Energy, Mines and Resources Canada
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Énergie, Mines et Ressources Canada
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GEOTHERMAL SERVICE OF CANADA

A PERMAFROST MONITORING PROGRAM AT ALERT, N.W.T.

-- FIRST YEAR OF DATA

A.E. Taylor

iv + 31 pp. including 19 figures, 5 tables.

Price $14.50

Earth Physics Branch Open File Number 79-17
Ottawa, Canada 1979

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SUMMARY

This report outlines preliminary results of a permafrost study undertaken jointly by the Department of National Defence, the National Research Council of Canada and the Department of Energy, Mines and Resources at Canadian Forces Station Alert, N.W.T. (82°30'N, 62°26'W). The project commenced in September, 1978 with the drilling of five shallow holes to maximum depths of 61m in areas that would demonstrate the diverse nature of permafrost and the active layer at Alert. Temperature cables were installed in the drillholes and frequent measurements are being taken by DND personnel. Such detailed geothermal measurements have never before been available at such high Arctic latitudes.

A complete year of subsurface temperature observations, taken approximately every three weeks, is tabulated in this report. Graphs show the response of subsurface temperatures to seasonal climatic variation. While the two 15 m sites are similar thermally, the three 61 m sites are quite different from each other.

RESUME

Ce rapport détaille la base et les résultats préliminaires d'une étude du pergélisol entreprise conjointement par le Ministère de la défense nationale, le Conseil national des recherches du Canada et le Ministère de l'énergie, des mines et des ressources à la base des forces canadiennes, Alert, T.N.O. (82°30'N, 62°26'W). Le projet commença en septembre 1978 avec le forage peu profond de cinq trous, atteignant une profondeur maximum de 61m, dans des régions qui démontreraient le caractère divers du pergélisol et de la couche active à Alert. Des câbles de température furent installés dans les trous de forage et des mesures fréquentes sont prises par le personnel de la défense nationale. De telles mesures geothermiques n'ont jamais été prises si loin au nord.

Des mesures de la température du sol, prises toutes les trois semaines pendant une année complète, sont présentées dans ce rapport. Les graphiques démontrent l'effet des variations climatiques saisonnières sur les températures du sous-sol. Tandis que les caractères thermiques des deux sites de 15 m de profondeur se ressemblent, ceux des trois sites de 61 m sont très différents les uns des autres.

ACKNOWLEDGEMENTS

This project was undertaken with permission of the Canadian Armed Forces Communication Command. The success of the program is due largely to the interest of the personnel at Alert, who are taking the regular temperature measurements under difficult conditions and who have voluntarily repaired cables on several occasions.

We are aware of the following personnel who have taken measurements:

Oct. 19/78 - Nov. 2/78:	MWO R. Higgins and Sgt. A. Flemming
Nov. 18/78 - Jan. 18/79:	MWO R. Stover and Sgt. A. Flemming
Feb. 12/79 - May/79:	MWO R. Stover and Sgt. T. Shields
June/79 - July 31/79:	Sgt. T. Shields
Aug. 17/79 -	Sgt. G. Boulanger and Cpl. G. Withenshaw

The present author has benefitted from discussions with Dr. A.S. Judge (EMR), Dr. R.J.E. Brown (NRC) and Mr. J. Pilon (DND), who are involved in the Alert Program as well.

CONTENTS

INTRODUCTION

One year has passed since temperature measuring cables were installed to depths of up to 61m at five sites in the vicinity of Canadian Forces Station Alert, N.W.T. (Fig. 1). These thermistor cables have been read by Station personnel approximately every three weeks and the resulting subsurface temperatures represent a unique record in permafrost studies for such a high latitude. The project is continuing.

This report summarizes the activity in this project over the year, concentrating on progress made since a preliminary report was written in March (Brown et al., 1979). The data accumulated to the present time appear here as a set of five tables and sixteen graphs; a brief assessment of the data and their implications are discussed.

PROJECT ACTIVITY

During the year, 121 temperature logs have been taken, representing over 1300 individual subsurface temperatures. Tables 1 to 5 present the sequence of temperature - depth profiles measured at each site. Each temperature sensor is calibrated absolutely to 0.1K; however, these thermistors are very stable and have a repeatability at least an order of magnitude better than this. Successive logs at Alert demonstrate that temperature changes of the order of 0.01K are being resolved, a credit to the care with which the measurements are being taken.

A number of temperatures at two sites are missing, a result of foxes damaging the cables between the ground surface and the tripod. No data could be retrieved at site 3 after the end of December, until the cable was repaired by Sgt. Shields early in May, 1979. Foxes severed a number of wires within

the cable at site 5, and generally readings at five depths are missing from Dec. 28 until the cable was repaired by Sgt. Shields in June 1979. The cable at site 2 was broken by animals in early September, 1979 but the cable was repaired without loss of any temperature measurements. As a result of this experience at Alert and at several other areas, thermistor cables are now manufactured with braided shielding slipped over the section expected to protrude above the surface.

Measurements of snow depth and snow density were instituted in May 1979. These measurements were taken at four places in the vicinity of each site and will prove very helpful in assessing the response of subsurface temperatures to weather conditions. Monthly climatological summaries, providing daily mean temperatures and other data observed at the Alert weather station, have been obtained from the Canadian Climate Centre, Environment Canada.

THE DATA

A selection of the temperature profiles listed in Tables 1 to 5 are presented graphically in Figures 2 to 6. Temperature profiles at the deep sites show that the seasonal variation is less than 0.2 K at depths greater than 20m. Typical winter and summer temperature profiles at the five sites are compared in Figure 7. These graphs show that wide variations in temperature have occurred over the year in the upper few metres; the minimum and maximum subsurface temperatures experienced last year are compared for each site in Figure 8.

As data has been collected regularly throughout the year, temperatures measured at several depths are plotted for each site versus date (Figures 9-13). Weekly mean air temperatures, extracted from the climatological

summary sheets of the Alert weather station for the same period, are plotted on these graphs. The gap in measurements at site 3 makes this comparison of little value at present.

The data may also be viewed when contoured with respect to temperature. This analysis is particularly sensitive to a regularly spaced density of measurements in depth and time. The contour plot in figure 14 for site 1 emphasizes that most of the subsurface temperature variations occur in the upper 10 to 15m. Figure 15 shows the detail in this region, as recorded at site 4.

The relationship between air and subsurface temperatures is important to the interpretation of the subsurface thermal regime. Snow cover insulates the ground from severe fluctuations of air temperature and measurements of snow depth and density have been added to the program. Figure 16 depicts the snow depths averaged over four locations near each cable site since spring, 1979.

DEEP TEMPERATURES

Figure 7 may be used to compare the temperature gradients in the lower section of holes 1, 2 and 3. The high gradient at site 1 (about 54 mK/m) is undoubtedly a result of its proximity to the sea and of the large drop in surface temperature as this near-shore site emerged from the sea several thousand years ago, in response to glacial unloading (Brown et al., 1979).

The geothermal gradients at sites 2 and 3 (27 mK/m and 14 mK/m) are in the range expected for this geologic environment. Further analysis must await the completion of thermal conductivity measurements on the drill core.

SHALLOW TEMPERATURES

The seasonal variation in subsurface temperatures is depicted in the upper portion of the deep sites, and at sites 4 and 5 (Fig. 5 and 6). The temperature sensors nearest the surface are at depths of 0.8m and this is generally below the active layer that seasonally thaws. At site 4, temperatures reached 0°C at the end of July but at site 5, the temperature did not warm further than -1.47°C at this depth (Table 4 and 5).

Temperatures near the surface tend to lag behind air temperatures. At a depth of 0.8m temperatures lag about a week, but the lag time increases at greater depths. The effect is seen in Fig. 12 and 13 if the seasonal air temperature minimum or maximum is compared to the occurrence of a similar, but smoothed, peak in the subsurface temperatures. While one week averages have been taken for the air temperatures, subsurface temperatures have been measured approximately every three weeks. In addition, the ground acts as a filter, reducing the detail seen in successively deeper temperatures. This is readily seen in figures 9-13.

The time lag observed in the propagation of surface temperature changes into the ground results in subsurface temperatures between 6 and 10m being warmer in the winter than in the summer. Figure 7 shows the subsurface temperature curves peaking to warmer temperature in winter (upper) but cooler temperatures in summer (lower). Similarly, Figure 14 depicts the -14°C isotherm penetrating deeper than the first thermistor by mid-November, 1978 at site 1; this isotherm reaches its maximum depth by the end of July. Although the mean annual air temperature is -18°C, (Environment Canada, 1975), the ground deeper than about one meter experiences temperatures colder than this to a relatively shallow depth and for a short period of time (stipled area in

figure 14). At site 4, the -18°C isotherm reaches its maximum penetration of about 10m by early July (stipled, Fig. 15).

The range of temperatures recorded over the year at four of the five sites is depicted in figure 8. Site 3 is omitted because of the absence of several months of winter data. The span between the "minimum" curve for a site, and the "maximum", represents the range of temperatures experienced at that site for the upper 8m.

Site 1 exhibits the smallest range, possibly due to the moderating influence of the sea; site 1 is also a warmer site since the median of its envelope is displaced several degrees higher relative to envelopes of the other sites.

Sites 4 and 5, on south - and north - facing slopes, respectively (figure 1), are surprisingly similar in their temperature ranges (figure 8) and snow cover (figure 16). Distinct thermal differences are observed on north - and south - facing slopes at much lower latitudes; also, the local topography of these sites would have suggested a much deeper snow accumulation.

SURFACE TEMPERATURES

This project was not designed to take direct measurements within the active layer. Extrapolating temperatures measured well below the penetration of the seasonal variation yields a surface temperature that represents average conditions over tens of years. This extrapolation, shown on figure 7 (upper), gives the following results:

$$\text{Site 1, } T_{surface} = -13.5°C$$

$$\text{Site 2, } T_{surface} = -16.3°C$$

$$\text{Site 3, } T_{surface} = -14.6°C$$

All values are significantly warmer than the 20 year average air temperature (-18°C). Site 1 is significantly warmer than the other two sites. Site 2 is the coldest, possibly because of its exposed plateau location. Figure 16 shows, of the three deep sites, that the least snow cover occurred at site 2, although this represents snow depth measurements only since late May.

CONCLUSION

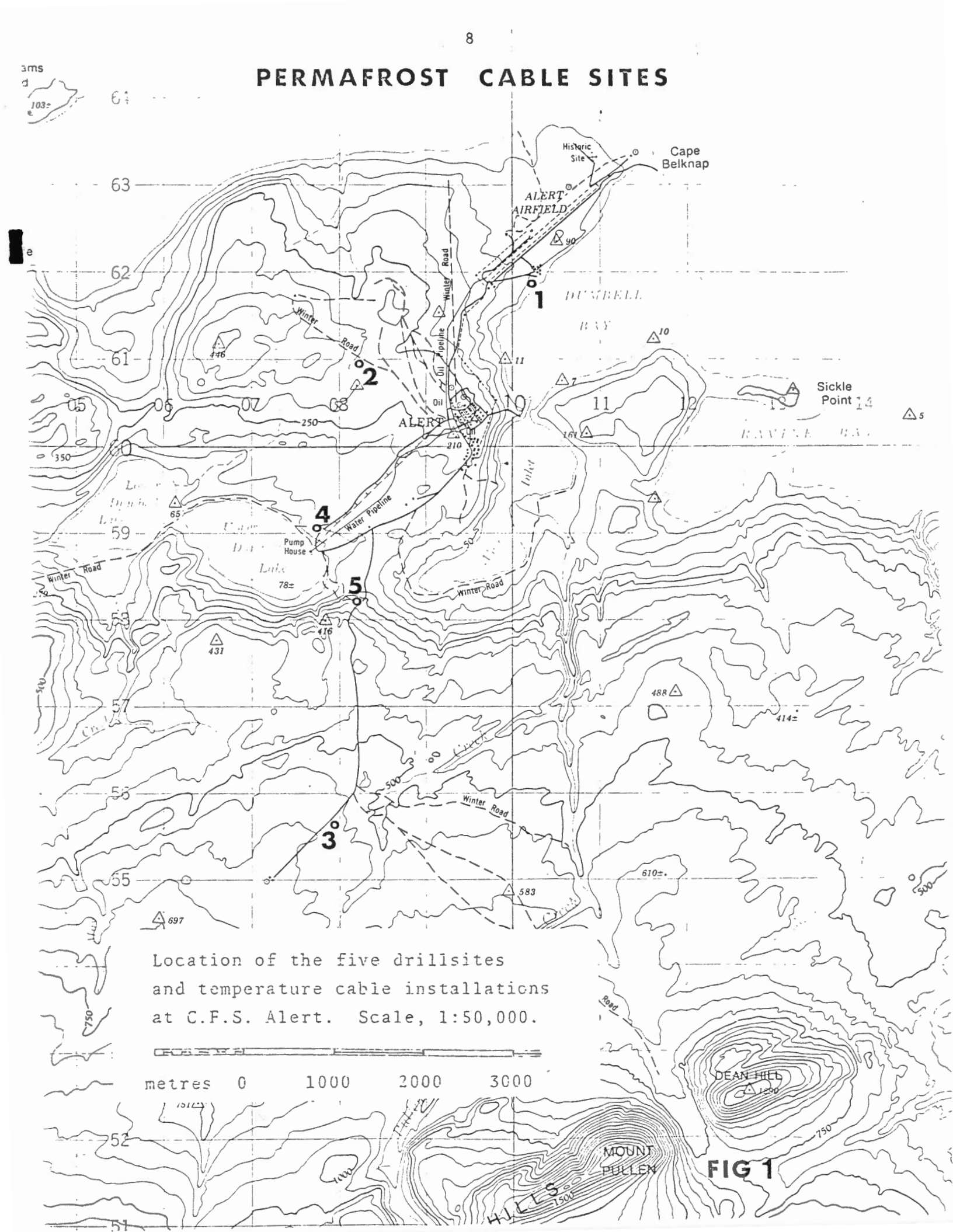
The temperature data accumulated at Alert is of exceptionally high quality. Measurements in 1980 will reinforce trends seen in the first year's results, and will provide data missed at some sites due to cable damage. Further detailed studies using this data will be undertaken in the coming year, leading to an understanding of the dynamic behaviour of near-surface permafrost at Alert.

