TEI-764

Nuclear Explosions--Peaceful Applications

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUPPLEMENTARY REPORT ON GEOLOGIC INVESTIGATIONS IN SUPPORT OF PHASE II, PROJECT CHARIOT IN THE VICINITY OF CAPE THOMPSON, NORTHWESTERN ALASKA*

By

Reuben Kachadoorian, A. H. Lachenbruch, G. W. Moore, and R. M. Waller

This report is preliminary
and has not been edited for
conformity with Geological
Survey format and nomenclature.

*This report concerns work done on behalf of San Francisco Operations Office, U. S. Atomic Energy Commission.

June 1960

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Geologic Division
345 Middlefield Road
Menlo Park, California

AEC-M-20/0

June 15, 1960

Mr. John F. Philip, Director
Special Projects Division
U. S. Atomic Energy Commission
2111 Bancroft Way
Berkeley, California

Dear Mr. Philip:

Transmitted herewith, in accordance with instructions contained in Mr. E. D. Campbell's memorandum of April 19, 1960, are 40 copies of TEI-764, "Supplementary report on geologic investigations in support of Phase II, Project Chariot, in the vicinity of Cape Thompson, northwestern Alaska" by Kachadoorian, Lachenbruch, Moore, and Waller.

This report presents new information obtained by the Geological Survey since preparation of TEI-753.

These 40 copies represent preliminary distribution to AEC-SAN for redistribution to members of the Environmental Committee in advance of the Fern Lake meetings scheduled for June 28-29, 1960, and to other participants of the environmental program. Formal distribution will be completed by our Washington office as soon as feasible.

We plan to release this report to the public in open files.

Sincerely yours,

G. Donald Eberlein

G. Donald Eberlein
Chief
Alaskan Geology Branch

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SUPPLEMENTARY REPORT ON GEOLOGIC

INVESTIGATIONS IN SUPPORT OF PHASE II, PROJECT

CHARIOT IN THE VICINITY OF CAPE THOMPSON, NORTHWESTERN ALASKA

By

Reuben Kachadoorian, A. H. Lachenbruch, G. W. Moore and R. M. Waller

INTRODUCTION

By

Reuben Kachadoorian

General introduction

Since 1958 the U. S. Geological Survey, on behalf of the Atomic Energy Commission, has conducted geological studies to develop data which will contribute to determining the feasibility and safety of detonating several nuclear devices to create an excavation at the mouth of Ogotoruk Creek, northwestern Alaska. The proposed test excavation is Project Chariot of the Atomic Energy Commission's Operation Plowshare Program.

As a result of its Project Chariot investigations to date, the Geological Survey has transmitted four reports to the Atomic Energy Commission. They are:

(1) "Engineering geology bearing on harbor site selection along the northwest coast of Alaska from Nome to Point Barrow", by T. L. Péwé, D. M. Hopkins, and A. H. Lachenbruch, 1959, TEI-778.

(2) "Geology of the Ogotoruk Creek area, northwestern Alaska", by Reuben Kachadoorian, R. H. Campbell, C. L. Sainsbury, and D. W. Scholl, 1958, TEM-976.

(3) "Marine geology and bathymetry of the nearshore shelf of the Chukchi Sea, Ogotoruk Creek area, northwest Alaska", by D. W. Scholl and C. L. Sainsbury, 1959, TEI-606.

(4) "Geologic investigations in support of Project Chariot in the vicinity of Cape Thompson, northwestern Alaska--Preliminary Report", by Reuben Kachadoorian and others, TEI-753.

The Geological Survey investigations in support of Project Chariot Phase II consisted of six parts: (1) site geologic investigations, (2) areal geologic mapping, (3) coastal processes investigations, (4) geothermal investigations, (5) seismic velocity investigations, and (6) water resources investigations. Seismic velocity investigations were in two categories; in-hole velocity and seismic refraction studies. Water resources investigations were in three categories;surface water, ground water, and quality of water studies. The preliminary results of the Survey's 1959 summer field work were reported in TEI-753.

This supplementary report presents significant new geothermal and ground water information obtained during the winter and spring months of 1959-1960. Other Survey Phase II technical studies in progress have not yielded information that would materially affect the results reported in TEI-753. This report also contains observations and preliminary conclusions resulting from coastal processes studies in the field from May 3-9, 1960. A brief geologic summary also is included. The reader, however, is referred to the reports previously listed for further details and additional background information concerning the geologic findings to date.

