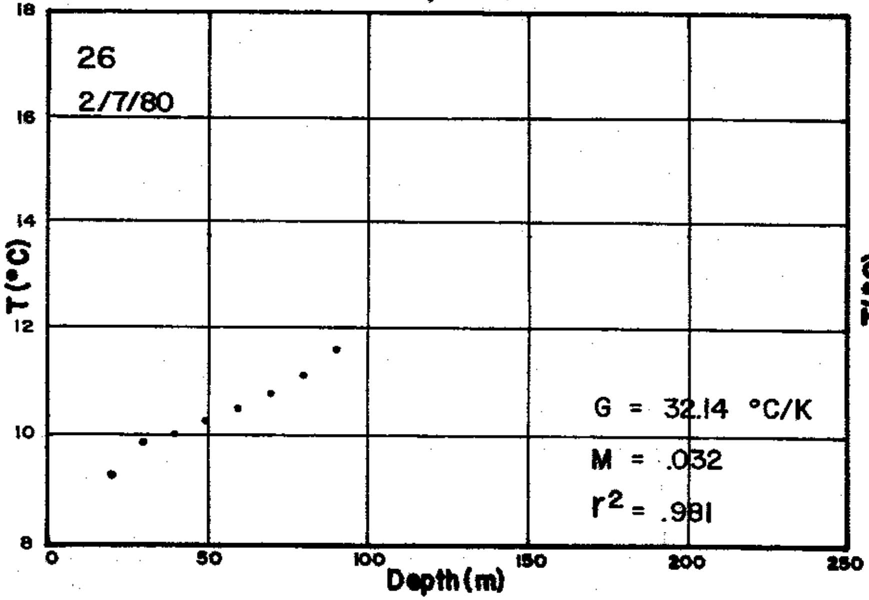

21
1/28/80
G = 7.80 °C/K
M = .008
r^2 = .976
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

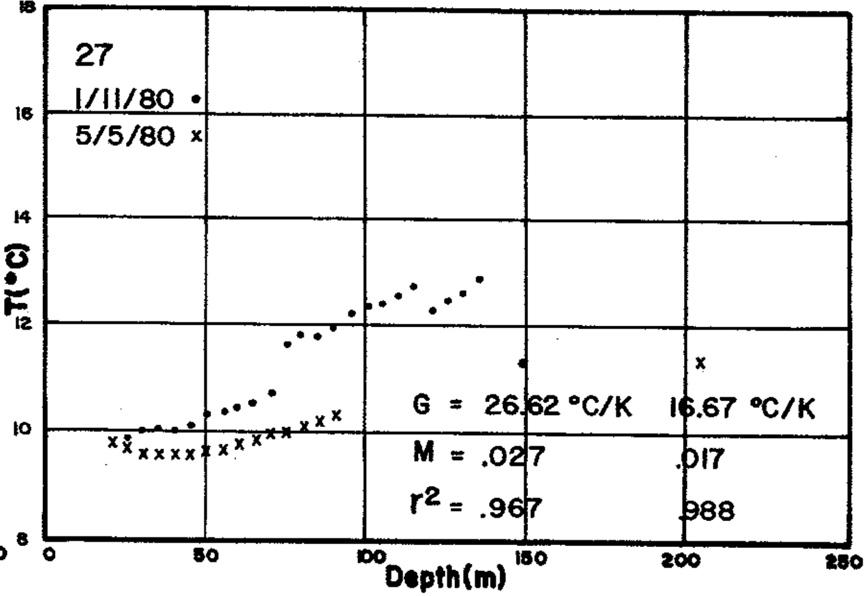

22
1/9/80
G = 29.64 °C/K
M = .030
r^2 = .999
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

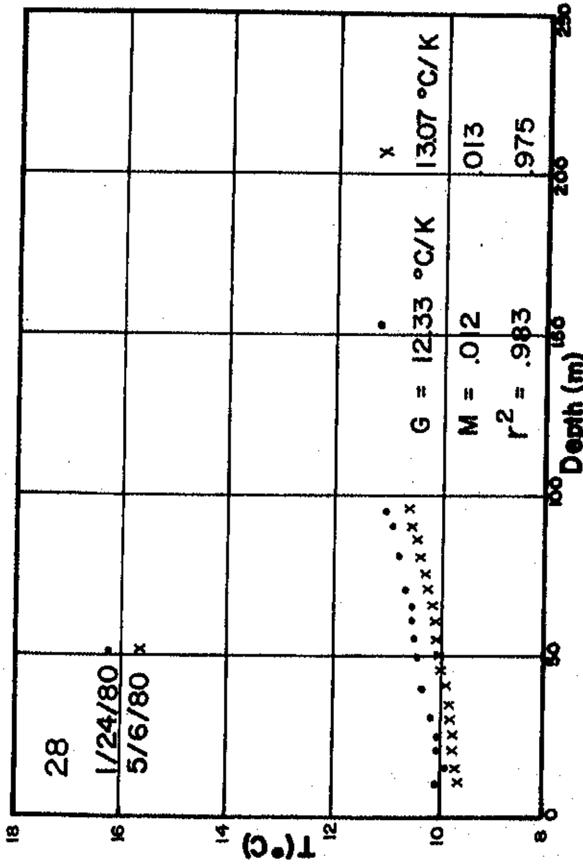

23
10/12/79
G = 22.60 °C/K
M = .023
r^2 = .950
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

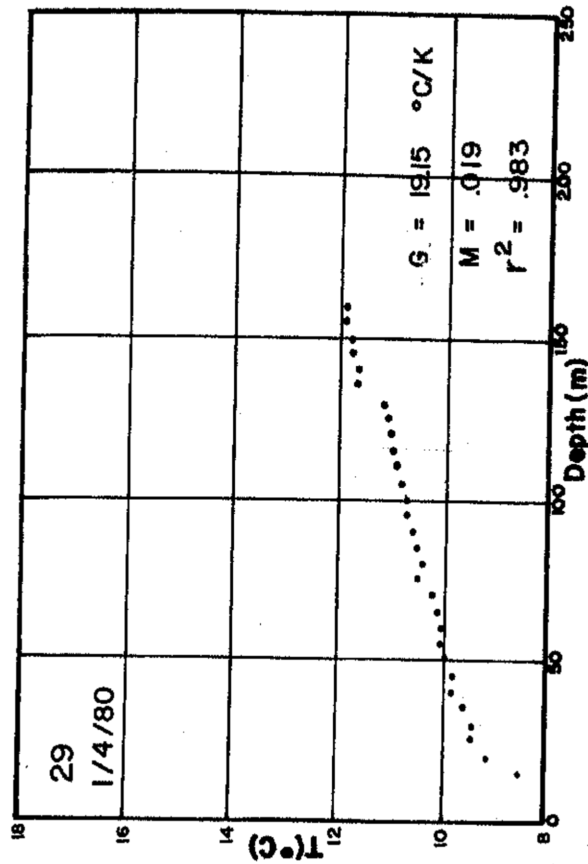

24
2/1/80 •
5/2/80 x
G = 15.92 °C/K 14.79 °C/K
M = .016 .015
r² = .982 .996
T(°C)
8
10
12
14
16
18
0
50
100
150
200
250
Depth (m)

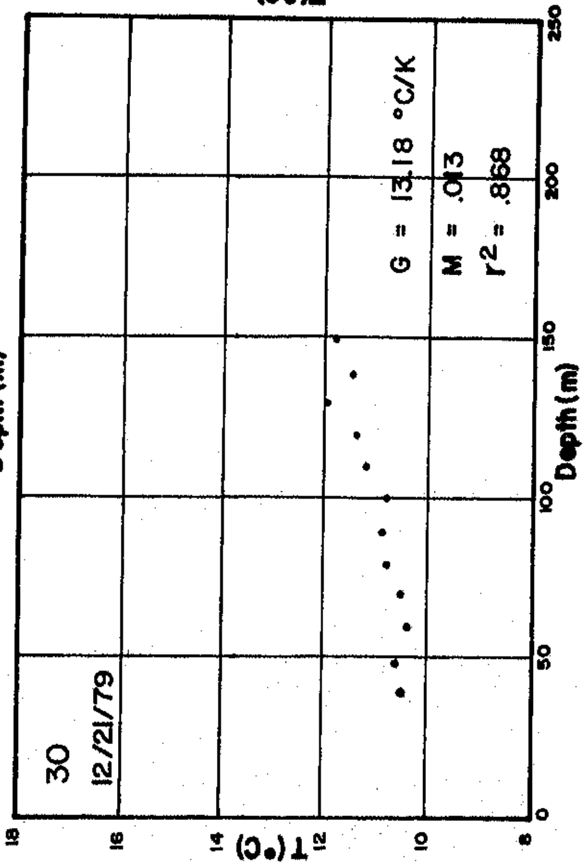

25
2/1/80 •
5/5/80 x
G = 30.39 °C/K 20.18 °C/K
M = .030 .020
r² = .995 .997
T(°C)
8
10
12
14
16
18
0
50
100
150
200
250
Depth (m)

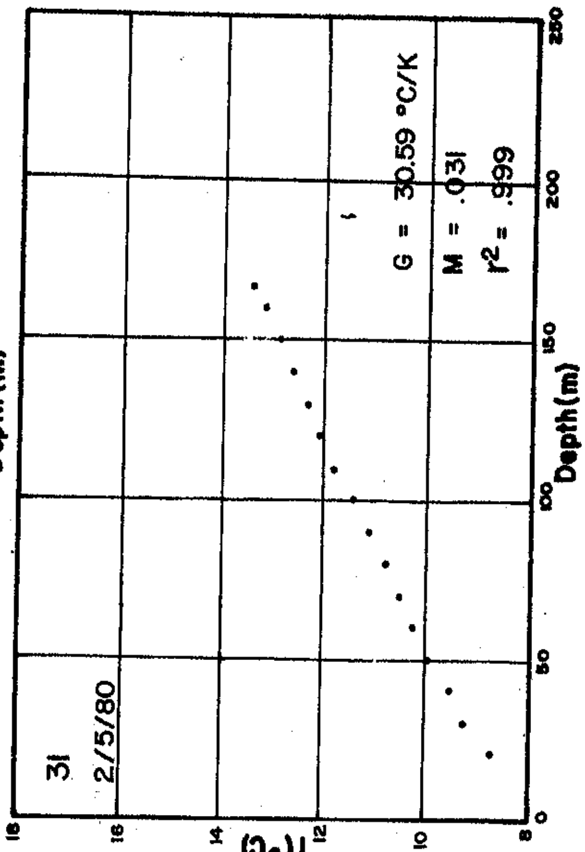

26
2/7/80
G = 32.14 °C/K
M = .032
r² = .981
T(°C)
8
10
12
14
16
18
0
50
100
150
200
250
Depth (m)

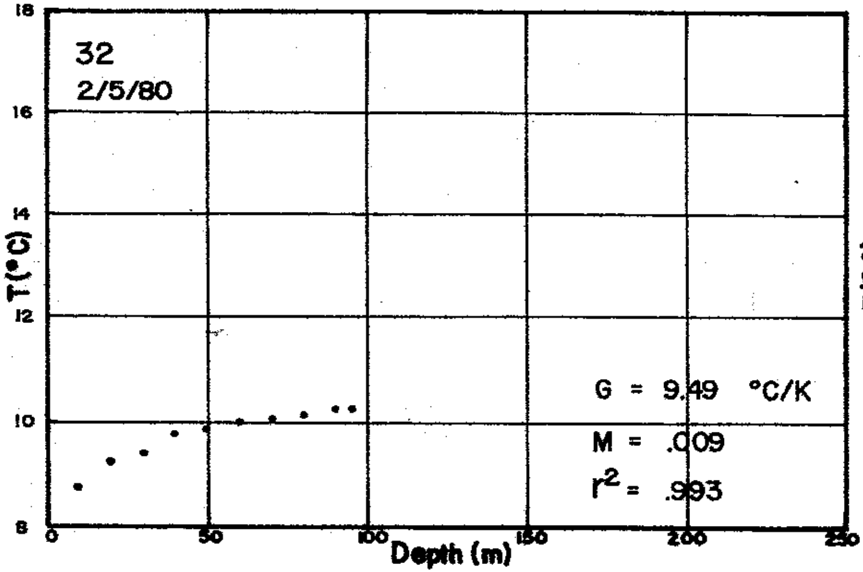

27
1/11/80 •
5/5/80 x
G = 26.62 °C/K 16.67 °C/K
M = .027 .017
r² = .967 .988
T(°C)
8
10
12
14
16
18
0
50
100
150
200
250
Depth (m)

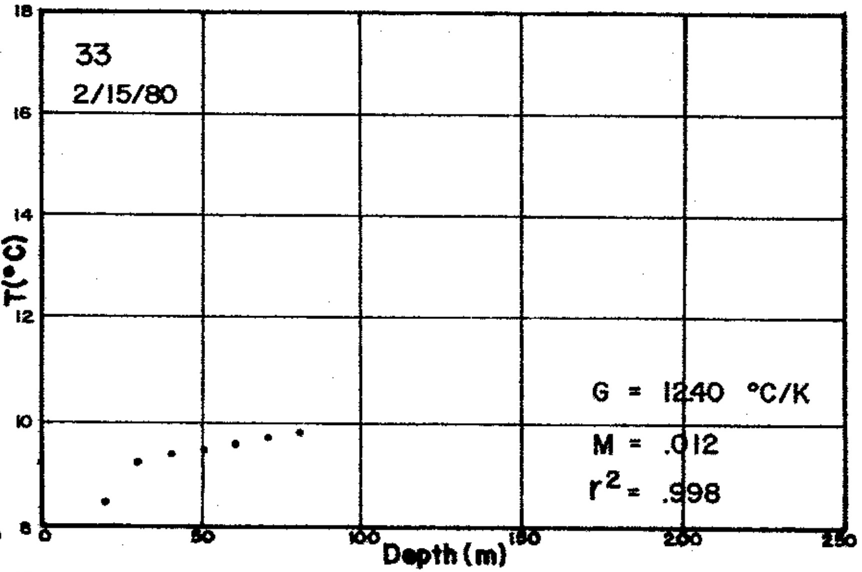

28
1/24/80
5/6/80
G = 12.33 °C/K
M = .012
r2 = .983
x 13.07 °C/K
.013
.975
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

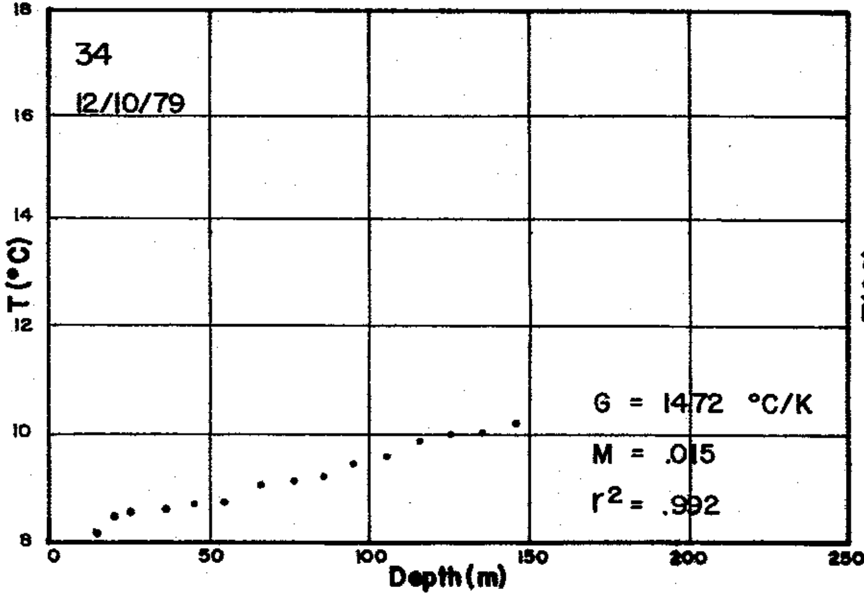

29
1/4/80
G = 19.15 °C/K
M = .019
r2 = .983
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

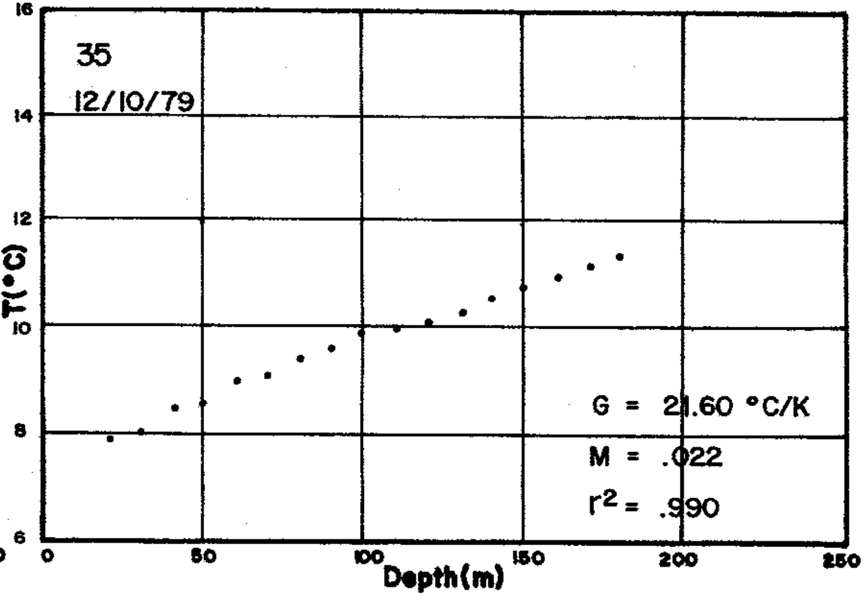

30
12/21/79
G = 13.18 °C/K
M = .013
r2 = .868
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

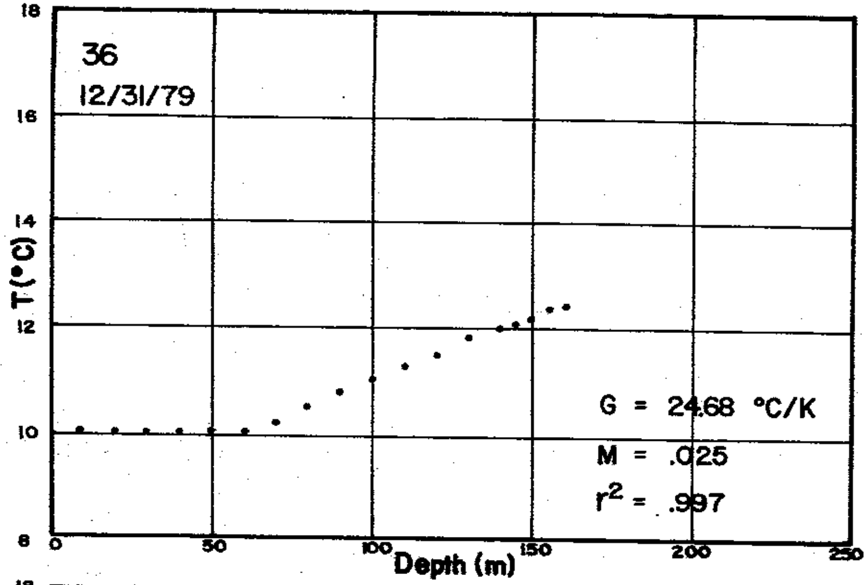

31
2/5/80
G = 30.59 °C/K
M = .031
r2 = .999
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

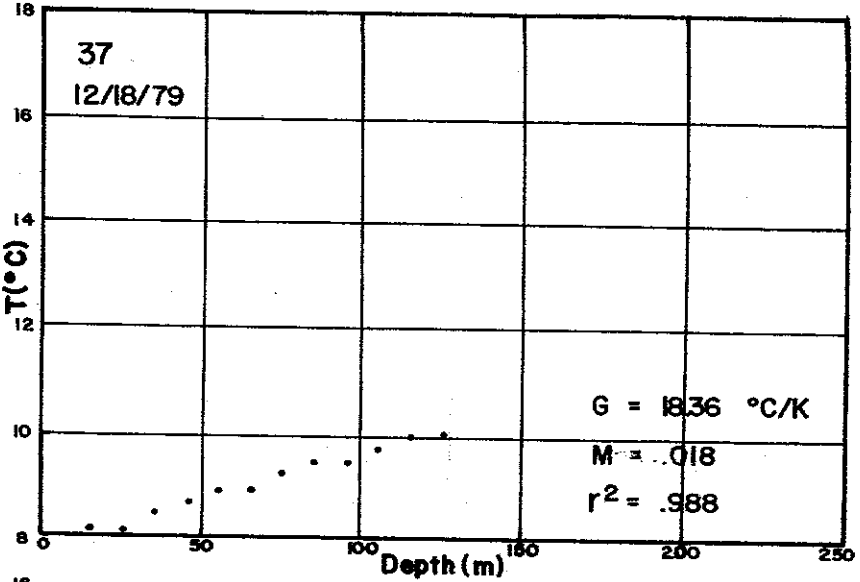

32
2/5/80
G = 9.49 °C/K
M = .009
r² = .993
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

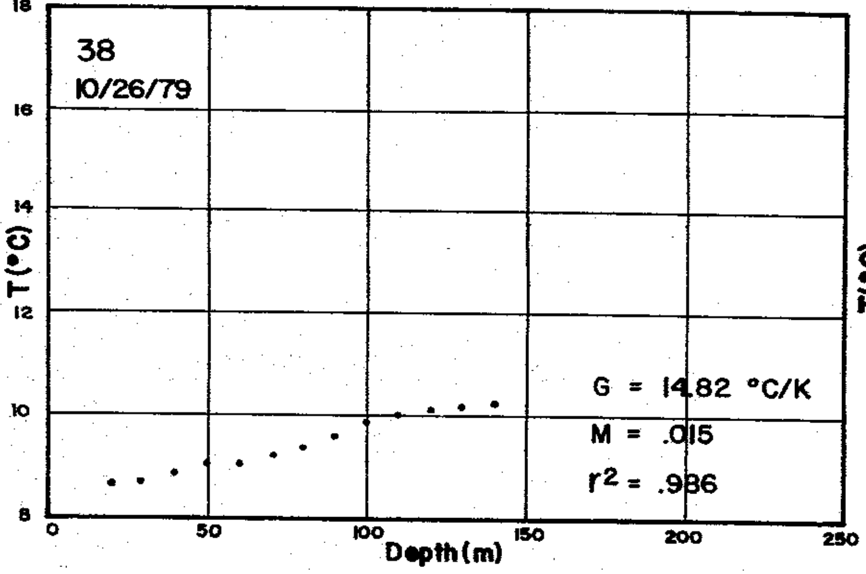

33
2/15/80
G = 12.40 °C/K
M = .012
r² = .998
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

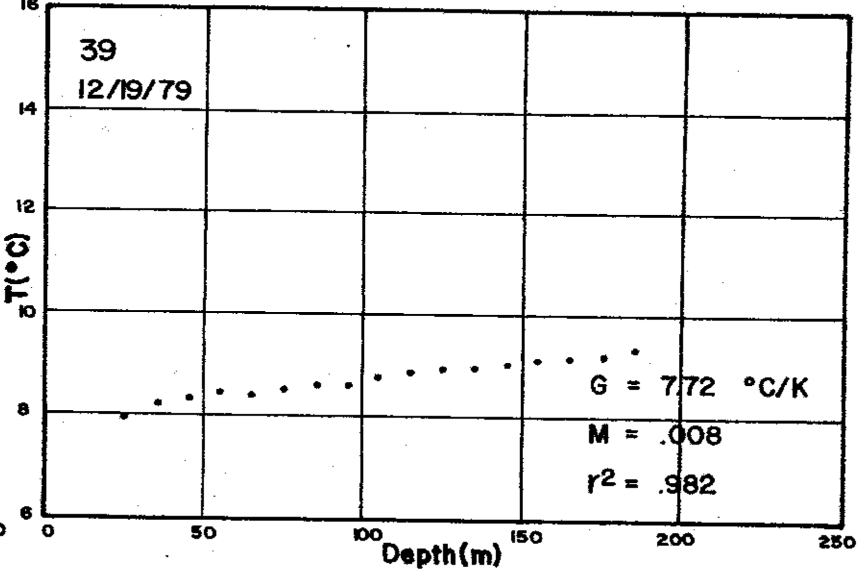

34
12/10/79
G = 14.72 °C/K
M = .015
r² = .992
T(°C)
Depth (m)
18
16
14
12
10
8
0
50
100
150
200
250

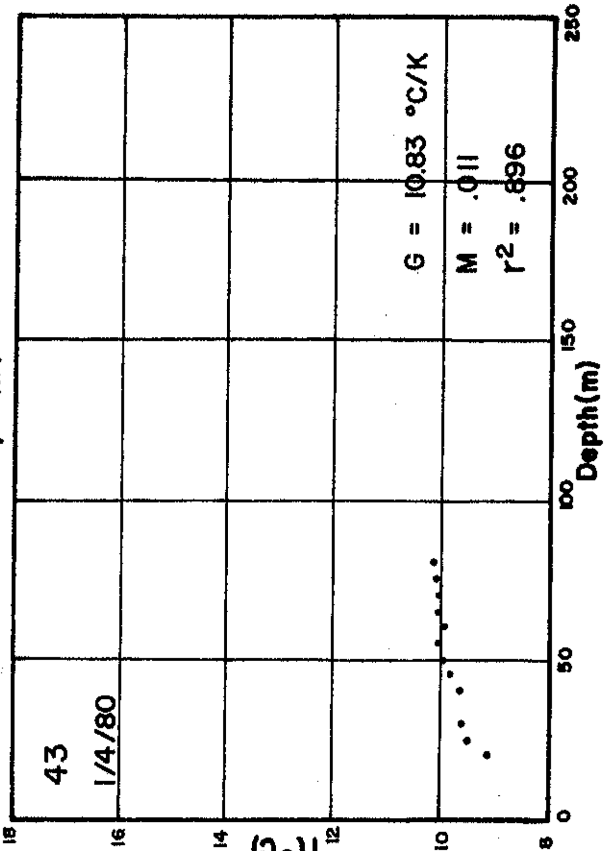

35
12/10/79
G = 21.60 °C/K
M = .022
r² = .990
T(°C)
Depth (m)
16
14
12
10
8
6
0
50
100
150
200
250

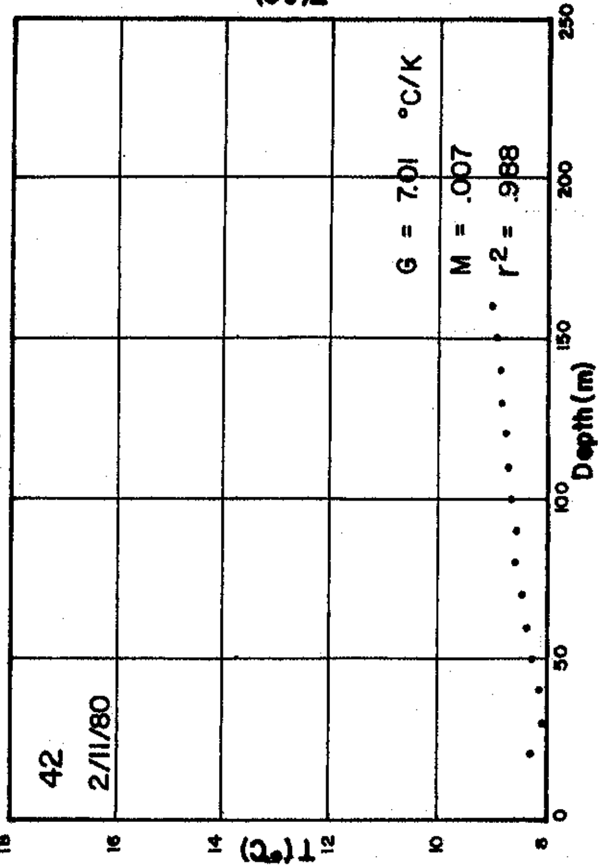

36
12/31/79
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)
G = 24.68 °C/K
M = .025
r² = .997

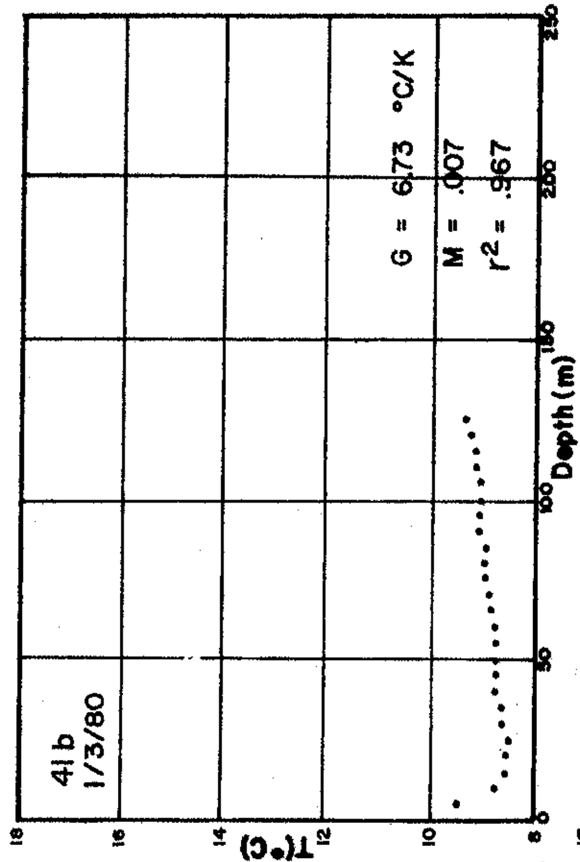

37
12/18/79
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)
G = 18.36 °C/K
M = .018
r² = .988

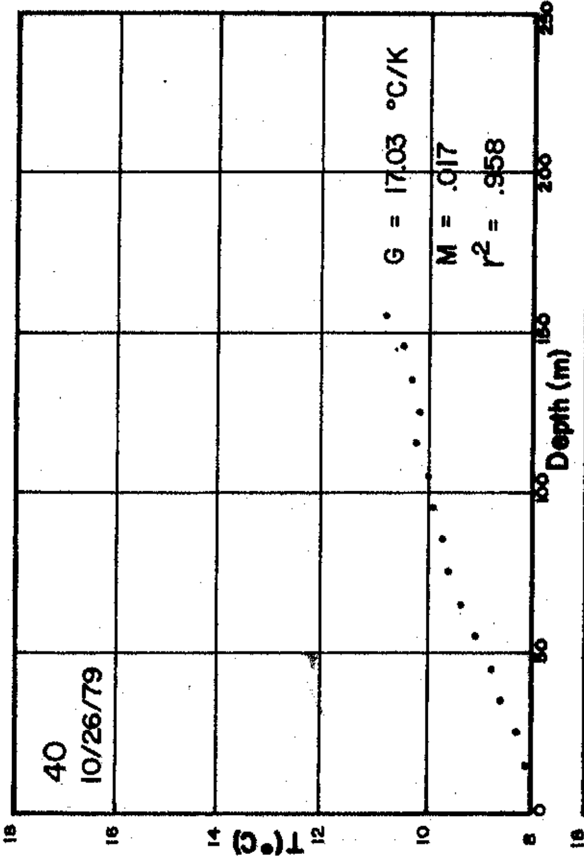

38
10/26/79
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)
G = 14.82 °C/K
M = .015
r² = .986