BIBLIOGRAPHY

Brown, R.J.E., A.S. Judge, J. Pilon, A.E. Taylor and P.E. Gratton-Bellew, 1979. A permafrost monitoring program at Alert, N.W.T. ---Project description and preliminary results. Earth Physics Branch, E.M.R., open file number 79-5, 48 pp.

Environment Canada, 1975. Canadian Normals - Temperature, 1941-1970, Vol. I - SI. Downsview, 198 pp.

PERMAFROST CABLE SITES



Location of the five drillsites and temperature cable installations at C.F.S. Alert. Scale, 1:50,000.

metres 0 1000 2000 3000

FIG 1

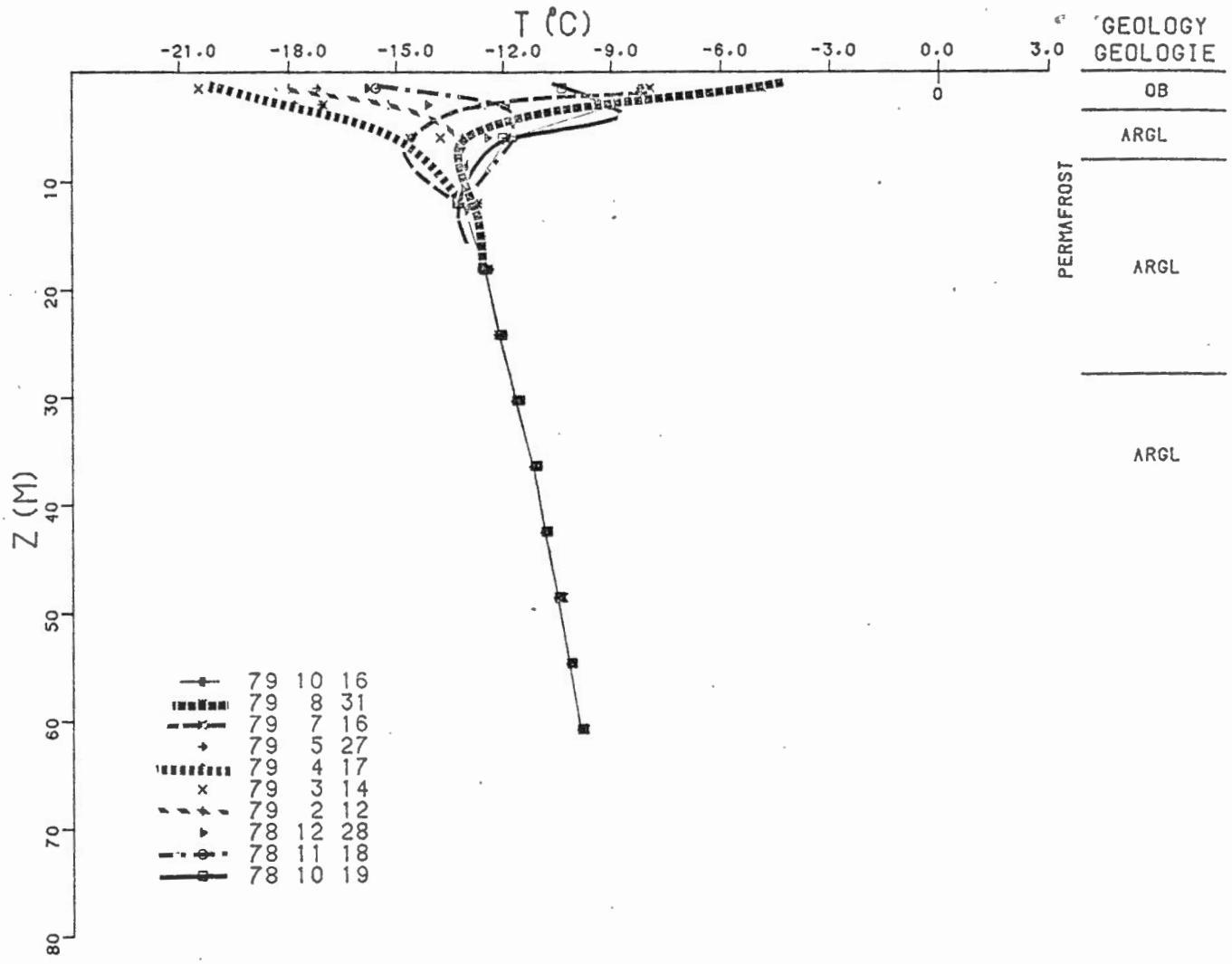


FIGURE 2a

Temperature profiles measured on various dates at site 1. OB, overburden. ARGL, argillite.

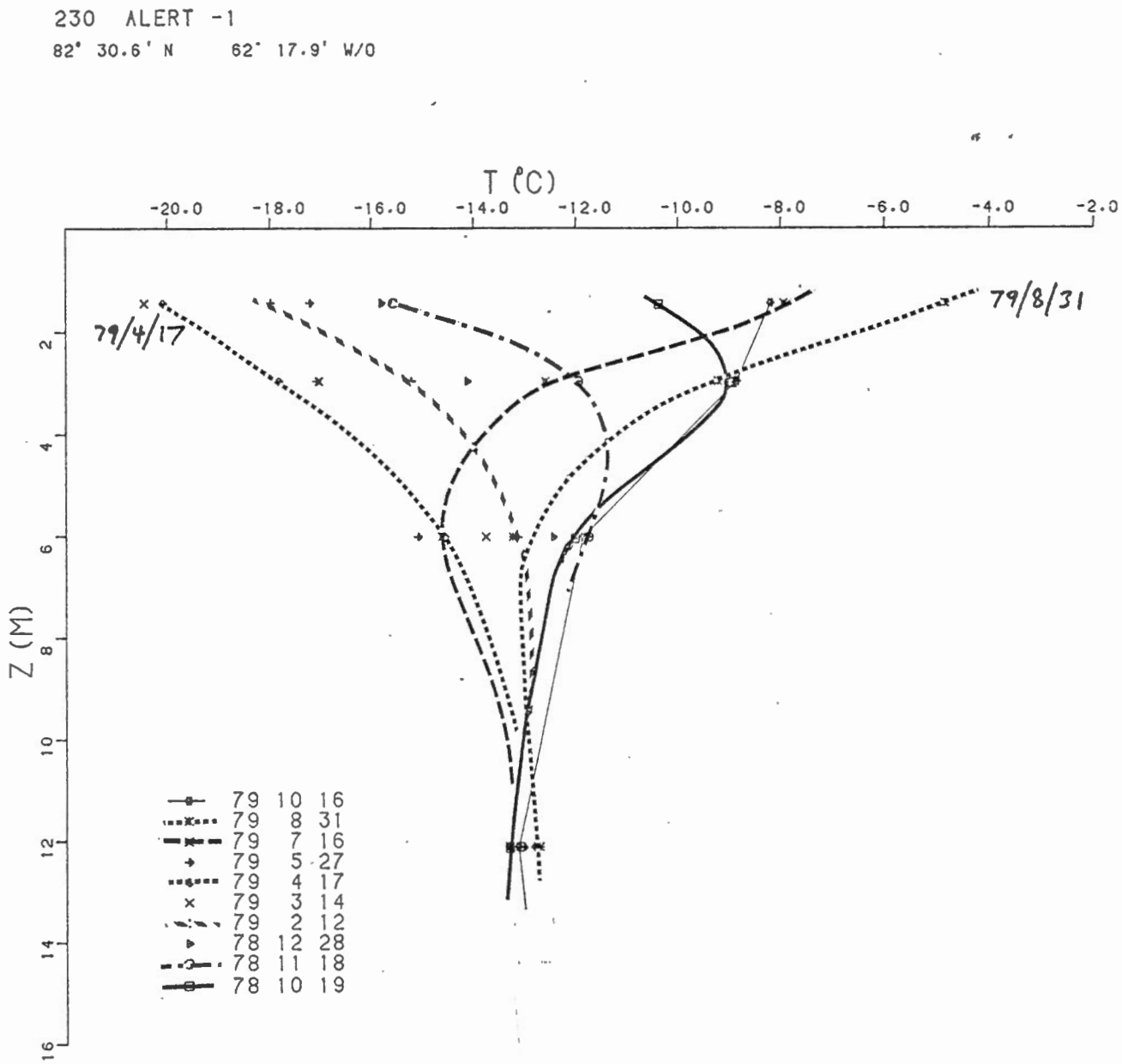


FIGURE 2b.

Temperature profiles measured on various dates at site 1.

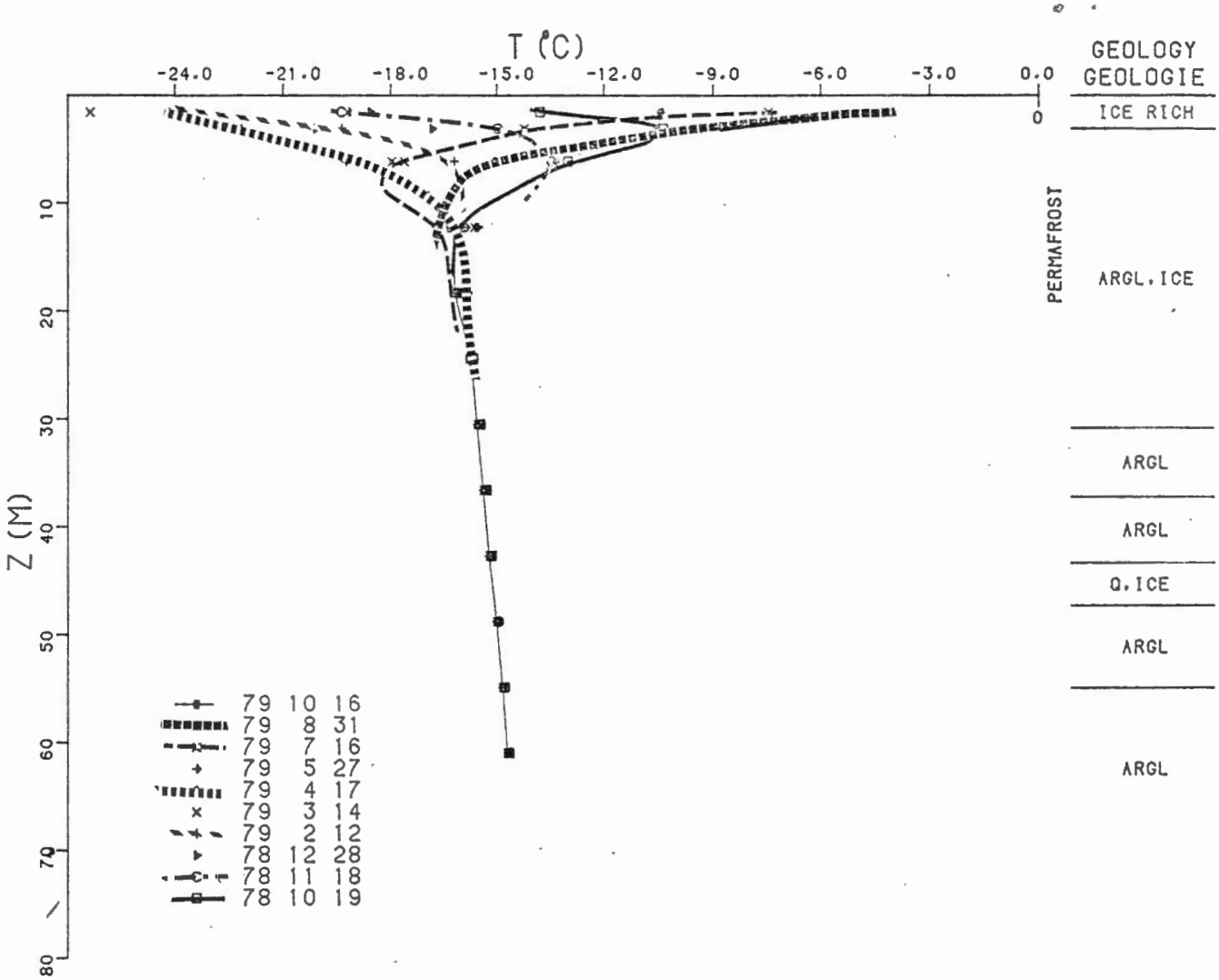


FIGURE 3a

Temperature profiles measured on various dates at site 2. ARGL, argillite. Q, quartz.