Acknowledgments

The Geological Survey wishes gratefully to acknowledge Mr. Harry Spencer, Holmes and Narver, Inc., representative at the Chariot site, who made periodic observations on thermal installations in Holes Able and Baker throughout the winter of 1959-1960.

Summary of geologic investigations

The Chariot test site at Ogotoruk Creek in the vicinity of Cape Thompson, Alaska (fig. 1) is topographically and geologically well-suited for construction of an experimental excavation with nuclear devices as proposed by the Atomic Energy Commission.

The consolidated rocks of the Ogotoruk Creek area consist entirely of clastic and chemical sediments of marine and brackish water depositional environments. These sediments include sandstone, calcitic and dolomitic limestone, chert, argillite, mudstone, siltstone, and graywacke. Although the rocks have been highly deformed, they are only slightly metamorphosed. The bedrock is overlain by unconsolidated deposits as much as 50 feet thick consisting of ancient beach deposits, terrace deposits, colluvium, silt and sand, flood plain deposits, alluvial fan deposits, swamp deposits, and beach deposits.

The consolidated rocks range in age from Early Mississippian to Jurassic(?) and Cretaceous while the unconsolidated sediments are of Recent age. Permafrost exists generally within 1 to 2 feet of the surface in areas underlain by unconsolidated deposits. Depth to top of permafrost in bedrock areas is unknown but believed to be less than 10 feet.