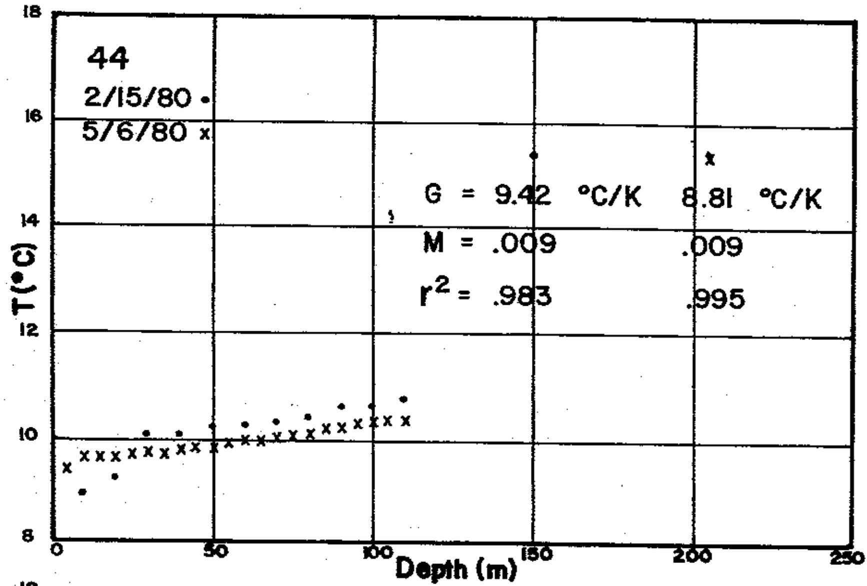

39
12/19/79
T(°C)
16
14
12
10
8
6
0
50
100
150
200
250
Depth(m)
G = 7.72 °C/K
M = .008
r² = .982

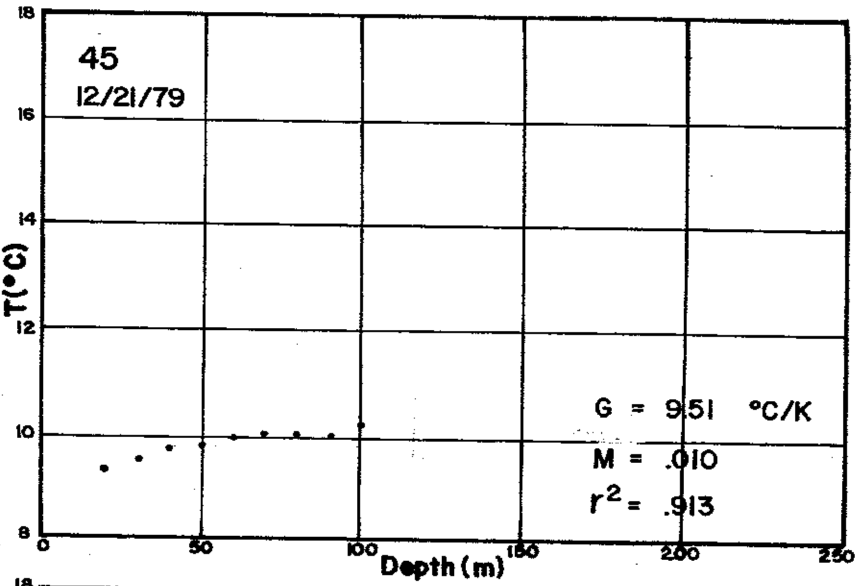

43
1/4/80
G = 10.83 °C/K
M = .011
r^2 = .896
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

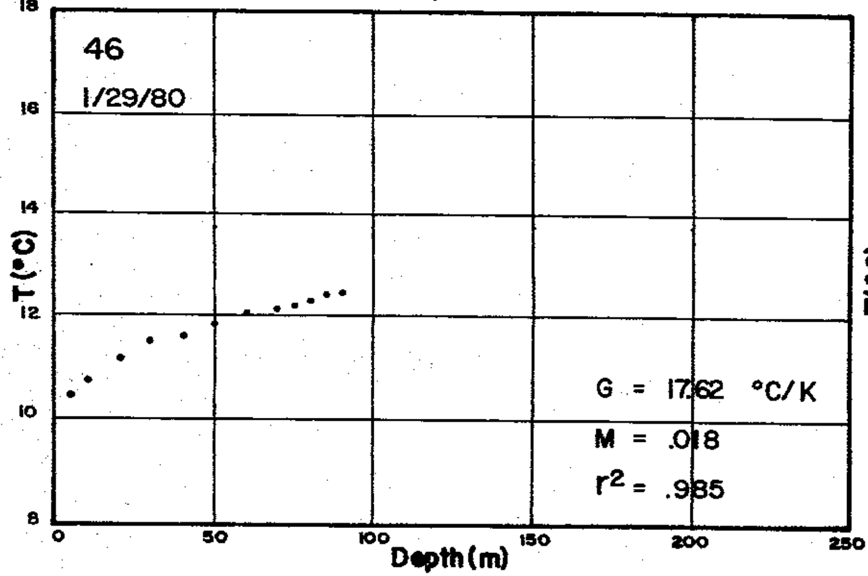

42
2/11/80
G = 7.01 °C/K
M = .007
r^2 = .988
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

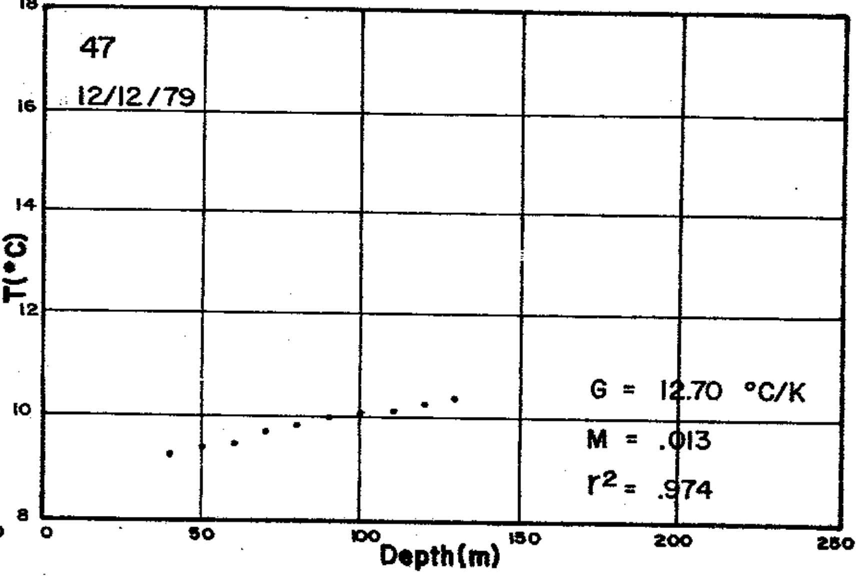

41 b
1/3/80
G = 6.73 °C/K
M = .007
r^2 = .967
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

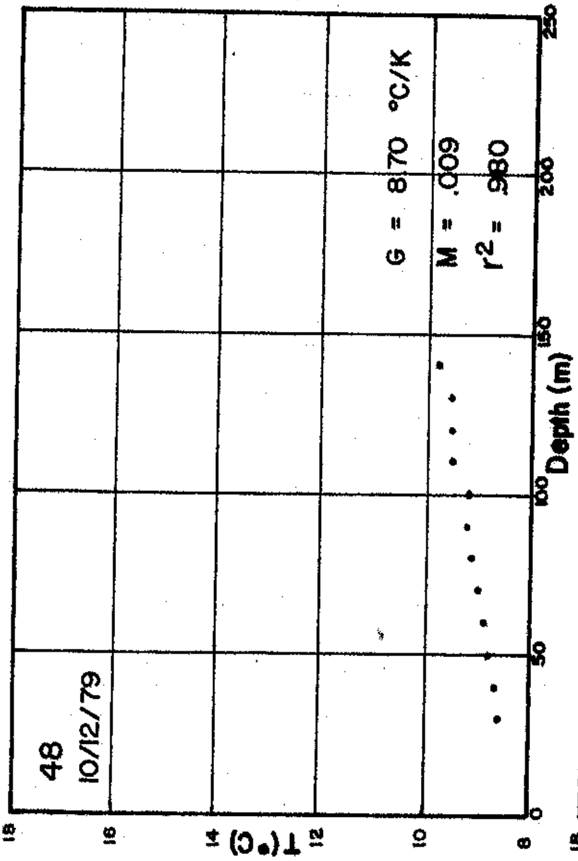

40
10/26/79
G = 17.03 °C/K
M = .017
r^2 = .958
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

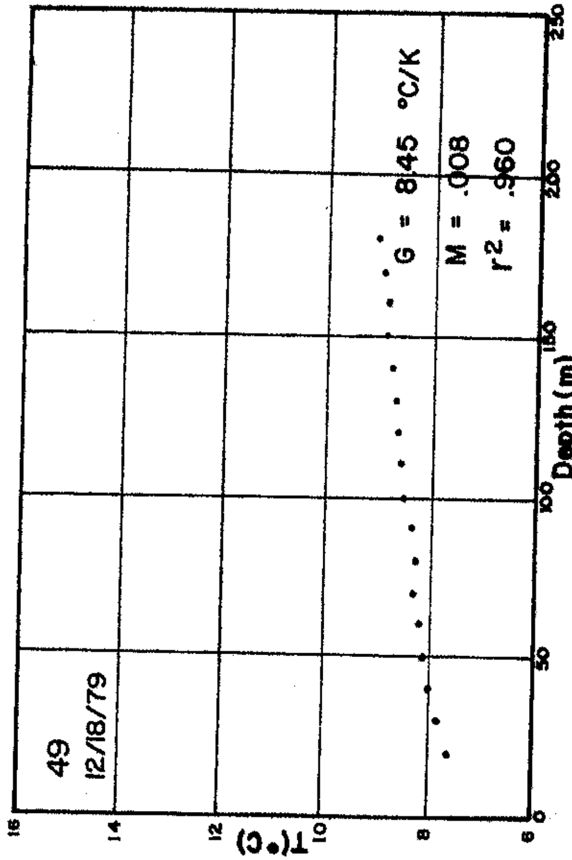

44
2/15/80 •
5/6/80 x
G = 9.42 °C/K
M = .009
r2 = .983
8.81 °C/K
.009
.995
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)

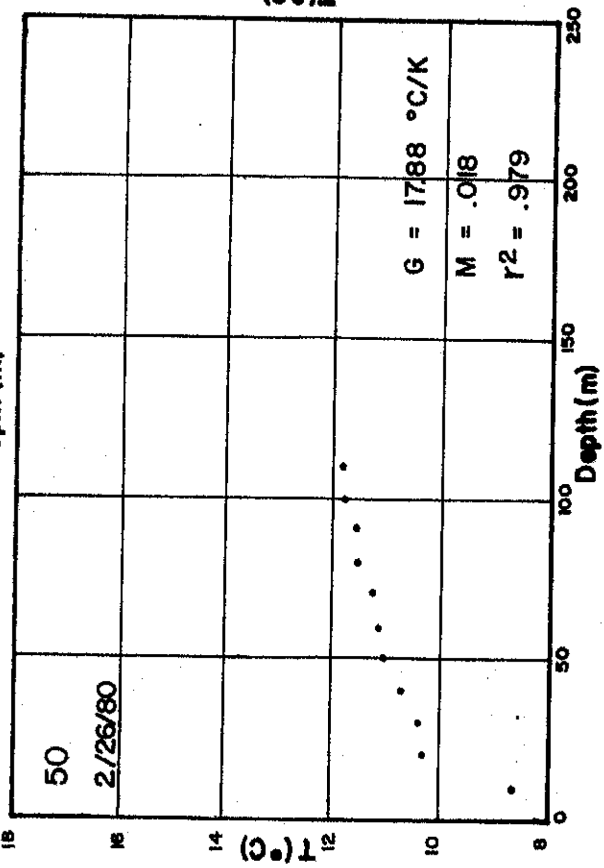

45
12/21/79
G = 9.51 °C/K
M = .010
r2 = .913
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)

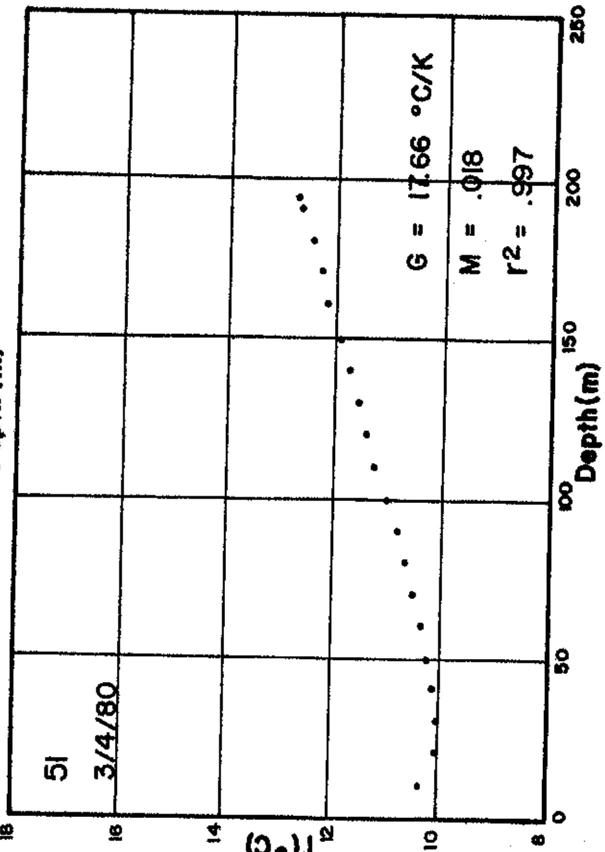

46
1/29/80
G = 17.62 °C/K
M = .018
r2 = .985
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)

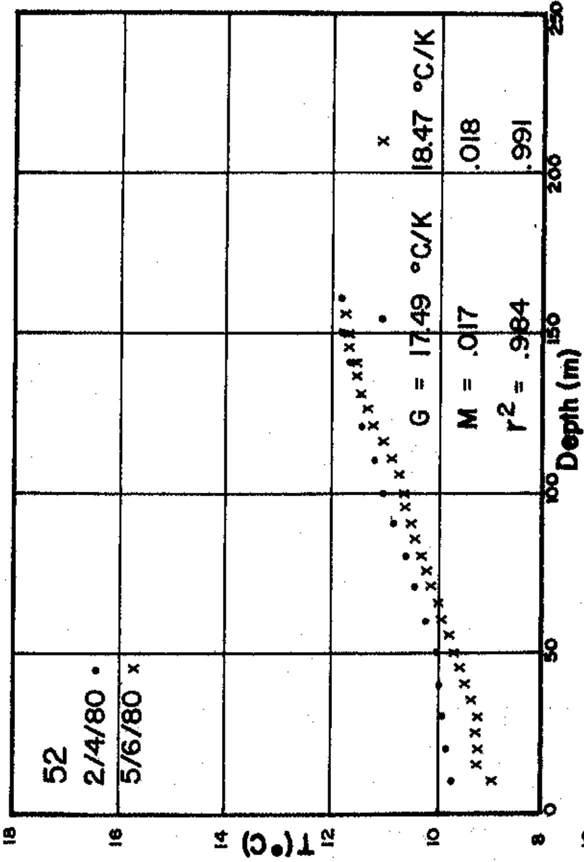

47
12/12/79
G = 12.70 °C/K
M = .013
r2 = .974
T(°C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)

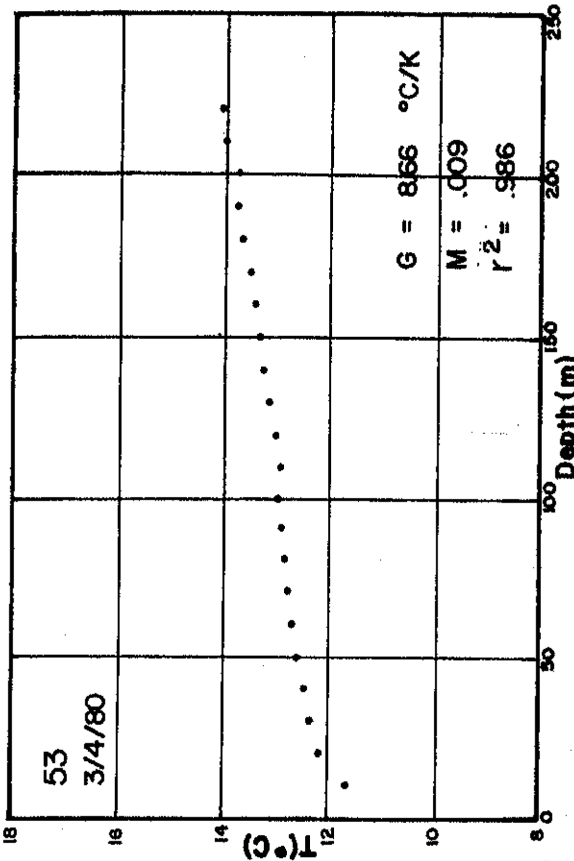

48
10/12/79
G = 8.70 °C/K
M = .009
r^2 = .980
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

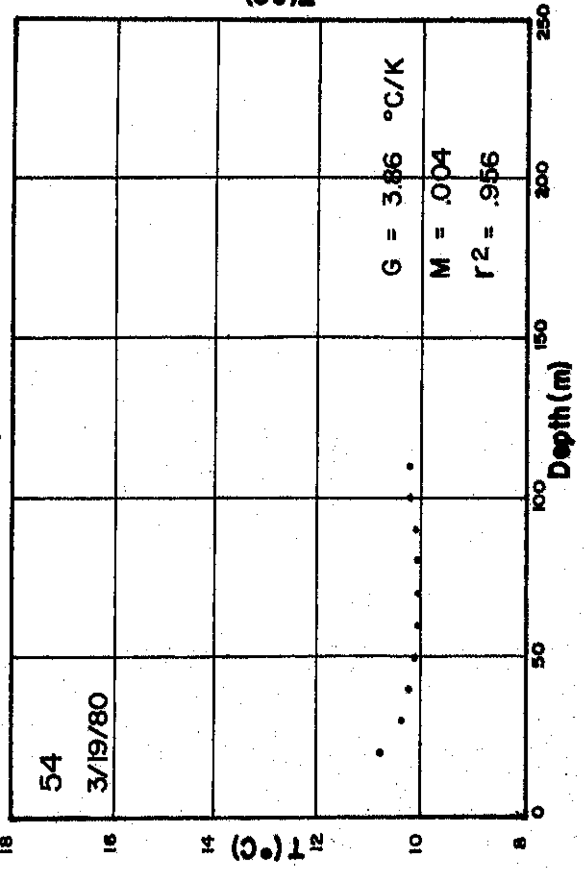

49
12/18/79
G = 8.45 °C/K
M = .008
r^2 = .960
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

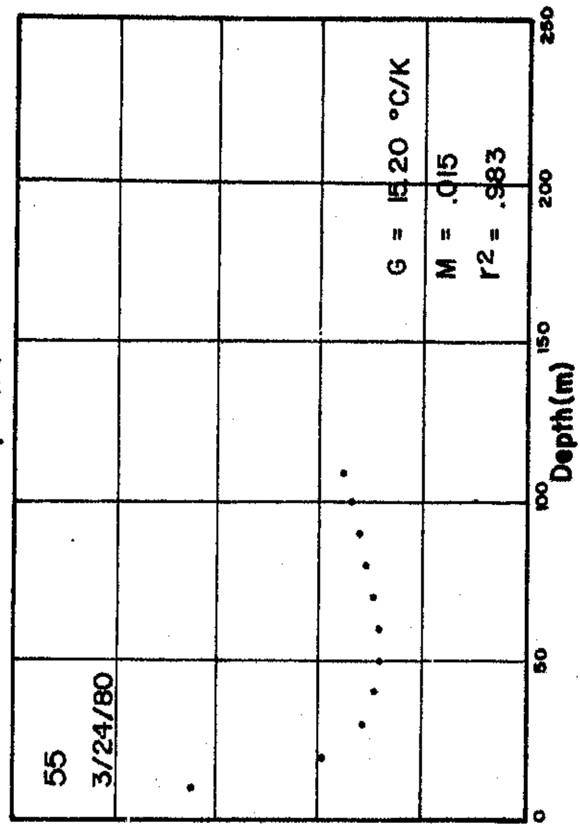

50
2/26/80
G = 17.88 °C/K
M = .018
r^2 = .979
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

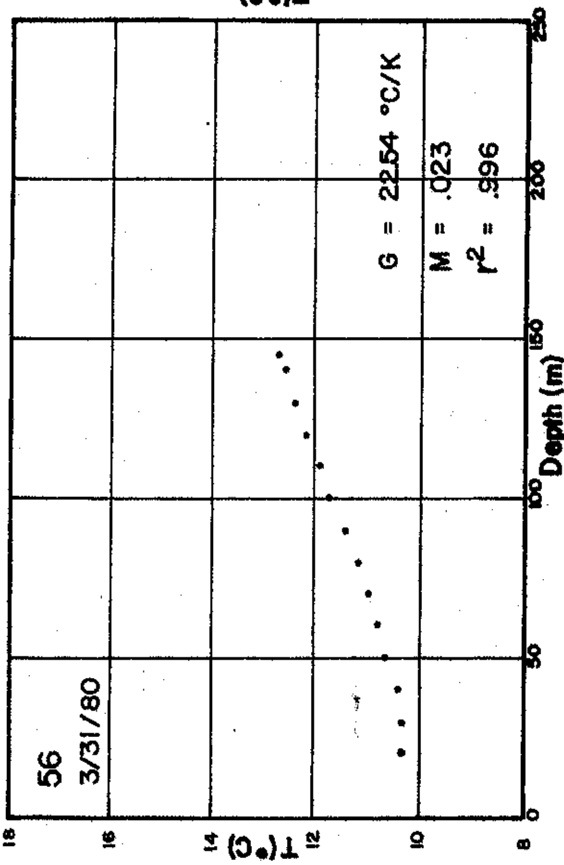

51
3/4/80
G = 17.66 °C/K
M = .018
r^2 = .997
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

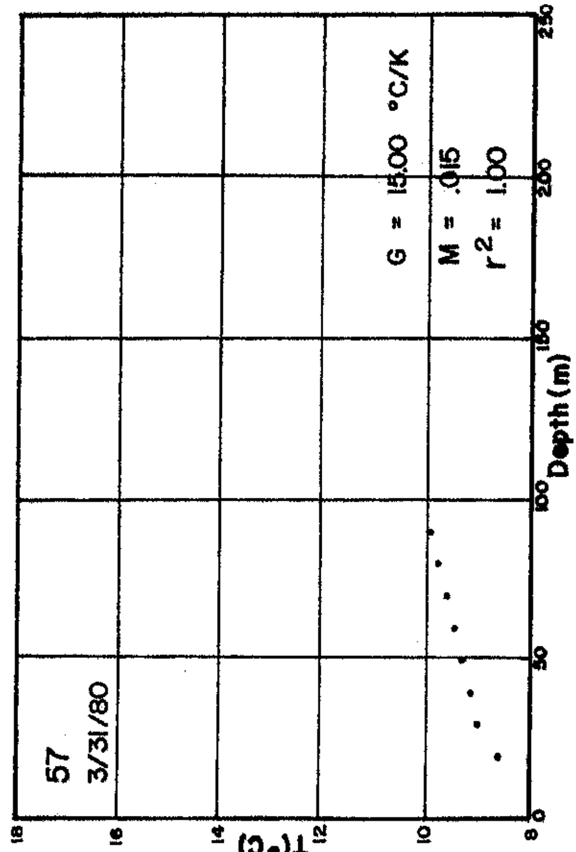

52
2/4/80 •
5/6/80 x
G = 17.49 °C/K
M = .017
r² = .984
x
18.47 °C/K
.018
.991
T(°C)
Depth (m)
8
10
12
14
16
18
0
50
100
150
200
250

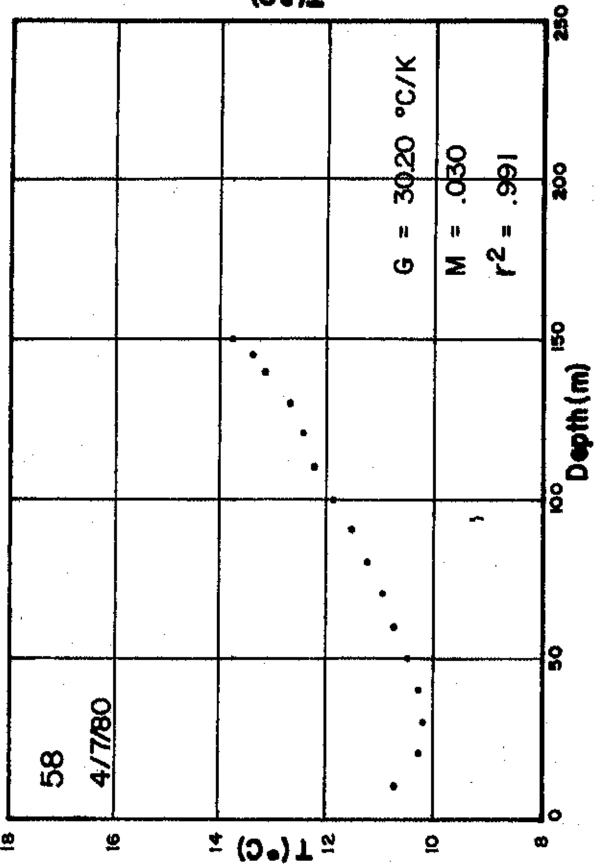

53
3/4/80
G = 8.66 °C/K
M = .009
r² = .986
T(°C)
Depth (m)
8
10
12
14
16
18
0
50
100
150
200
250

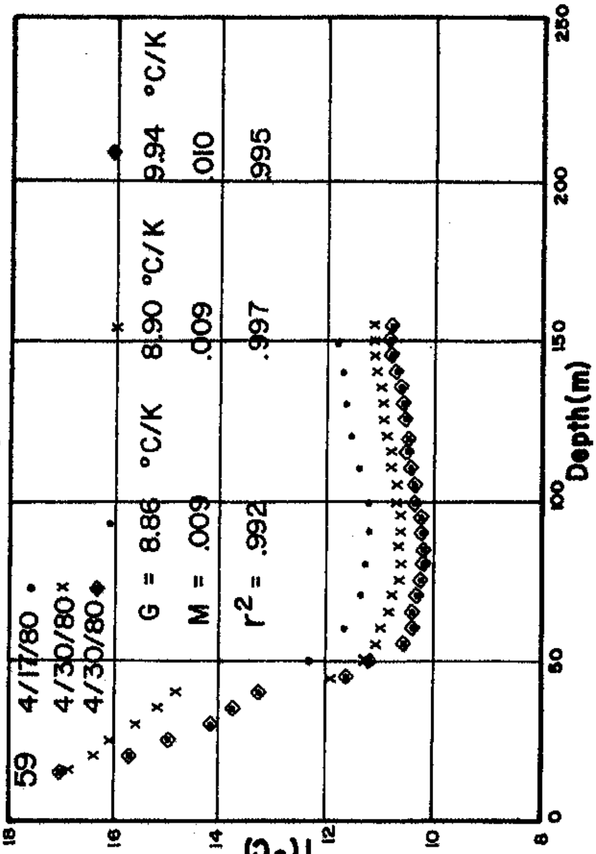

54
3/19/80
G = 3.86 °C/K
M = .004
r² = .956
T(°C)
Depth (m)
8
10
12
14
16
18
0
50
100
150
200
250

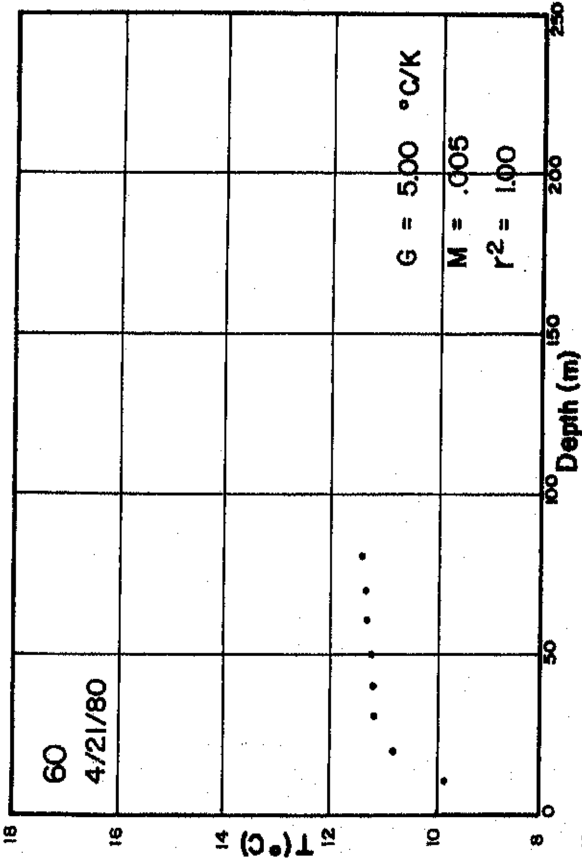

55
3/24/80
G = 15.20 °C/K
M = .015
r² = .983
T(°C)
Depth (m)
8
10
12
14
16
18
0
50
100
150
200
250

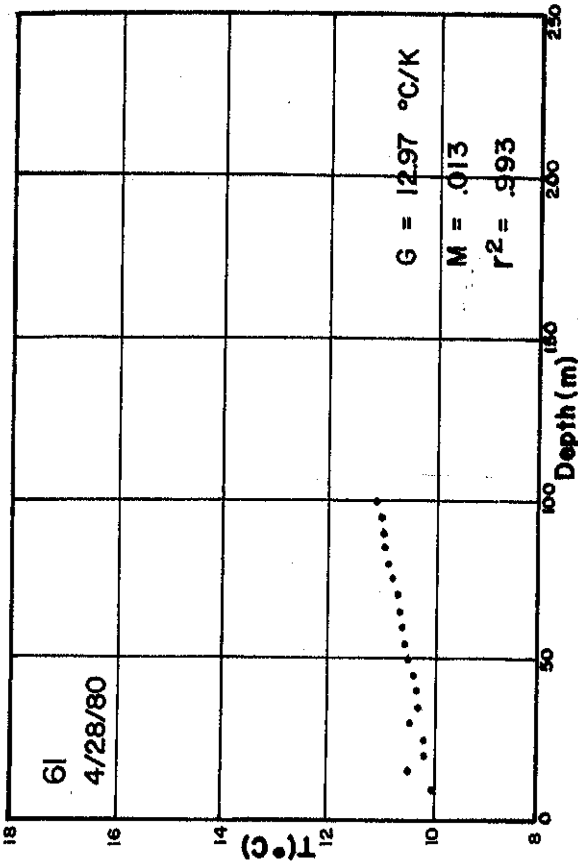

56
3/31/80
G = 22.54 °C/K
M = .023
r^2 = .996
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

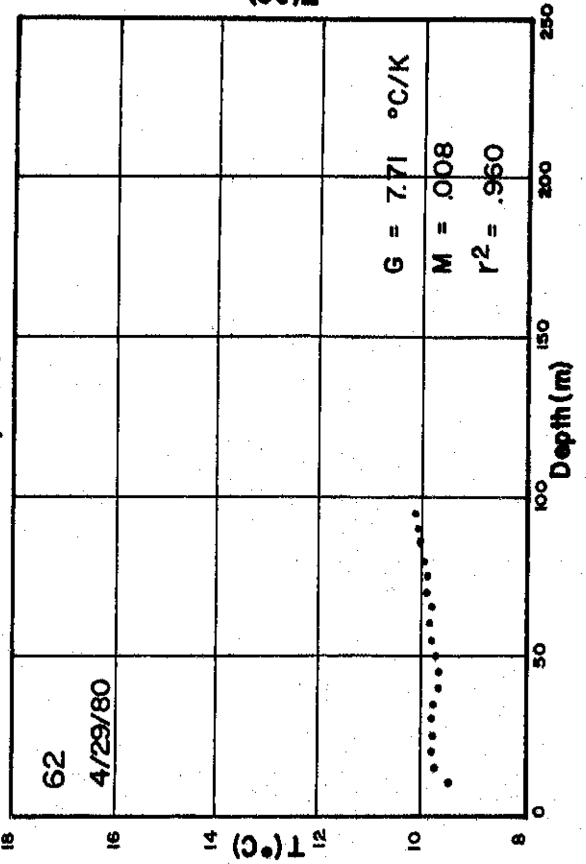

57
3/31/80
G = 15.00 °C/K
M = .015
r^2 = 1.00
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