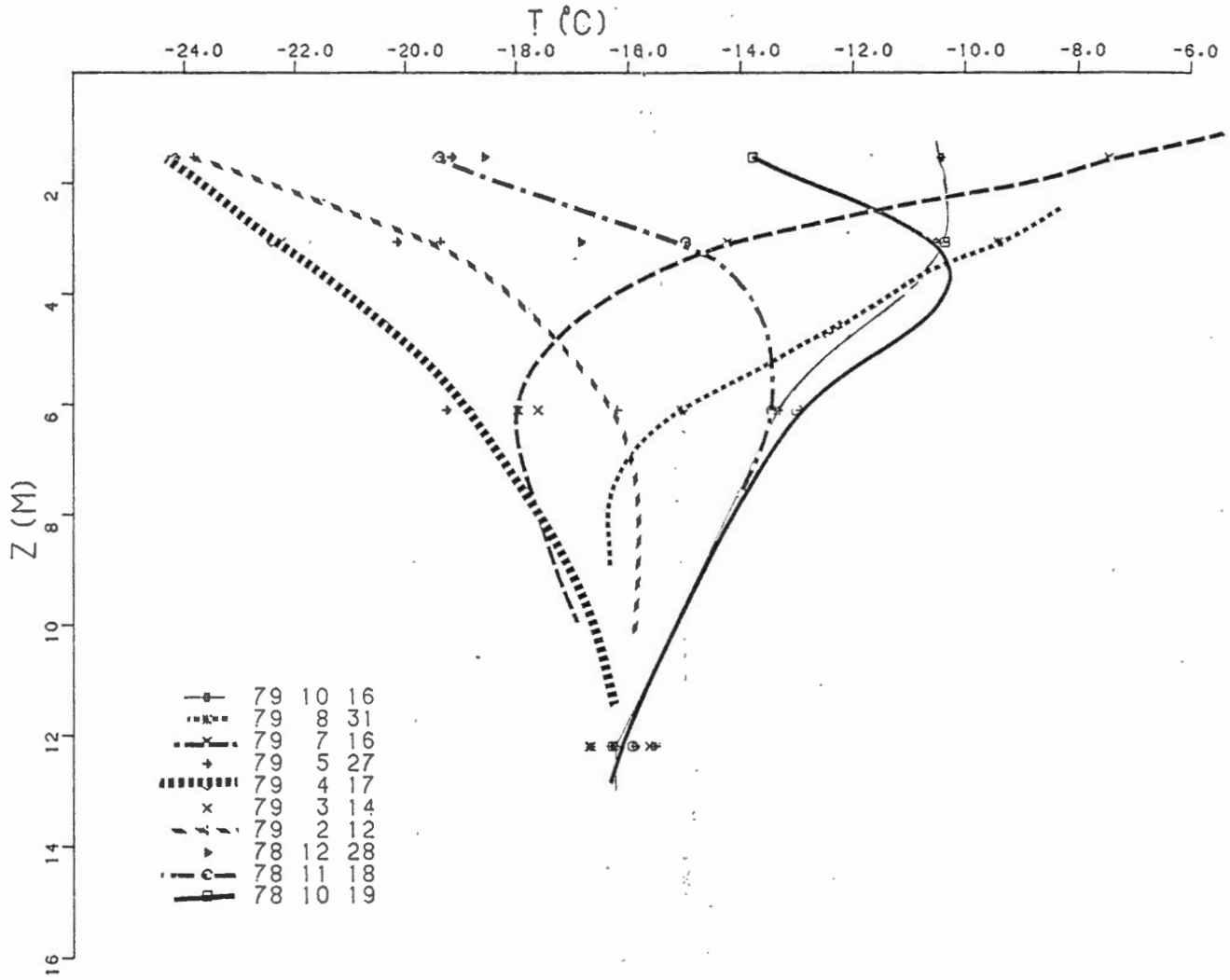


FIGURE 3b

Temperature profiles measured on various dates at site 2.

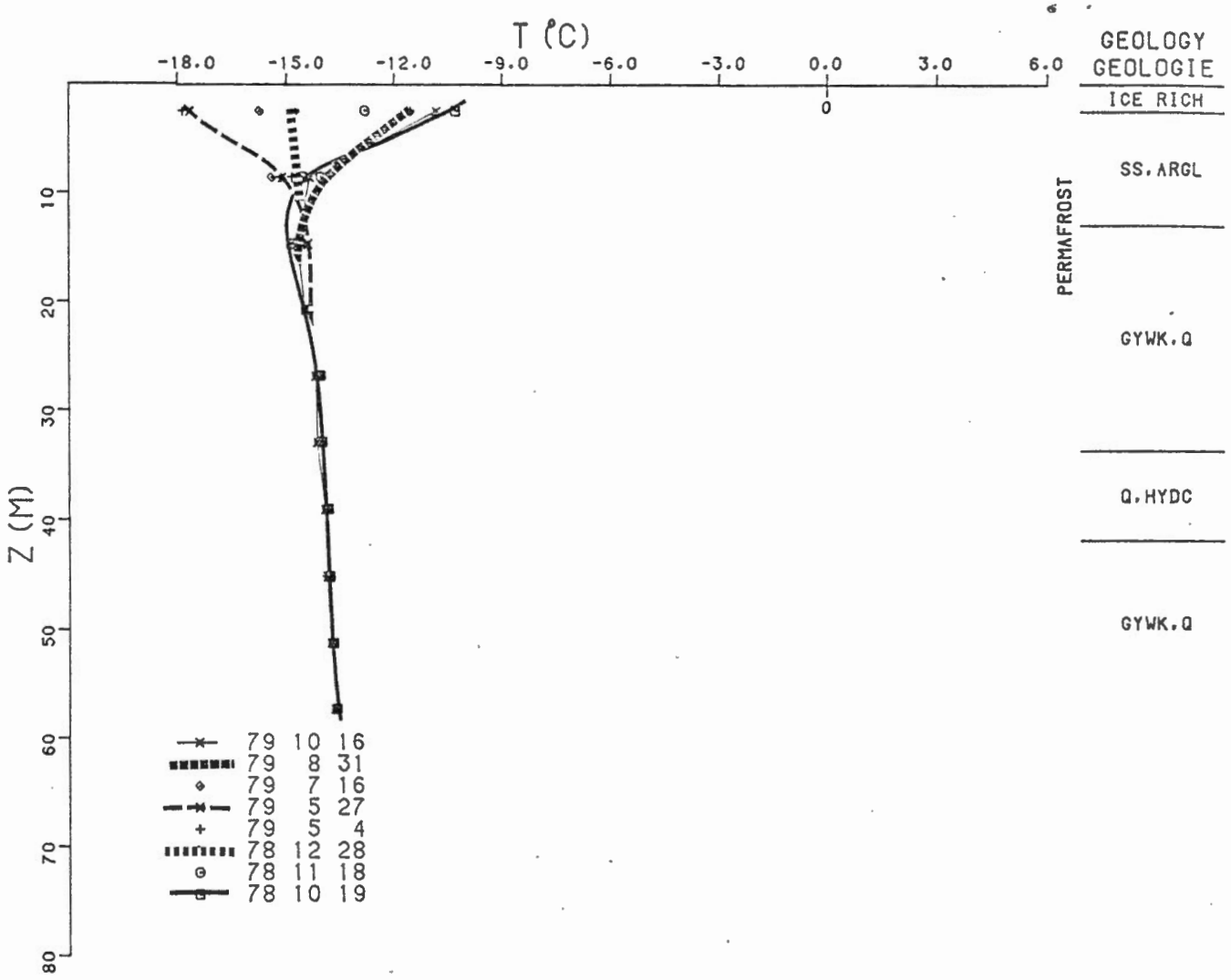


FIGURE 4a

Temperature profiles taken on various dates at site 3. ARGL, argillite. GYWK, greywacke. Q, quartz. HYDC, hydrocarbon. SS, sandstone.

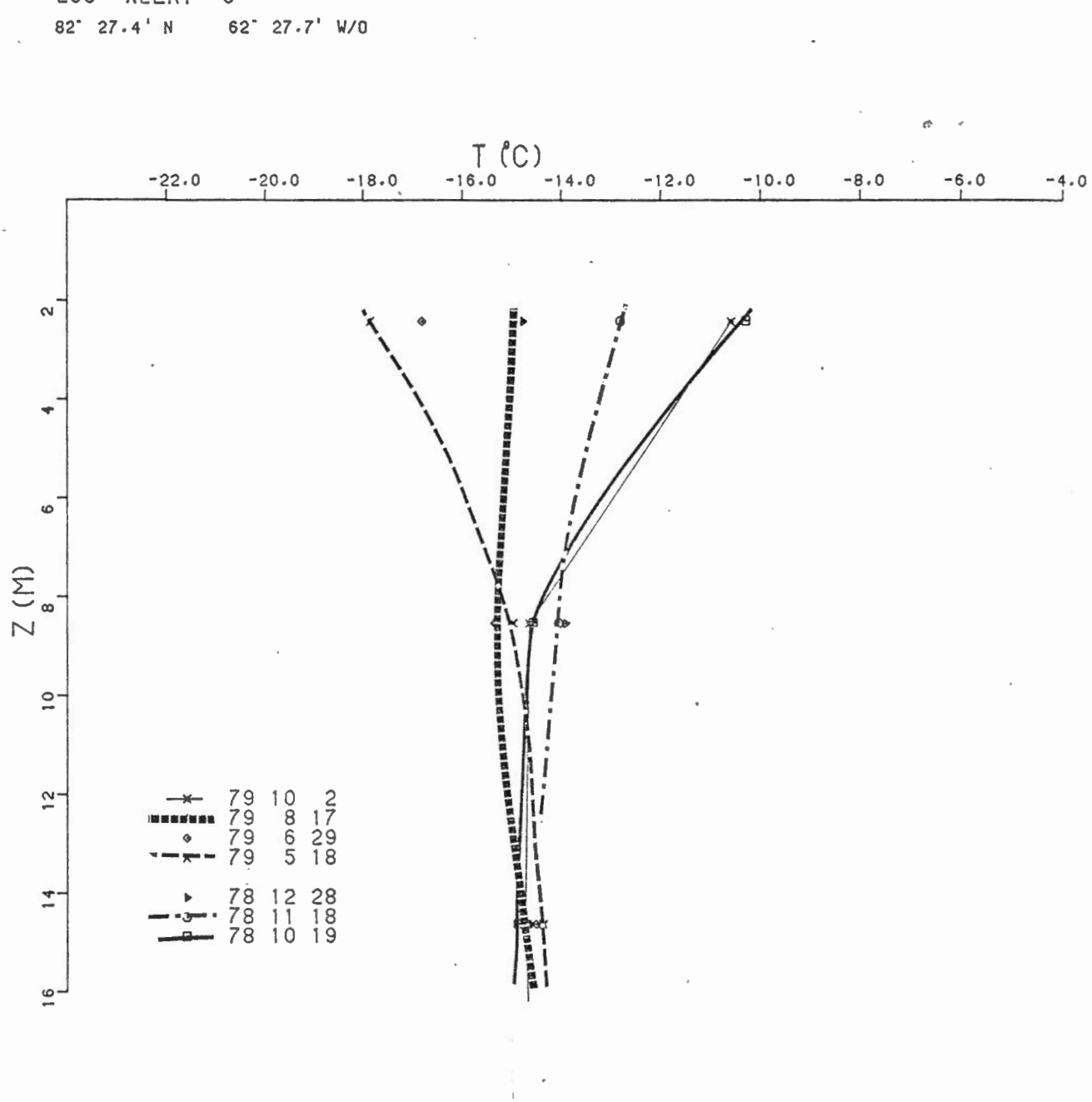


FIGURE 4b

Temperature profiles taken on various dates at site 3.

230 ALERT -4
82° 29.1' N 62° 28.3' W/O

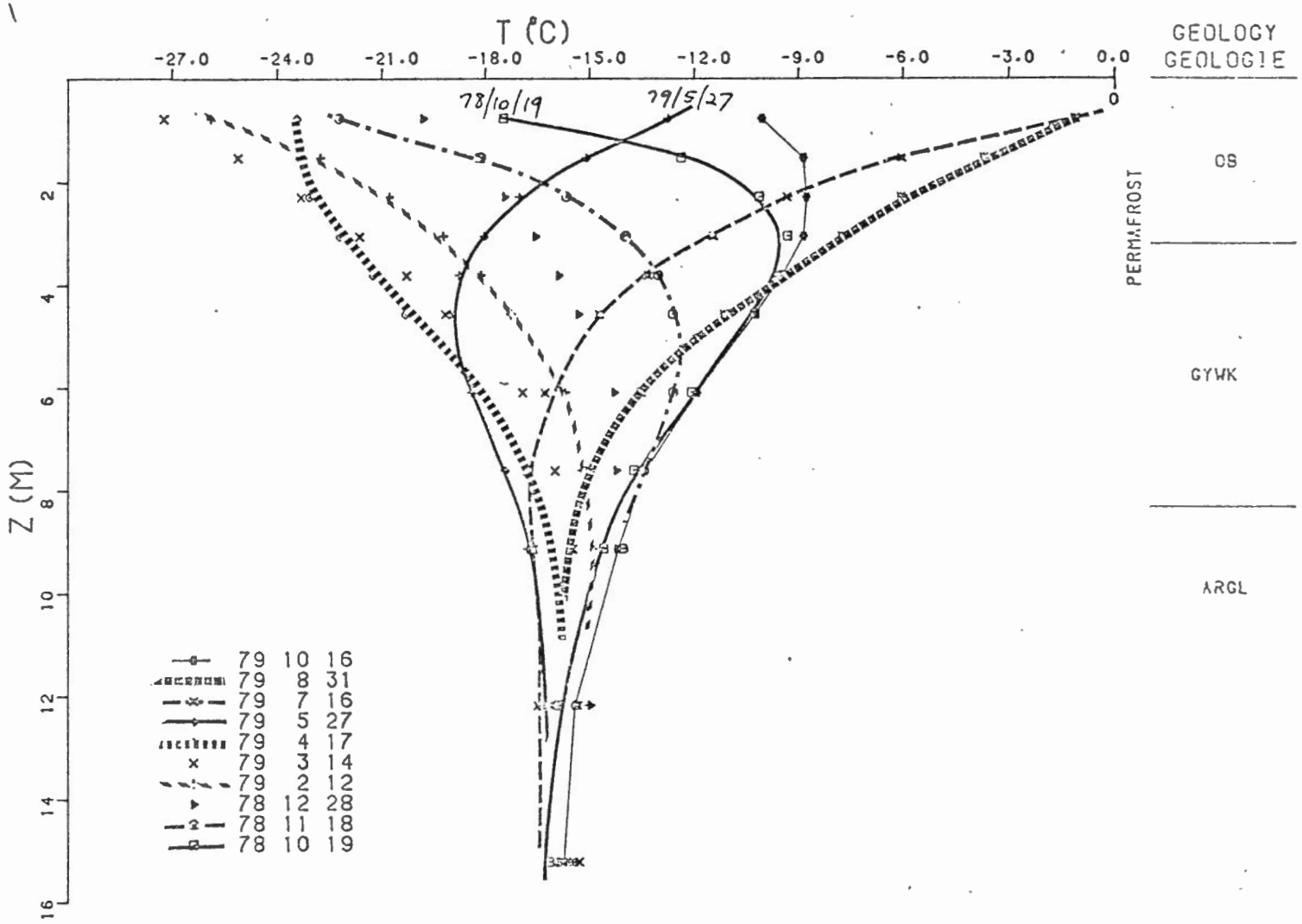


FIGURE 5

Temperature profiles measured on various dates at site 4. OB, overburden. GYWK, greywacke. ARGL, argillite.