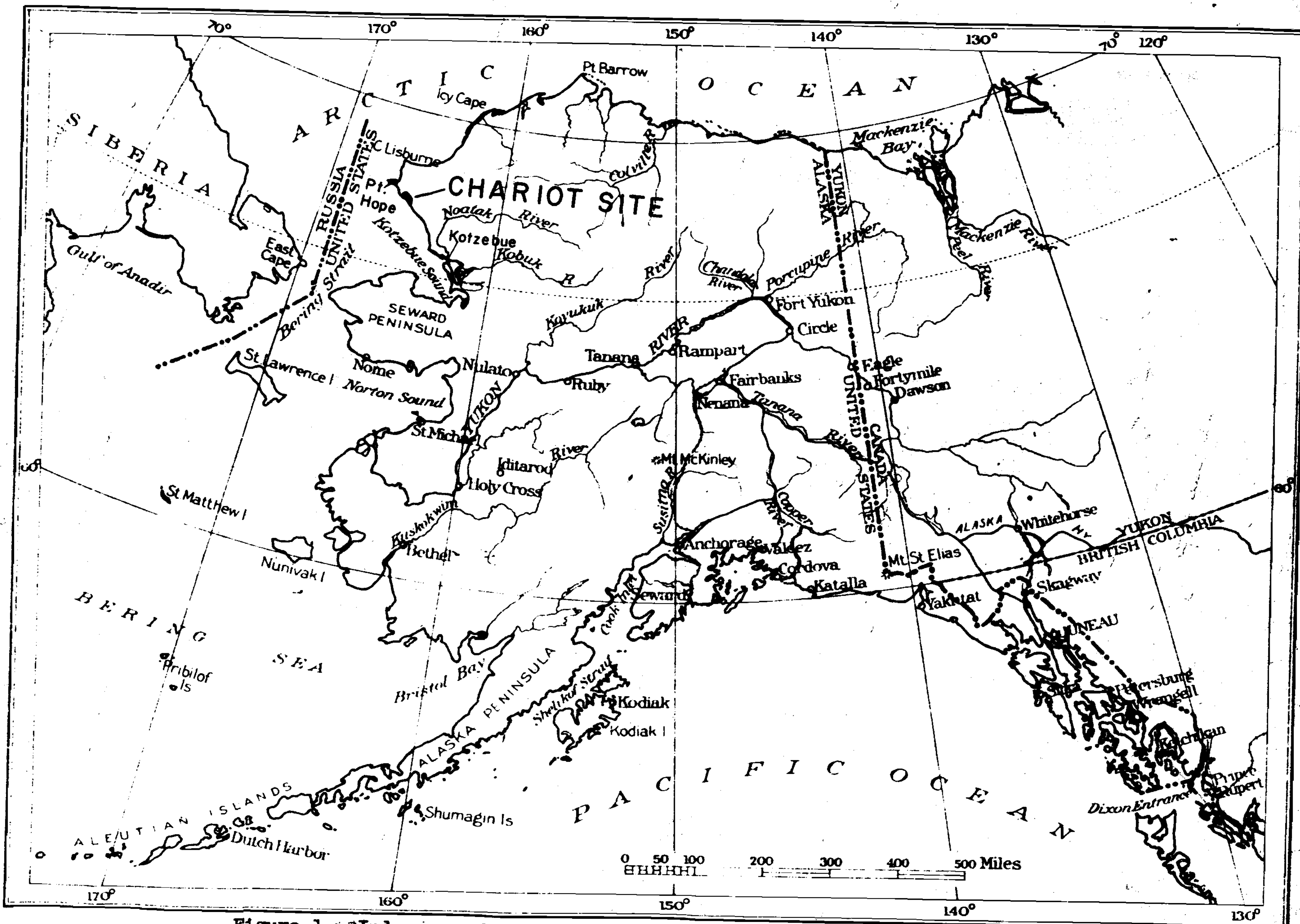

Figure 1.--Index map showing location of Chariot site, northwestern Alaska

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The Chariot test site is underlain chiefly by mudstone, siltstone, and sandstone of the Tiglukpuk formation of Jurassic(?) age. These rocks are overlain by as much as 30 feet of unconsolidated deposits consisting of flood plain deposits, colluvium, silt and sand, and terrace deposits. Test holes Able and Baker indicate that device placement as now planned will be entirely in frozen mudstone containing numerous small faults. The fault zones are generally less than 1 foot thick. In Hole Baker, however, there is a 14.1-foot fault zone. In addition to the faults, the mudstone is so highly fractured that it occurs as splinters 1/8- to 1/4-inch thick, 1/2- to 1-inch wide, and about 3 inches long.

During the drilling program in 1959 the walls of Holes Able and Baker slumped into the bottom of the holes when the relatively warm drilling fluid thawed the permafrost in the mudstone and the overlying unconsolidated deposits. This slumping of the walls prevented drilling Hole Able to its required depth of 1,000 feet and Hole Baker to its required depth of 1,500 feet. It became necessary to stop drilling Hole Able at 598 feet and Hole Baker at 1,172 feet.

The results of geothermal investigation are discussed in a later chapter in this report and therefore are not included in this summary.

Seismic measurements conducted in 1959 in the frozen Tiglukpuk rocks indicate velocities ranging from 11,500 to 14,500 fps (feet per second) and averaging about 13,500 fps. Surface refraction measurements suggest a slight increase of velocity with depth, but this increase with depth is not supported by the in-hole velocity logs of Hole Able.

The beach at the Chariot test site is in a relatively steady-state condition and is eroding at a rate of about 1 to 2 feet a century. The net alongshore transport of sediments is approximately 5 cubic yards an hour to the southeast during the ice-free periods. During heavy storms, however, transport may be as much as 1,000 cubic yards per hour.

Shallow aquifers consisting principally of unconsolidated material and deep aquifers in permeable portions of bedrock exist in the area. The shallow aquifers depend upon recharge from surface sources during the summer and the deep aquifers receive recharge water from distant sources. Both types of aquifers may be contaminated by any radioactive fallout from the proposed nuclear test. The shallow aquifer would receive contaminated surface water immediately, whereas the deep aquifers may take several years to receive the contaminated recharge water.

The suspended sediment discharge of Ogotoruk Creek can be considered minor compared to the size of the proposed excavation. The chemical composition of the waters indicates springs as well as surface water exist in the vicinity of the Chariot test site. The radiochemical levels of fresh waters are low and in the same order of magnitude as normally found throughout the United States. The highest beta activity of the fresh waters was found in the two ponds about 6 miles north of the test site. This high beta activity might be ascribed to fallout which has accumulated from previous nuclear detonations which has not been flushed out due to lack of natural drainage.

Surface water studies indicate that for all practical purposes no flow occurred in Ogotoruk Creek from October 1, 1958 to late May 1959. There may be some flow on certain days but amounts are probably too low to be considered of any importance. No definite conclusions can be drawn from the limited streamflow records obtained thus far, except that little flow is likely between mid-October and mid-May.