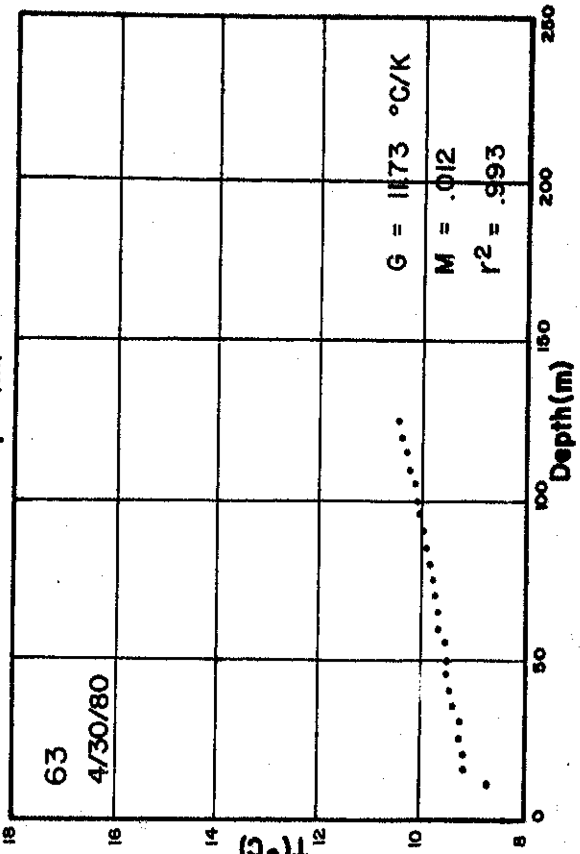

58
4/7/80
G = 30.20 °C/K
M = .030
r^2 = .991
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

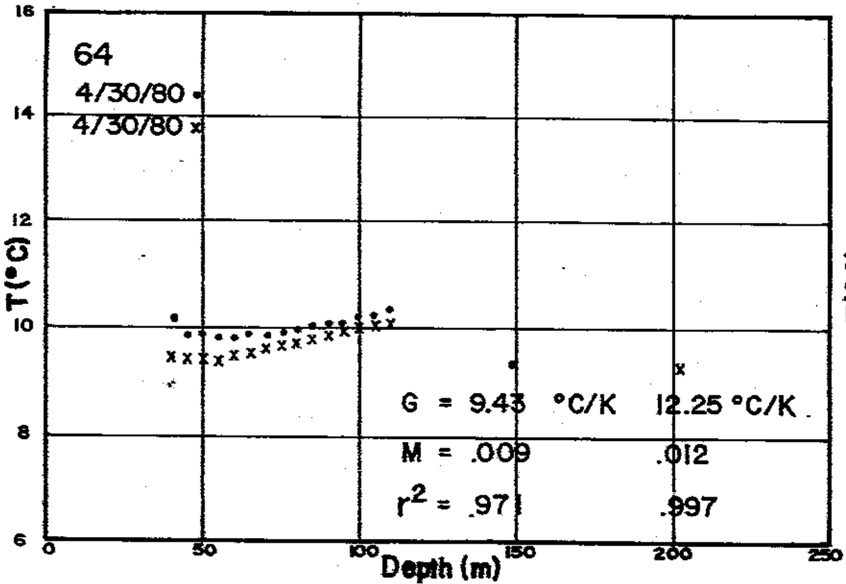

59
4/17/80 •
4/30/80 ×
4/30/80 ◈
G = 8.86 °C/K
M = .009
r^2 = .992
8.90 °C/K
.009
.997
9.94 °C/K
.010
.995
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

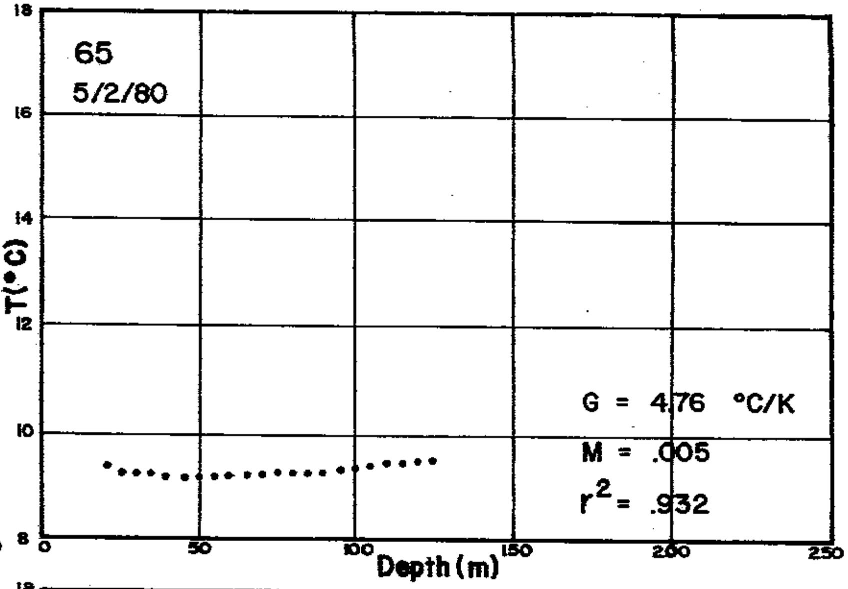

60
4/21/80
G = 5.00 °C/K
M = .005
r^2 = 1.00
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

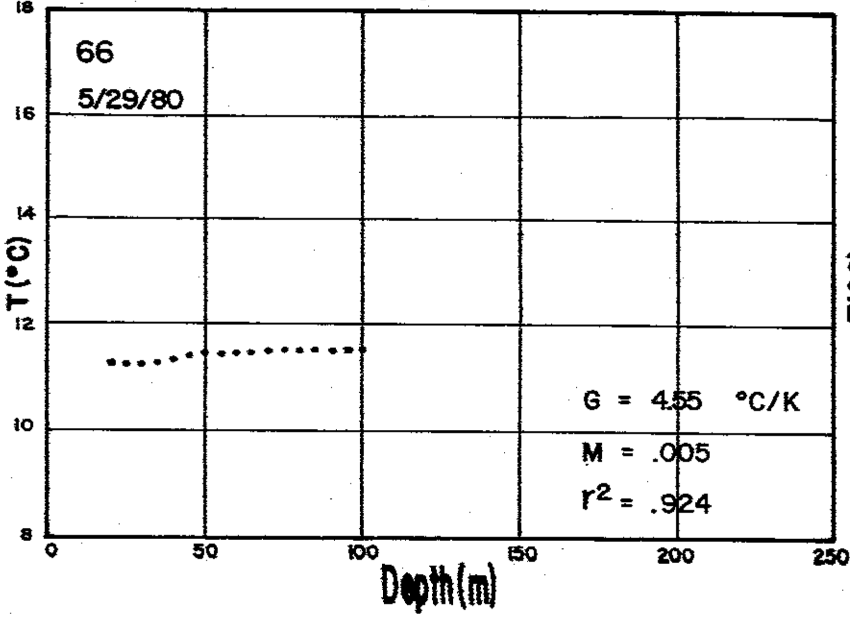

61
4/28/80
G = 12.97 °C/K
M = .013
r^2 = .993
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

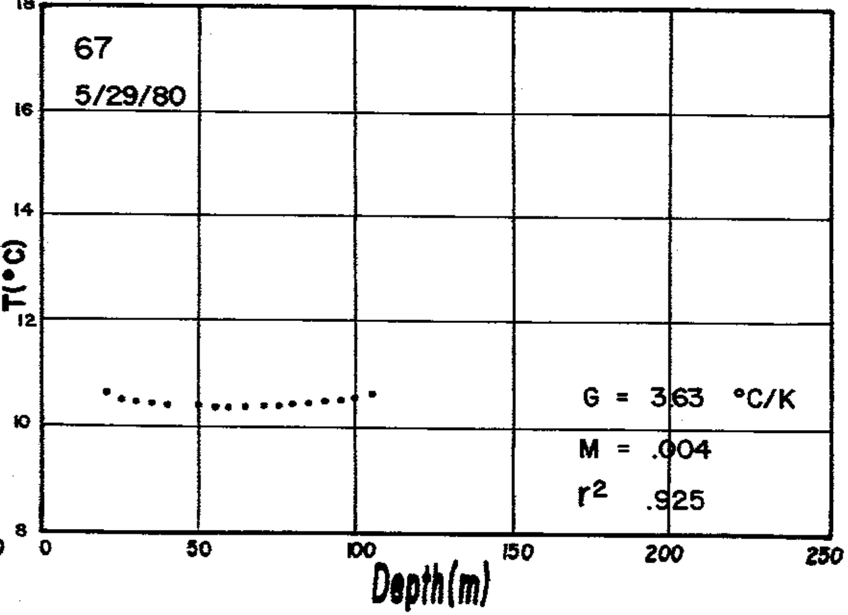

62
4/29/80
G = 7.71 °C/K
M = .008
r^2 = .960
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

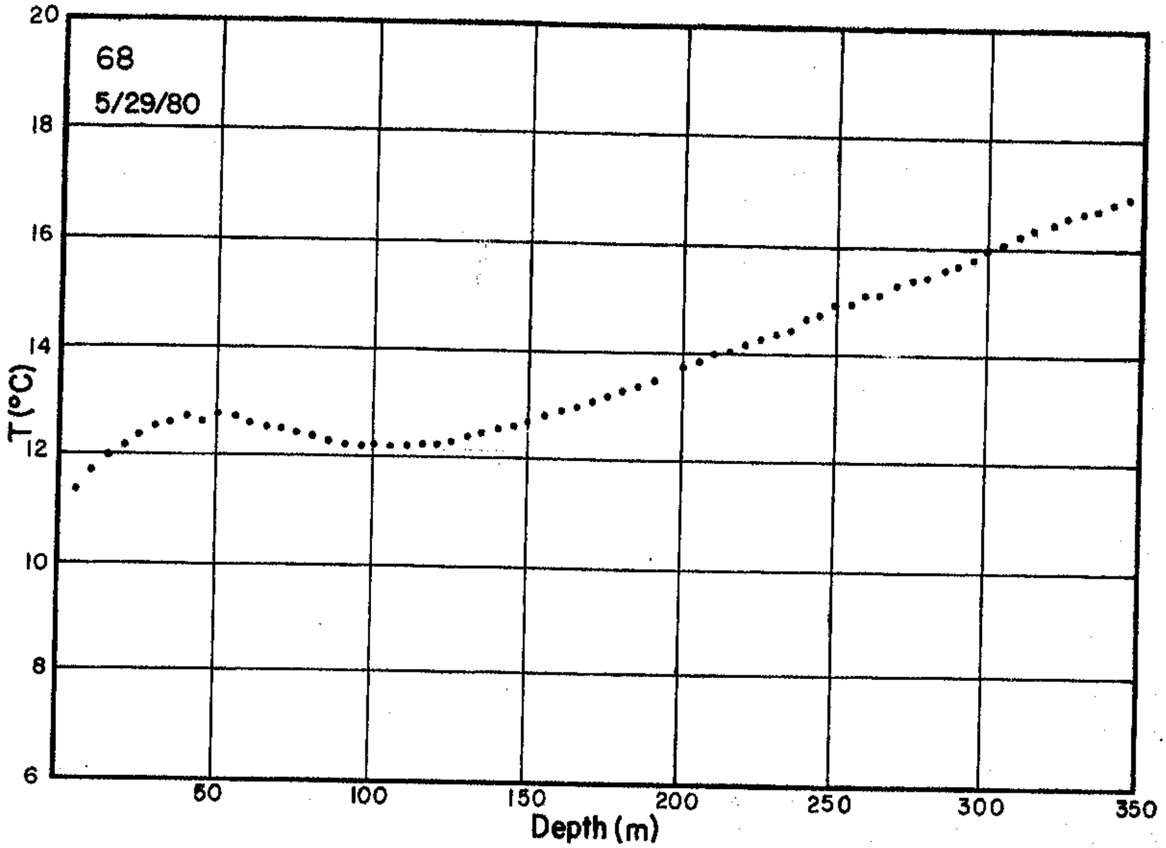

63
4/30/80
G = 11.73 °C/K
M = .012
r^2 = .993
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

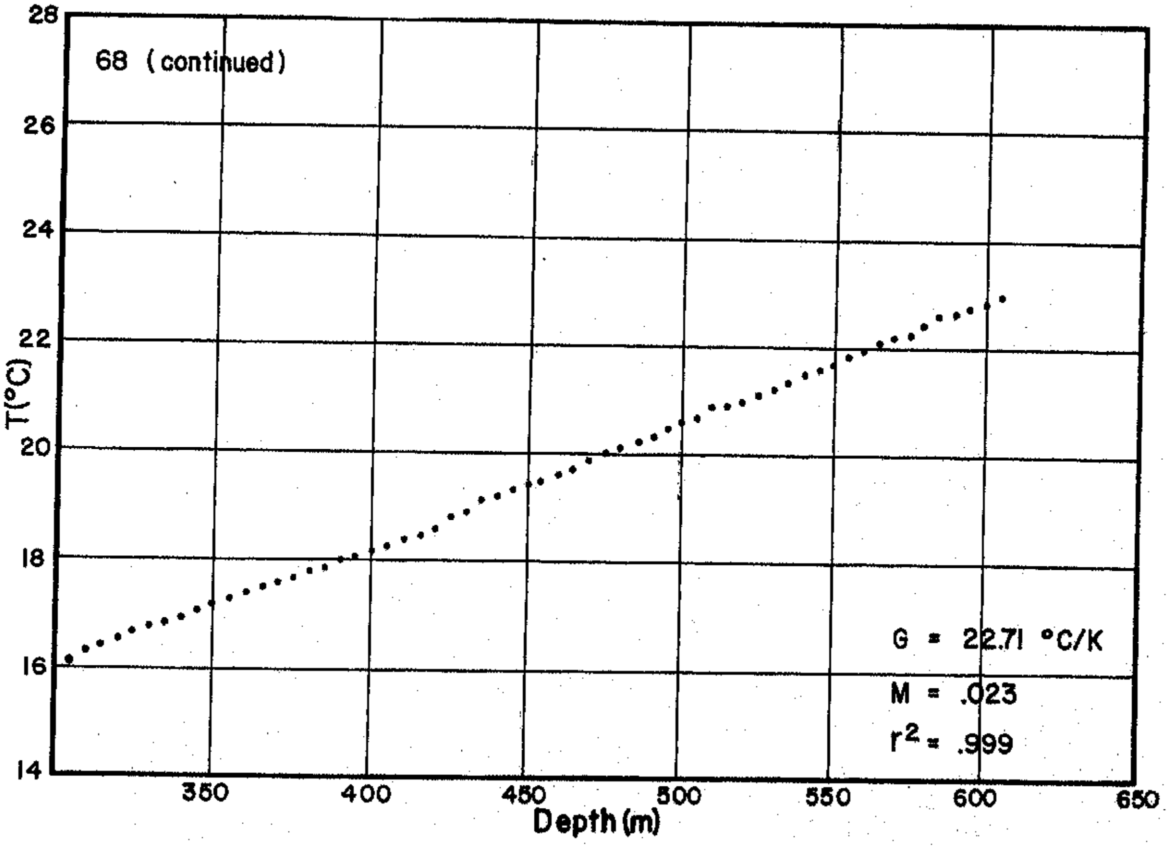

64
4/30/80 •
4/30/80 x
T(•C)
16
14
12
10
8
6
0
50
100
150
200
250
Depth (m)
G = 9.43 °C/K 12.25 °C/K
M = .009 .012
r^2 = .971 .997

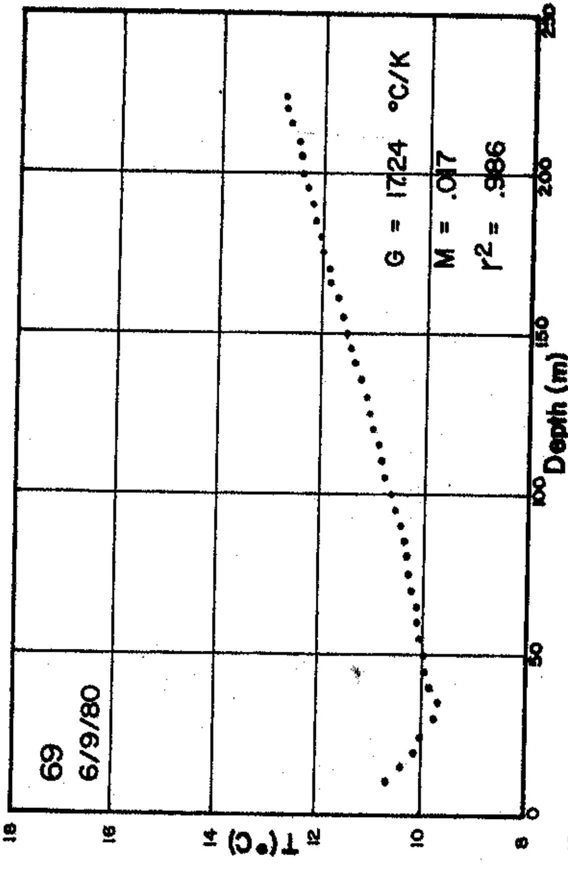

65
5/2/80
T(•C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth (m)
G = 4.76 °C/K
M = .005
r^2 = .932

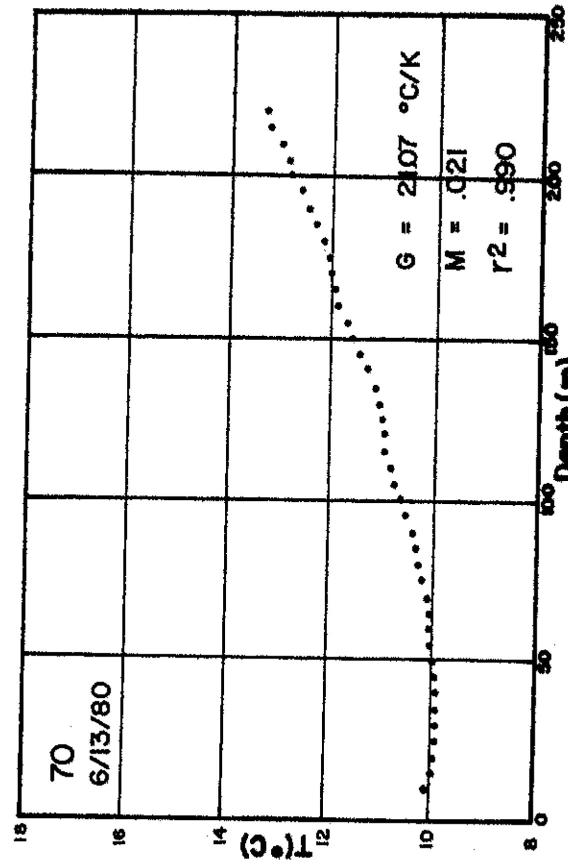

66
5/29/80
T(•C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth(m)
G = 4.55 °C/K
M = .005
r^2 = .924

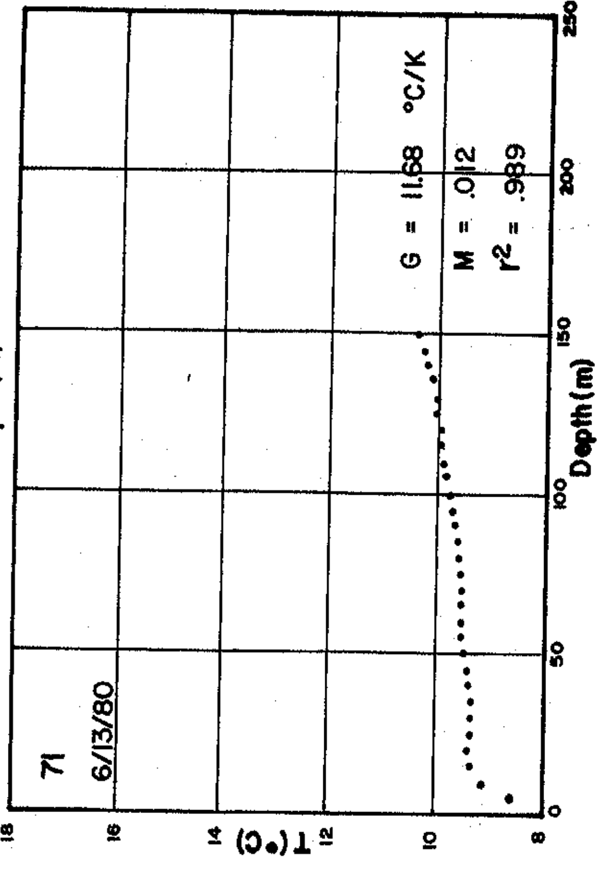

67
5/29/80
T(•C)
18
16
14
12
10
8
0
50
100
150
200
250
Depth(m)
G = 3.63 °C/K
M = .004
r^2 .925

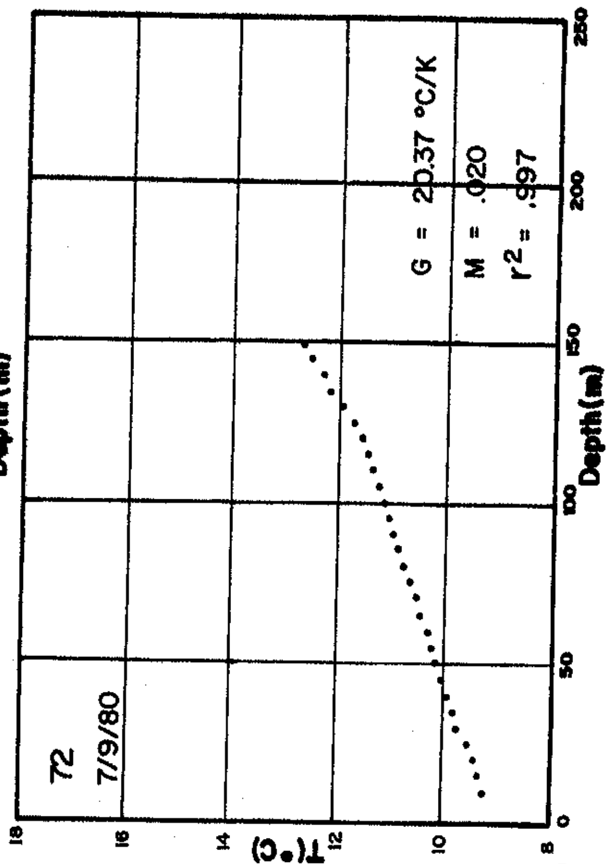

68
5/29/80
T(°C)
6
8
10
12
14
16
18
20
50
100
150
200
250
300
350
Depth (m)

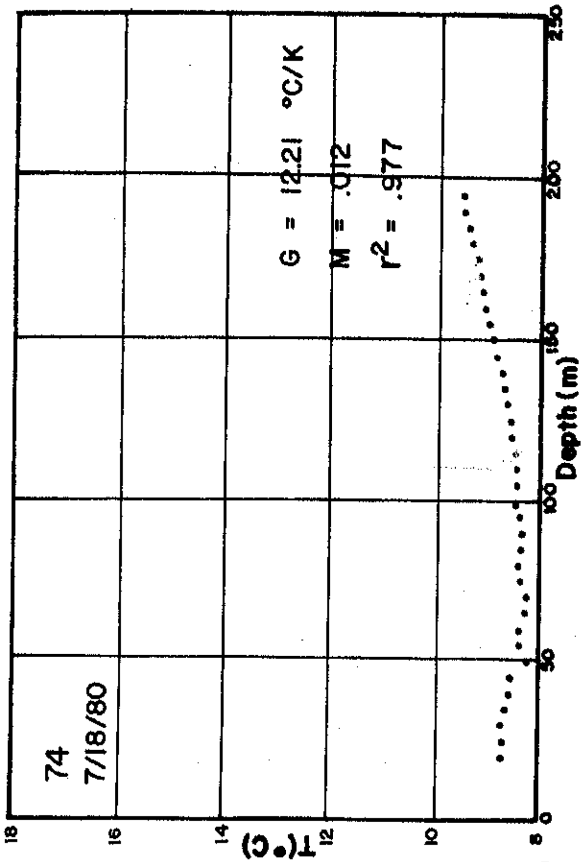

68 (continued)
T(°C)
14
16
18
20
22
24
26
28
350
400
450
500
550
600
650
Depth (m)
G = 22.71 °C/K
M = .023
r^2 = .999

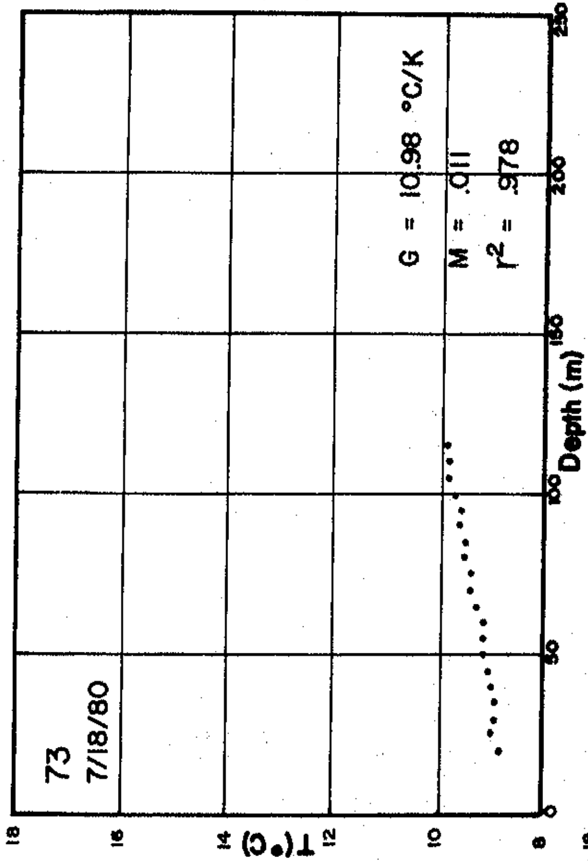

69
6/9/80
G = 17.24 °C/K
M = .017
r² = .986
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

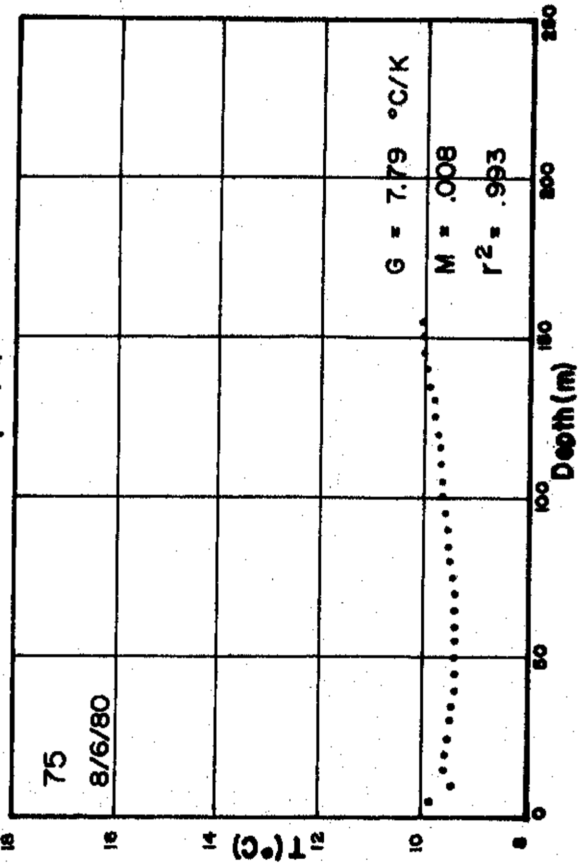

70
6/13/80
G = 21.07 °C/K
M = .021
r² = .990
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

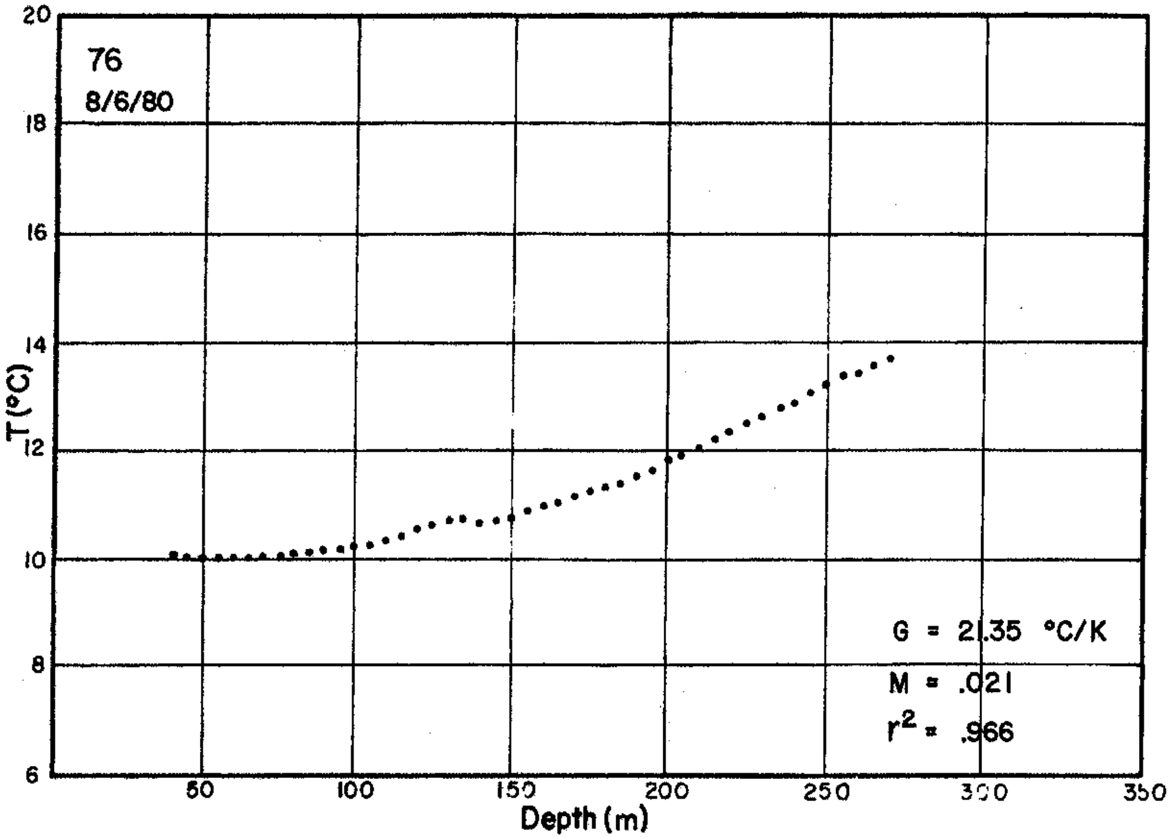

71
6/13/80
G = 11.68 °C/K
M = .012
r² = .989
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