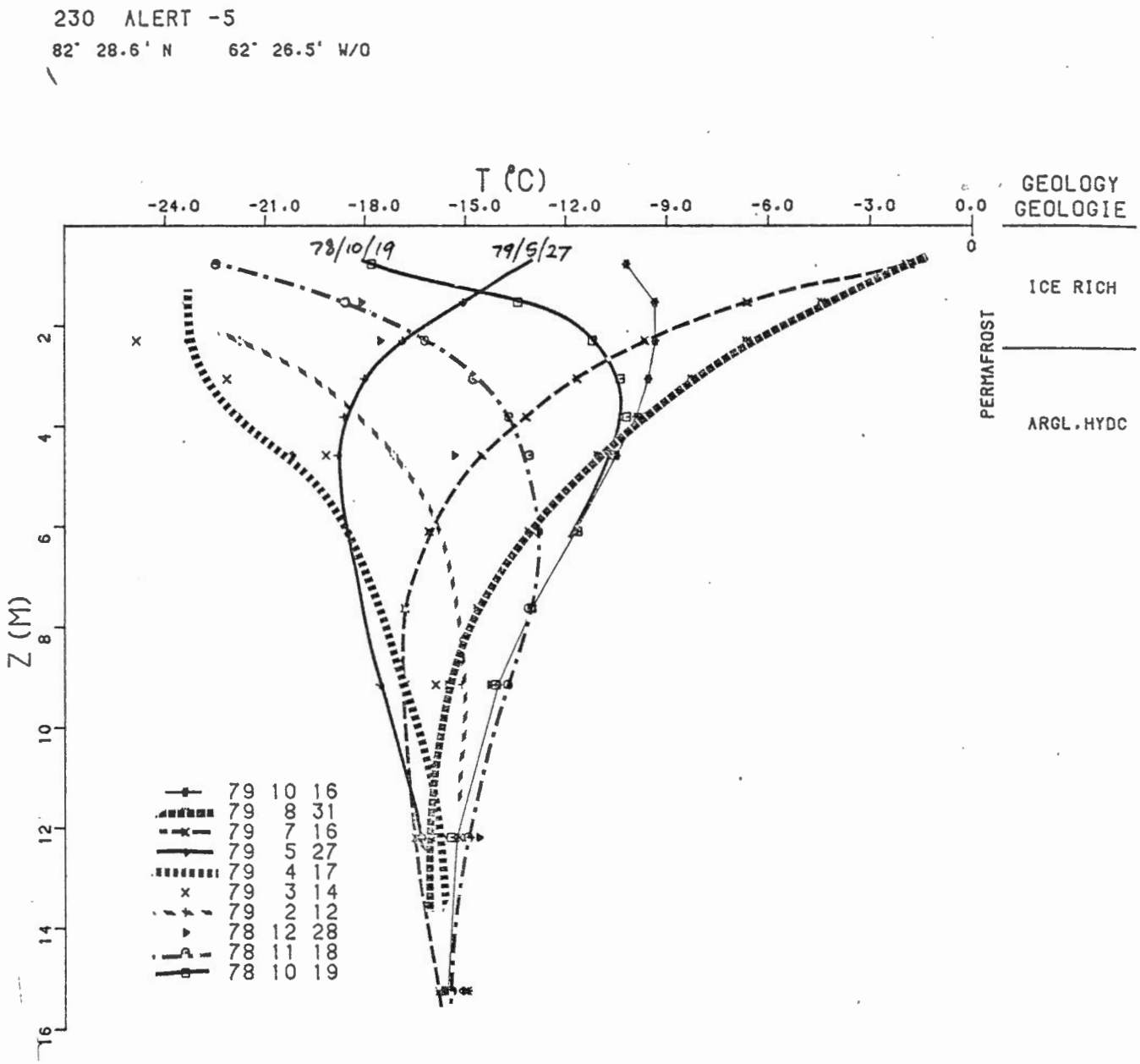


FIGURE 6

Temperature profiles measured on various dates at site 5. ARGL, argillite. HYDC, hydrocarbon.

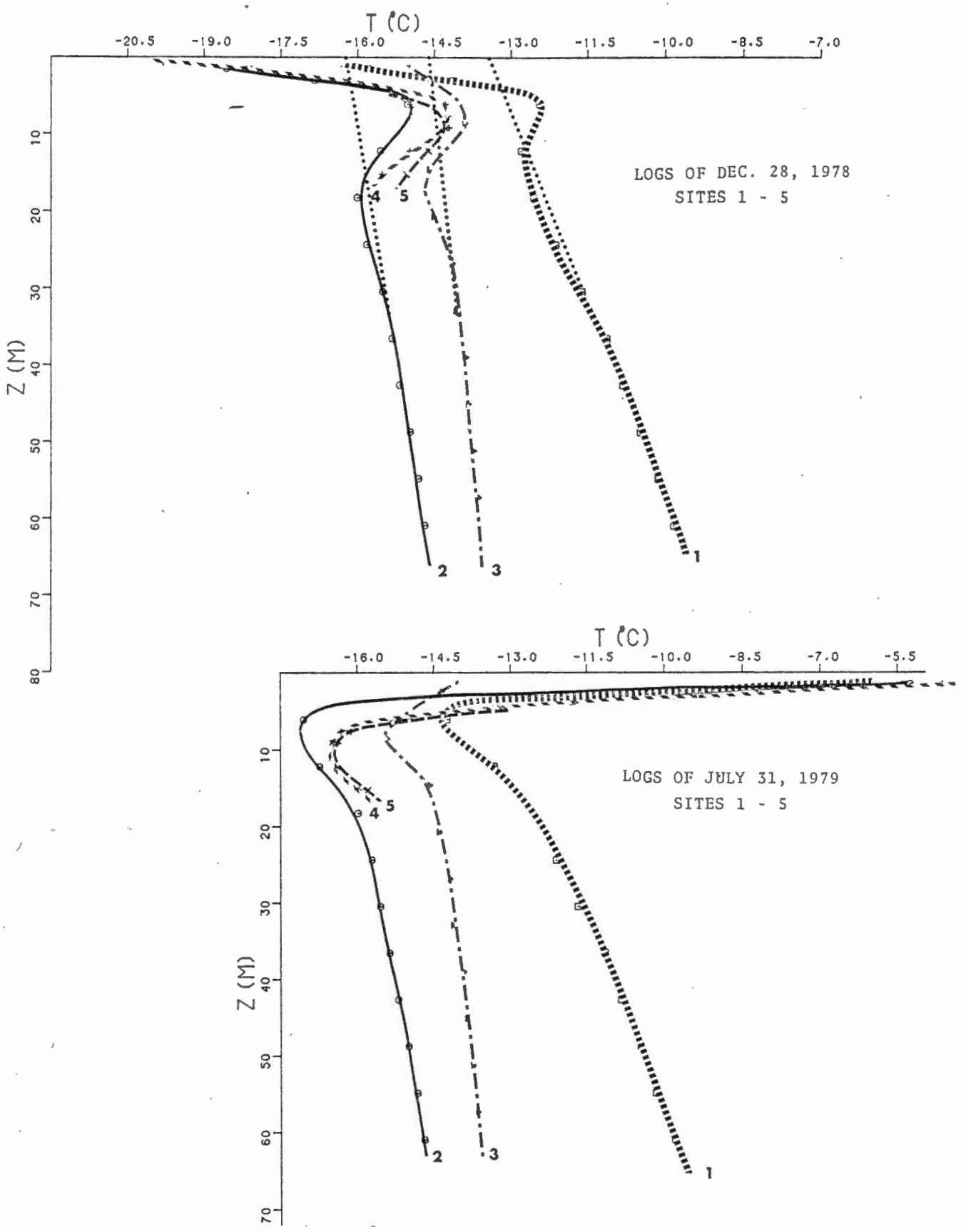


FIGURE 7

Temperature profiles measured in the winter and summer

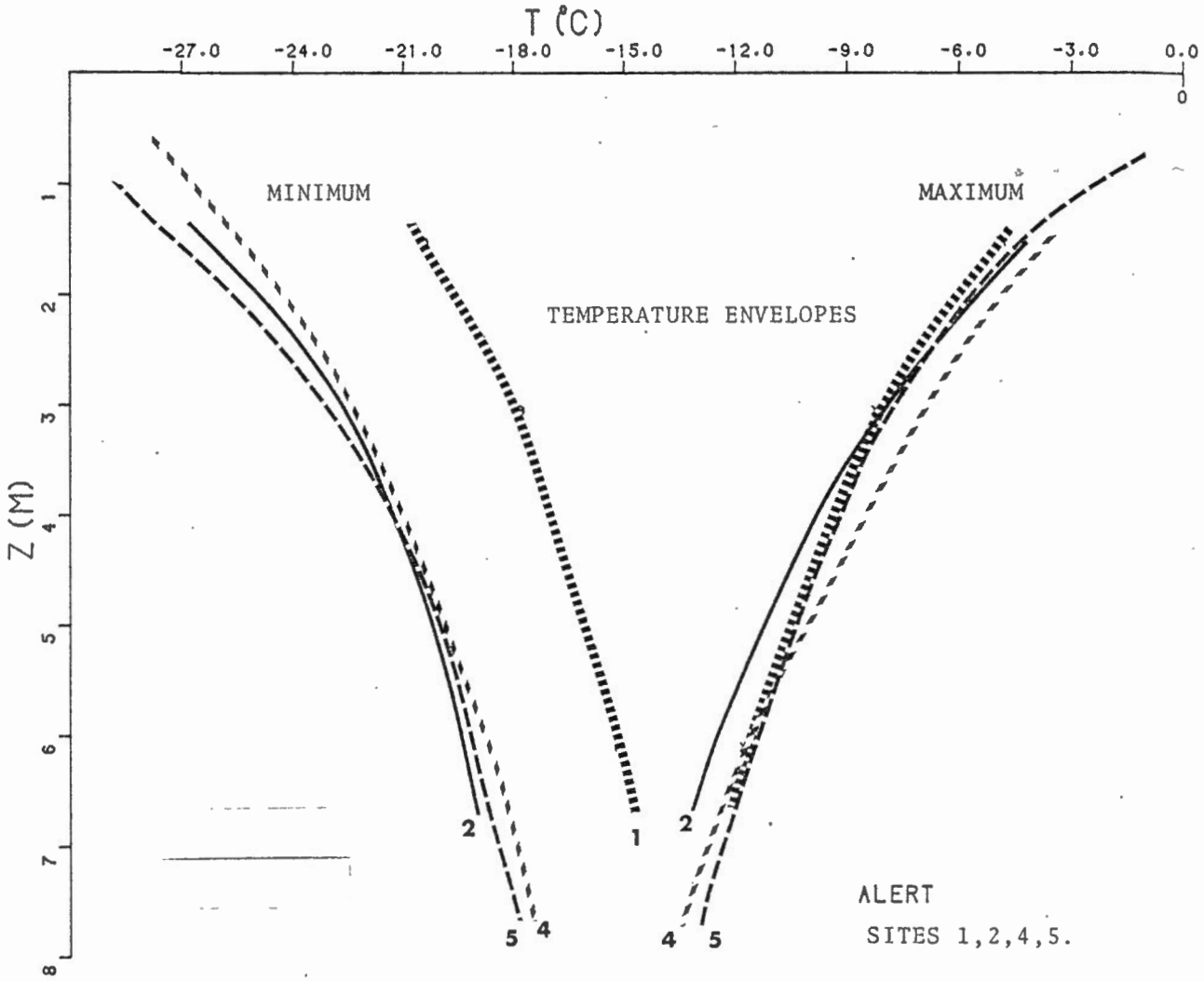


FIGURE 8

Minimum to maximum temperature envelope observed in the upper 8m at the sites (except site 3), for a full year. Oct. 1978 - Oct. 1979.

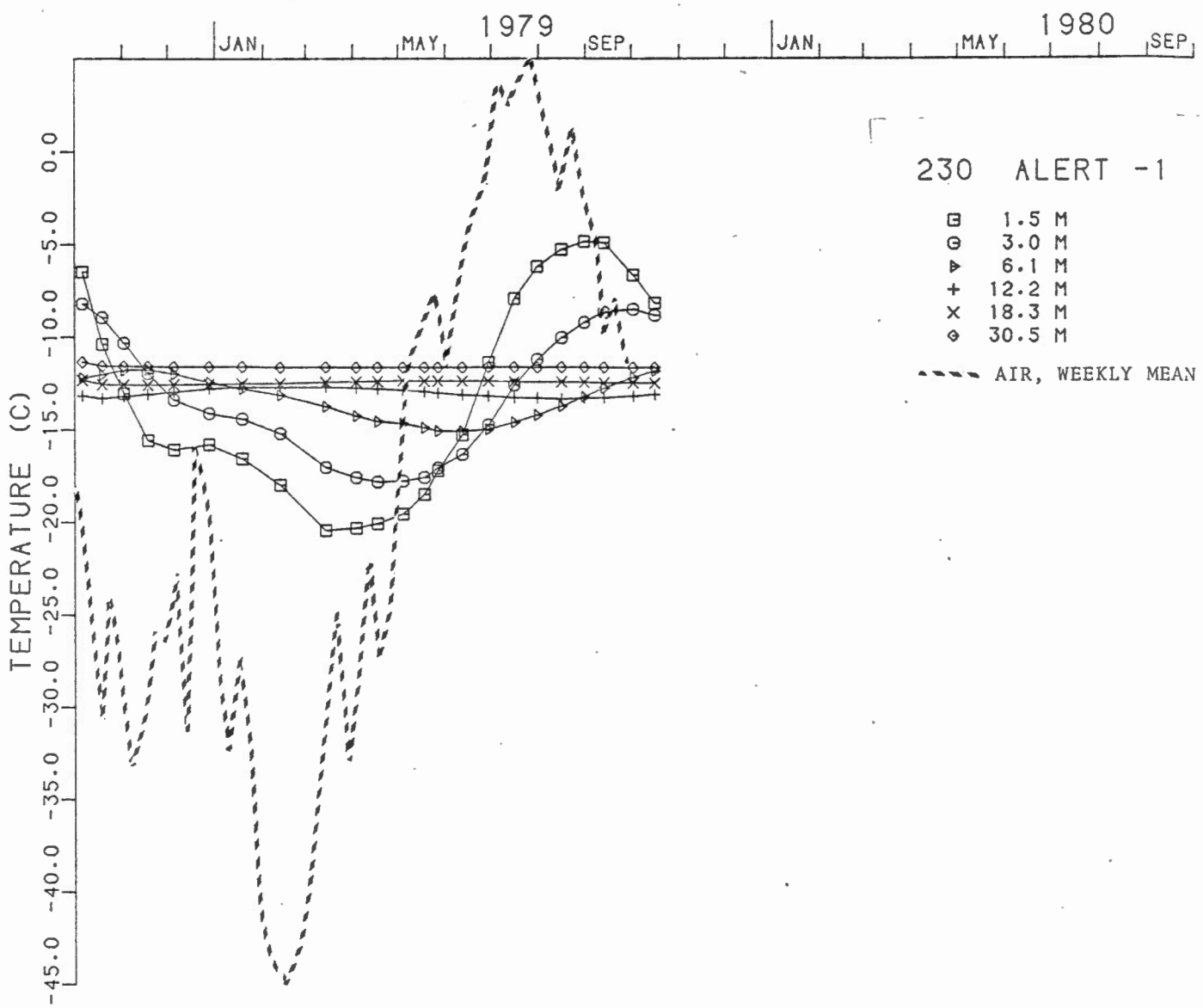


FIGURE 9

Variation of temperature with time at selected depths at site 1. Weekly mean air temperatures are included for comparison.