PRELIMINARY INTERPRETATION OF GEOTHERMAL DATA FROM OGOTORUK CREEK, ALASKA

By

Arthur H. Lachenbruch

Introduction

During the winter of 1959-1960 additional geothermal data from Holes Able and Baker at the Project Chariot test site were obtained and analyzed. As a result of this additional information it is now possible to offer a few preliminary interpretative comments to supplement the descriptive material presented in the chapter on geothermal studies in TEI Report 753 (1960). These comments are preliminary because some of the temperatures are still disturbed appreciably by the thermal effects of the initial drilling, and because data have not yet been obtained from the critical 500- to 1,000-foot depth interval. As explained in the earlier report (TEI-753), temperatures at depth are important to an interpretation of thermal events at the surface. Such temperatures were not obtained last summer owing to difficulties in drilling and thermal cable installation.

Recent temperature observations at Holes Able and Baker

Mr. Harry Spencer, Holmes and Narver, Inc. representative at the Chariot site, has taken 10 sets of measurements which postdate the September 22, 1959 data presented in TEI-753. The most recent set, taken April 17, 1960, is presented graphically in figures 2 and 3. As of that date all thermal elements to a depth of 365 feet in Hole Baker were evidently operating satisfactorily (fig. 2). The thermistor at 465 feet in Hole Baker became inoperative after the December 22, 1959 reading, which is also shown in figure 2. All data taken below 500 feet were erratic and evidently unreliable. Hole Baker was obstructed at the 500-foot depth and below by caving debris which damaged the lower part of the cable on installation.

At least 4 of the 18 thermistors in Hole Able are yielding unreliable data, probably as a result of punctures in the cable jacket occurring during the difficult installation of the thermal cable (fig. 3). However, the remaining data are adequate to characterize general aspects of the thermal regime at Hole Able to the depth available, 585 feet.

Dissipation of drilling disturbance and estimation of mean annual surface temperature

The temperatures are decreasing more or less systematically at all depths in both holes as the heat introduced by drilling is dissipating. According to theory (Lachenbruch and Brewer, 1959) a plot of successive temperature measurements at a single depth vs. log $\frac{t-s}{t}$ should yield a straight line. Here t is the time elapsed since the drill bit first reached the depth in question, and t-s is the time elapsed since drilling ceased. Extrapolation of this line to infinite time ($\log \frac{t-s}{t} = 0$) yields the equilibrium temperature, the quantity of primary importance. The method is illustrated in figure 4 with data from the 114-foot depth at Hole Baker. The good alignment of points is a tribute to the observer, Harry Spencer. Extrapolation to infinite time yields an