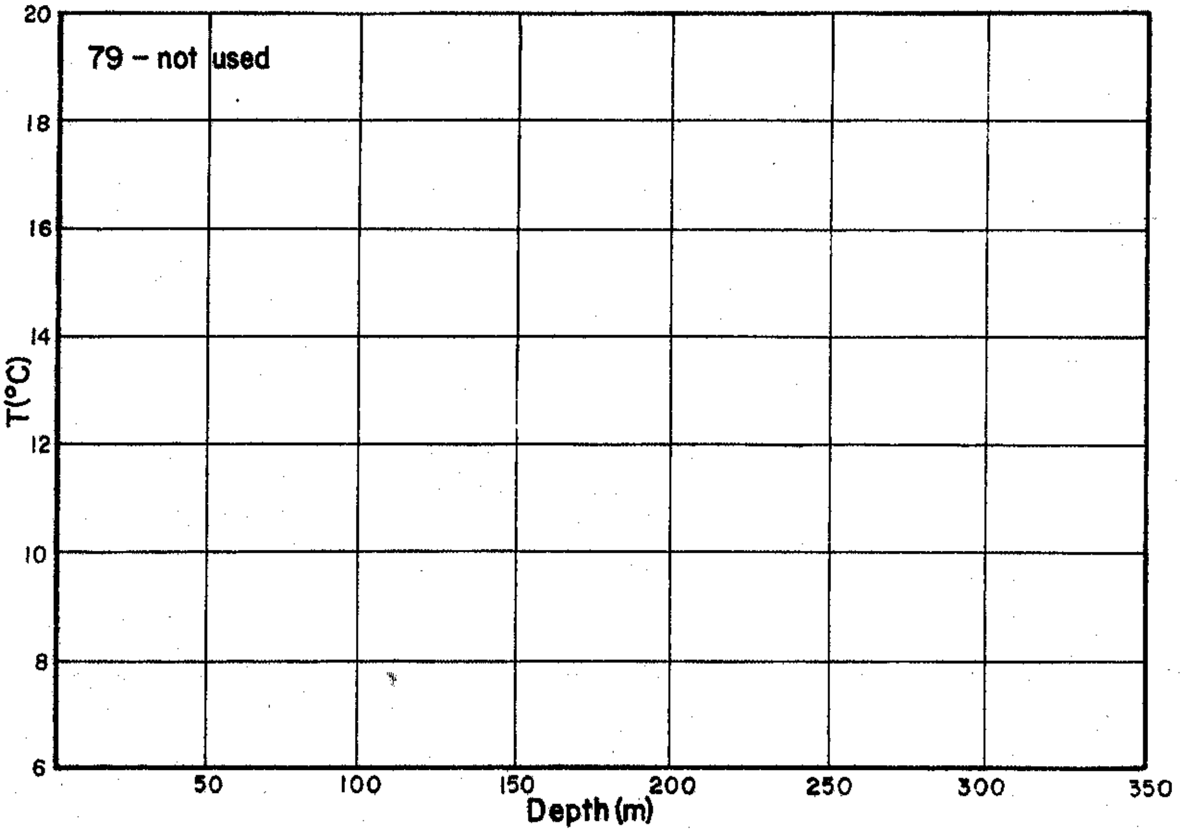

72
7/9/80
G = 20.37 °C/K
M = .020
r² = .997
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

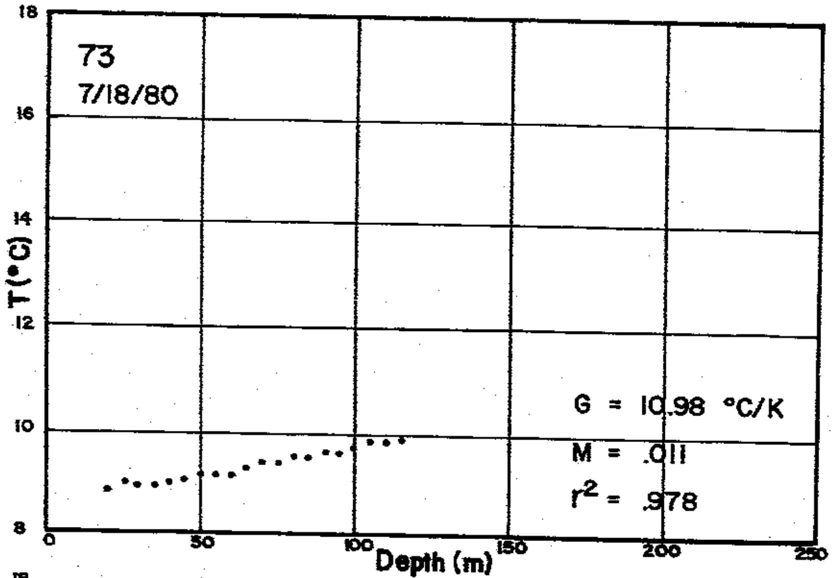

74
7/18/80
G = 12.21 °C/K
M = .012
r² = .977
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

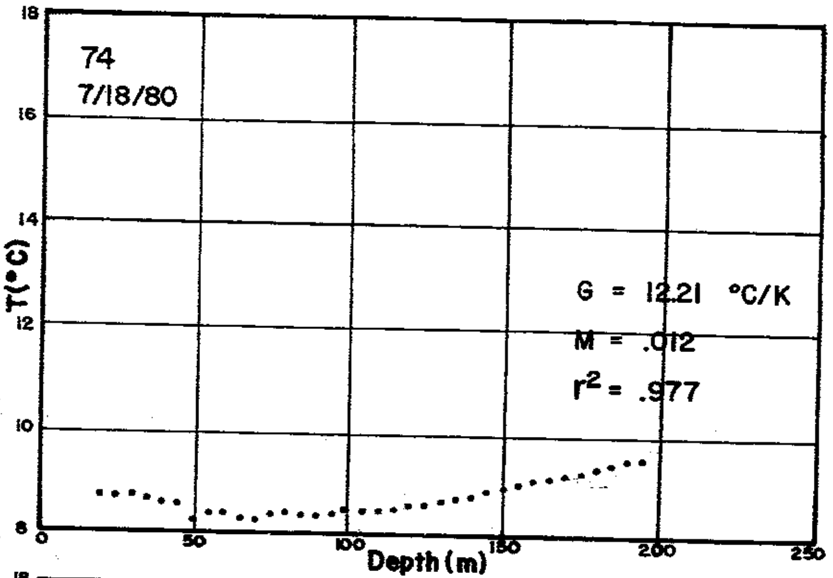

73
7/18/80
G = 10.98 °C/K
M = .011
r² = .978
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

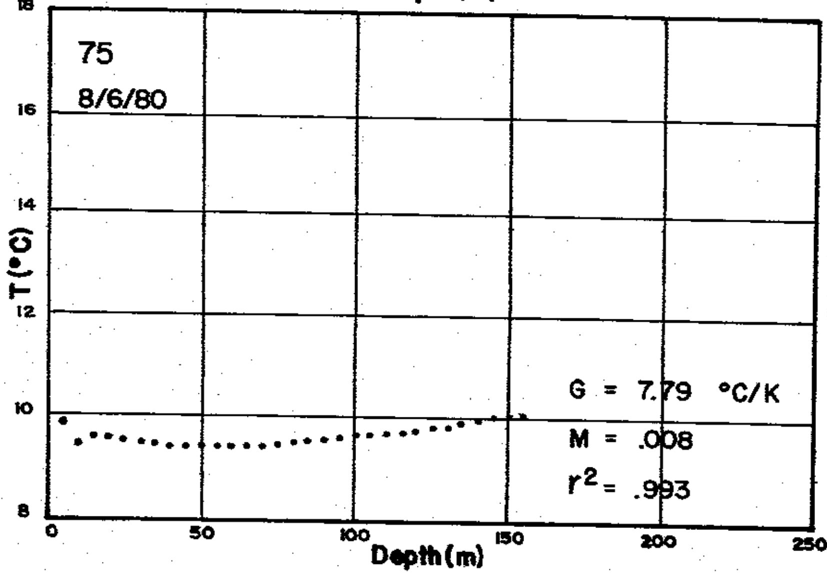

75
8/6/80
G = 7.79 °C/K
M = .008
r² = .993
T(°C)
8
10
12
14
16
18
Depth (m)
0
50
100
150
200
250

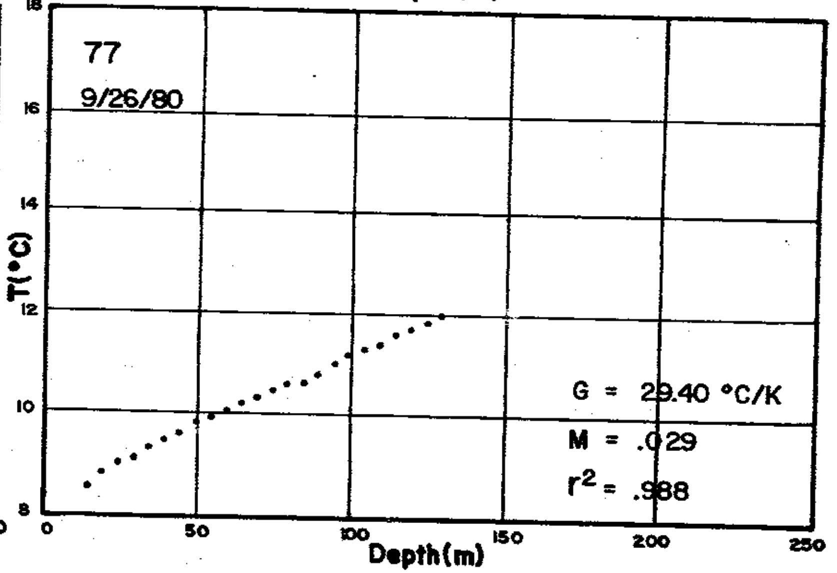

76
8/6/80
G = 21.35 °C/K
M = .021
r^2 = .966
T(°C)
6
8
10
12
14
16
18
20
Depth (m)
50
100
150
200
250
300
350

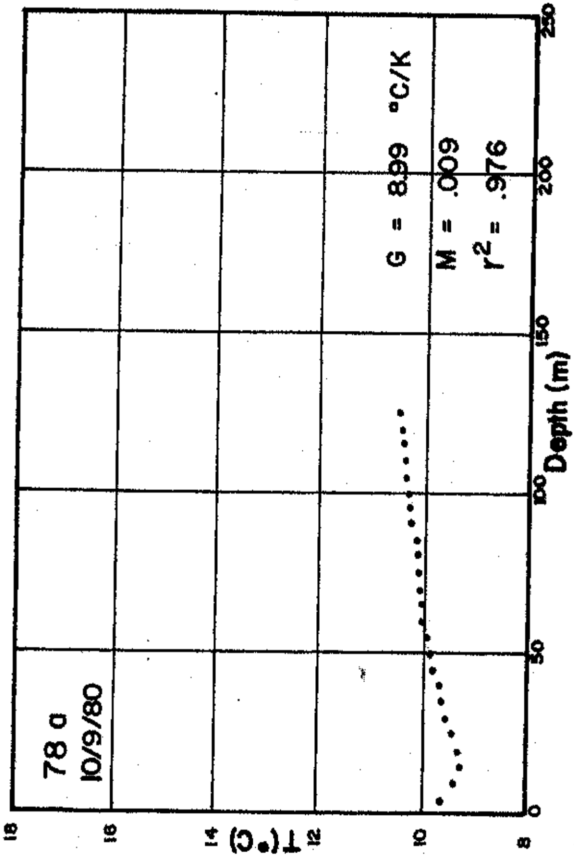

79 – not used
T(°C)
6
8
10
12
14
16
18
20
Depth (m)
50
100
150
200
250
300
350

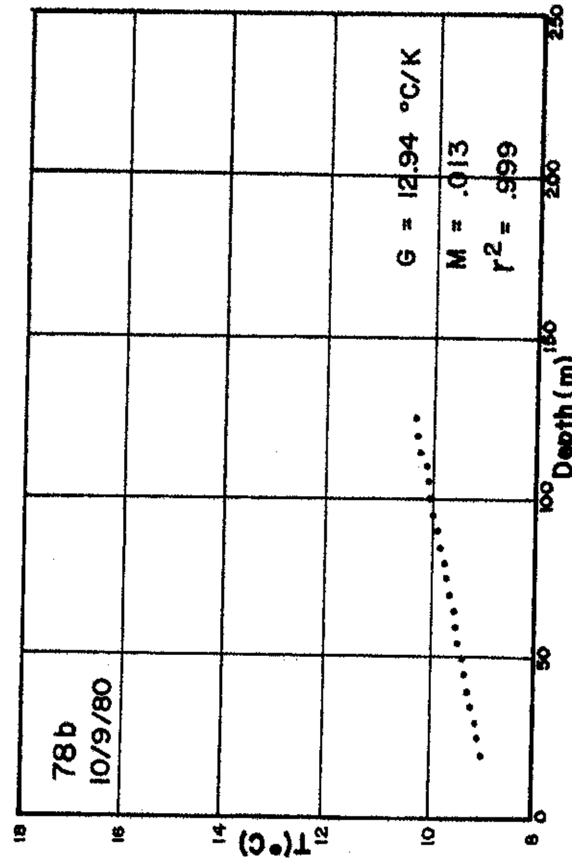

73
7/18/80
G = 10.98 °C/K
M = .011
r² = .978
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

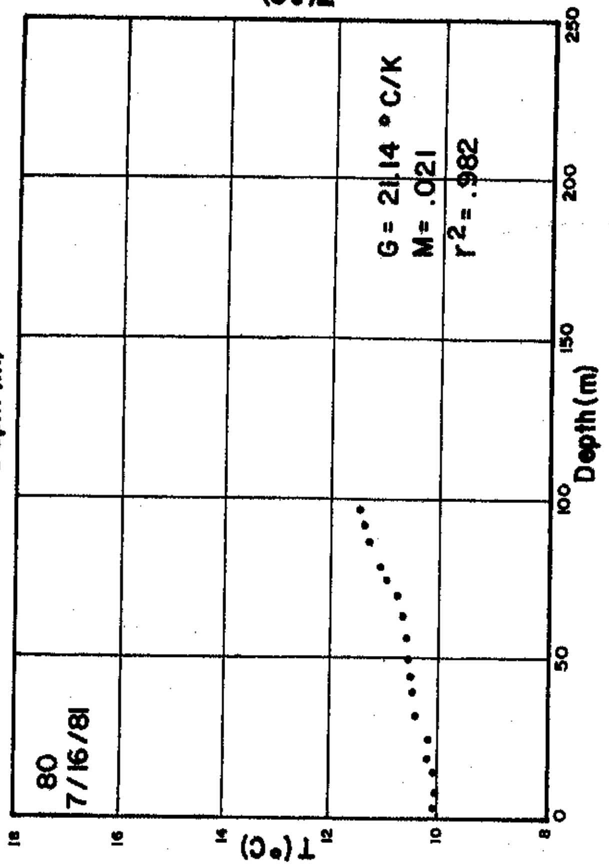

74
7/18/80
G = 12.21 °C/K
M = .012
r² = .977
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

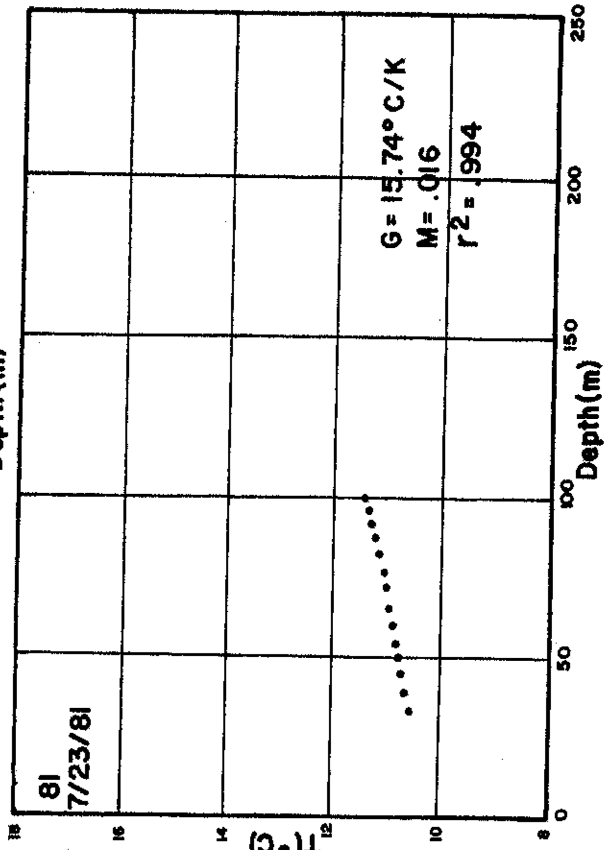

75
8/6/80
G = 7.79 °C/K
M = .008
r² = .993
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250


77
9/26/80
G = 29.40 °C/K
M = .029
r² = .988
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250


78 a
10/9/80
G = 8.99 °C/K
M = .009
r² = .976
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250


78 b
10/9/80
G = 12.94 °C/K
M = .013
r² = .999
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250


80
7/16/81
G = 21.14 °C/K
M = .021
r² = .982
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250


81
7/23/81
G = 15.74 °C/K
M = .016
r² = .994
T(°C)
18
16
14
12
10
8
Depth (m)
0
50
100
150
200
250

APPENDIX E

ABANDONED WELL TEMPERATURE GRADIENT DATA

INTRODUCTION

Temperature gradient data are compiled in tabular form from Phase II and Phase III data gathering surveys. Samples may be located by their latitude and longitude, or by United States Geological Survey 7-1/2- minute quadrangle maps. See Appendix B for quadrangle abbreviation listing. Alternatively sample numbers are posted on Figure 4-1 of the text with the corresponding cross location on the map. An explanatory legend is located at the end of the table. Additional explanatory material can be found in Section 4 of this report.

Some well samples in Appendix D are beyond the geographic limits of the computer database listed here in Appendix E (example - samples 1-4, 41, 62, 66-67, 70-71). Sample 39 and 48 could not be located precisely for the computer. Sample 79 was never used as a valid sample number. Locations are listed below:

TABLE E-1

DATA SPECIFICS FOR UNUSED ABANDONED TEMPERATURE GRADIENT WELLS

Well		Coordinates			
No.	Owner	Lagitude	Longitude	Quad	Location Notes
1	Herbert	43°35'40"	73°56'50"	Johnsburg	South Johnsburg Road 1.75 miles South of Johnsburg, New York
2	Fort Ann School	43°24'47"	73°29'19"	Ft. Ann	Fort Ann, New York
3	Smith Basin Dairy	43°21'30"	73°29'40"	Hartford	Site Destroyed
4	CIBA-GEIGY	43°19'00"	73°36'15"	Hudson Falls	Hudson Falls, New York
39	Nyewriter	Unavailable		Hancock	Saltbox Farm Road, Hancock, Massachusetts
41	Zucker Isgood	Unavailable		Hancock	Bailey Road, Hancock, Massachusetts
48	Kennedy	42°19'15"	73°27'35"	State Line	Austerlitz, New York
62	Hallsville Supply				
66	Sandy Hill Iron Works	43°17'04"	73°35'33"	Hudson Falls	Hudson Falls, New York
67	Hudson Falls Water Works	43°18'35"	73°35'10"	Hudson Falls	Hudson Falls, New York
70	Mosher	Unavailable		Schuylerville	Unavailable
71	Walker	43°24'13"	73°29'31"	Fort Ann	1 mile south on Route 4 Fort Ann, New York

#	Quad.	Lat.	Long.	D	QI	Grad.	R^2	Elev.	T°Surf	T°-100
5	GNSVT	43.1782	-73.7365	100.	0	10.00	.875	148.	9.660	11.14
6	SARSP	43.0739	-73.7729	92.	1	12.42	.994	124.	9.410	10.95
7	MDGRV	43.0198	-73.9812	140.	0	16.08	.997	212.	8.570	11.98
8	MDGRV	43.0297	-73.9903	160.	0	22.51	.991	205.	9.010	12.39
9	SARSP	43.0265	-73.7958	95.	0	15.65	.936	110.	9.150	10.88
10	QKSPR	43.0123	-73.6832	160.	0	19.21	.989	212.	8.720	11.90
11	RNDLK	42.9750	-73.8621	165.	1	25.02	.998	134.	8.890	12.23
12	SARSP	43.0103	-73.7970	90.	0	17.00	.957	135.	9.100	11.39
13	BRTHL	42.9353	-73.8768	85.	0	29.68	.996	160.	9.020	15.11
14	RNDLK	42.9351	-73.8482	120.	1	31.79	.999	127.	8.380	12.41
15	BRTHL	42.9116	-73.9524	104.	1	29.51	.996	153.	8.520	13.00
16	SCOKE	42.9058	-73.5896	105.	0	14.85	.973	150.	11.150	13.37
17	BRTHL	42.8856	-73.9789	80.	0	16.48	.992	206.	10.020	13.60
18	ROJUN	42.8545	-74.0021	90.	1	42.63	.990	111.	5.630	10.25
19	ROJUN	42.8472	-74.0185	125.	1	25.20	.998	108.	9.070	11.84
20	SCHEN	42.8231	-73.9280	300.	0	25.93	.995	111.	8.960	11.84
21	DUANE	42.7757	-74.2321	105.	0	10.55	.982	341.	8.960	12.56
22	NISKY	42.7809	-73.8331	178.	0	21.88	.998	91.	9.050	11.20
23	NPWNL	42.8051	-73.2664	220.	0	22.60	.950	189.	9.200	13.46
24	ALTAM	42.6331	-74.0028	120.	1	14.79	.996	306.	8.070	12.60
25	ALTAM	42.6935	-74.0435	130.	1	20.04	.998	282.	8.620	14.22
26	CLKSV	42.6099	-73.9586	90.	0	15.79	.971	156.	9.270	11.73
27	CLKSV	42.6068	-73.9583	135.	1	18.56	.989	165.	8.600	11.97
28	EGRNB	42.6095	-73.7345	95.	1	13.07	.975	144.	9.310	11.19
29	EGRNB	42.6134	-73.7365	160.	0	19.15	.983	123.	8.880	11.25
30	TROYS	42.6924	-73.6776	155.	0	13.18	.868	131.	9.750	11.48
31	AVPRK	42.7109	-73.5500	167.	0	18.68	.998	218.	8.620	12.69
32	NPWNL	42.7681	-73.3624	95.	0	9.49	.993	397.	9.330	13.09
33	HANCK	42.5541	-73.3721	80.	0	12.40	.998	360.	8.780	13.24
34	HANCK	42.5483	-73.3689	145.	0	14.72	.992	296.	8.080	12.44
35	STEPH	42.5295	-73.4097	185.	0	21.60	.990	296.	7.580	13.97
36	HANCK	42.5239	-73.3733	160.	0	24.68	.997	334.	8.530	16.75
37	BERLN	42.6272	-73.2810	130.	0	18.36	.988	351.	7.760	14.19
38	HANCK	42.5791	-73.3015	140.	0	14.82	.986	448.	8.270	14.91
40	HANCK	42.5627	-73.2855	155.	0	17.03	.958	424.	8.110	15.33
42	HANCK	42.5037	-73.2770	160.	0	7.01	.988	392.	7.870	10.62
43	STEPH	42.5058	-73.3855	80.	0	10.83	.896	331.	9.270	12.85
44	NASSA	42.5863	-73.5070	120.	1	8.81	.995	202.	9.410	11.18
45	NASSA	42.5000	-73.6186	100.	0	9.51	.913	148.	9.250	10.66
46	DELMR	42.5168	-73.7509	90.	0	17.62	.985	79.	10.900	12.29
47	CHATM	42.3107	-73.5600	130.	0	12.70	.974	369.	8.690	13.37
49	CANAA	42.3905	-73.3960	185.	0	8.45	.960	436.	7.610	11.29
50	EGRNB	42.5271	-73.6519	110.	0	17.88	.979	178.	9.990	13.18
51	CHATM	42.3251	-73.5422	192.	0	17.66	.997	256.	9.280	13.80
52	CHATM	42.3322	-73.5679	160.	1	18.47	.991	262.	9.210	13.79
53	CHATM	42.3124	-73.5108	220.	0	8.66	.986	399.	9.120	12.58
54	NPWNL	42.8746	-73.2755	105.	0	3.86	.956	280.	9.750	10.83
55	EGRNB	42.5831	-73.6996	109.	0	15.20	.983	138.	9.870	11.96

#	Quad.	Lat.	Long.	D	QI	Grad.	R^2	Elev.	T°Surf	T°-100
56	ALTAM	42.7315	-74.0275	145.	0	22.54	.996	213.	9.420	14.23
57	GLUPV	42.6909	-74.1744	90.	0	15.00	.999	414.	8.550	14.76
58	ROJUN	42.8453	-74.0150	142.	1	28.69	.995	117.	8.400	11.57
60	HLSDL	42.1769	-73.5278	80.	1	5.00	.999	238.	11.000	12.19
61	CLKSV	42.6006	-73.9557	100.	1	12.97	.993	157.	9.820	11.86
63	ALTAM	42.7103	-74.1019	125.	1	11.73	.993	332.	8.870	12.77
64	ALTAM	42.7155	-74.0990	110.	1	12.25	.997	331.	9.220	12.34
65	WSTRL	42.5415	-74.1215	125.	1	4.56	.932	460.	8.850	11.04
68	MECHV	42.9123	-73.6824	605.	1	22.71	.999	59.	9.220	10.57
69	GNSVT	43.1769	-73.7115	220.	1	16.78	.992	118.	9.070	11.00
72	RNDLK	42.9537	-73.7894	150.	1	20.37	.997	130.	9.170	11.81
73	BERLN	42.6343	-73.3504	115.	1	10.98	.978	399.	8.600	12.98
75	BERLN	42.7069	-73.3261	155.	1	7.79	.993	375.	8.760	11.68
76	DUANE	42.7881	-74.2395	270.	1	20.95	.968	297.	7.440	14.32
77	ALTAM	42.6993	-74.0335	130.	1	29.40	.988	177.	8.240	13.44
78	GRNVL	42.4213	-74.0414	125.	1	12.94	.999	259.	9.350	11.68
80	RNDLK	42.9646	-73.8632	95.	1	21.14	.982	154.	9.520	12.77
81	TROYN	42.8489	-73.6371	100.	1	15.74	.994	148.	0.0	0.0
82	SARSP	43.0724	-73.8532	154.	1	7.32	.984	148.	8.930	10.01
83	MYERS	42.8530	-73.9810	121.	1	23.12	.996	113.	9.115	11.72
84	PIOTR	42.8300	-73.9540	122.	1	36.60	.997	107.	6.820	10.75
85	FGRVE	42.9080	-73.8790	121.	1	31.65	.999	120.	8.683	12.49
86	TIVOL	42.6710	-73.7600	122.	1	19.30	.978	76.	9.438	10.76
87	WSTLF	42.7860	-73.9110	155.	1	20.68	.994	133.	9.094	11.84
88	RINPK	42.7880	-73.9820	139.	1	18.83	.989	133.	9.470	11.97
89	GSASN	42.8370	-73.9880	142.	1	29.13	.996	119.	0.0	0.0
90	CLARK	42.8930	-74.0180	146.	1	21.34	.996	111.	9.381	11.76
91	SSWTS	42.8060	-73.9510	138.	1	20.88	.994	102.	9.401	11.53

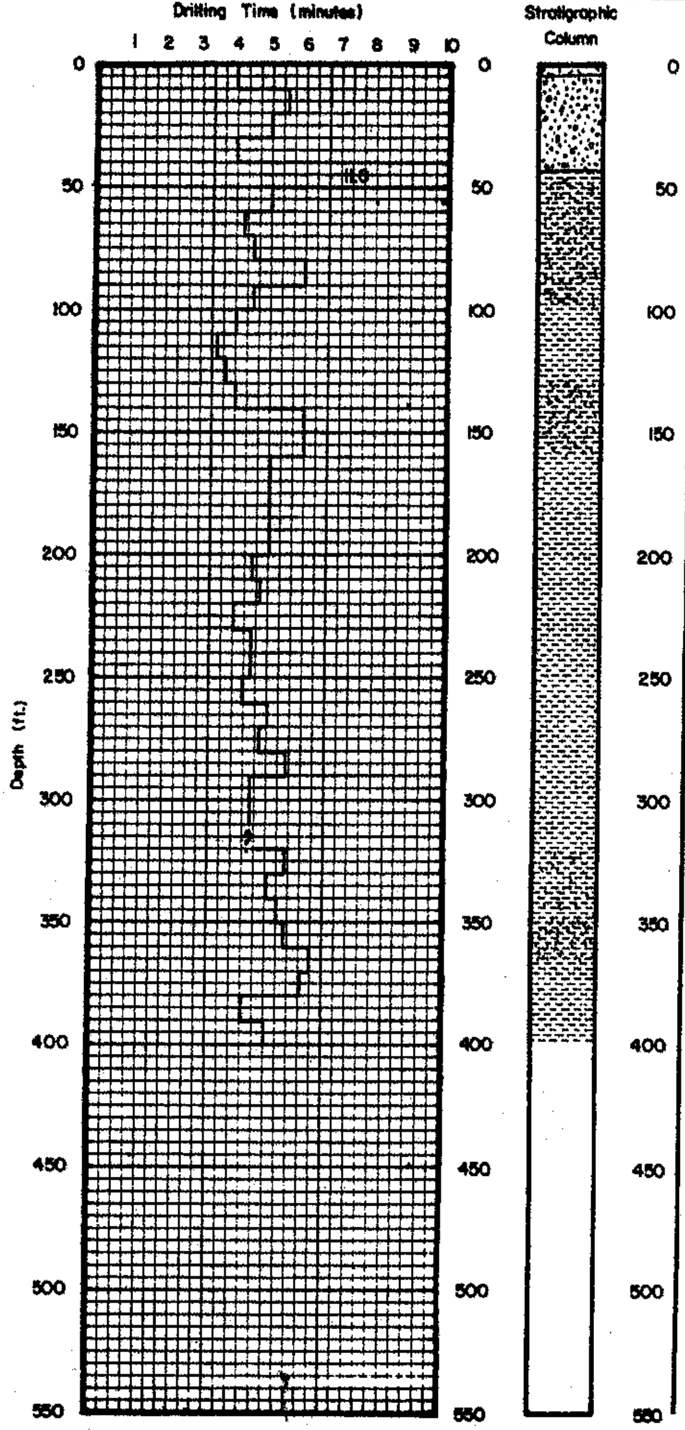
# = Sample No.
Quad. = Topographic Quadrangle
Lat. = Latitude
Long. = Longitude
D = Depth (metersO
QI = Gradient quality indicator
1=good; 0=suspect

Grad. = Gradient °c/km
R^2 = Coef. of determination
Elev. = Location elevation (feet)
T°Surf = Calculated or meas. surface temperature in °C
T°-100 = Calculated water temperature at 100 feet below sea level

APPENDIX F

SHALLOW WELL LOGS

GEOTHERMAL DRILLING PROGRAM
HOLE *DH-1*
LOCATION *MYERS FARM*
DATE DRILLED *10/30/81*



Description

Soil, gray w/ silt
6' - gravel, sand & silt

35' - Boulder
41' - Begin black shales, fine grained to gray, silty shale and graywacke, medium light gray, medium grained, w/ medium dark shale, fine laminae
Graywacke & shale
A/A* w/ minor silty shale