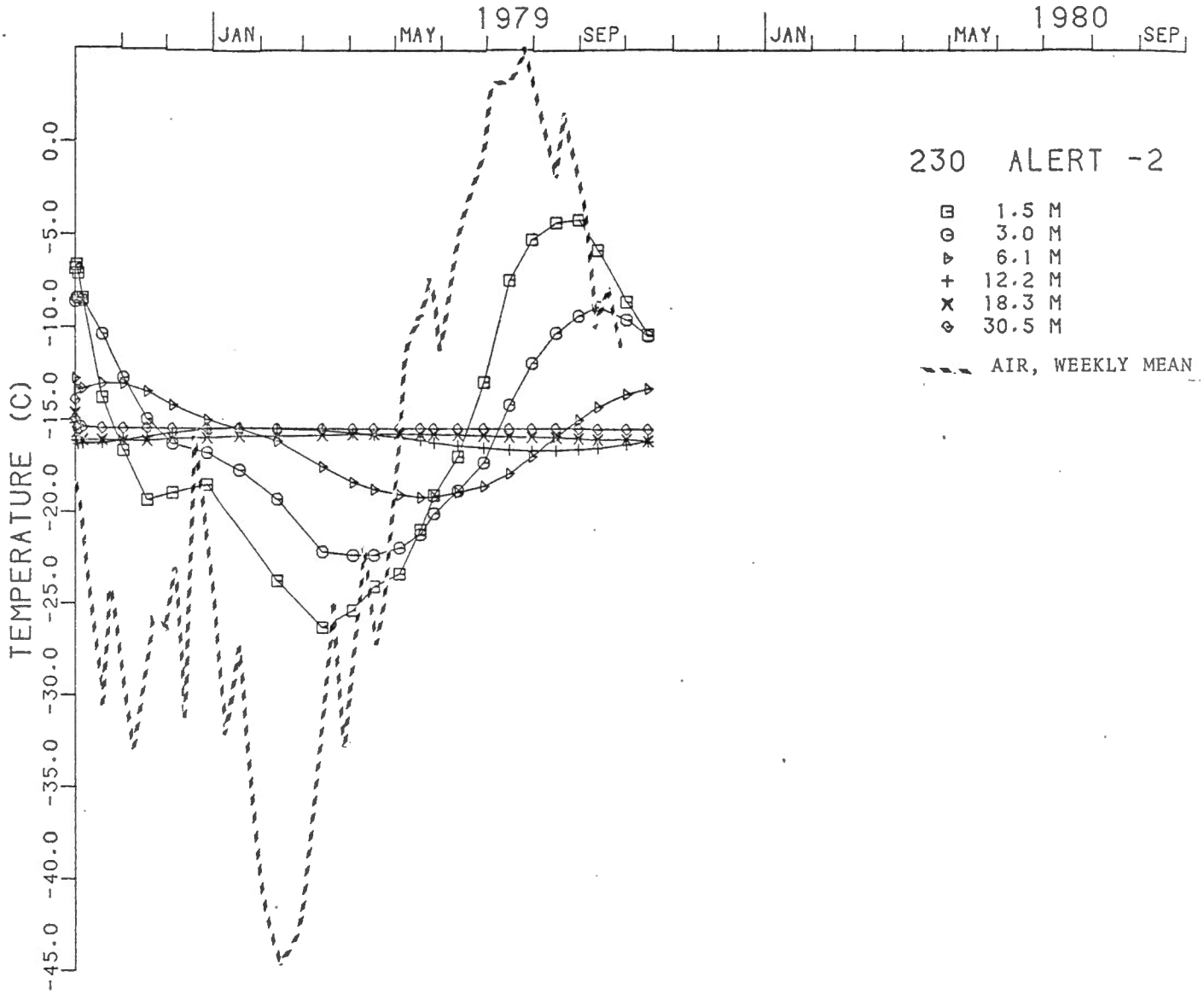


FIGURE 10

Variation of temperature with time at selected depths for site 2. Weekly mean air temperatures are included for comparison.

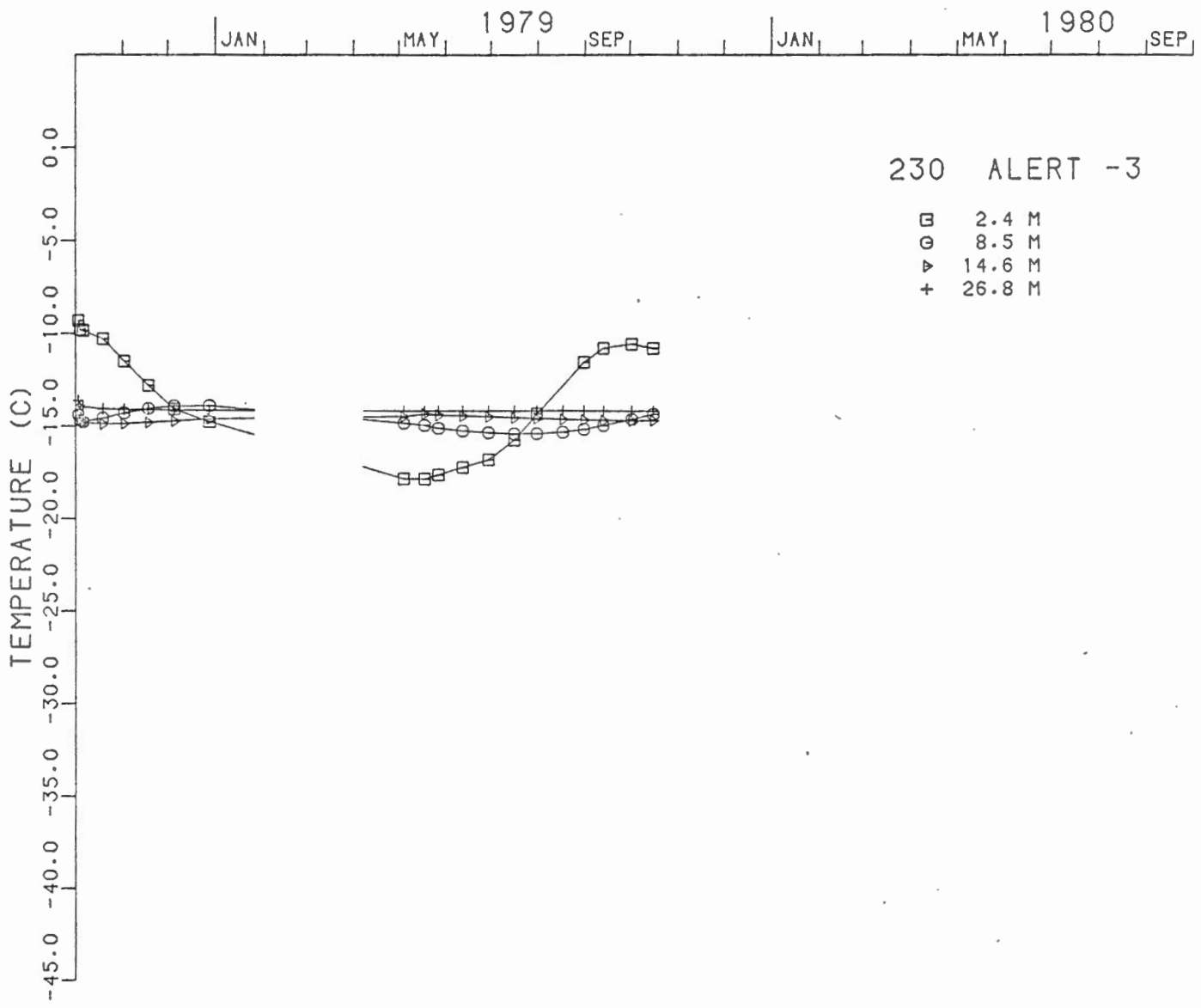


FIGURE 11

Variation of temperature with time at selected depths at site 3. Cable damage prevented measurements during winter, 1979.

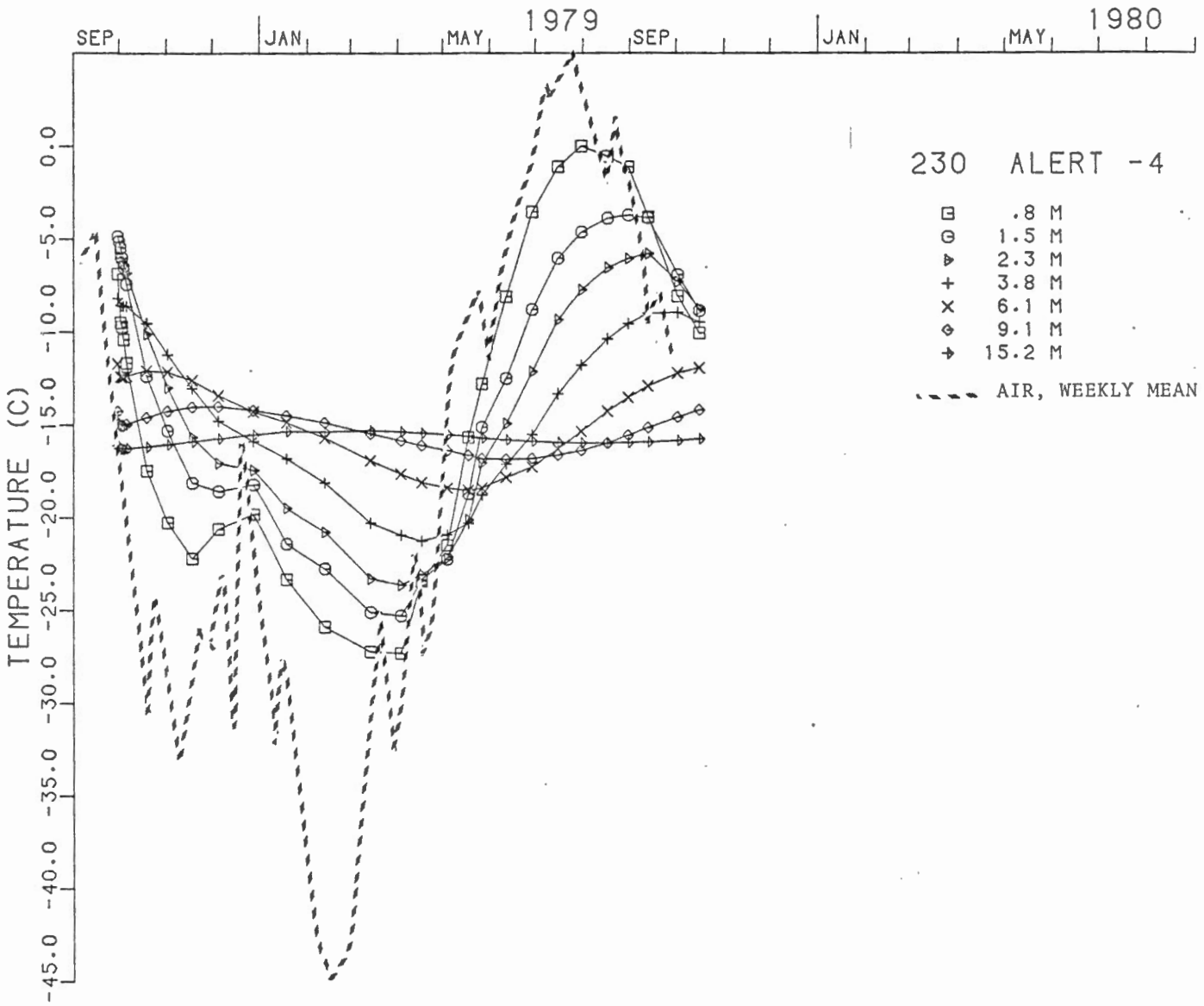


FIGURE 12

Variation of temperature with time at selected depths at site 4. Weekly mean air temperatures are included for comparison.