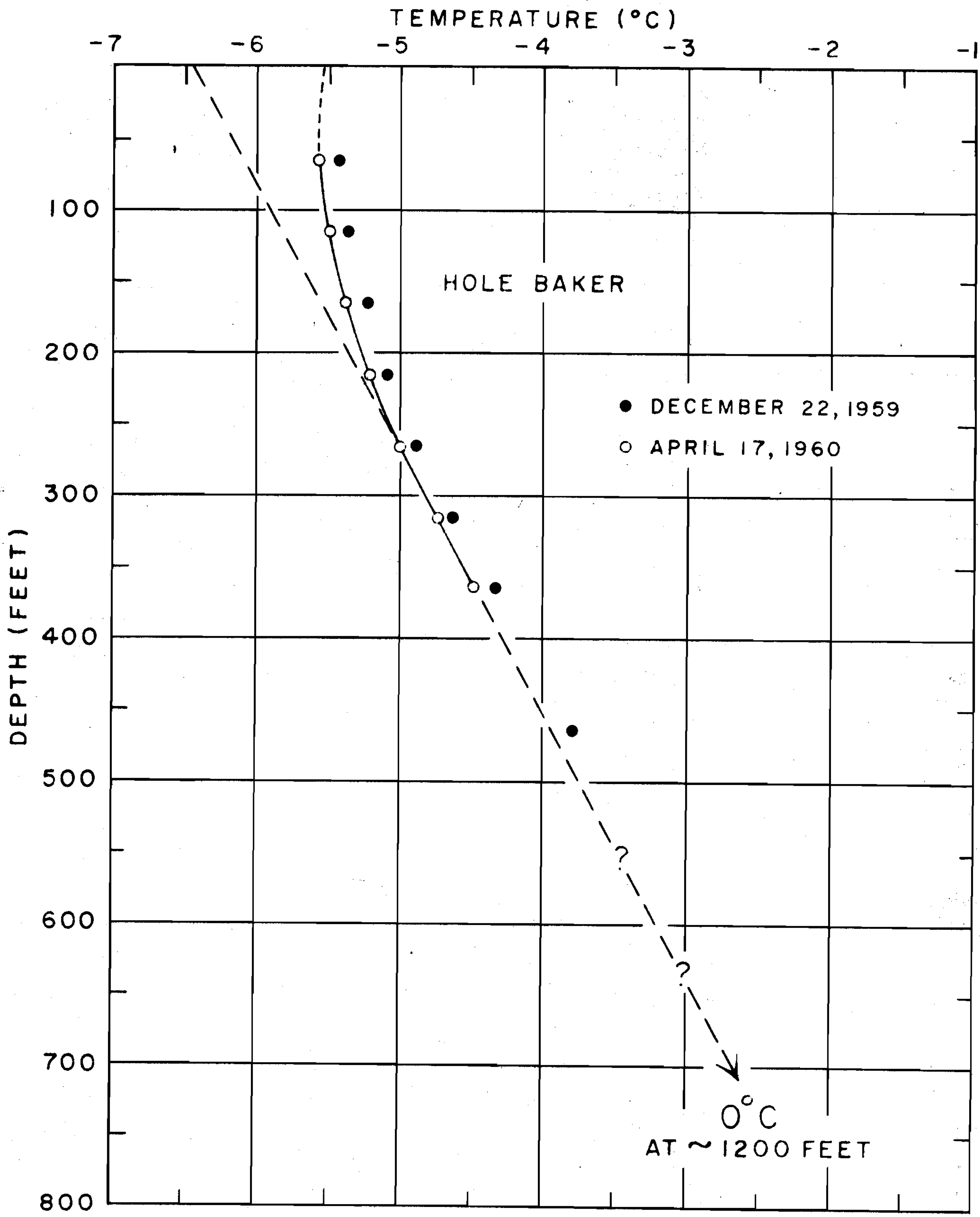

Figure 2. Temperature measurements at Hole Baker. Linear portion of curve extrapolated downward to estimate permafrost thickness, and upward to estimate surface temperature at start of climatic change.