Shale, some graywacke w/ silty shale
silty shale, little graywacke & black shale

Silty shale w/ graywacke & black shale

Water 1 gpm
Predominantly black shale w/ silty shale

A/A* with rare gray weathered shale

Black shale with some reddish staining
Black shale
A/A* w/ some reddish staining

Black shale
Water show - minor flow

Dark gray and black shale, more silty

Dark gray and black shale, less silty

A/A*, but more silty w/ rare graywacke

A/A*, but w/ more graywacke

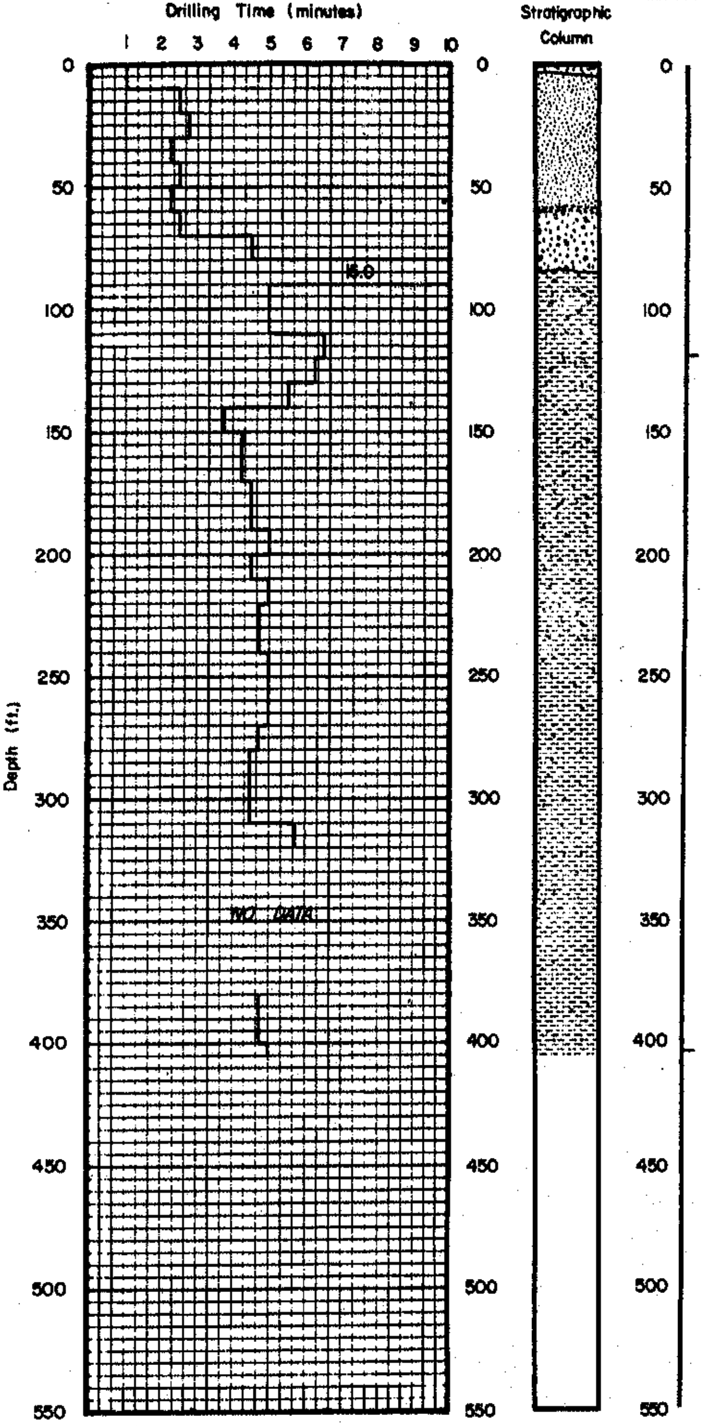
Silty shale, graywacke & black shale

A/A*, but less silt and graywacke, some red staining
Predominantly black, fine grained to slightly silty shale

Final Depth 405'
Est. 3/4 gpm water flow

*as above

GEOTHERMAL DRILLING PROGRAM
HOLE DH-2
LOCATION PIOTROWSKI FARM
DATE DRILLED 11/2/81



Description

Sand, brown soil, overburden
Gravel, quartz, sandstone, metamorphic fragments, some shale

40' - water-bearing SAND & GRAVEL

clay (59-63')
Till, gravel, sand, some clay
Graywacke, mixed shale & silty shale interbeds, dark gray to black, fine grained to silty or fine sand
Water at 95'
A/A*, shale content less
Water at 120'
A/A*, little black, fine grained shale
A/A*, slightly darker shale with interbedded graywacke (138')

A/A*, with some light gray weathered shale

A/A*, no light gray shale

A/A*, somewhat silty

Graywacke on shale, thinly bedded

Shale, minor graywacke beds, less silty, shale & graywacke, somewhat darker gray

Shale, minor graywacke
A/A*, with increased siltiness & some graywacke, slightly lighter gray color
A/A*, intermixed dark gray shale & lighter gray silty shale & graywacke

A/A*, somewhat less graywacke

A/A*, significant silty shale

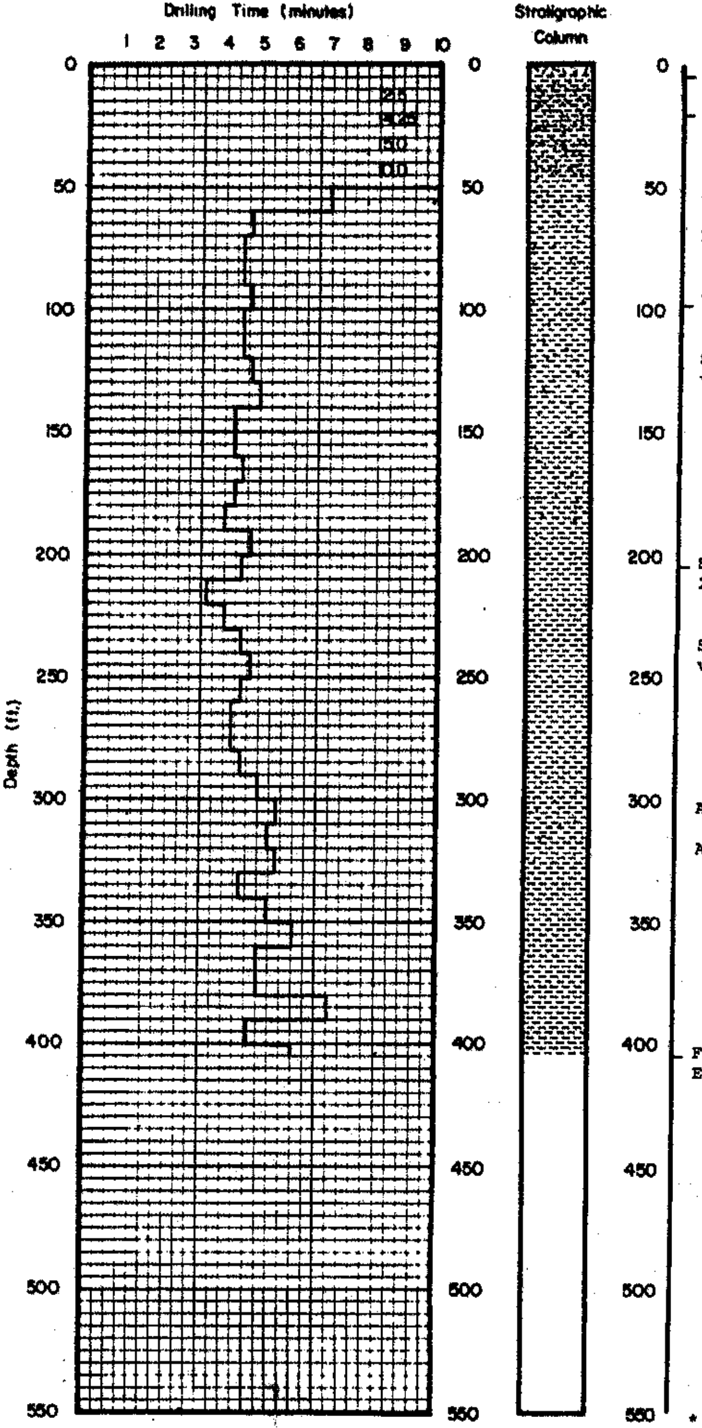
A/A*, more silty shale

Final depth 405'
Est. water flow 4 gpm

* as above

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-3
LOCATION FIREMAN'S GROVE
DATE DRILLED 11/3/81



Description

0 – 5' - Shale, dark gray to black with weathered red silty shale changing to gray siltstone and graywacke.
20'- Water show, probably perched.

50 – Graywacke with shale

Dark silty shale
silt content decreasing

98-99' thin weathered zone

100 – Shale, dark gray with minor silt content; very fine laminae

150

200 – Shale, darker with no silt content
210' - water show < 2 gpm

Shale, dark gray and black, very fine laminae, no silt

250

300 – A/A*, minor graywacke content

A/A*, no graywacke

350

400 – Final depth - 405'
Est. water flow 3/4 - 1 gpm

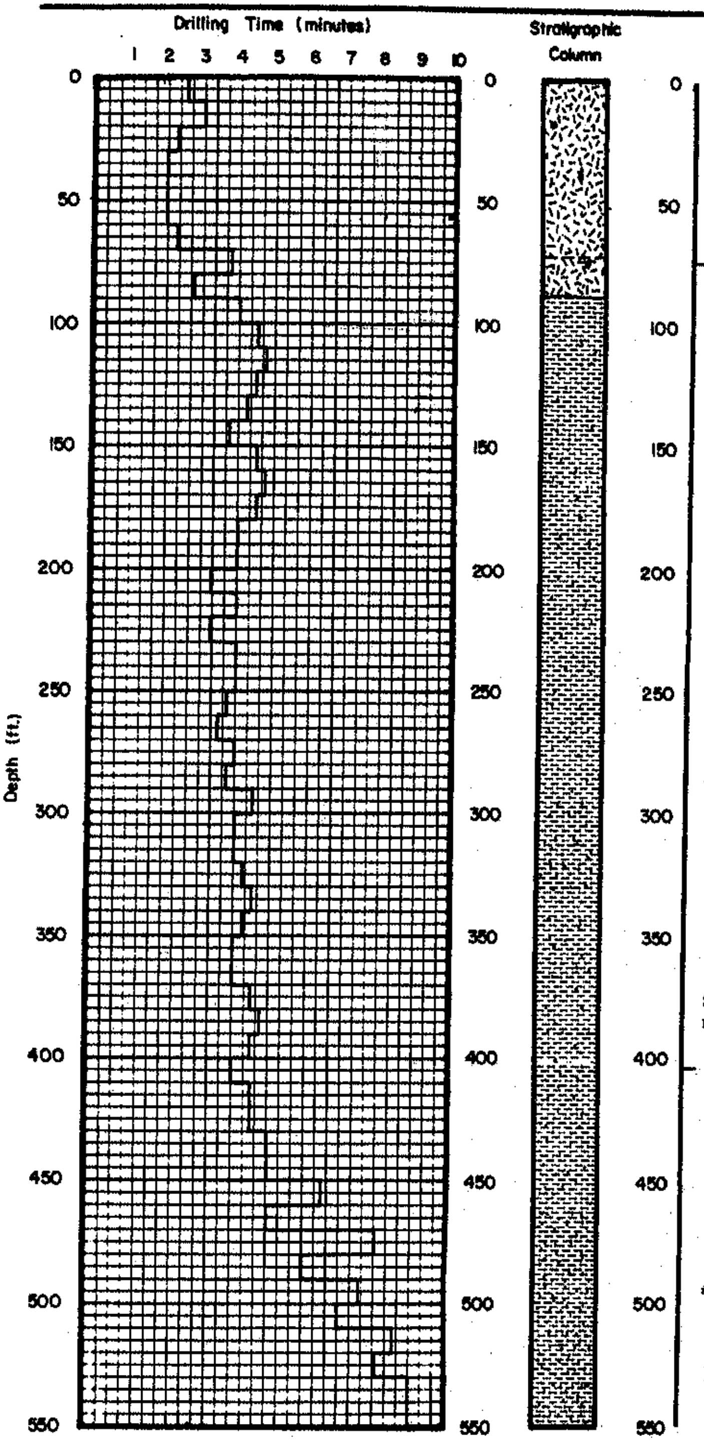
450

500

550 – * as above

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-4
LOCATION TIVOLI PARK
DATE DRILLED 11/4/81, 9/17/82



Overburden, clay, silt, sand, gray to brown w/ occasional quartz, shale pebbles (1-2 mm) & organic fragments

75' – thin shale layer

Shale, medium to dark gray, ext. fine, ext. finely laminated, some silty shale

Water 15 gpm H_2S odor

Shale w/ graywacke, fine grained, silty
Shale & graywacke, medium to dark gray,
Shale, minor graywacke, some silty shale

A/A* w/ some vein calcite

A/A*, no graywacke

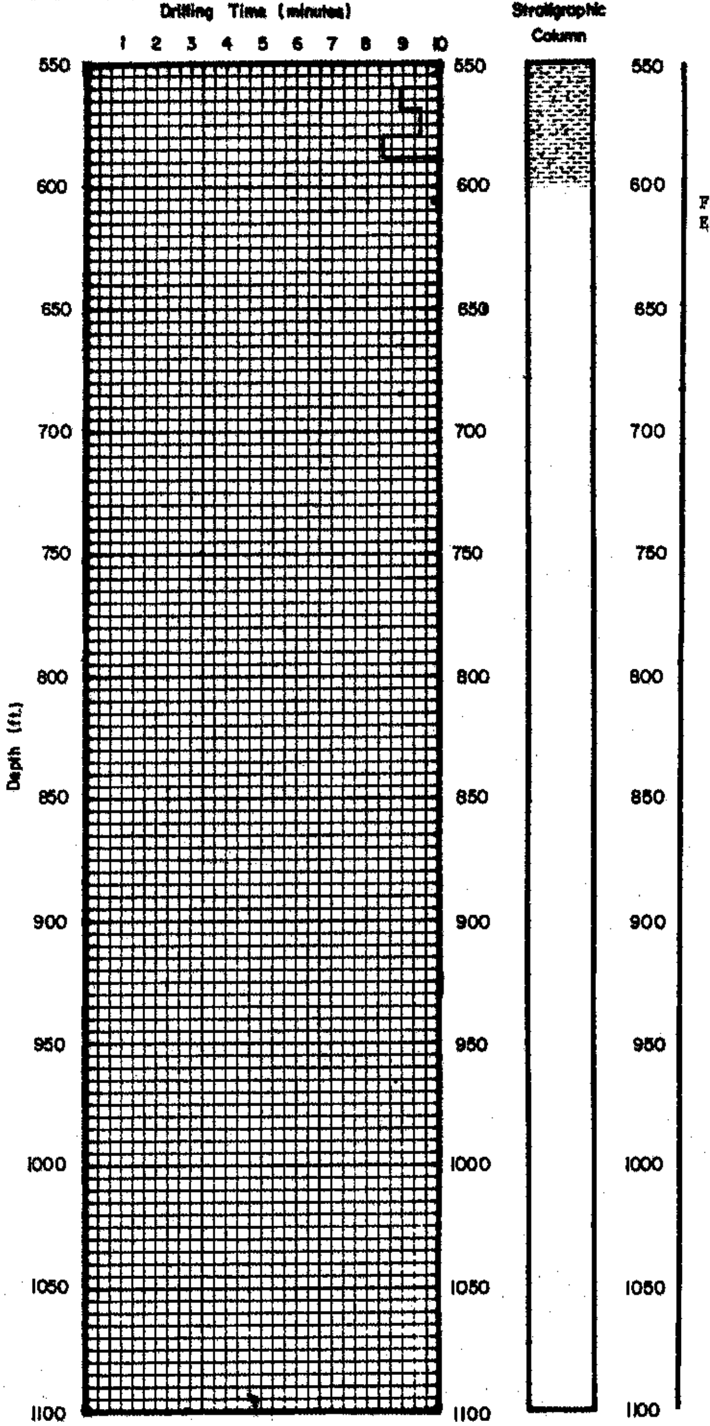
A/A*, mostly silty shale

Shale w/ silty shale, medium to dark gray, not different from above

* as above

DUNN GEOSCIENCE CORPORATION

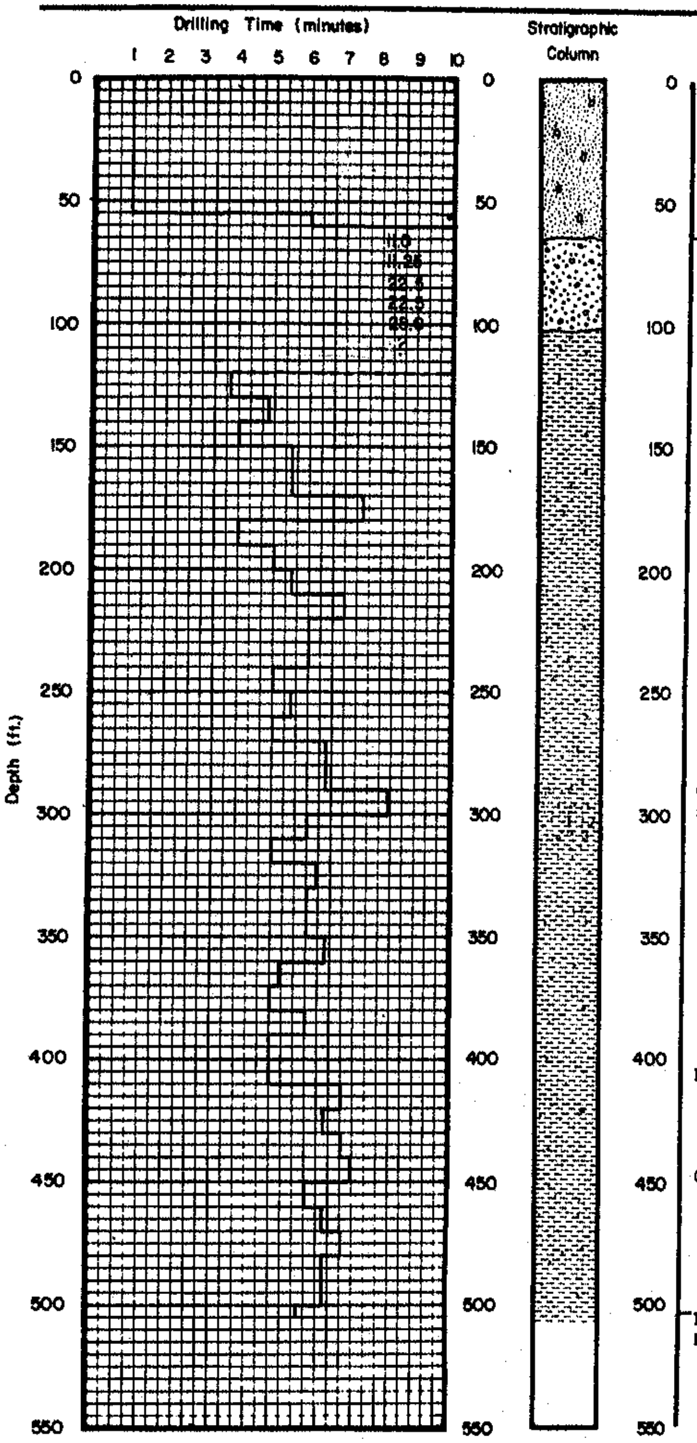
GEOTHERMAL DRILLING PROGRAM
HOLE DH-4
LOCATION TIVOLI PARK
DATE DRILLED 11/4/81, 9/17/82



Final Depth - 600'
Est. Water Flow - 40 gpm

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-5
LOCATION WESTSIDE LANDFILL
DATE DRILLED 11/5/81



Description

Soil, w/ sand & silt

65' - gravel, some sand, silt & cobbles

Shale, dark gray to black, fine grained silty shale to fine graywacke

Graywacke w/ shale

Shale, some graywacke

Graywacke, some shale
Shale, some graywacke

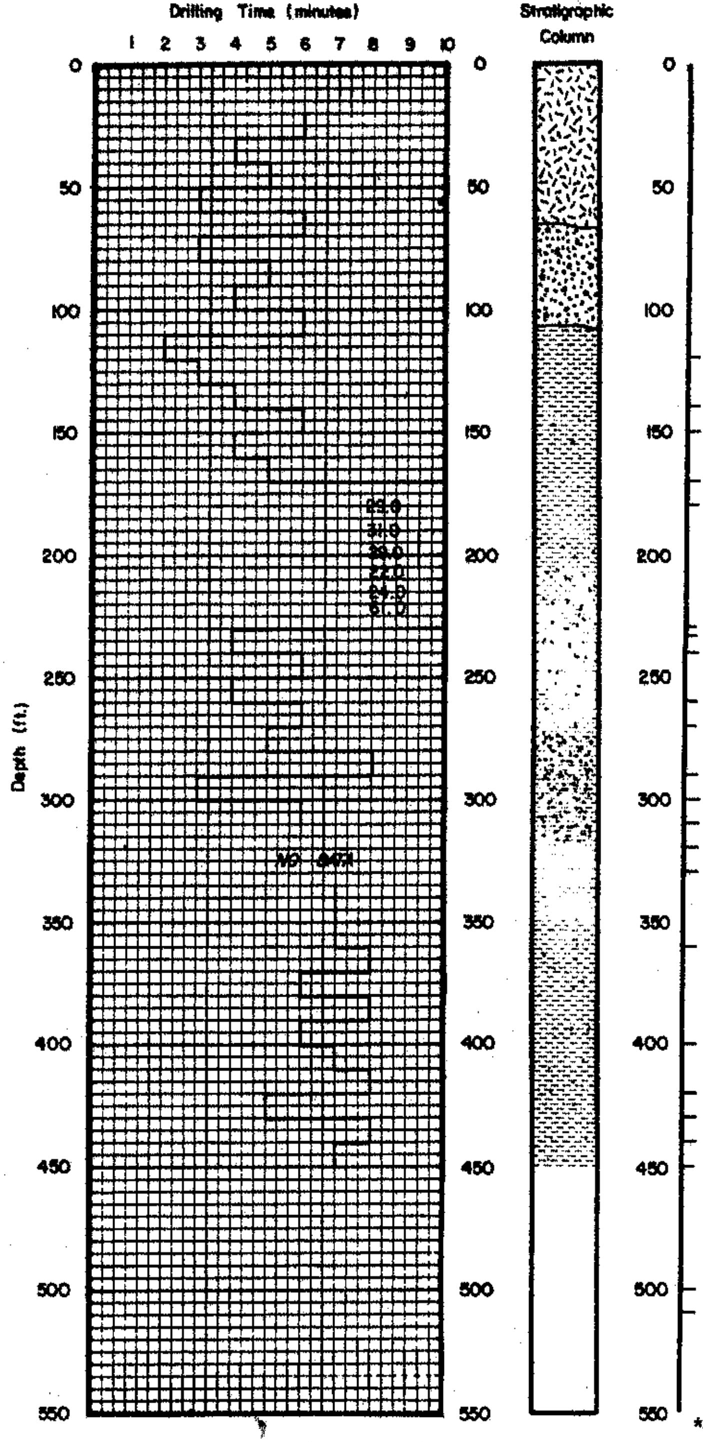
Drilling rate decreased

Graywacke and shale, interbedded

Final depth 505'
Est. water flow 2 gpm

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-6
LOCATION ROTTERDAM INDUSTRIAL PARK
DATE DRILLED 12/21/81



Description

Overburden - sand, soil, some clay gray to brown w/ organic remains, occasional gravel.

120' Shale - gray in clay

140' - Water 1 1/2 gpm, calcite veins A/A* w/ some graywacke

170' - A/A* less graywacke, calcite gone

180' - Mostly shale, Lt. gray clay

230' - Graywacke & shale

232' - Bedrock

240' - Shale

260' - Fine grained shale & graywacke, calcite veins

270-272' Hard zone

270' - Graywacke & shale

290' - Graywacke & little shale

300' - Graywacke

310' - Shale

320' - Calcite prominent w/ shale w/ fine graywacke

330' - Shale & graywacke

360' - Shale w/ graywacke

400' - Shale & graywacke

420' - Calcite veins

430' - Graywacke w/ shale, no calcite

440' - Graywacke & shale

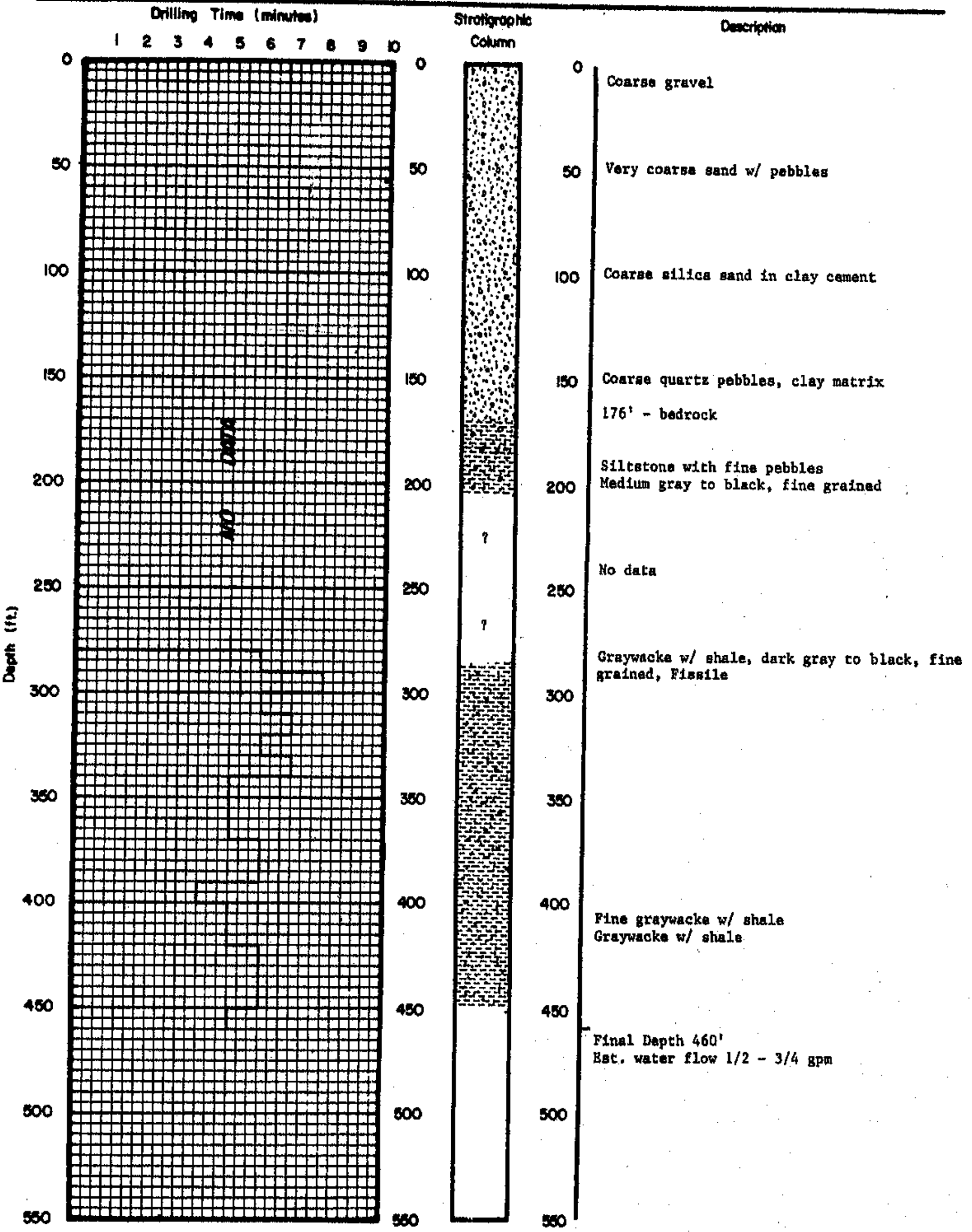
450' - Shale & graywacke

Final depth 450'
Est. water flow 2 gpm

*as above

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-7
LOCATION SCOTIA NAVAL DEPOT
DATE DRILLED



Coarse gravel

Very coarse sand w/ pebbles

Coarse silica sand in clay cement

Coarse quartz pebbles, clay matrix

176' - bedrock

Siltstone with fine pebbles
Medium gray to black, fine grained

No data

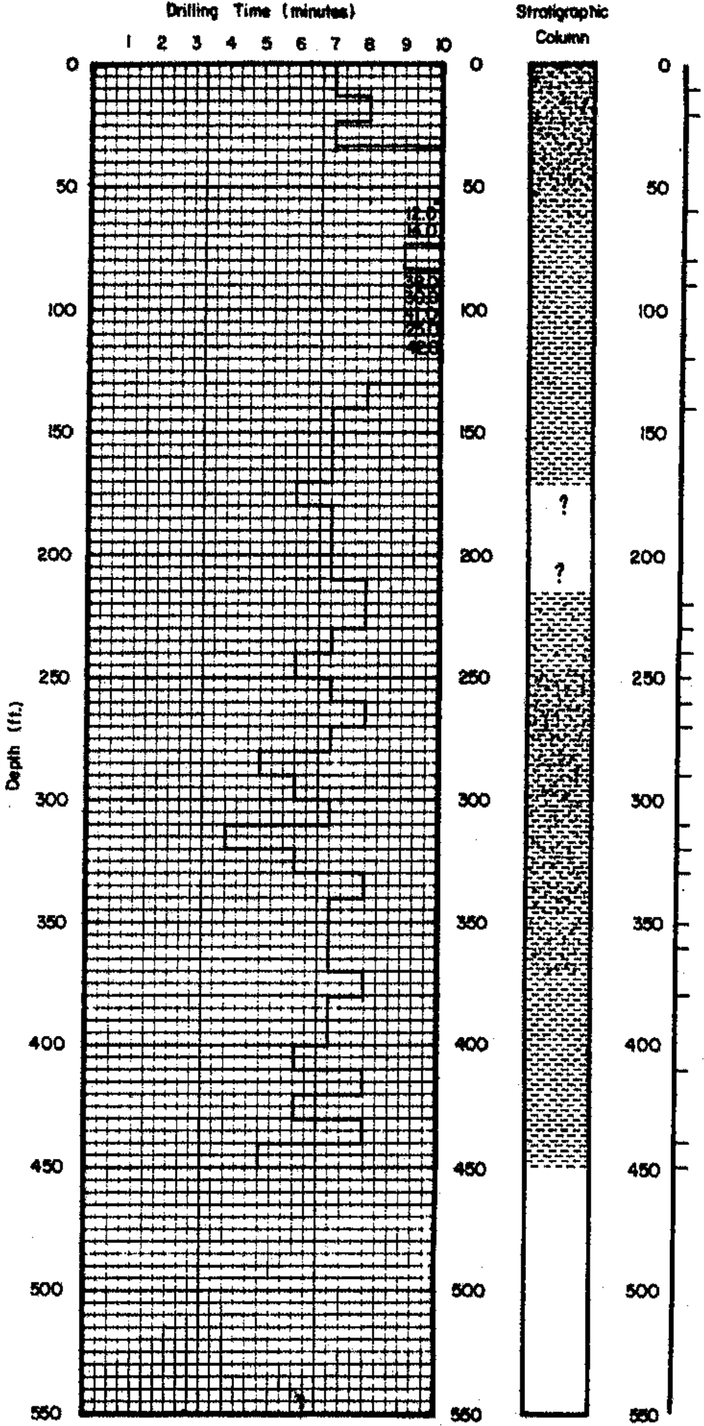
Graywacke w/ shale, dark gray to black, fine grained, Fissile

Fine graywacke w/ shale
Graywacke w/ shale

Final Depth 460'
Est. water flow 1/2 - 3/4 gpm

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM
HOLE DH-8
LOCATION CLARKE & BROWN
DATE DRILLED 12/28 - 12/30/81



Description

10' - gray clay w/ pebbles (rounded)
20' - pebbles and gray clay (till)

60' - gray clay w/ some shale

80' - A/A*, more shale
90' - Shale and clay

120' - gray clay w/ some shale; occasional cobbles
140' - Gray clay, little shale

No data

220' - gray shale w/ some graywacke
230' - Shale & graywacke
240' - Graywacke & shale

250' - Graywacke
266' - Shale & graywacke
276' - Shale & graywacke

290' - Graywacke w/ some shale
300' - Shale & graywacke
316' - Graywacke & shale
320' - Graywacke & little shale
330' - Shale & little graywacke

350' - Shale & graywacke
366' - Graywacke & shale

386' - Shale & graywacke

416' - Shale dark gray

440' - A/A*

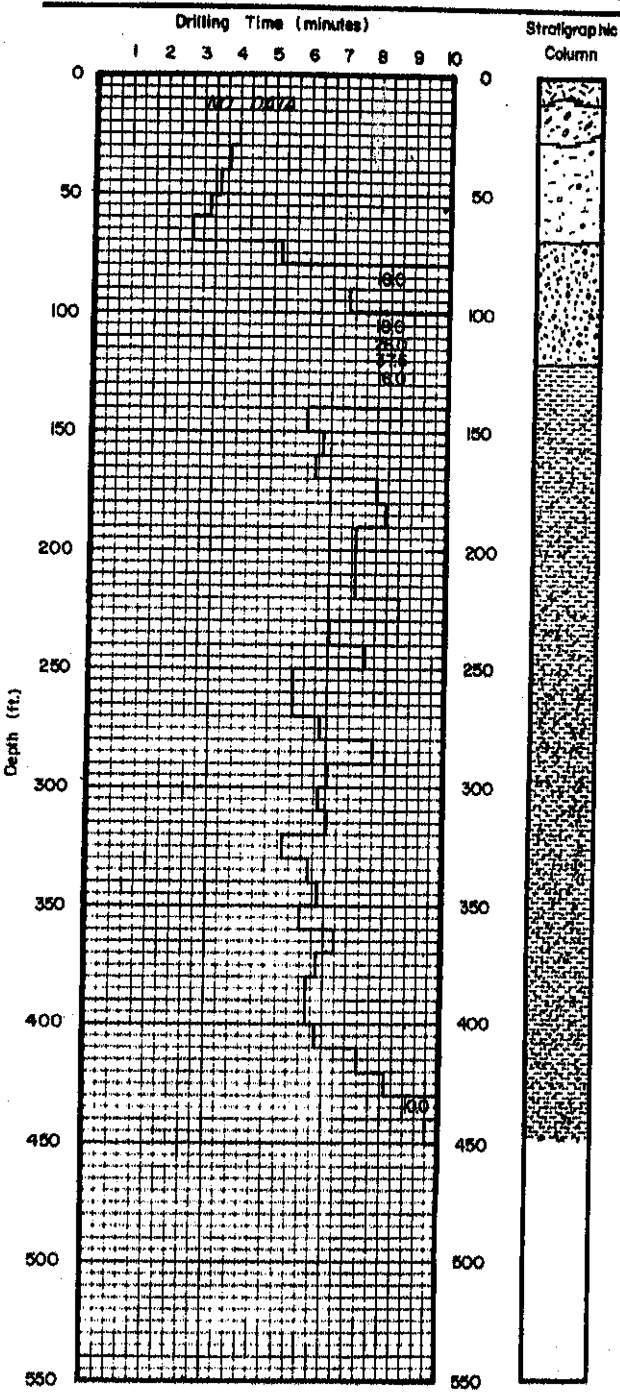
Final depth 450'
Est. water flow 1/2 gpm

* as above

DUNN GEOSCIENCE CORPORATION

GEOTHERMAL DRILLING PROGRAM

HOLE DH-9
LOCATION SOLID WASTE TRANSFER STATION
DATE DRILLED 3/15-16/82



Description

0 Overburden - Soil, sand, silt, clay, some man-made materials (i.e. concrete chunks)
Bog - soft, organic clays and silty w/ rich abundant plant fragments (woody). Some occasional sand stringers, but mostly clayey or silty.