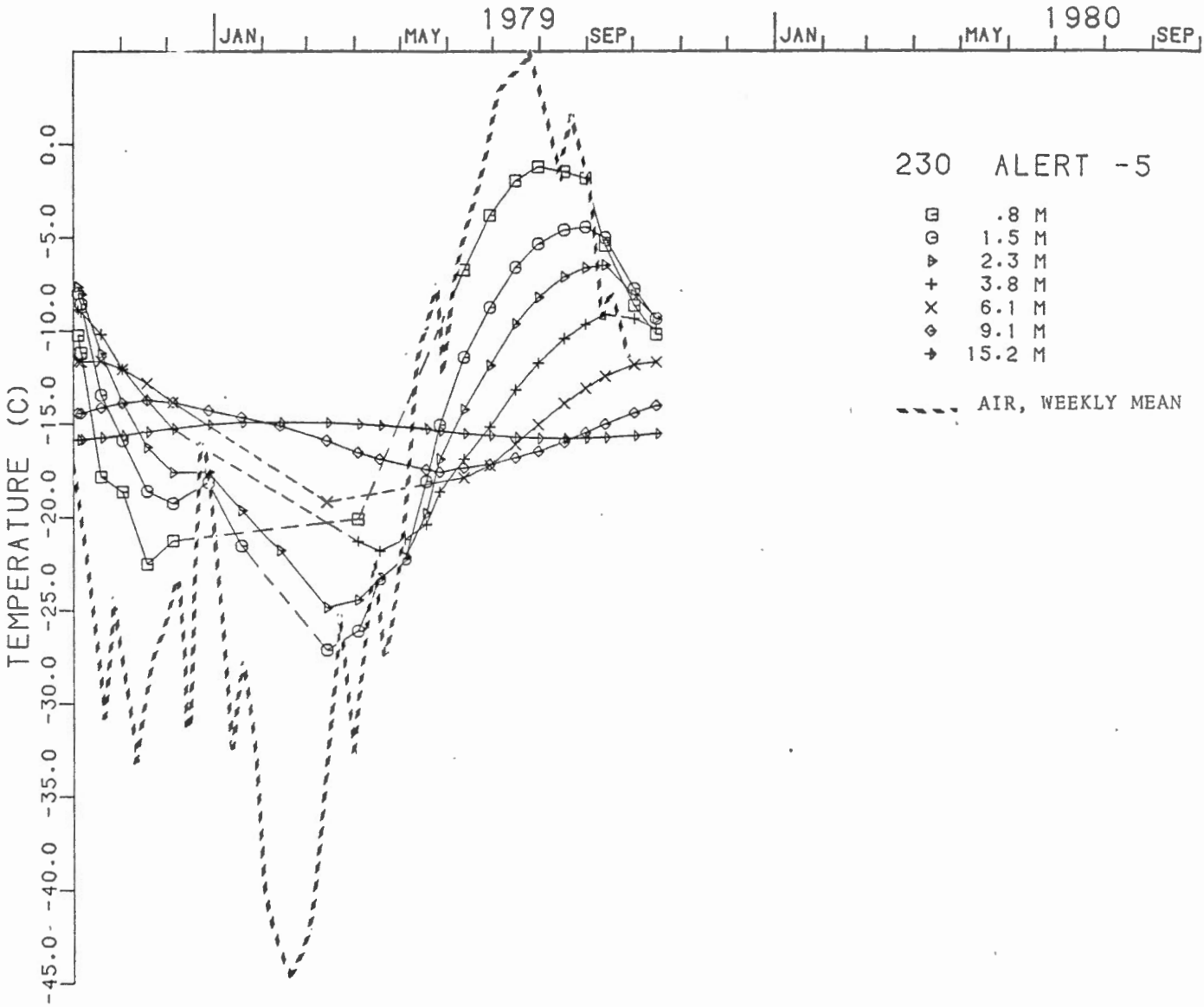


FIGURE 13

Variation of temperature with time at selected depths at site 5. Weekly mean air temperatures are included for comparison.

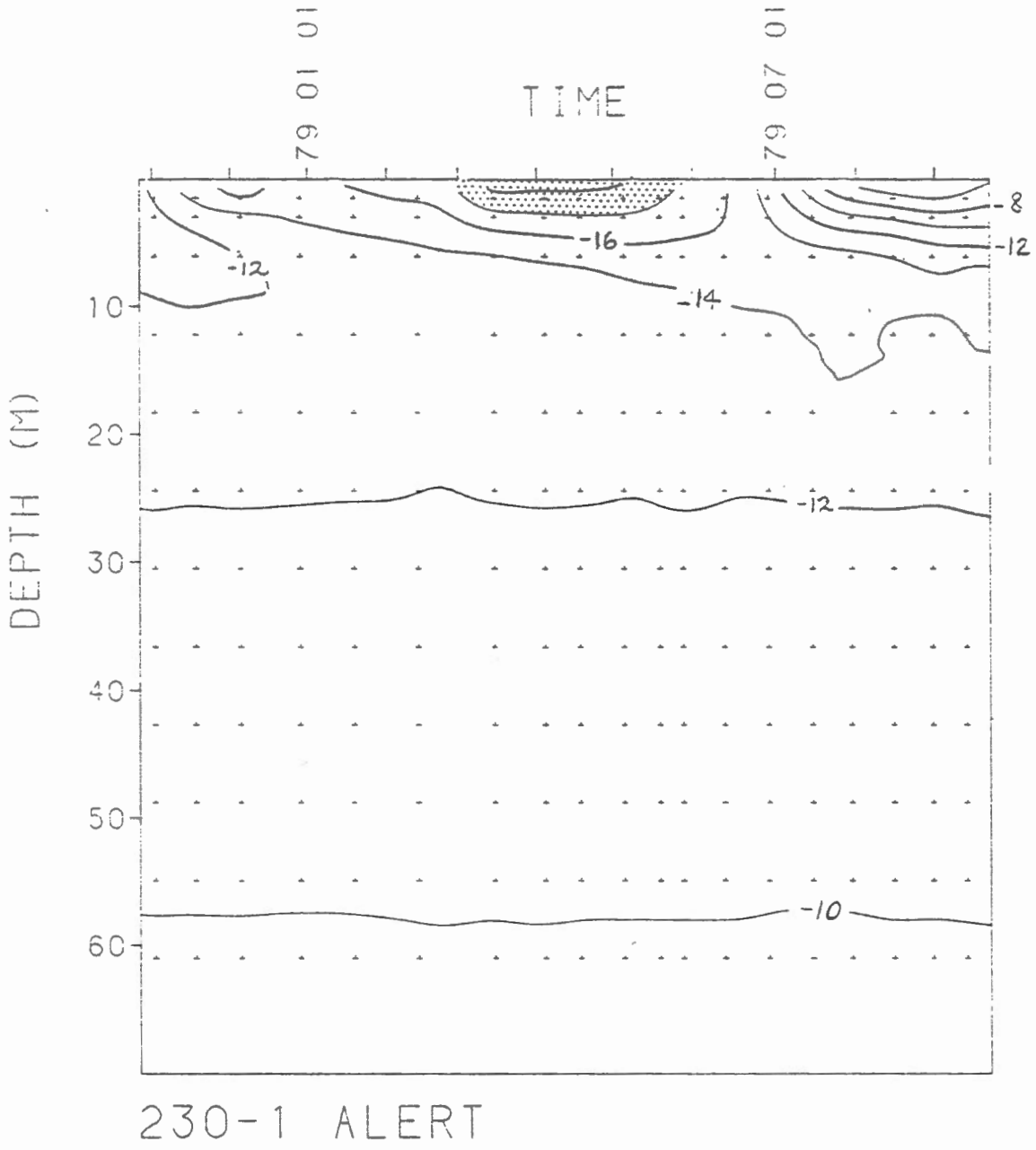


FIGURE 14

Temperatures contoured in depth and time at site 1. Contour interval, 2K. Small + are data points. The part of the year, and depth interval, for which ground temperatures are colder than the mean annual air temperature are stipled.

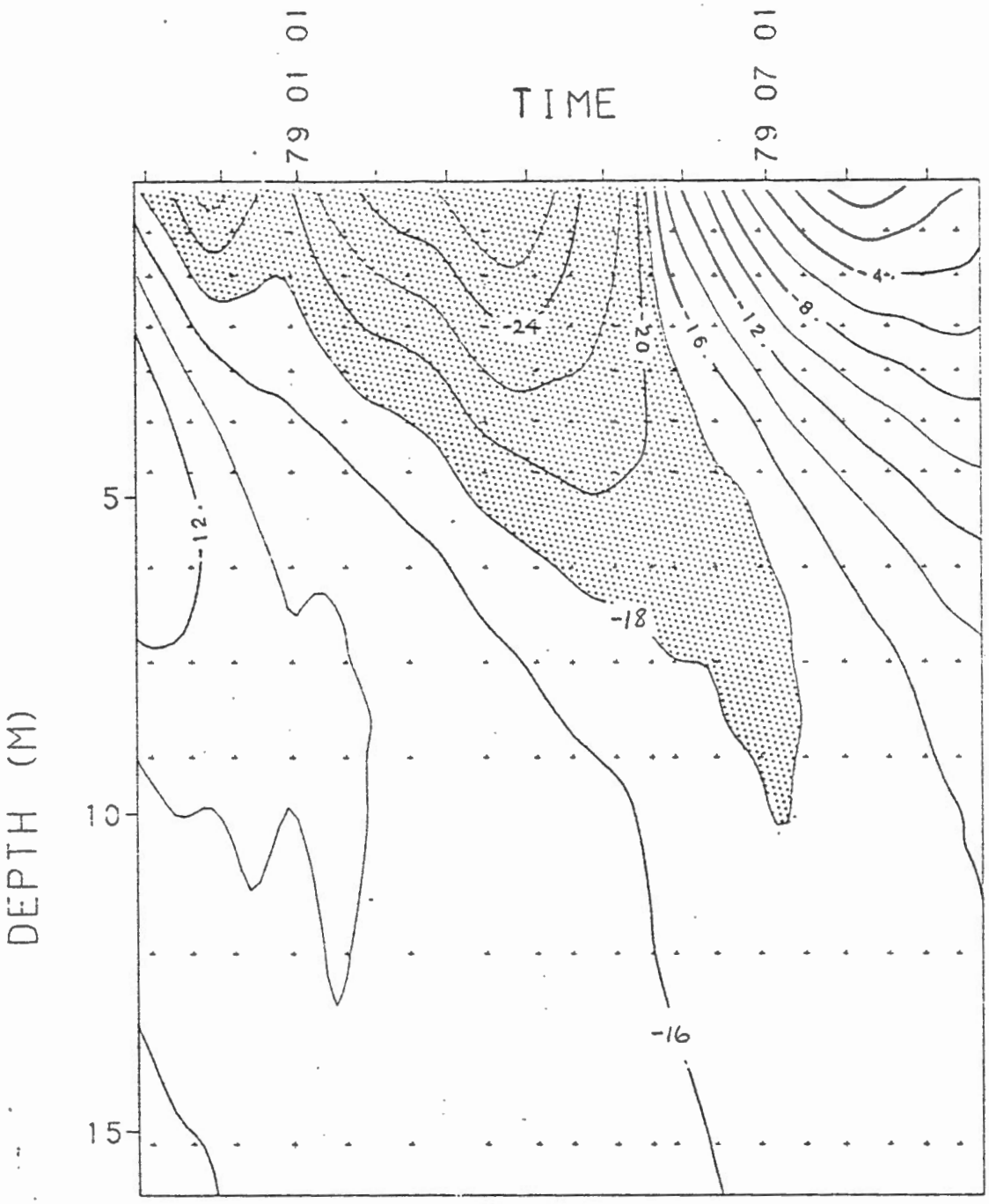


FIGURE 15

Temperatures contoured in depth and time at site 4. Contour interval, 2K. Small + are data points. The part of the year, and depth interval, for which ground temperatures are colder than the mean annual air temperature are stipled.

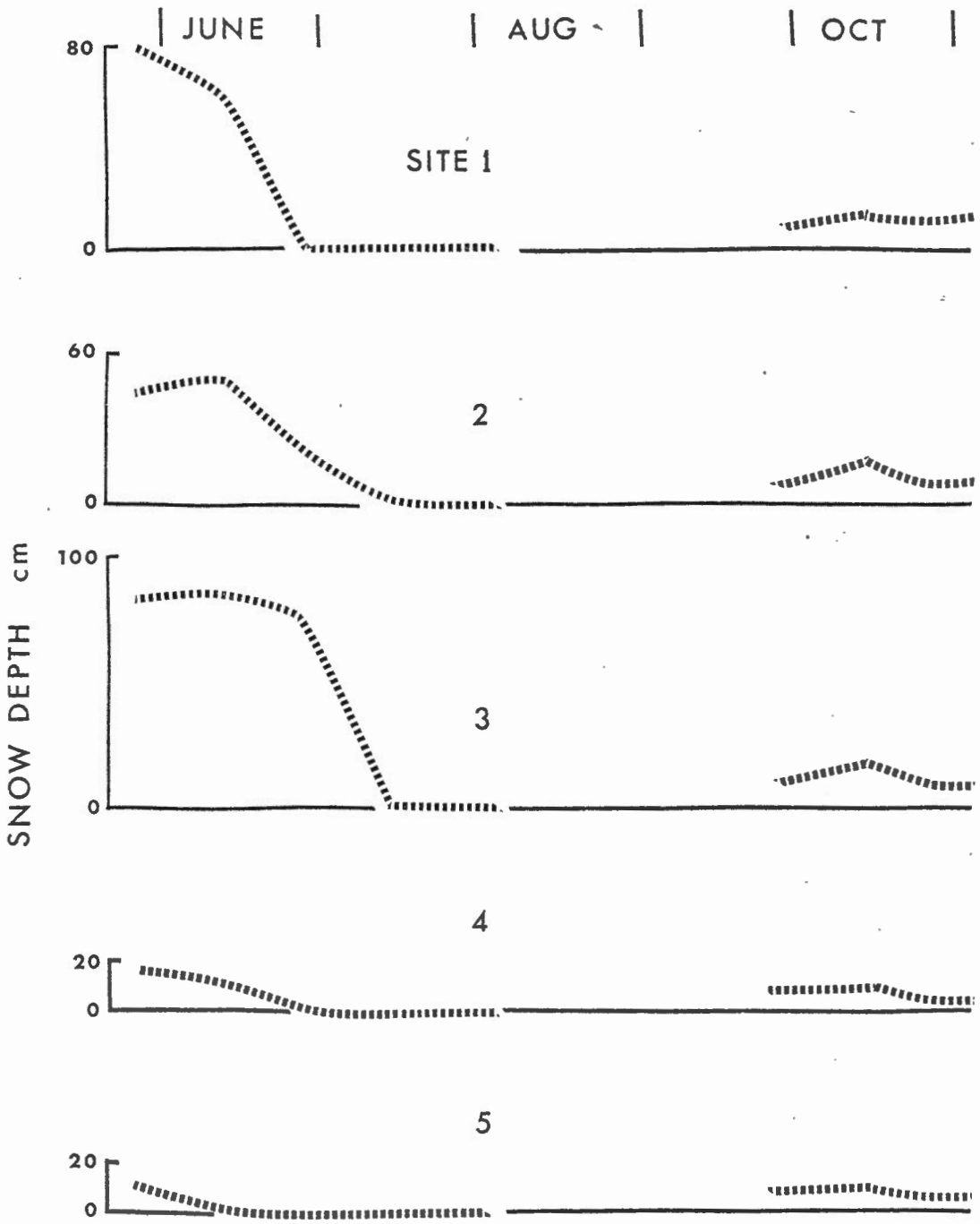


FIGURE 16

Snow coverage since late May, 1979, at the five sites.