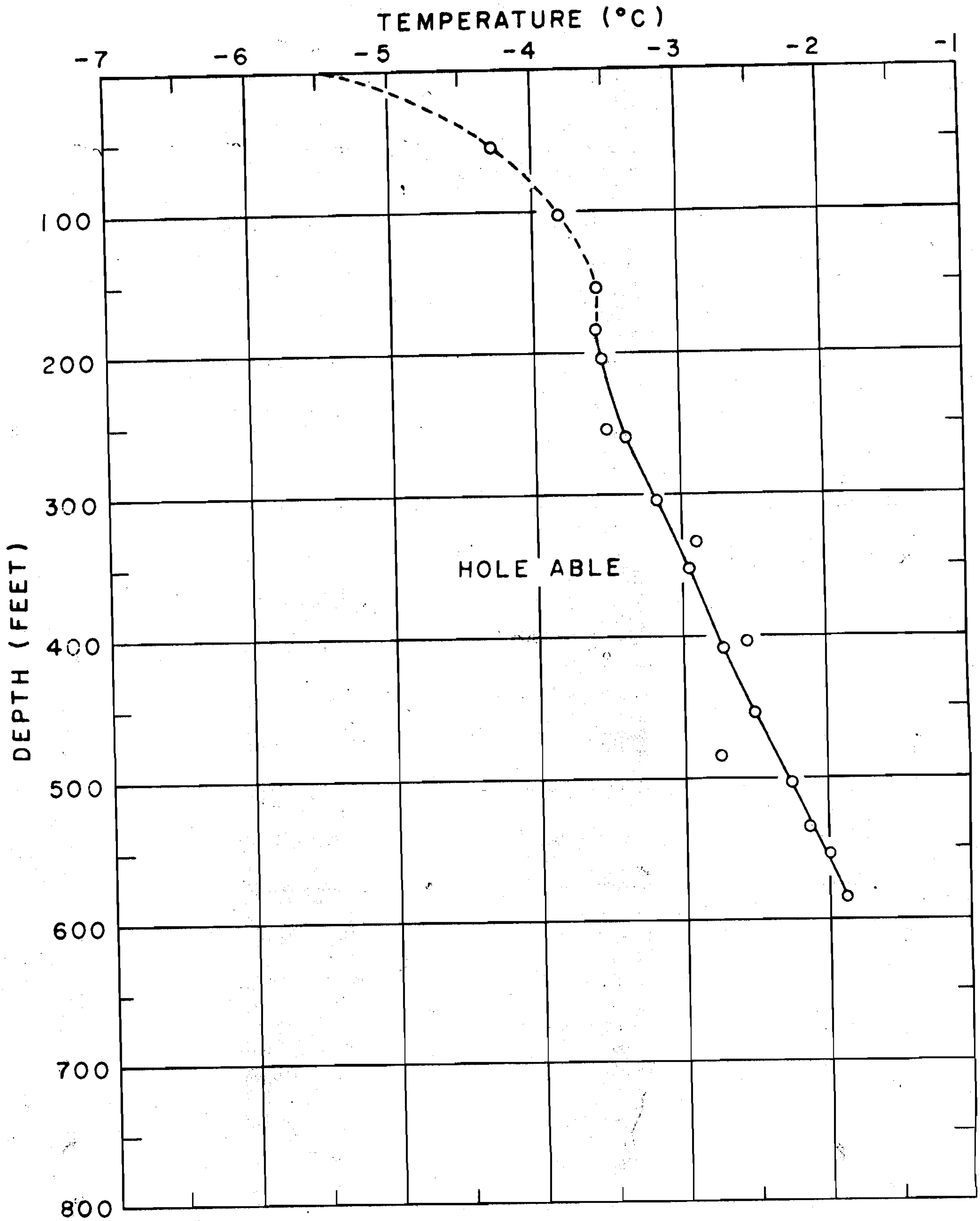

Figure 3. Temperature measurements of April 17, 1960 at Hole Able.