75' - gravel zone begins
88' - hard, gravel rich zone
100' - Organic clay
109' - hard gravel rich zone
122' - slight water influx at bedrock surface
130' - Shale w/ fine graywacke
170' - Shale & graywacke
210' - Graywacke & shale
220' - Graywacke w/ shale
270' - Graywacke
292' - possible water influx
300' - Graywacke, fine grained
361', 364' - possible water influx
410' - Graywacke, coarser grained

Final Depth 455'
Est. water flow 1/2 gpm

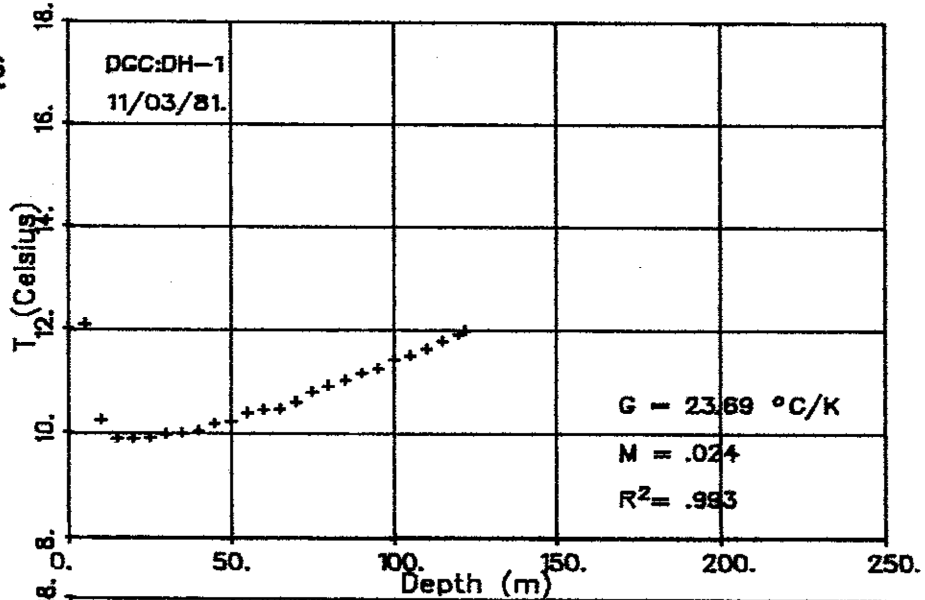
DUNN GEOSCIENCE CORPORATION

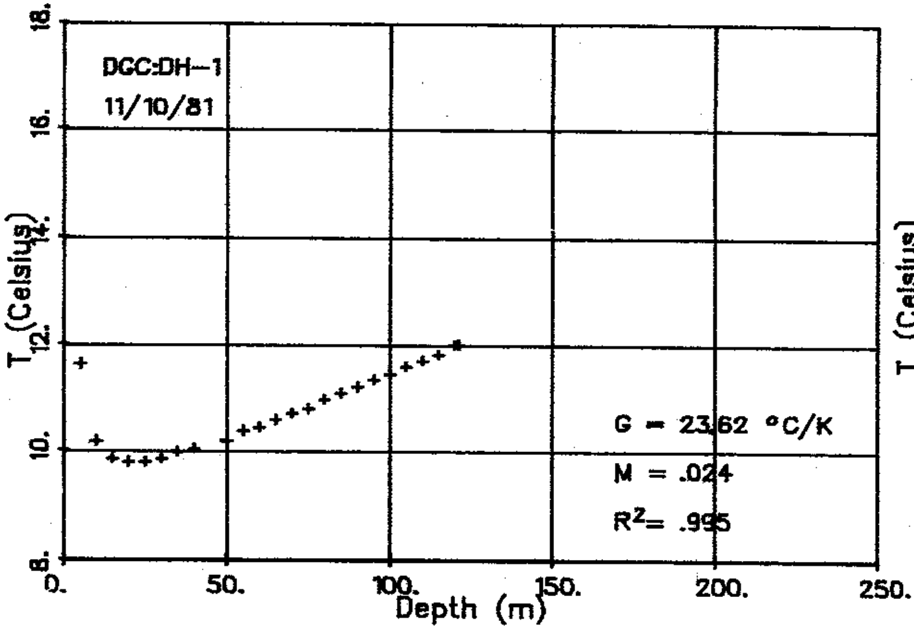
APPENDIX G

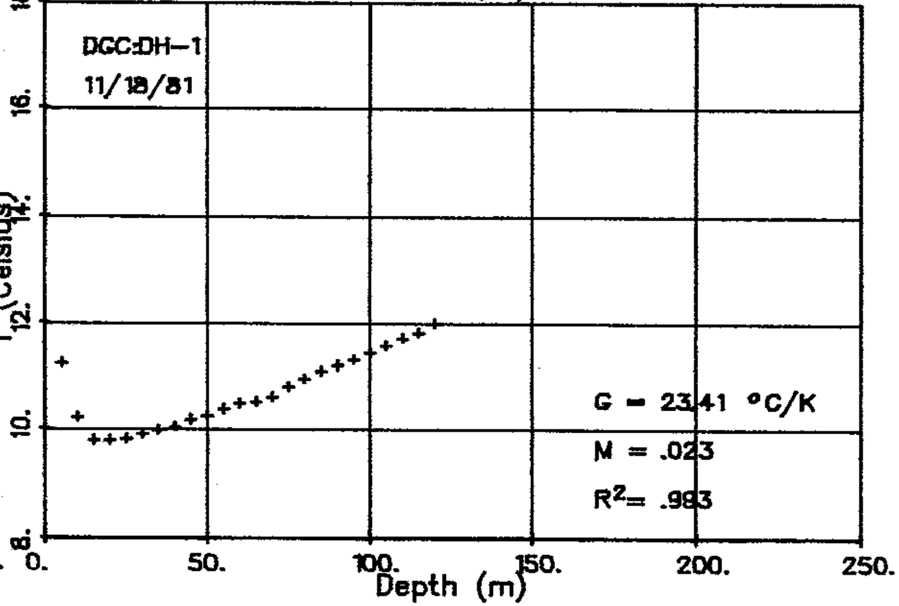
SHALLOW WELL GRADIENT

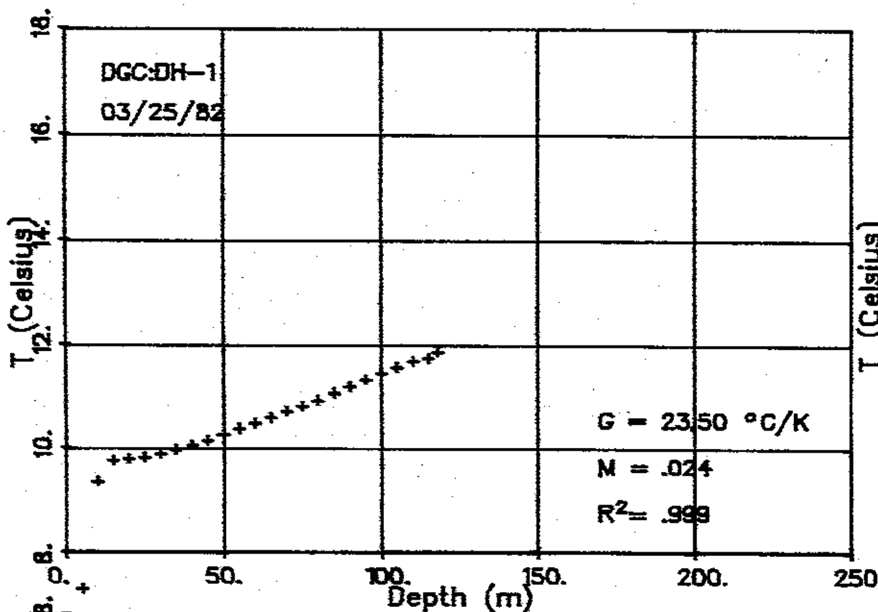
SHALLOW TEST WELL TEMPERATURE PROFILES

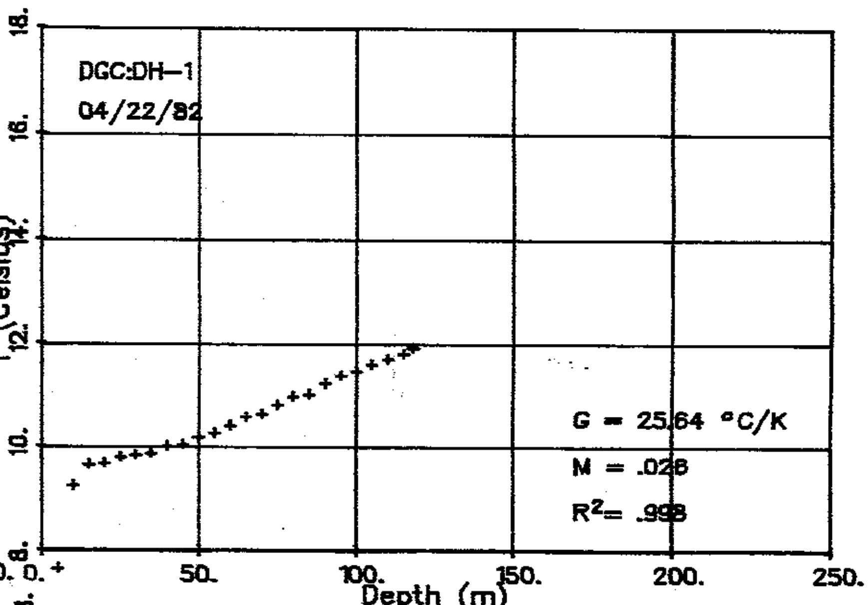
G = Gradient in ° Celsius per kilometer
M = Calculated slope of gradient profile
R^2 = Coefficient of determination

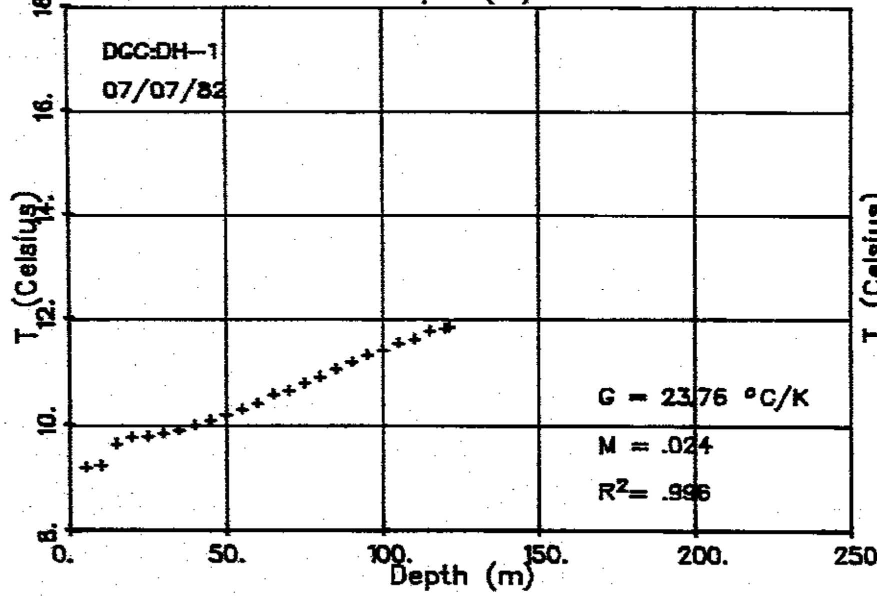


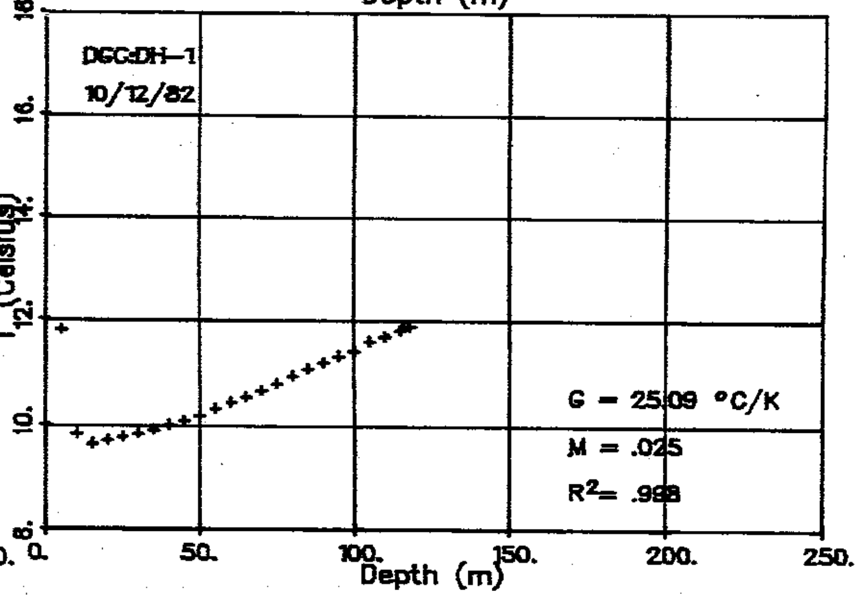


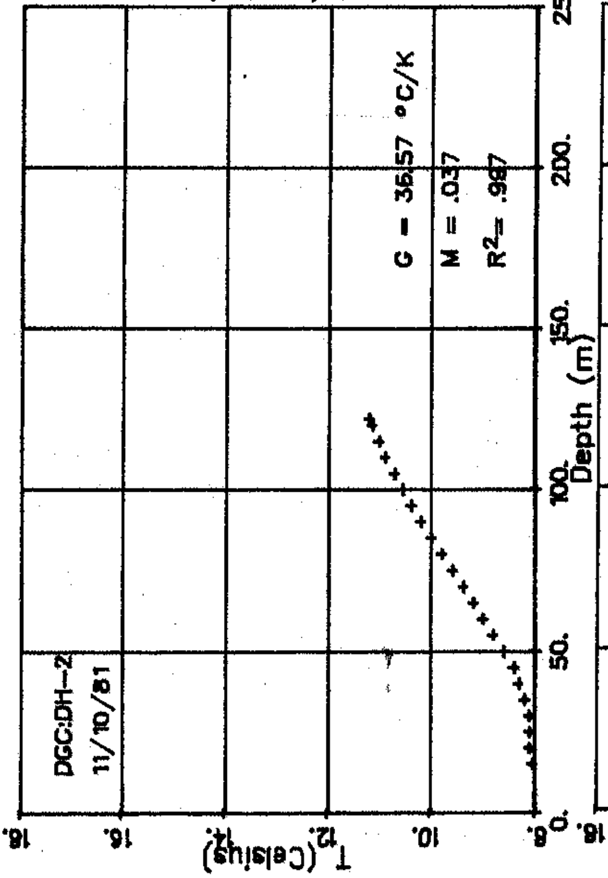


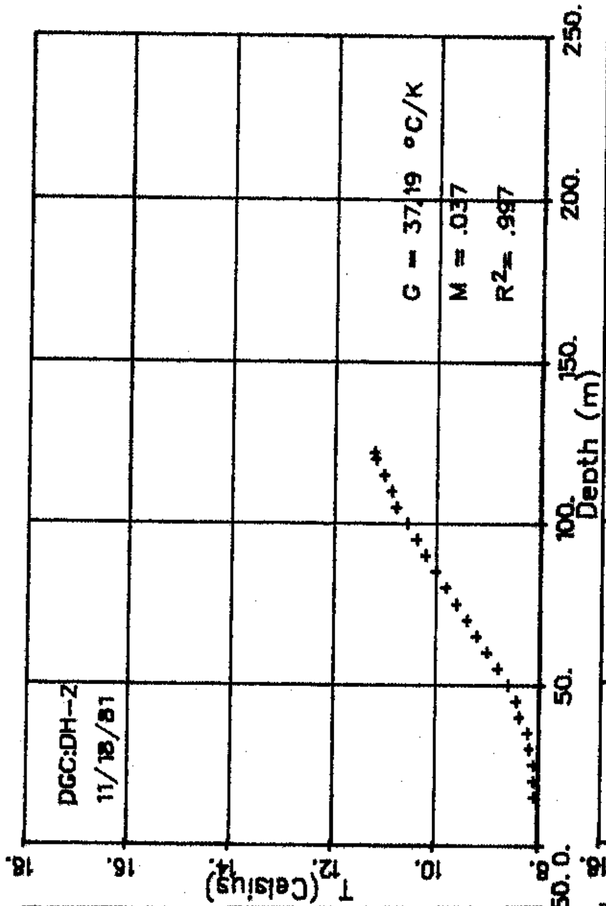

DGC:DH-1
03/25/82
G = 23.50 °C/K
M = .024
R² = .999
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

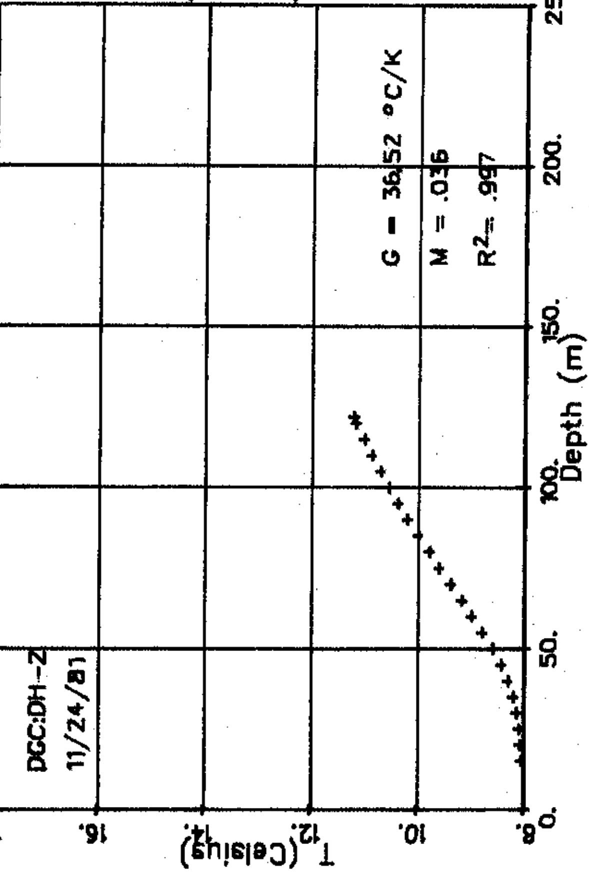

DGC:DH-1
04/22/82
G = 25.64 °C/K
M = .028
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

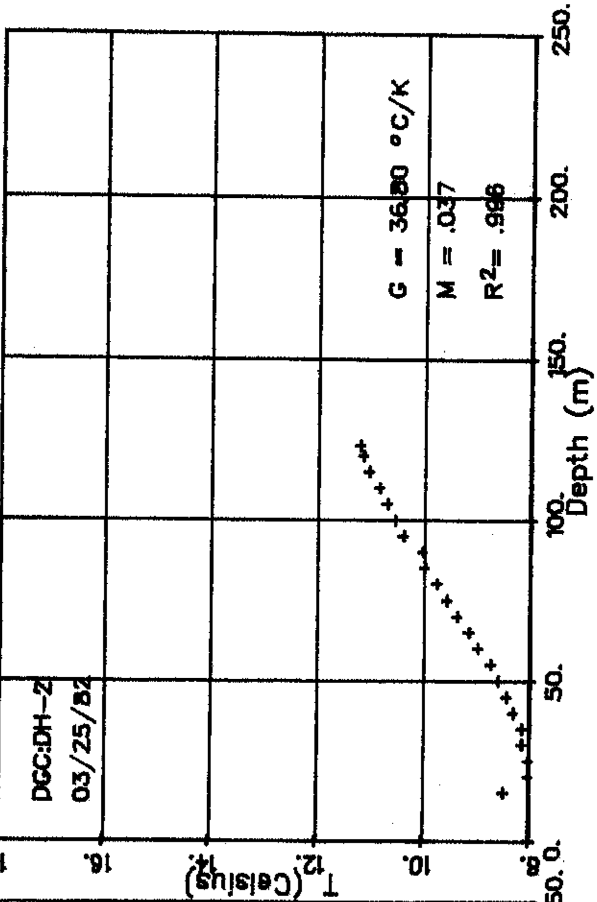

DGC:DH-1
07/07/82
G = 23.76 °C/K
M = .024
R² = .996
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

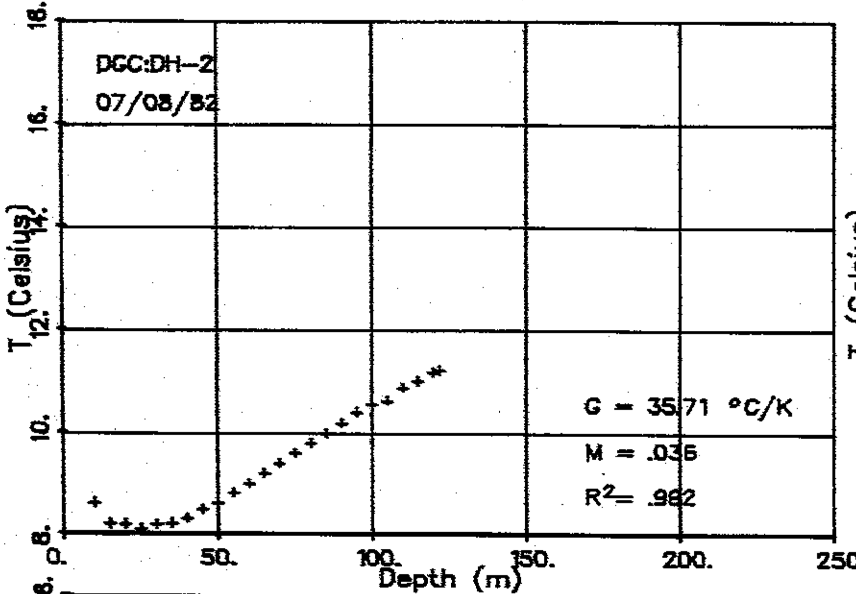

DGC:DH-1
10/12/82
G = 25.09 °C/K
M = .025
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

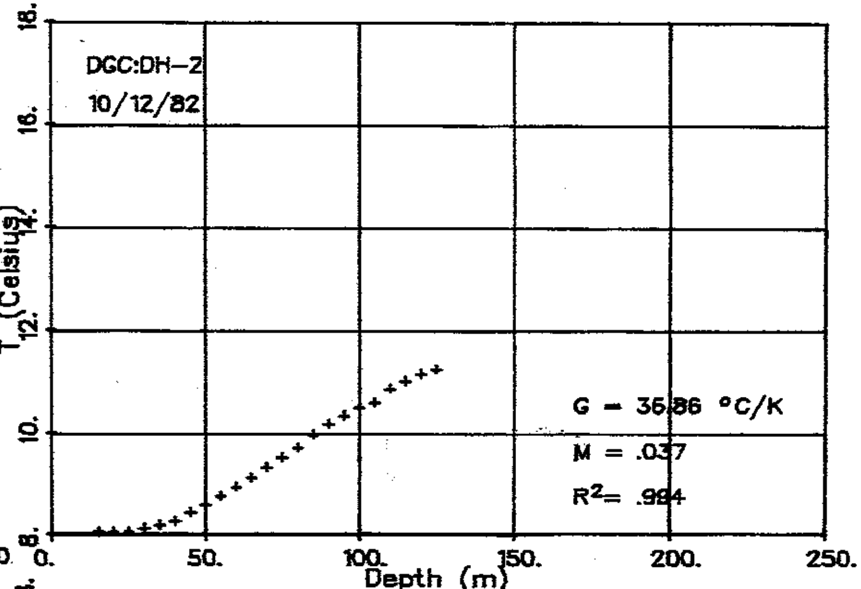

DGC:DH-2
11/10/81
G = 36.57 °C/K
M = .037
R² = .997
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

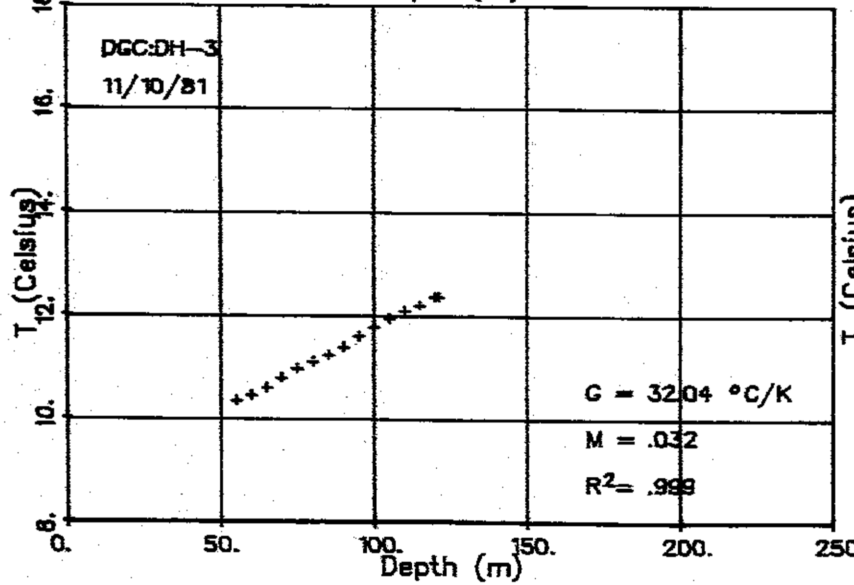

DGC:DH-2
11/18/81
G = 37.19 °C/K
M = .037
R² = .997
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

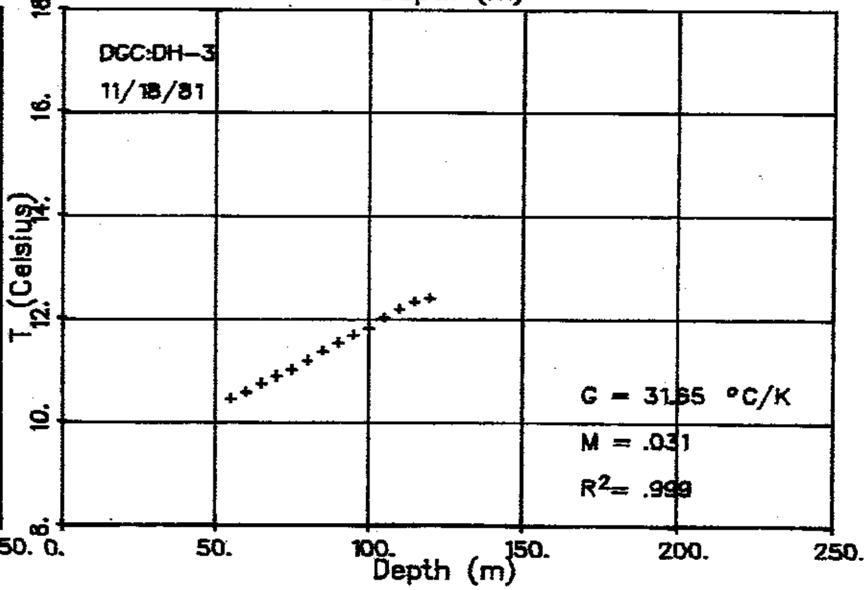

DGC:DH-2
11/24/81
G = 36.52 °C/K
M = .036
R² = .997
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

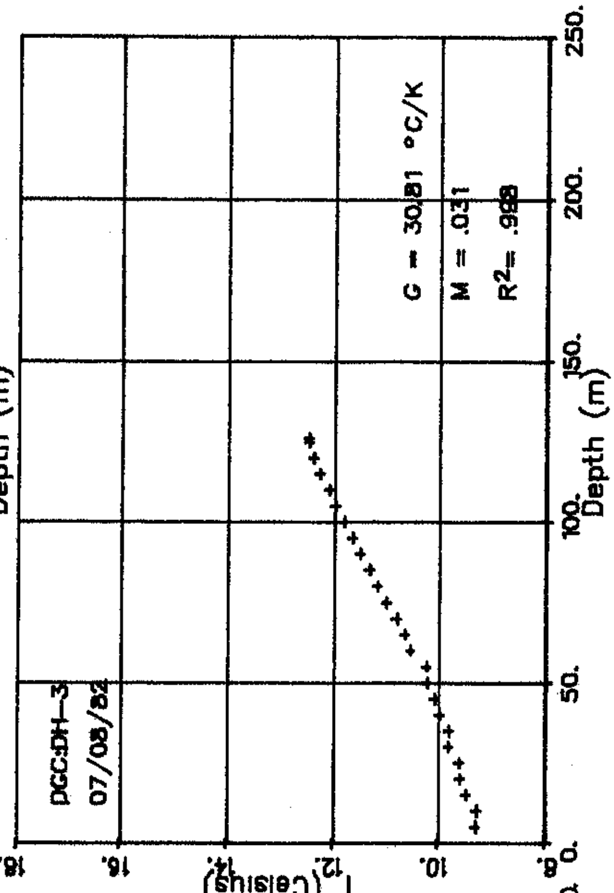

DGC:DH-2
03/25/82
G = 36.80 °C/K
M = .037
R² = .996
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