EARTH PHYSICS BRANCH NO. 230 ALERT -1
DIRECTION DE LA PHYSIQUE DU GLOBE NO.

****

82 DEGREES 30.6 MINUTES NORTH — 82 DEGRES 30.6 MINUTES NORD
62 DEGREES 17.9 MINUTES WEST — 62 DEGRES 17.9 MINUTES OUEST

ELEVATION 10 METRES

SUMMARY OF DEPTH-TEMPERATURE LOGS — DIAGRAPHIES DONNANT LA TEMPERATURE EN FONCTION DE LA PROFONDEUR

	DATE 78 10 6	DATE 78 10 19	DATE 78 11 2	DATE 78 11 18	DATE 78 12 5	DATE 78 12 28	DATE 79 1 18	DATE 79 2 12	DATE 79 3 14	DATE 79 4 3	DATE 79 4 17
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
1.5	-6.47	-10.38	-13.03	-15.57	-16.08	-15.80	-16.57	-17.99	-20.46	-20.33	-20.09
3.0	-8.20	-8.94	-10.33	-11.95	-13.38	-14.13	-14.43	-15.22	-17.05	-17.60	-17.84
6.1	-12.20	-12.02	-11.78	-11.76	-11.99	-12.45	-12.80	-13.15	-13.77	-14.28	-14.57
12.2	-13.16	-13.30	-13.20	-13.09	-12.96	-12.80	-12.72	-12.72	-12.73	-12.78	-12.82
18.3	-12.32	-12.55	-12.58	-12.59	-12.57	-12.56	-12.53	-12.52	-12.46	-12.44	-12.41
24.4	-11.80	-12.04	-12.06	-12.09	-12.11	-12.11	-12.12	-12.16	-12.15	-12.15	-12.13
30.5	-11.35	-11.56	-11.58	-11.59	-11.61	-11.61	-11.61	-11.65	-11.65	-11.66	-11.66
36.6	-10.87	-11.08	-11.10	-11.11	-11.12	-11.12	-11.12	-11.16	-11.15	-11.15	-11.15
42.7	-10.60	-10.80	-10.81	-10.83	-10.83	-10.82	-10.83	-10.86	-10.86	-10.86	-10.85
48.8	-10.30	-10.45	-10.46	-10.47	-10.49	-10.47	-10.48	-10.51	-10.50	-10.52	-10.50
54.9	-10.02	-10.12	-10.13	-10.14	-10.14	-10.13	-10.13	-10.18	-10.16	-10.18	-10.16
61.0	-9.80	-9.82	-9.82	-9.83	-9.84	-9.83	-9.83	-9.87	-9.86	-9.86	-9.85

	DATE 79 5 4	DATE 79 5 18	DATE 79 5 27	DATE 79 6 12	DATE 79 6 29	DATE 79 7 16	DATE 79 7 31	DATE 79 8 16	DATE 79 8 31	DATE 79 9 13	DATE 79 10 2	DATE 79 10 16
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
1.5	-19.57	-18.51	-17.23	-15.29	-11.38	-7.94	-6.22	-5.29	-4.86	-4.93	-6.68	-8.20
3.0	-17.79	-17.59	-17.09	-16.35	-14.76	-12.60	-11.23	-10.06	-9.23	-8.69	-8.54	-8.86
6.1	-14.70	-14.92	-15.10	-15.12	-15.00	-14.63	-14.24	-13.76	-13.24	-12.79	-12.22	-11.87
12.2	-12.89	-12.96	-13.04	-13.15	-13.20	-13.29	-13.31	-13.37	-13.32	-13.31	-13.23	-13.14
18.3	-12.37	-12.40	-12.40	-12.39	-12.39	-12.44		-12.45	-12.47	-12.50	-12.51	-12.53
24.4	-12.13	-12.13	-12.12	-12.12	-12.12	-12.08	-12.09	-12.10	-12.10	-12.11	-12.13	-12.14
30.5	-11.66	-11.65	-11.66	-11.66	-11.64	-11.65	-11.66	-11.65	-11.65	-11.66	-11.69	-11.69
36.6	-11.15	-11.14	-11.15	-11.15	-11.14	-11.15	-11.15	-11.15	-11.16	-11.17	-11.20	-11.20
42.7	-10.85	-10.85	-10.86	-10.86	-10.84	-10.85	-10.83	-10.85	-10.85	-10.86	-10.89	-10.89
48.8	-10.48	-10.49	-10.50	-10.50	-10.46	-10.38	-10.46	-10.45	-10.48	-10.49	-10.52	-10.53
54.9	-10.16	-10.16	-10.16	-10.16	-10.14	-10.14	-10.16	-10.16	-10.16	-10.18	-10.20	-10.20
61.0	-9.85	-9.85	-9.85	-9.85	-9.83	-9.79	-9.78	-9.85	-9.84	-9.85	-9.88	-9.88

TEMPERATURE RESULTS ARE OBTAINED FROM A MULTITHERMISTOR CABLE. FURTHER TEMPERATURE LOGS ARE EXPECTED FOR THIS HOLE.

TEMPERATURES OBTENUES A PARTIR D'UN CABLE A THERMISTORS MULTIPLES. ON PREVOIT ENTREPRENDRE D'AUTRES SONDAGES DE LA TEMPERATURE DE CE PUITS.

DND-NRC-EMR ALERT PERMAFROST EXPT
-WELL SPUDDED 78 10 3
-DRILLING FOR 1 DAYS
-TOTAL DEPTH 61 METRES
-DRILLING STOPPED 78 10 4

DND-NRC-EMR ALERT PERMAFROST EXPT
-DEMARRAGE DU PUITS LE 78 10 3
-FORAGE PENDANT 1 JOURS
-PROFONDEUR TOTALE 61 METRES
-FORAGE ARRETE LE 78 10 4

TABLE 1

LOCATIONS AND ELEVATIONS APPROX.

EARTH PHYSICS BRANCH NO. 230 ALERT -2
DIRECTION DE LA PHYSIQUE DU GLOBE NO.

****

82 DEGREES 30.1 MINUTES NORTH — 82 DEGRES 30.1 MINUTES NORD
62 DEGREES 26.0 MINUTES WEST — 62 DEGRES 26.0 MINUTES OUEST

ELEVATION 92 METRES

SUMMARY OF DEPTH-TEMPERATURE LOGS — DIAGRAPHIES DONNANT LA TEMPERATURE EN FONCTION DE LA PROFONDEUR

	DATE 78 10 1	DATE 78 10 2	DATE 78 10 3	DATE 78 10 6	DATE 78 10 19	DATE 78 11 2	DATE 78 11 18	DATE 78 12 5	DATE 78 12 28	DATE 79 1 18	DATE 79 2 12
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
1.5	-6.81	-6.61	-7.07	-8.41	-13.79	-16.68	-19.38	-18.99	-18.56		-23.83
3.0	-8.59	-8.40	-8.40	-8.53	-10.36	-12.71	-14.98	-16.32	-16.83	-17.79	-19.36
6.1	-12.74	-13.24	-13.33	-13.29	-13.01	-13.04	-13.45	-14.22	-15.02	-15.54	-16.20
12.2	-15.21	-16.14	-16.33	-16.30	-16.28	-16.13	-15.93	-15.73	-15.55	-15.49	-15.52
18.3	-14.64	-15.70	-15.90	-16.11	-16.11	-16.15	-16.16	-16.05	-16.01	-15.94	-15.94
24.4	-14.07	-15.25	-15.46	-15.58	-15.66	-15.73	-15.72	-15.76	-15.82	-15.73	-15.73
30.5	-13.92	-15.08	-15.31	-15.40	-15.47	-15.48	-15.48	-15.51	-15.50	-15.50	-15.52
36.6	-13.82	-14.94	-15.14	-15.23	-15.30	-15.31	-15.30	-15.34	-15.32	-15.32	-15.36
42.7	-13.63	-14.80	-15.00	-15.09	-15.15	-15.16	-15.17	-15.18	-15.17	-15.15	-15.19
48.8	-13.66	-14.66	-14.84	-14.89	-14.95	-14.95	-14.96	-14.97	-14.96	-14.96	-14.99
54.9	-13.81	-14.58	-14.70	-14.76	-14.80	-14.79	-14.79	-14.81	-14.80	-14.80	-14.82
61.0	-14.28	-14.58	-14.63	-14.64	-14.66	-14.66	-14.67	-14.69	-14.67	-14.67	-14.70

	DATE 79 3 14	DATE 79 4 3	DATE 79 4 17	DATE 79 5 4	DATE 79 5 18	DATE 79 5 27	DATE 79 6 12	DATE 79 6 29	DATE 79 7 16	DATE 79 7 31	DATE 79 8 16
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
1.5	-26.37	-25.44	-24.14	-23.46	-21.04	-19.15	-17.06	-12.98	-7.45	-5.24	-4.36
3.0	-22.24	-22.44	-22.43	-22.03	-21.30	-20.15	-18.91	-17.39	-14.23	-11.95	-10.35
6.1	-17.61	-18.46	-18.84	-19.13	-19.28	-19.26	-19.01	-18.66	-17.96	-17.05	-15.97
12.2	-15.63	-15.77	-15.88	-16.01	-16.17	-16.31	-16.46	-16.58	-16.68	-16.73	-16.72
18.3	-15.89	-15.85	-15.83	-15.82	-15.83	-15.85	-15.88	-15.92	-15.96	-15.98	-16.01
24.4	-15.73	-15.75	-15.72	-15.71	-15.69	-15.70	-15.69	-15.68	-15.69	-15.71	-15.70
30.5	-15.54	-15.56	-15.55	-15.55	-15.53	-15.54	-15.54	-15.54	-15.54	-15.54	-15.54
36.6	-15.37	-15.36	-15.35	-15.36	-15.36	-15.36	-15.36	-15.36	-15.36	-15.36	-15.36
42.7	-15.20	-15.20	-15.18	-15.19	-15.19	-15.19	-15.19	-15.19	-15.19	-15.19	-15.19
48.8	-15.00	-14.99	-14.98	-14.98	-14.99	-14.99	-14.99	-14.99	-14.99	-14.99	-14.99
54.9	-14.83	-14.83	-14.82	-14.82	-14.82	-14.82	-14.82	-14.82	-14.82	-14.82	-14.82
61.0	-14.71	-14.70	-14.69	-14.69	-14.69	-14.69	-14.69	-14.69	-14.69	-14.69	-14.69

	DATE 79 8 31	DATE 79 9 13	DATE 79 10 2	DATE 79 10 16
Z(M)	T(C)	T(C)	T(C)	T(C)
1.5	-4.21	-5.86	-8.66	-10.43
3.0	-9.42	-8.93	-9.62	-10.51
6.1	-15.06	-14.34	-13.63	-13.33
12.2	-16.66	-16.59	-16.40	-16.23
18.3	-16.08	-16.14	-16.12	-16.19
24.4	-15.70	-15.76	-15.73	-15.74
30.5	-15.54	-15.58	-15.57	-15.57
36.6	-15.36	-15.40	-15.39	-15.39
42.7	-15.19	-15.23	-15.22	-15.23
48.8	-14.99	-15.02	-15.02	-15.02
54.9	-14.82	-14.85	-14.85	-14.85
61.0	-14.69	-14.72	-14.72	-14.71

TEMPERATURE RESULTS ARE OBTAINED FROM A MULTITHERMISTOR CABLE. FURTHER TEMPERATURE LOGS ARE EXPECTED FOR THIS HOLE.

DND-NRC-EMR ALERT PERMAFROST EXPT
-WELL SPUDDED 78 9 30
-DRILLING FOR 1 DAYS
-TOTAL DEPTH 61 METRES
-DRILLING STOPPED 78 10 1

LOCATIONS AND ELEVATIONS APPROX.

TEMPERATURES OBTENUES A PARTIR D'UN CABLE A THERMISTORS MULTIPLES. ON PREVOIT ENTREPRENDRE D'AUTRES SONDAGES DE LA TEMPERATURE DE CE PUITS.

DND-NRC-EMR ALERT PERMAFROST EXPT
-DEMARRAGE DU PUITS LE 78 9 30
-FORAGE PENDANT 1 JOURS
-PROFONDEUR TOTALE 61 METRES
-FORAGE ARRETE LE 78 10 1

TABLE 2

EARTH PHYSICS BRANCH NO. 230 ALERT -3
DIRECTION DE LA PHYSIQUE DU GLOBE NO.