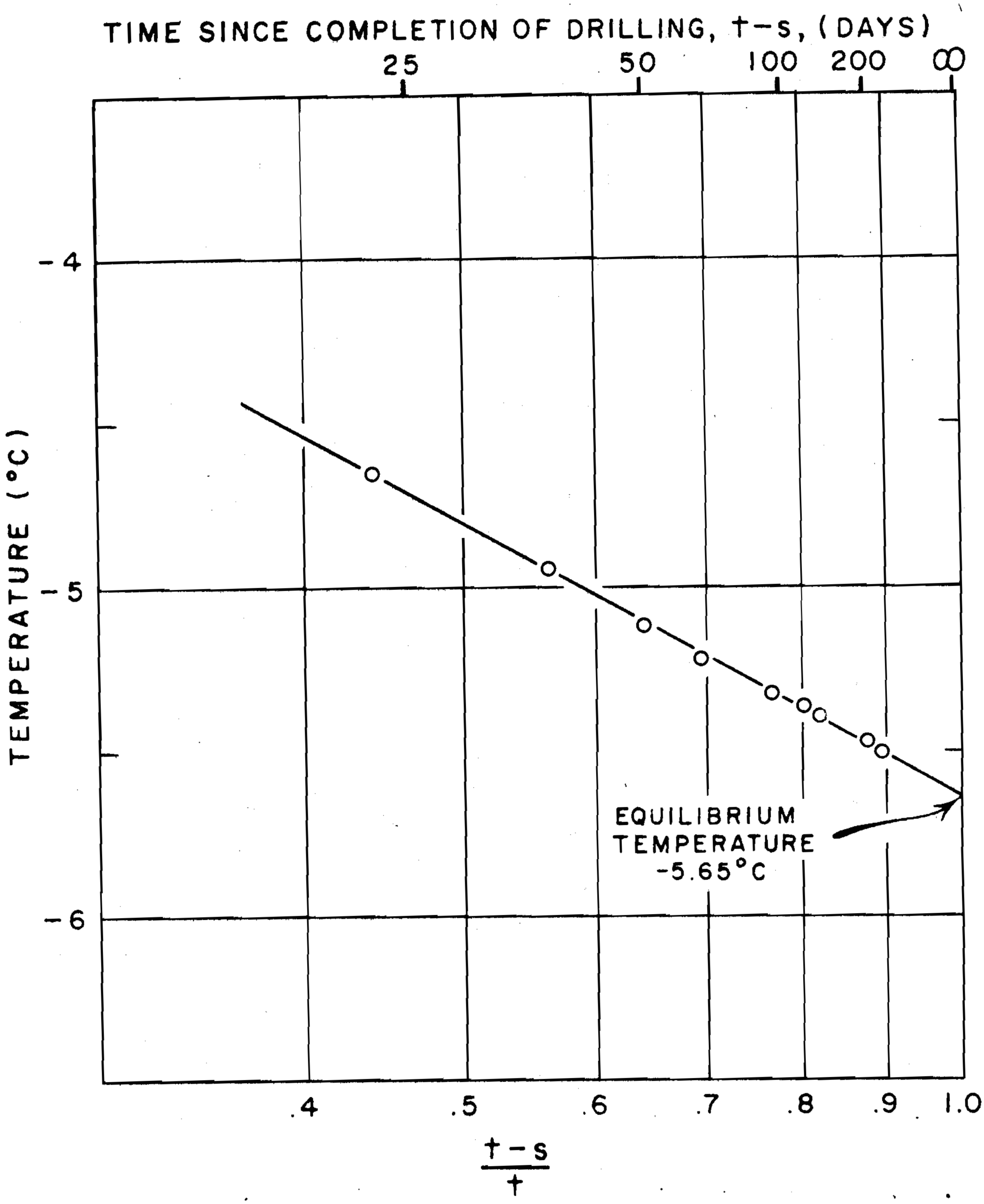

Figure 4. Dissipation of the thermal anomaly due to drilling at 114-foot depth in Hole Baker.

equilibrium temperature of -5.65°C. The drilling disturbance remaining at the time of the last observation (about 9 months after completion of drilling) was about 0.15°C. About half of this can be expected to dissipate in the next 10 months.

Because of the small thermal gradient in the upper 100 feet at Hole Baker (fig. 2), the equilibrium temperature at the 114-foot depth can be used as a generalized value for the mean annual temperature of the ground surface in tundra covered portions of the interior of Ogotoruk Creek Valley. This mean temperature, which represents an averaging out of small-scale microclimatic effects and random, short-term annual climatic fluctuations, cannot be obtained from surface measurements without several years' continuous observation at a number of costly stations.

Applying the analysis to Hole Able, we find that temperatures to the 104-foot depth are currently about 0.1°C from their equilibrium values, and below 180 feet the anomaly is generally less. At the 154-foot depth, however, the drilling disturbance is evidently about three times as great. This is the expected effect of the heat of hydration of cement, injected during drilling to stop caving at the 150-foot horizon. With further dissipation of the cementing anomaly it is likely that much of the curvature in the 100- to 200-foot portion of the temperature profile for Hole Able will vanish. The extent to which this curvature persists in the equilibrium profile will have an important bearing on the reconstruction of recent shoreline movements.

Thermal effects of bodies of water and shoreline history

In high latitudes the mean temperature of the perenially thawed sediments beneath bodies of water is appreciably greater than the mean annual temperature of the emergent land surface. Therefore when a shoreline moves the temperature of part of the earth's surface changes radically and the resulting geothermal anomaly propagates slowly downward and laterally into the earth. Measurement of these anomalies can yield information on the chronology of past shoreline movements, a knowledge of which is fundamental to an understanding of the geothermal regime in coastal permafrost areas (Lachenbruch, 1957a). The thermal anomaly that would now occur in Holes Able and Baker from a rapid movement of the straight shoreline to its present position at various times in the past has been calculated theoretically and plotted in figure 5. For these calculations it was necessary to extend previously published tables of the appropriate mathematical function (see Appendix). The solution to the three-dimensional problem (Lachenbruch, 1957b) applied to the equilibrium effect of Ogotoruk Lagoon on Hole Able is also shown. The calculations are based upon an assumed difference in mean temperature between land surface and ocean bottom of 8°C, and a thermal diffusivity for the earth materials of .0075 cm^2 sec^{-1}. Errors in the estimates of these quantities probably do not exceed 10 or 20 percent and should not affect the order of magnitude of the results. Figure 6, curve I shows a very preliminary, if not premature, estimate of the difference between predrilling temperatures at Holes Able and Baker. Curve II is an estimate of what the difference would be if the ground were in