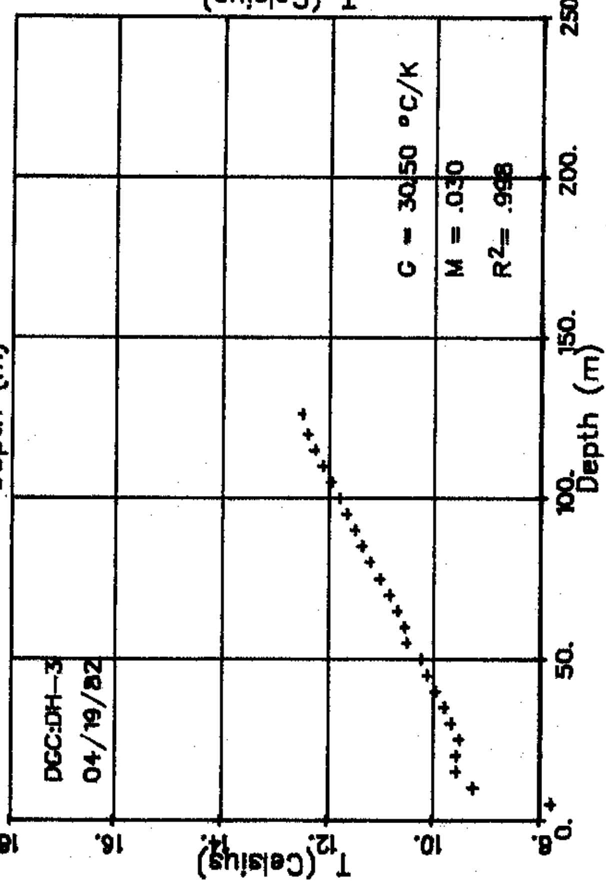

DGC:DH-2
07/08/82
G = 35.71 °C/K
M = .036
R² = .982
T (Celsius)
8.
10.
12.
14.
16.
18.
0.
50.
100.
150.
200.
250.
Depth (m)

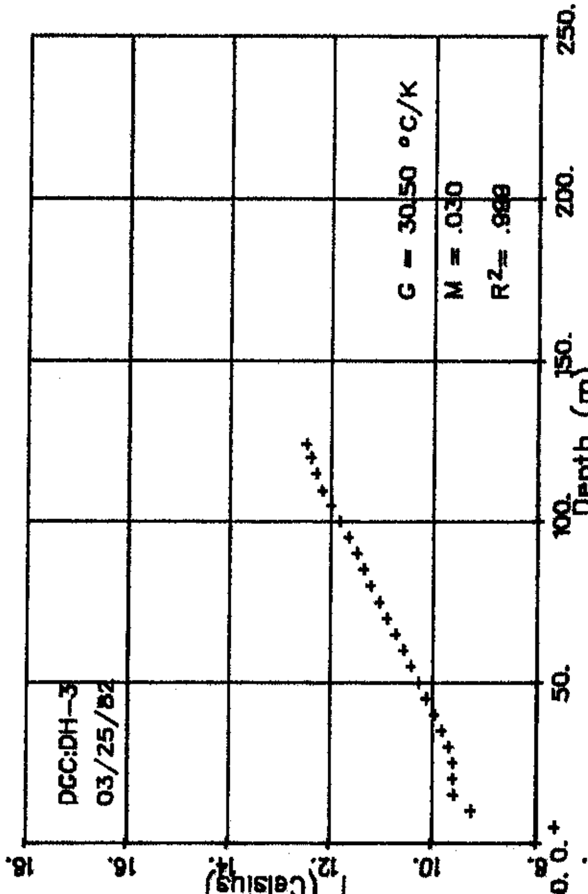

DGC:DH-2
10/12/82
G = 36.86 °C/K
M = .037
R² = .994
T (Celsius)
8.
10.
12.
14.
16.
18.
0.
50.
100.
150.
200.
250.
Depth (m)

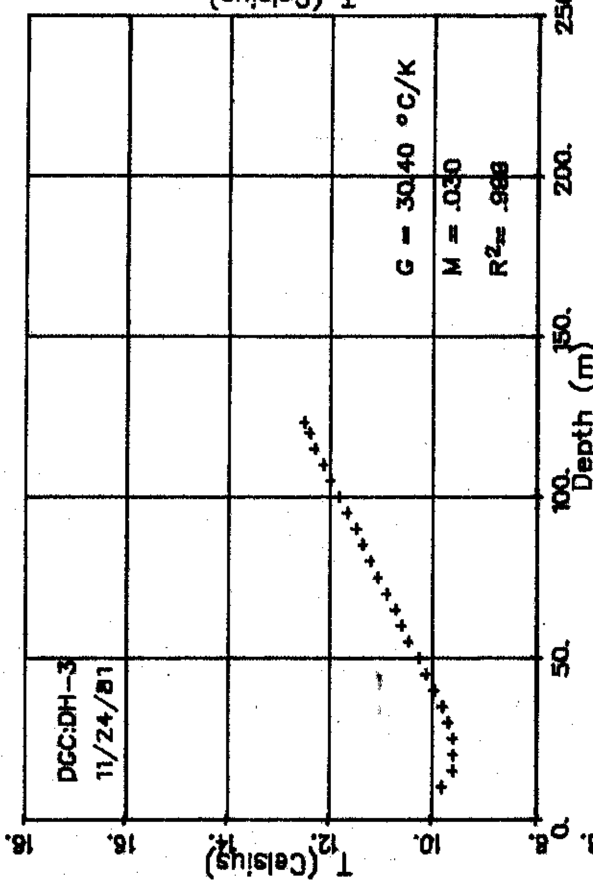

DGC:DH-3
11/10/81
G = 32.04 °C/K
M = .032
R² = .999
T (Celsius)
8.
10.
12.
14.
16.
18.
0.
50.
100.
150.
200.
250.
Depth (m)

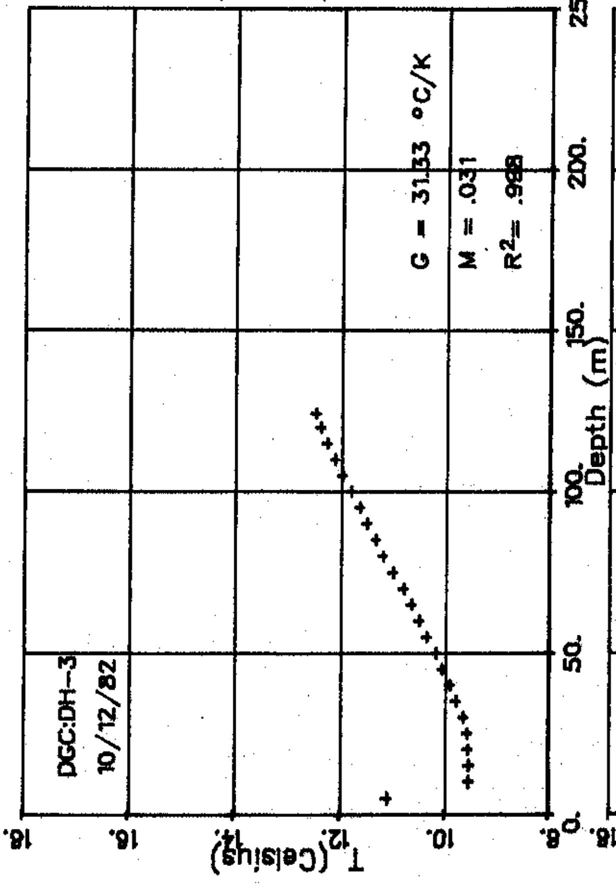

DGC:DH-3
11/18/81
G = 31.65 °C/K
M = .031
R² = .999
T (Celsius)
8.
10.
12.
14.
16.
18.
0.
50.
100.
150.
200.
250.
Depth (m)

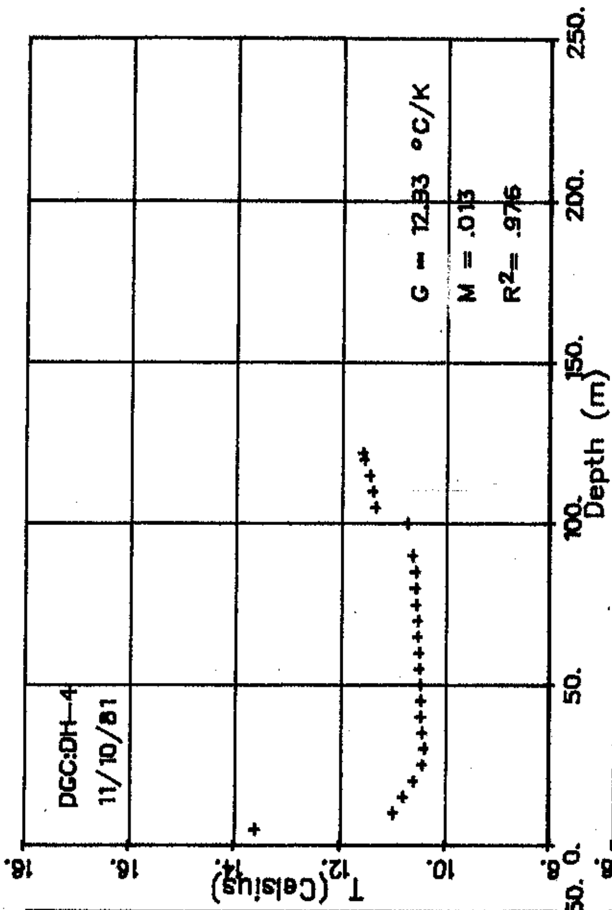

DGC:DH-3
07/08/82
G = 30.81 °C/K
M = .031
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

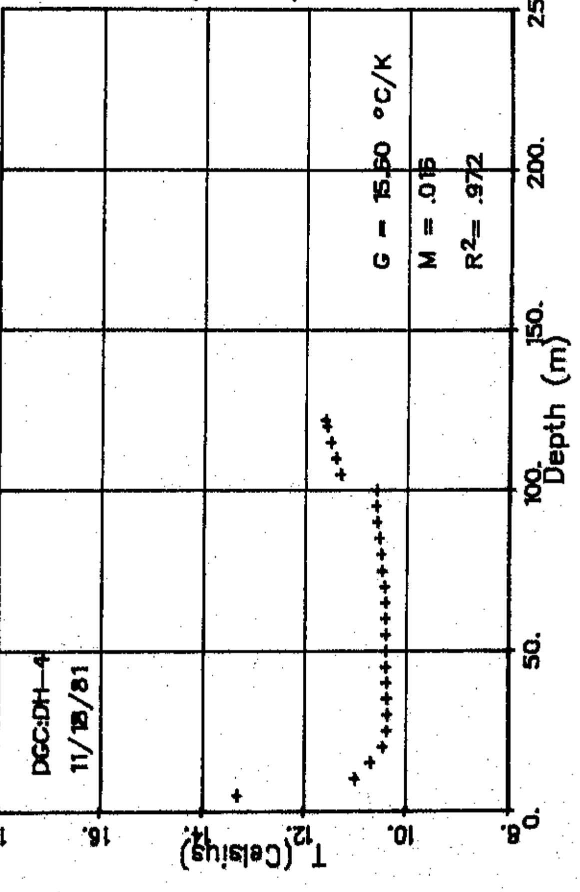

DGC:DH-3
04/19/82
G = 30.50 °C/K
M = .030
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

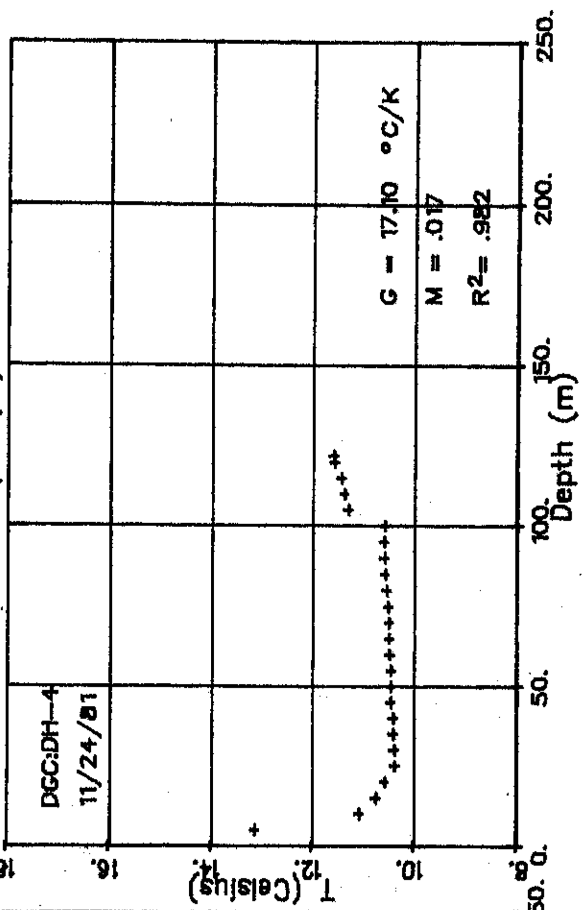

DGC:DH-3
03/25/82
G = 30.50 °C/K
M = .030
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

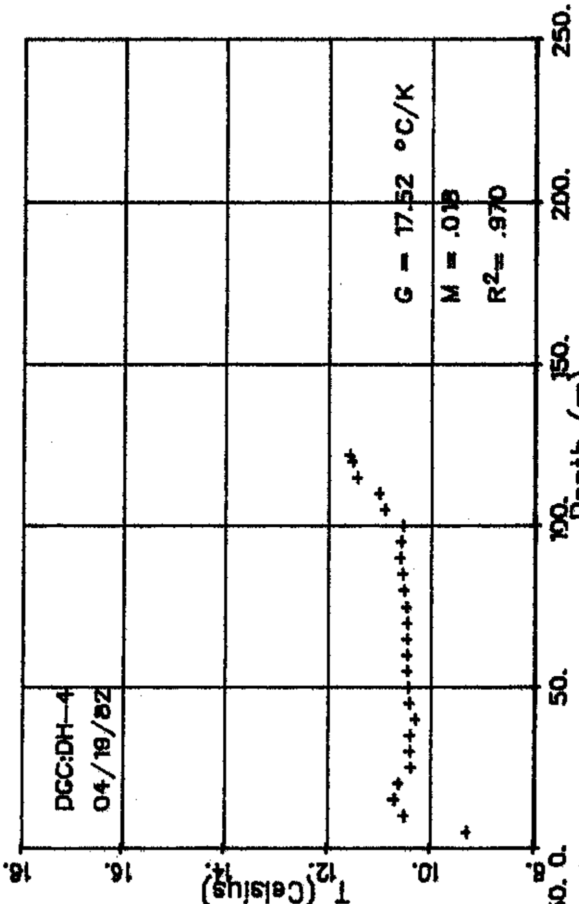

DGC:DH-3
11/24/81
G = 30.40 °C/K
M = .030
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

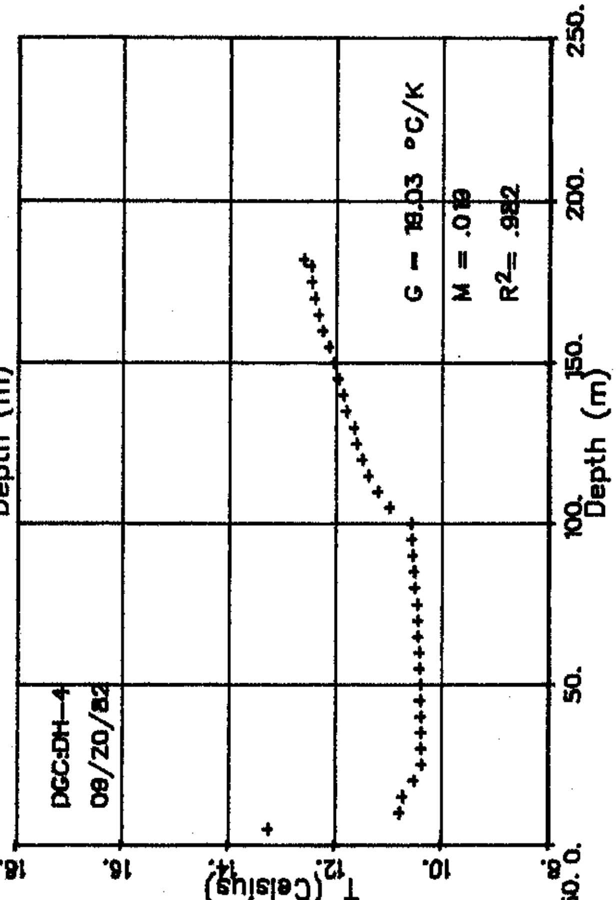

DGC:DH-3
10/12/82
G = 31.33 °C/K
M = .031
R2= .988
T(Celsius)
8. 10. 12. 14. 16. 18.
Depth (m)
0. 50. 100. 150. 200. 250.

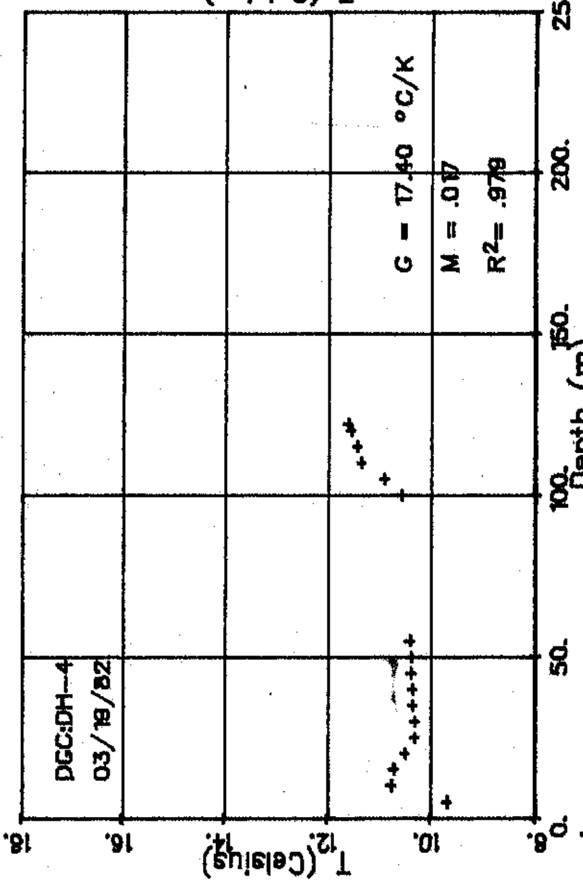

DGC:DH-4
11/10/81
G = 12.33 °C/K
M = .013
R2= .976
T(Celsius)
8. 10. 12. 14. 16. 18.
Depth (m)
0. 50. 100. 150. 200. 250.

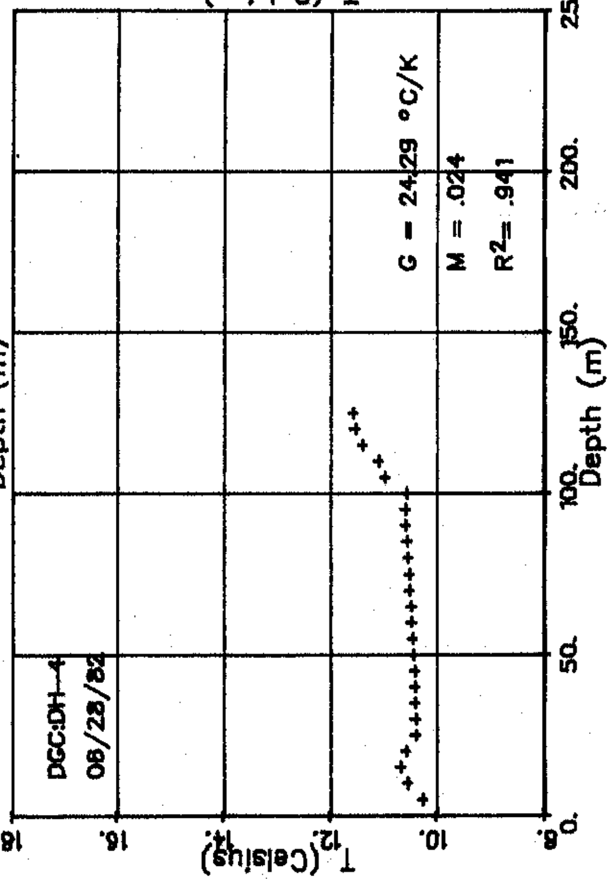

DGC:DH-4
11/18/81
G = 15.50 °C/K
M = .015
R2= .972
T(Celsius)
8. 10. 12. 14. 16. 18.
Depth (m)
0. 50. 100. 150. 200. 250.

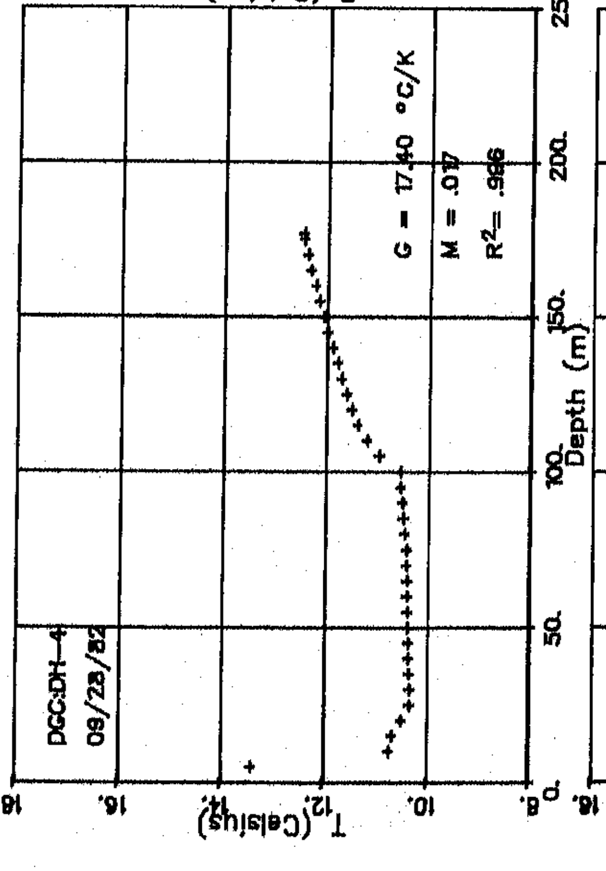

DGC:DH-4
11/24/81
G = 17.10 °C/K
M = .017
R2= .982
T(Celsius)
8. 10. 12. 14. 16. 18.
Depth (m)
0. 50. 100. 150. 200. 250.

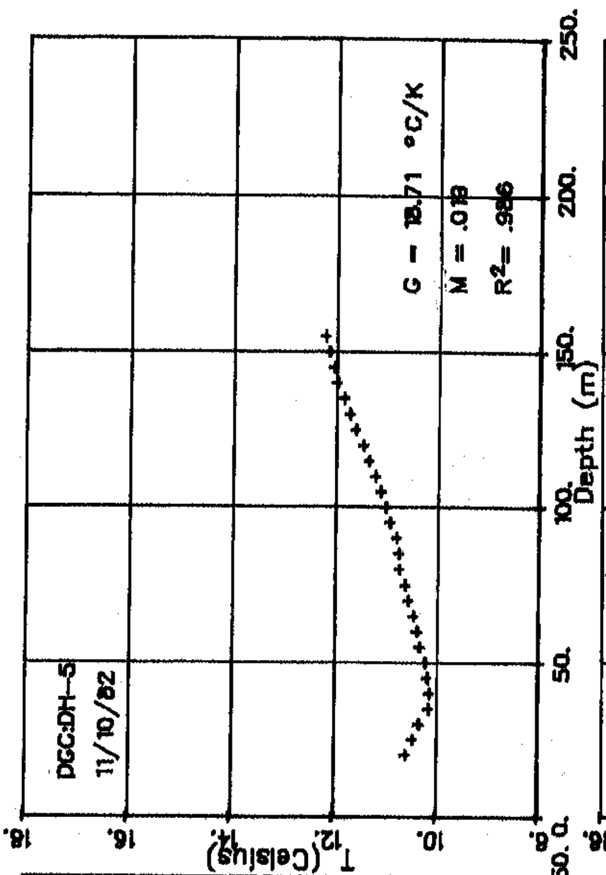

DGC:DH-4
04/19/82
G = 17.52 °C/K
M = .018
R² = .970
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

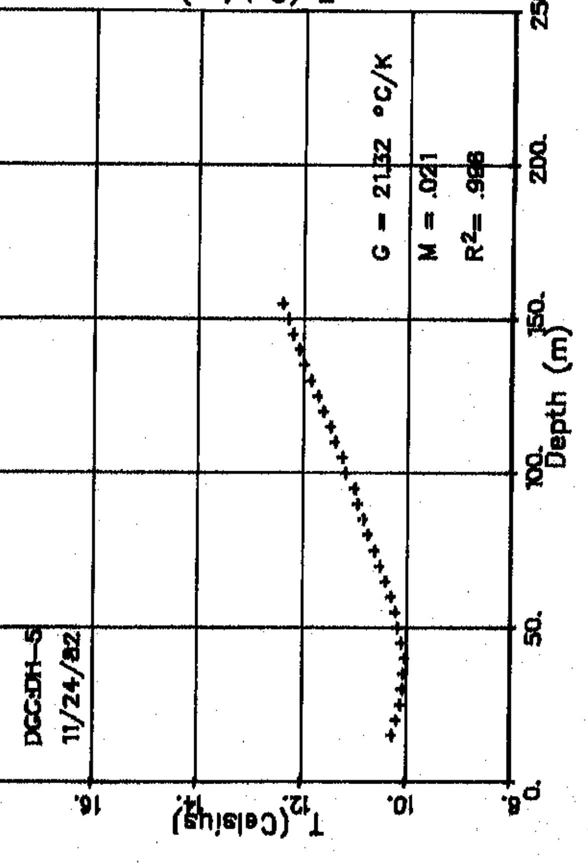

DGC:DH-4
08/20/82
G = 18.03 °C/K
M = .018
R² = .982
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

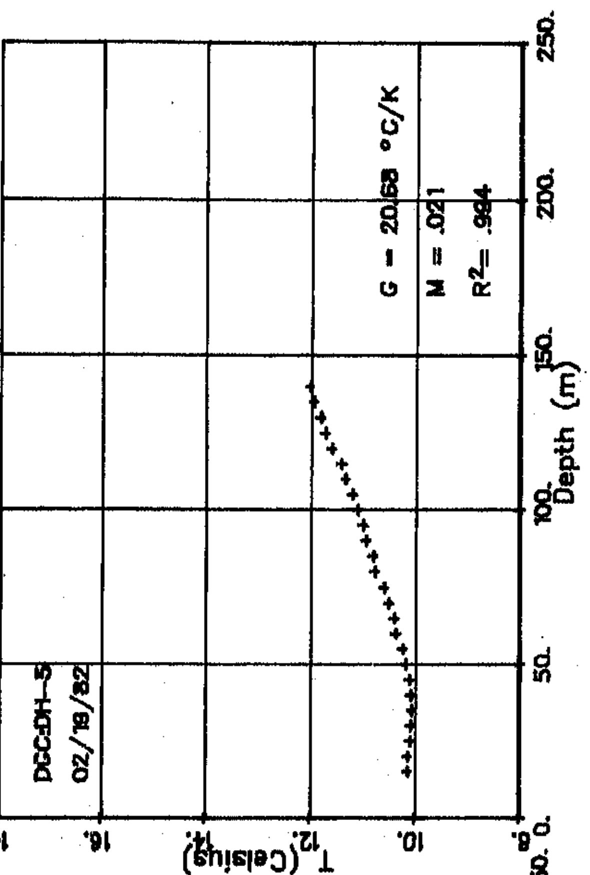

DGC:DH-4
03/18/82
G = 17.40 °C/K
M = .017
R² = .979
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

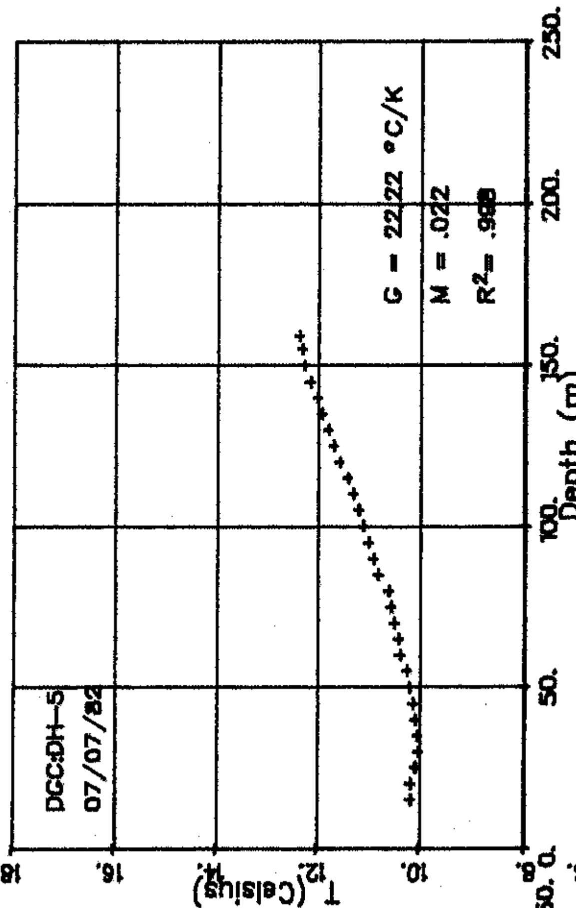

DGC:DH-4
08/28/82
G = 24.29 °C/K
M = .024
R² = .941
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

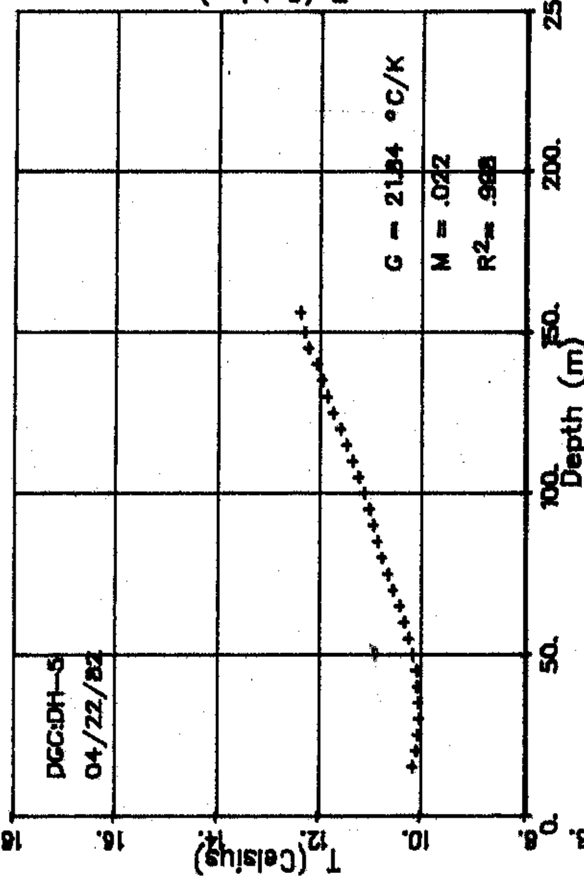

DGC:DH-4
09/28/82
G = 17.40 °C/K
M = .017
R² = .996
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