****

82 DEGREES 27.4 MINUTES NORTH — 82 DEGRES 27.4 MINUTES NORD
62 DEGREES 27.7 MINUTES WEST — 62 DEGRES 27.7 MINUTES OUEST

ELEVATION 160 METRES

SUMMARY OF DEPTH-TEMPERATURE LOGS — DIAGRAPHIES DONNANT LA TEMPERATURE EN FONCTION DE LA PROFONDEUR

	DATE 78 10 3	DATE 78 10 4	DATE 78 10 6	DATE 78 10 19	DATE 78 11 2	DATE 78 11 18	DATE 78 12 5	DATE 78 12 28	DATE	DATE 79 5 4	DATE 79 5 18
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)		T(C)	T(C)
2.4	-9.30	-9.79	-9.84	-10.29	-11.50	-12.81	-14.08	-14.77		-17.86	-17.87
8.5	-14.39	-14.70	-14.77	-14.56	-14.29	-14.05	-13.92	-13.91	CABLE	-14.85	-14.96
14.6	-14.39	-14.67	-14.79	-14.87	-14.86	-14.80	-14.72	-14.61	SEVERED	-14.48	-14.36
20.7	-13.89	-14.17	-14.30	-14.41	-14.46	-14.48	-14.52	-14.52		-14.43	-14.42
26.8	-13.62	-13.86	-13.97	-14.06	-14.10	-14.12	-14.13	-14.15	JAN.- APR.	-14.19	-14.19
32.9	-13.60	-13.85	-13.95	-14.02	-14.05	-14.05	-14.08	-14.08	1979	-14.12	-14.13
39.0	-13.45	-13.68	-13.77	-13.84	-13.87	-13.87	-13.88	-13.88		-13.90	-13.91
45.1	-13.45	-13.67	-13.74	-13.80	-13.82	-13.82	-13.84	-13.84		-13.90	-13.82
51.2	-13.45	-13.60	-13.66	-13.70	-13.72	-13.72	-13.73	-13.73		-13.73	-13.74
57.3	-13.52	-13.59	-13.60	-13.61	-13.62	-13.62	-13.63	-13.63		-13.63	-13.64

	DATE 79 5 27	DATE 79 6 12	DATE 79 6 29	DATE 79 7 16	DATE 79 7 31	DATE 79 8 17	DATE 79 8 3*	DATE 79 9 13	DATE 79 10 2	DATE 79 10 16
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
2.4	-17.65	-17.24	-16.83	-15.76	-14.34		-11.56	-10.80	-10.59	-10.82
8.5	-15.13	-15.27	-15.36	-15.43	-15.41	-15.32	-15.17	-14.97	-14.64	-14.36
14.6	-14.42	-14.45	-14.50	-14.55	-14.58	-14.63	-14.67	-14.69	-14.72	-14.71
20.7	-14.42	-14.41	-14.41	-14.41	-14.41	-14.41	-14.43	-14.44	-14.47	-14.48
26.8	-14.19	-14.19	-14.19	-14.19	-14.18	-14.16	-14.18	-14.18	-14.20	-14.20
32.9	-14.13	-14.13	-14.13	-14.14	-14.12	-14.13	-14.13	-14.14	-14.16	-14.16
39.0	-13.91	-13.91	-13.91	-13.91	-13.91	-13.91	-13.92	-13.92	-13.94	-13.94
45.1	-13.85	-13.85	-13.85	-13.85	-13.85	-13.85	-13.86	-13.86	-13.89	-13.88
51.2	-13.74	-13.74	-13.74	-13.74	-13.73	-13.74	-13.75	-13.75	-13.77	-13.77
57.3	-13.64	-13.64	-13.64	-13.64	-13.64	-13.63	-13.64	-13.65	-13.67	-13.66

TEMPERATURE RESULTS ARE OBTAINED FROM A MULTITHERMISTOR CABLE. FURTHER TEMPERATURE LOGS ARE EXPECTED FOR THIS HOLE.

TEMPERATURES OBTENUES A PARTIR D'UN CABLE A THERMISTORS MULTIPLES. ON PREVOIT ENTREPRENDRE D'AUTRES SONDAGES DE LA TEMPERATURE DE CE PUITS.

DND-NRC-EMR ALERT PERMAFROST EXPT
-WELL SPUDDED 78 10 1
-DRILLING FOR 1 DAYS
-TOTAL DEPTH 60 METRES
-DRILLING STOPPED 78 10 2

DND-NRC-EMR ALERT PERMAFROST EXPT
-DEMARRAGE DU PUITS LE 78 10 1
-FORAGE PENDANT 1 JOURS
-PROFONDEUR TOTALE 60 METRES
-FORAGE ARRETE LE 78 10 2

LOCATIONS AND ELEVATIONS APPROX.

TABLE 3

EARTH PHYSICS BRANCH NO. 230 ALERT -4
DIRECTION DE LA PHYSIQUE DU GLOBE NO.

82 DEGREES 29.1 MINUTES NORTH — 82 DEGRES 29.1 MINUTES NORD
62 DEGREES 28.3 MINUTES WEST — 62 DEGRES 28.3 MINUTES OUEST

ELEVATION 38 METRES

SUMMARY OF DEPTH-TEMPERATURE LOGS — DIAGRAPHIES DONNANT LA TEMPERATURE EN FONCTION DE LA PROFONDEUR

	DATE 78 9 30	DATE 78 10 1	DATE 78 10 2	DATE 78 10 3	DATE 78 10 4	DATE 78 10 6	DATE 78 10 19	DATE 78 11 2	DATE 78 11 18	DATE 78 12 5	DATE 78 12 28
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
.8	-6.87		-9.49	-9.70	-10.40	-11.66	-17.48	-20.27	-22.21	-20.61	-19.81
1.5	-4.86	-5.12	-5.48	-6.01	-6.51	-7.43	-12.38	-15.31	-18.13	-18.59	-18.22
2.3	-5.80	-5.98	-6.07	-6.21	-6.39	-6.83	-10.13	-12.99	-15.66	-17.07	-17.44
3.0	-6.87	-7.12	-7.15	-7.21	-7.26	-7.42	-9.31	-11.69	-13.98	-15.72	-16.56
3.8	-8.19		-8.54	-8.59	-8.60	-8.63	-9.55	-11.22	-13.04	-14.79	-15.88
4.6	-9.42		-9.96	-9.98	-9.99	-9.96	-10.27	-11.29	-12.62	-14.16	-15.32
6.1	-11.70		-12.41	-12.42	-12.41	-12.35	-12.08	-12.16	-12.61	-13.42	-14.29
7.6	-13.46	-14.26	-14.19	-14.19	-14.18	-14.11	-13.73	-13.46	-13.43	-13.69	-14.23
9.1	-14.26	-14.92	-15.01	-15.01	-15.01	-14.94	-14.59	-14.25	-14.03	-14.00	-14.21
12.2	-15.49	-16.26	-16.14	-16.15	-16.16	-16.12	-15.90	-15.64	-15.39	-15.15	-14.98
15.2	-16.11	-16.25	-16.27	-16.27	-16.28	-16.25	-16.17	-16.05	-15.89	-15.73	-15.52

	DATE 79 1 18	DATE 79 2 12	DATE 79 3 14	DATE 79 4 3	DATE 79 4 17	DATE 79 5 4	DATE 79 5 18	DATE 79 5 27	DATE 79 6 12	DATE 79 6 29	DATE 79 7 16
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
.8	-23.34	-25.90	-27.24	-27.32	-23.43	-21.49	-15.65	-12.76	-8.08	-3.53	-1.11
1.5	-21.42	-22.76	-25.13	-25.31	-23.36	-22.24	-18.70	-15.10	-12.48	-8.78	-6.03
2.3	-19.49	-20.78	-23.31	-23.65	-23.08	-22.18	-20.11	-17.03	-14.90	-12.11	-9.33
3.0	-17.88	-19.23	-21.64	-22.13	-22.19	-21.51	-20.34	-18.05	-16.12	-14.00	-11.44
3.8	-16.82	-18.13	-20.29	-20.95	-21.26	-20.92	-20.30	-18.77	-17.10	-15.50	-13.32
4.6	-16.09	-17.26	-19.16	-19.93	-20.33	-20.27	-19.98	-19.04	-17.71	-16.49	-14.72
6.1	-14.86	-15.69	-16.92	-17.65	-18.11	-18.40	-18.52	-18.39	-17.82	-17.26	-16.28
7.6	-14.69	-15.22	-15.99	-16.49	-16.80	-17.06	-17.31	-17.44	-17.28	-17.13	-16.79
9.1	-14.49	-14.87	-15.47	-15.84	-16.10	-16.36	-16.62	-16.79	-16.84	-16.79	-16.61
12.2	-14.95	-15.03	-15.33	-15.63	-15.85	-16.05	-16.16	-16.31	-16.45	-16.57	-16.48
15.2	-15.34	-15.36	-15.30	-15.35	-15.43	-15.50	-15.59	-15.69	-15.79	-15.86	-15.93

	DATE 79 7 31	DATE 79 8 17	DATE 79 8 31	DATE 79 9 13	DATE 79 10 2	DATE 79 10 16
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
.8	+ .00	-.55	-1.12	-3.81	-8.07	-10.06
1.5	-4.62	-3.88	-3.71	-3.86	-6.93	-8.86
2.3	-7.72	-6.54	-6.05	-5.79	-7.30	-8.77
3.0	-9.82	-8.44	-7.75	-7.30	-7.89	-8.86
3.8	-11.78	-10.37	-9.55	-8.99	-8.96	-9.47
4.6	-13.34	-11.99	-11.13	-10.50	-10.10	-10.25
6.1	-15.34	-14.25	-13.52	-12.89	-12.20	-11.92
7.6	-16.31	-15.53	-15.00	-14.48	-13.81	-13.41
9.1	-16.37	-15.97	-15.54	-15.13	-14.57	-14.18
12.2	-16.40	-16.23	-16.09	-15.93	-15.66	-15.43
15.2	-15.96	-15.96	-15.94	-15.90	-15.83	-15.74

TEMPERATURE RESULTS ARE OBTAINED FROM A MULTITHERMISTOR CABLE. FURTHER TEMPERATURE LOGS ARE EXPECTED FOR THIS HOLE.

DND-NRC-EMR ALERT PERMAFROST EXPT
-WELL SPUDDED 78 9 29
-DRILLING FOR 1 DAYS
-TOTAL DEPTH 15 METRES
-DRILLING STOPPED 78 9 30

LOCATIONS AND ELEVATIONS APPROX.

TABLE 4

EARTH PHYSICS BRANCH NO. 230 ALERT -5
DIRECTION DE LA PHYSIQUE DU GLOBE NO.

****

82 DEGREES 28.6 MINUTES NORTH — 82 DEGRES 28.6 MINUTES NORD
62 DEGREES 26.5 MINUTES WEST — 62 DEGRES 26.5 MINUTES OUEST

ELEVATION 87 METRES

SUMMARY OF DEPTH-TEMPERATURE LOGS — DIAGRAPHIES DONNANT LA TEMPERATURE EN FONCTION DE LA PROFONDEUR

	DATE 78 10 4	DATE 78 10 6	DATE 78 10 19	DATE 78 11 2	DATE 78 11 18	DATE 78 12 5	DATE 78 12 28	DATE 79 1 18	DATE 79 2 12	DATE 79 3 14	DATE 79 4 3
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
.8	-10.23	-11.18	-17.81	-18.62	-22.49	-21.25					-20.10
1.5	-7.96	-8.55	-13.44	-15.85	-18.59	-19.24	-18.12	-21.53		-27.13	-26.11
2.3	-7.63	-8.02	-11.20	-13.84	-16.22	-17.59	-17.56	-19.63	-21.78	-24.86	-24.44
3.0	-8.10	-8.33	-10.38	-12.73	-14.77	-16.37				-22.16	-22.64
3.8	-8.85	-8.98	-10.18	-12.06	-13.71	-15.28					-21.30
4.6	-9.82	-9.90	-10.53	-11.86	-13.11	-14.34	-15.34	-15.97	-17.15	-19.17	-19.93
6.1	-11.65	-11.67	-11.64	-12.06	-12.83	-13.86					
7.6	-13.25	-13.29	-13.03	-12.97	-13.13	-13.75					
9.1	-14.42	-14.44	-14.12	-13.89	-13.74	-13.86	-14.29	-14.65	-15.11	-15.90	-16.53
12.2	-15.64	-15.65	-15.44	-15.21	-14.93	-14.74	-14.61	-14.65	-14.85	-15.19	-15.48
15.2	-15.82	-15.81	-15.72	-15.62	-15.43	-15.26	-15.04	-14.94	-14.94	-14.95	-15.02

	DATE 79 4 17	DATE 79 5 4	DATE 79 5 18	DATE 79 5 27	DATE 79 6 12	DATE 79 6 29	DATE 79 7 16	DATE 79 7 31	DATE 79 8 17	DATE 79 8 31	DATE 79 9 13
Z(M)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)	T(C)
.8					-6.75	-3.81	-1.95	-1.22	-1.47	-1.82	-5.44
1.5	-23.32	-22.25	-18.10	-15.08	-11.45	-8.77	-6.62	-5.35	-4.61	-4.45	-5.03
2.3	-23.28	-22.18	-19.82	-16.89	-14.24	-11.89	-9.65	-8.22	-7.12	-6.64	-6.49
3.0	-22.77	-21.83	-20.44	-18.03	-15.86	-13.83	-11.65	-10.19	-8.93	-8.26	-7.87
3.8	-21.81	-21.19	-20.40	-18.65	-16.89	-15.18	-13.19	-11.77	-10.45	-9.68	-9.16
4.6	-20.20	-20.00	-19.70	-18.83	-17.65	-16.27	-14.52	-13.19	-11.88	-11.05	-10.45
6.1					-17.90	-17.24	-16.10	-15.06	-13.93	-13.12	-12.47
7.6					-17.82	-17.39	-16.81	-16.16	-15.32	-14.65	-14.07
9.1	-16.88		-17.44	-17.59	-17.35	-17.18	-16.81	-16.47	-15.98	-15.49	-15.04
12.2	-15.70		-16.12	-16.28	-16.43	-16.49	-16.48	-16.39	-16.21	-16.04	-15.85
15.2	-15.09		-15.30	-15.41	-15.54	-15.64	-15.73	-15.78	-15.80	-15.78	-15.75

	DATE 79 10 2	DATE 79 10 16
Z(M)	T(C)	T(C)
.8	-8.66	-10.20
1.5	-7.77	-9.36
2.3	-8.10	-9.35
3.0	-8.67	-9.55
3.8	-9.36	-9.90
4.6	-10.24	-10.49
6.1	-11.85	-11.69
7.6	-13.37	-13.02
9.1	-14.43	-14.04
12.2	-15.54	-15.27
15.2	-15.66	-15.54

TEMPERATURE RESULTS ARE OBTAINED FROM A MULTITHERMISTOR CABLE. FURTHER TEMPERATURE LOGS ARE EXPECTED FOR THIS HOLE.

DND-NRC-EMR ALERT PERMAFROST EXPT
-WELL SPUDDED 78 10 3
-DRILLING FOR 1 DAYS
-TOTAL DEPTH 15 METRES
-DRILLING STOPPED 78 10 4

LOCATIONS AND ELEVATIONS APPROX.

TEMPERATURES OBTENUES A PARTIR D'UN CABLE A THERMISTORS MULTIPLES. ON PREVOIT ENTREPRENDRE D'AUTRES SONDAGES DE LA TEMPERATURE DE CE PUITS.

DND-NRC-EMR ALERT PERMAFROST EXPT
-DEMARRAGE DU PUITS LE 78 10 3
-FORAGE PENDANT 1 JOURS
-PROFONDEUR TOTALE 15 METRES
-FORAGE ARRETE LE 78 10 4

TABLE 5