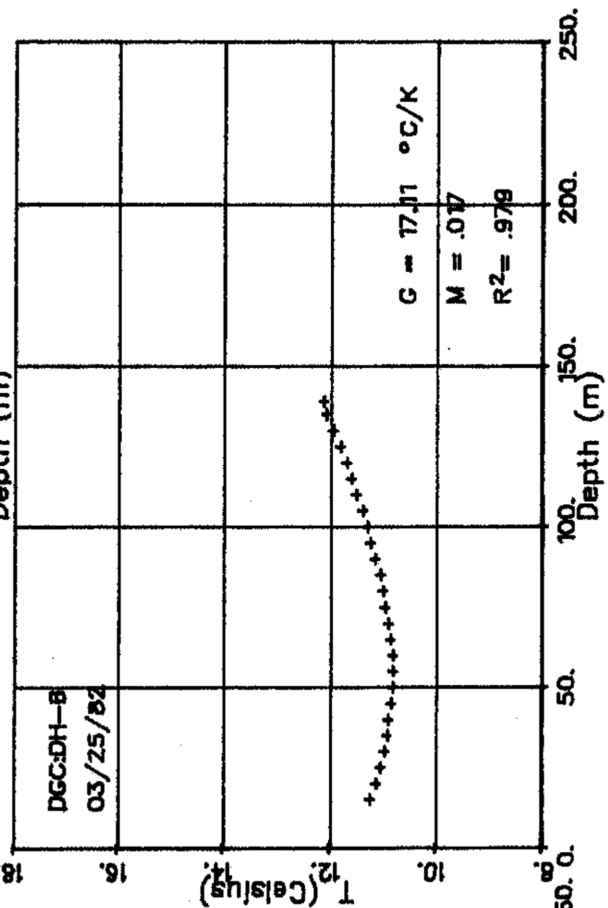

DGC:DH-5
11/10/82
G = 18.71 °C/K
M = .019
R² = .996
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

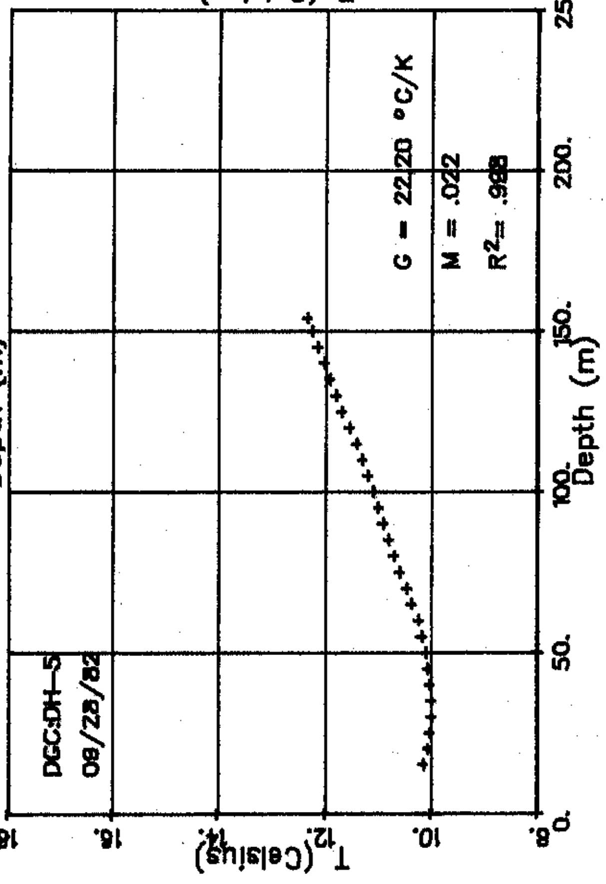

DGC:DH-5
11/24/82
G = 21.32 °C/K
M = .021
R² = .998
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

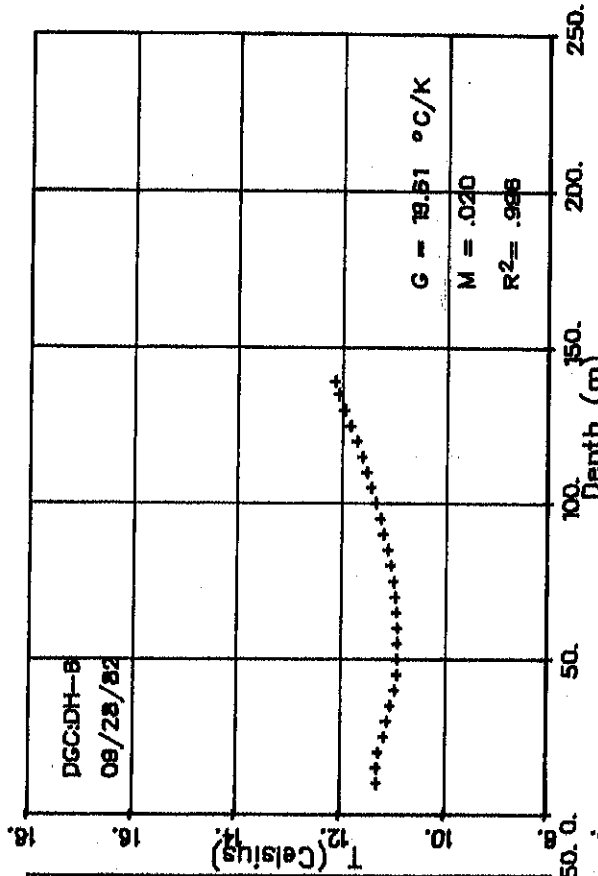

DGC:DH-5
02/18/82
G = 20.68 °C/K
M = .021
R² = .994
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

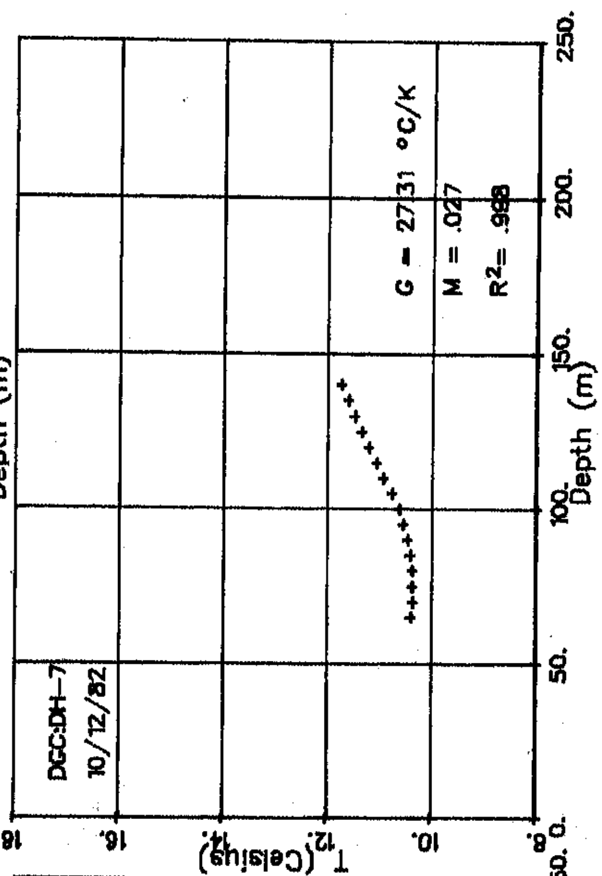

DGC:DH-5
07/07/82
G = 22.22 °C/K
M = .022
R² = .988
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

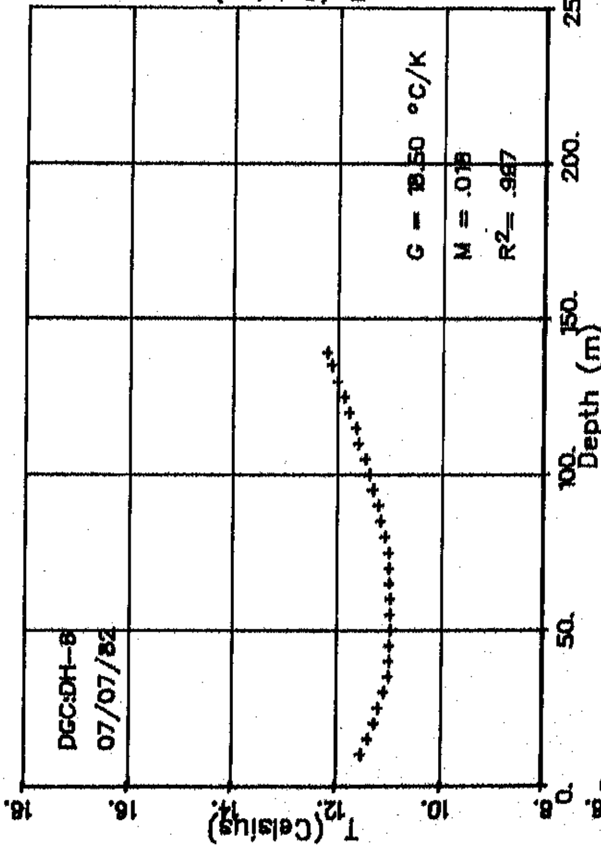

DGC:DH-5
04/22/82
G = 21.84 °C/K
M = .022
R² = .988
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

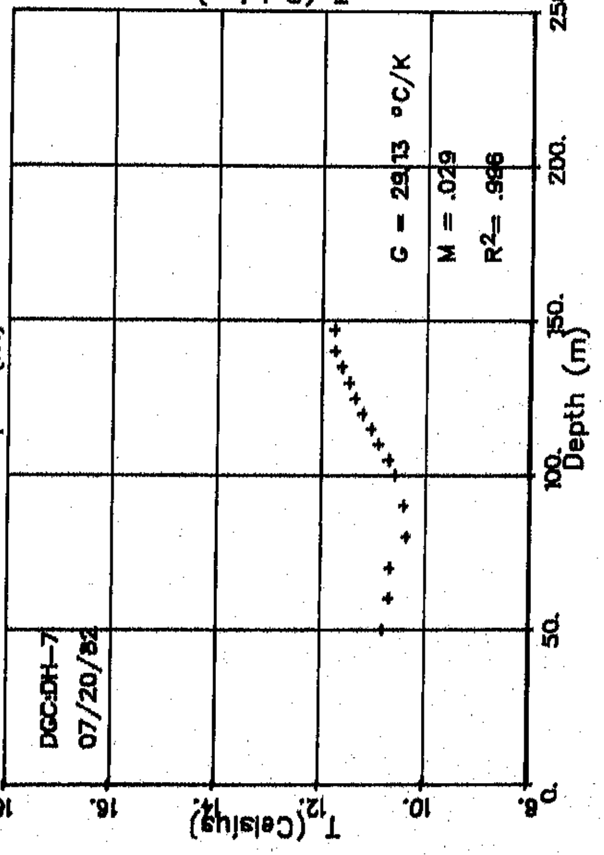

DGC:DH-8
03/25/82
G = 17.11 °C/K
M = .017
R² = .979
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

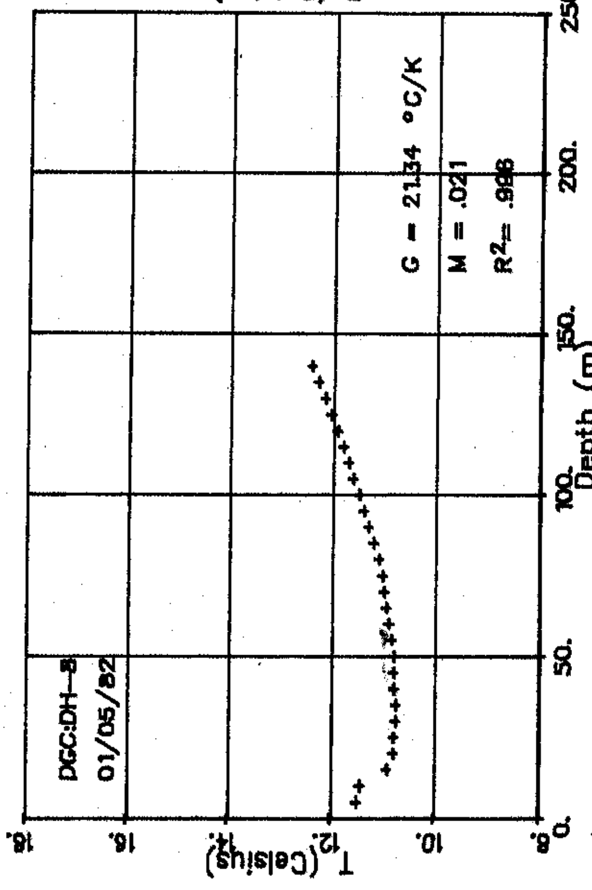

DGC:DH-5
08/28/82
G = 22.20 °C/K
M = .022
R² = .988
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

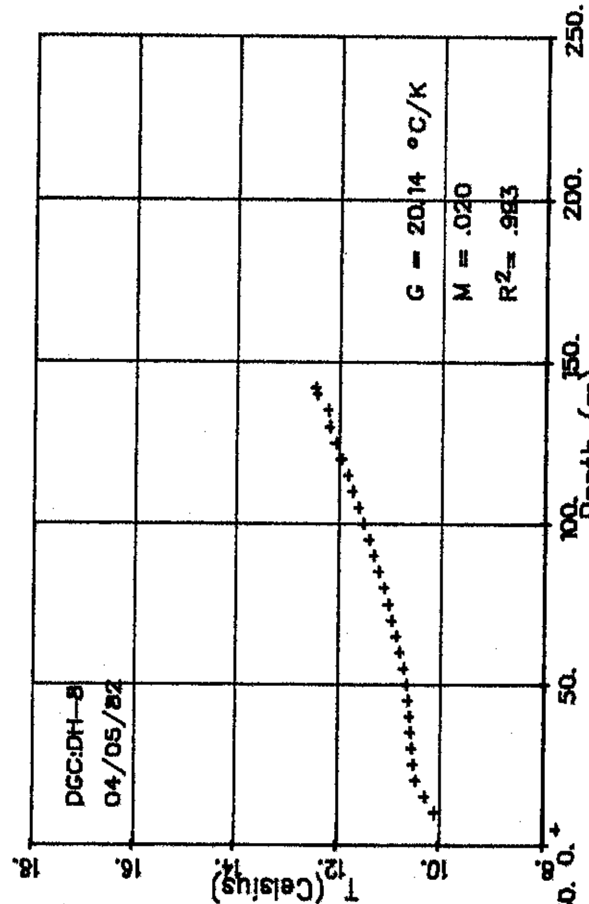

DGC:DH-8
09/28/82
G = 19.51 °C/K
M = .020
R² = .998
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

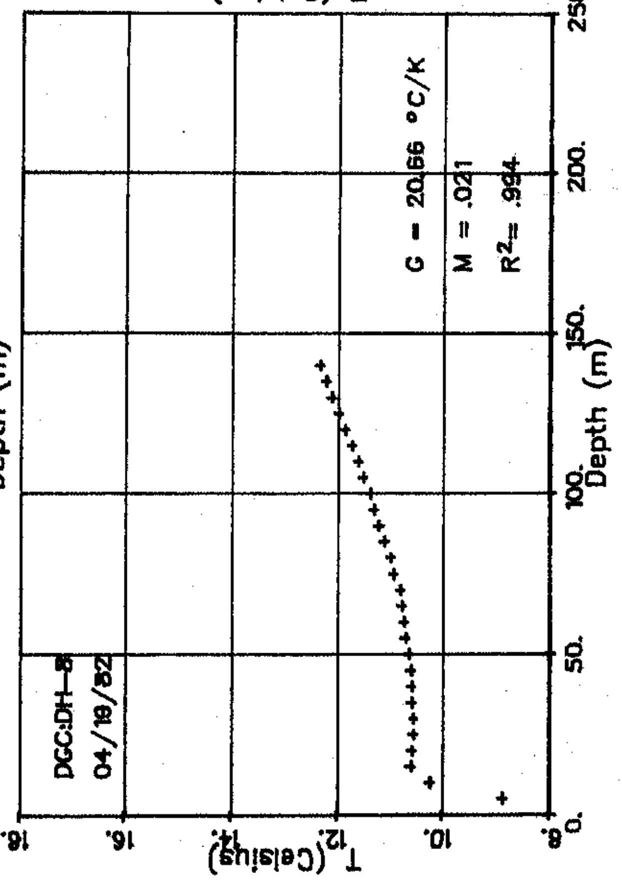

DGC:DH-7
10/12/82
G = 27.31 °C/K
M = .027
R² = .998
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

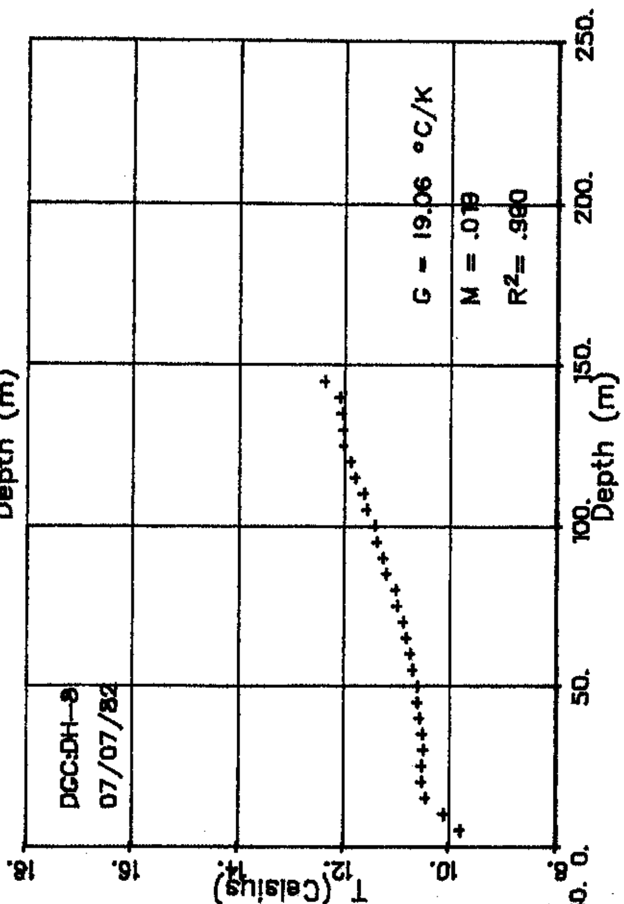

DGC:DH-8
07/07/82
G = 18.50 °C/K
M = .018
R² = .997
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

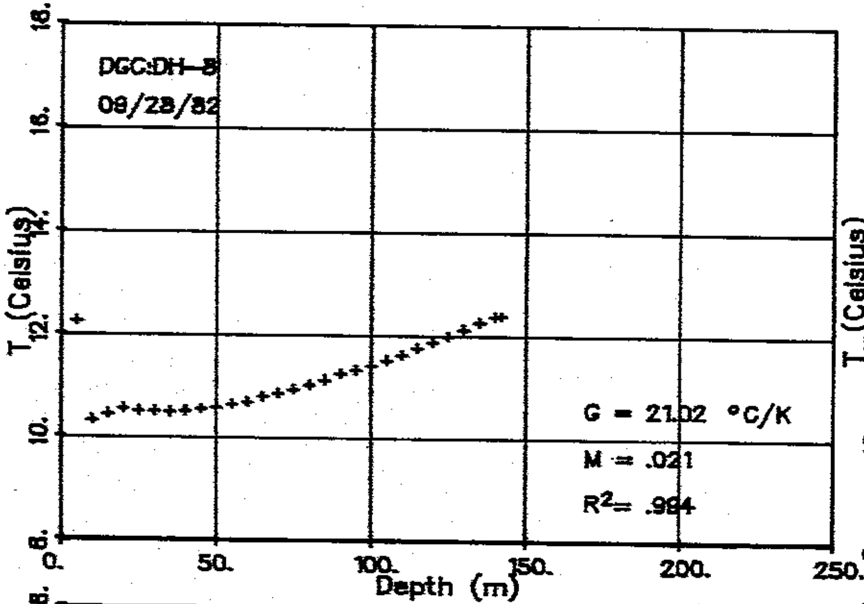

DGC:DH-7
07/20/82
G = 29.13 °C/K
M = .029
R² = .996
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

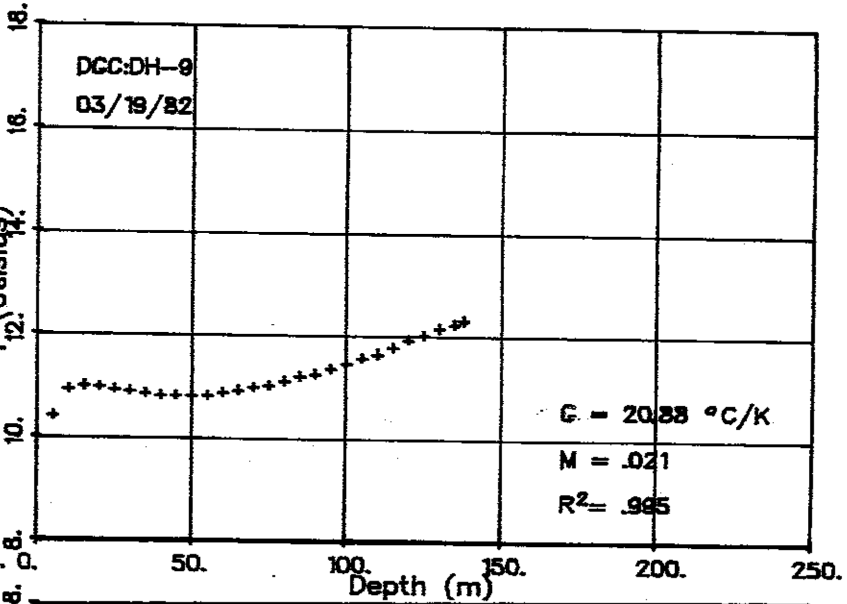

DGC:DH-8
01/05/82
G = 21.34 °C/K
M = .021
R² = .996
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

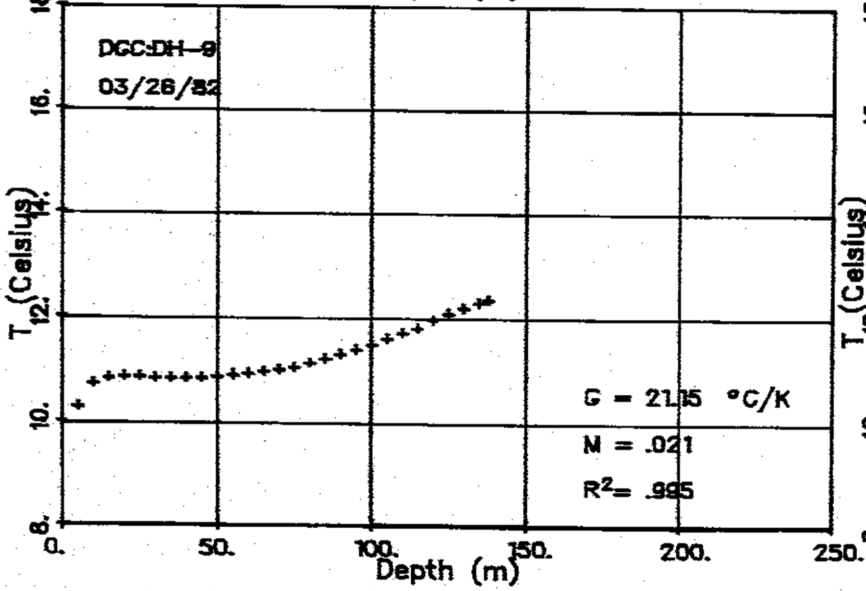

DGC:DH-8
04/05/82
G = 20.14 °C/K
M = .020
R² = .993
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

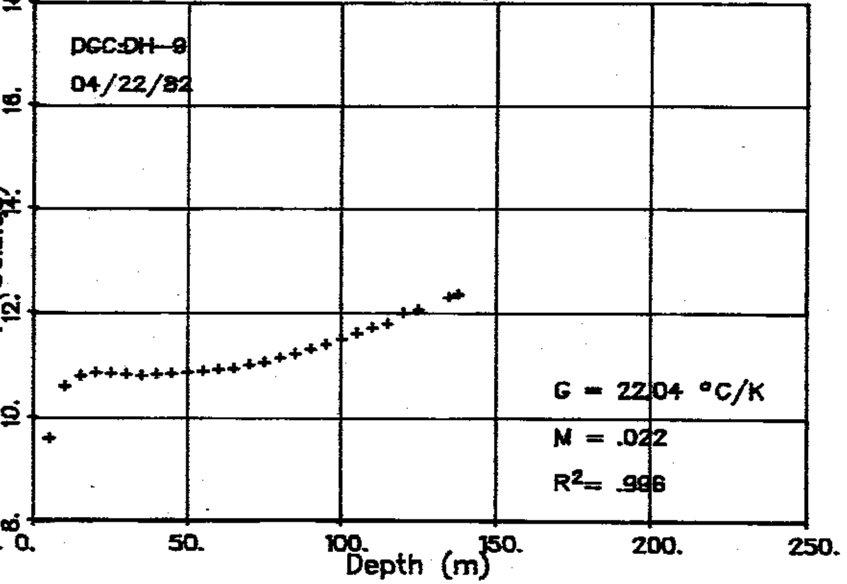

DGC:DH-8
04/18/82
G = 20.66 °C/K
M = .021
R² = .994
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

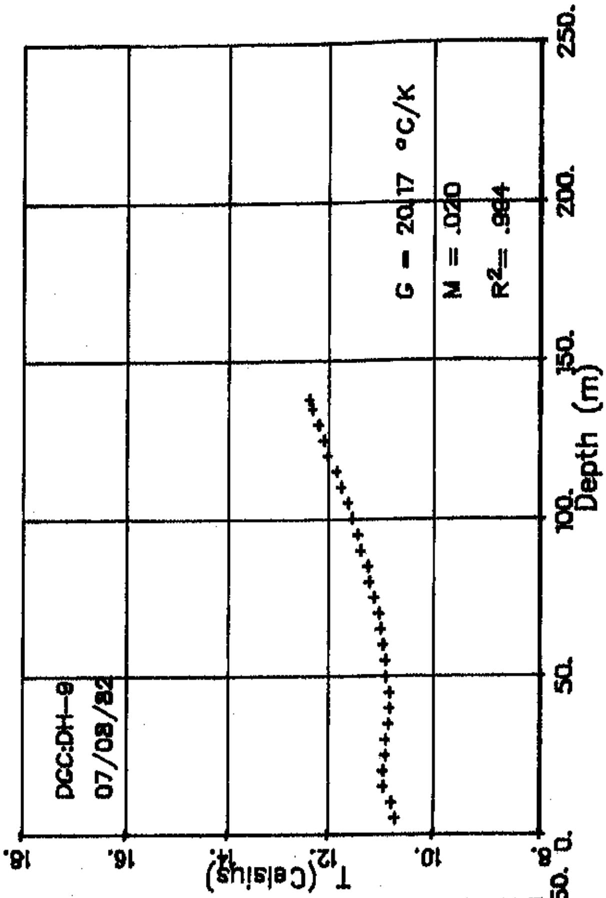

DGC:DH-8
07/07/82
G = 19.06 °C/K
M = .019
R² = .990
T (Celsius)
8.
10.
12.
14.
16.
18.
Depth (m)
0.
50.
100.
150.
200.
250.

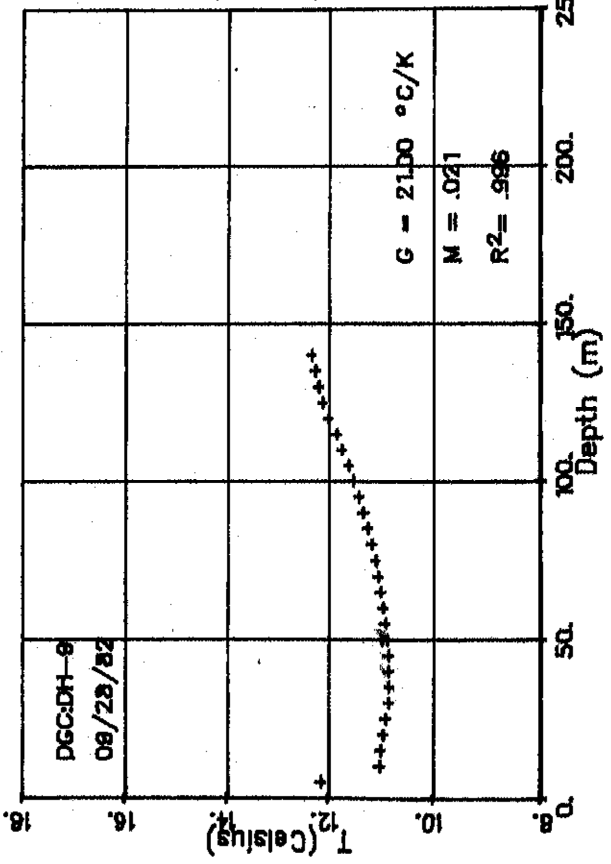

DGC:DH-8
09/28/82
G = 21.02 °C/K
M = .021
R^2= .994
T_{12}(Celsius)
18.
16.
14.
12.
10.
8.
0.
50.
100.
150.
200.
250.
Depth (m)


DGC:DH-9
03/19/82
G = 20.88 °C/K
M = .021
R^2= .995
T_{12}(Celsius)
18.
16.
14.
12.
10.
8.
0.
50.
100.
150.
200.
250.
Depth (m)


DGC:DH-9
03/26/82
G = 21.15 °C/K
M = .021
R^2= .995
T_{12}(Celsius)
18.
16.
14.
12.
10.
8.
0.
50.
100.
150.
200.
250.
Depth (m)


DGC:DH-9
04/22/82
G = 22.04 °C/K
M = .022
R^2= .996
T_{12}(Celsius)
18.
16.
14.
12.
10.
8.
0.
50.
100.
150.
200.
250.
Depth (m)


DGC:DH-9
07/08/82
G = 20.17 °C/K
M = .020
R^2= .984
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.


DGC:DH-9
08/28/82
G = 21.00 °C/K
M = .021
R^2= .996
Depth (m)
0.
50.
100.
150.
200.
250.
T (Celsius)
8.
10.
12.
14.
16.
18.

For further information
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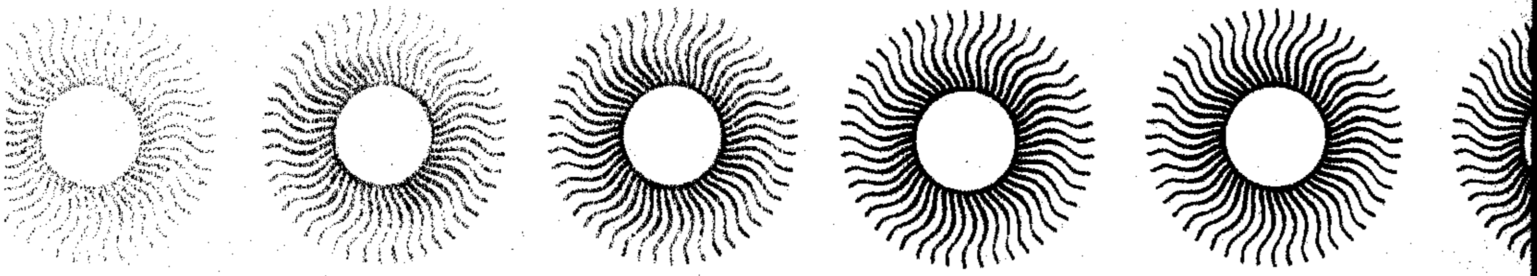
Director
Department of Communications
NYS Energy Research and
Development Authority
Two Rockefeller Plaza
Albany, N.Y. 12223
(518) 465-6251



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State of New York Mario M. Cuomo, Governor

New York State Energy Research and Development Authority
James L. Larocca, Chairman Irvin L. White, President