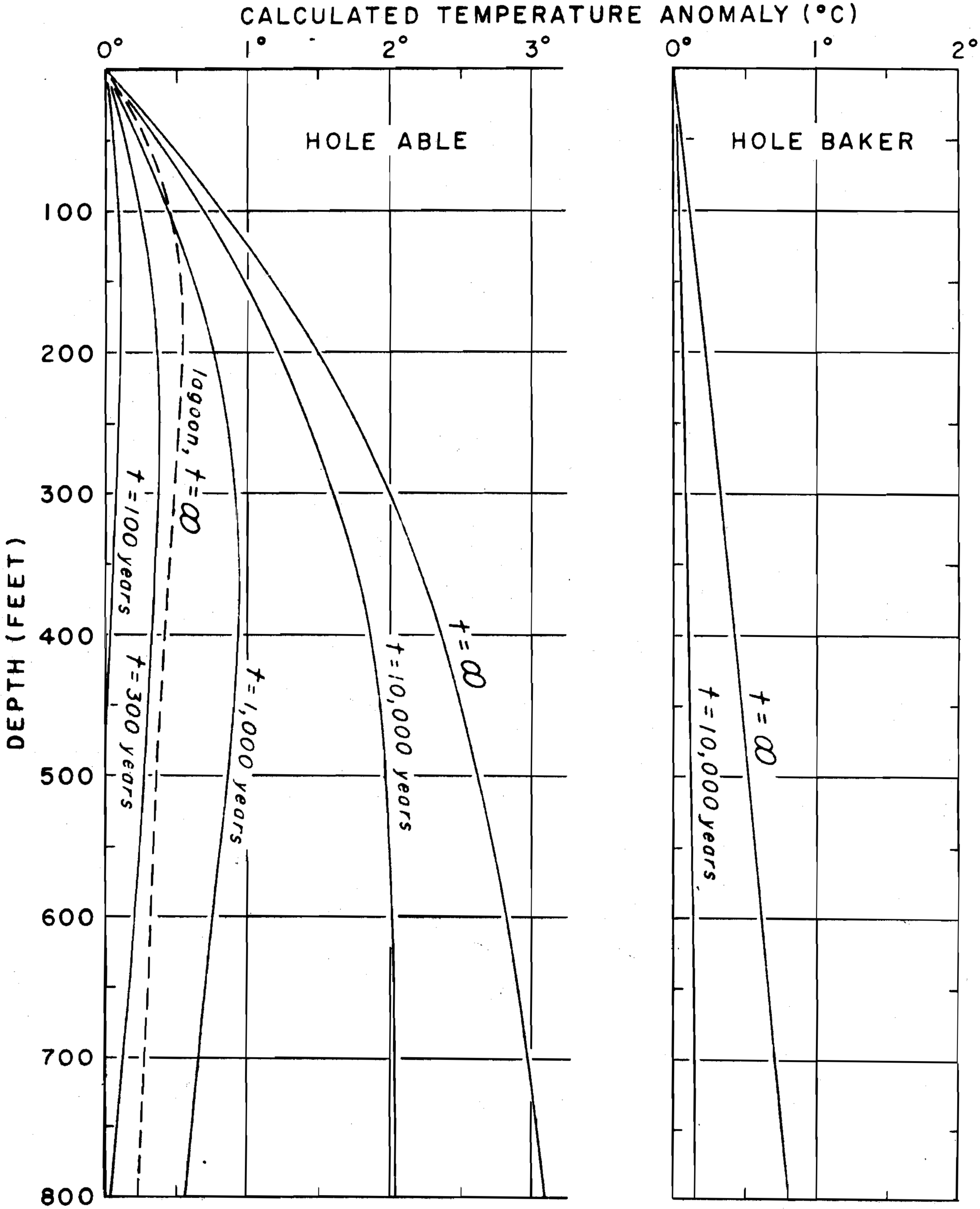

Figure 5. Calculated temperature anomaly due to ocean and lagoon at Holes Able and Baker. Solid lines are the effect at time t of a rapid movement, at time t=0, of the straight shoreline to the present position. Broken line shows equilibrium effect at lagoon on Hole Able.

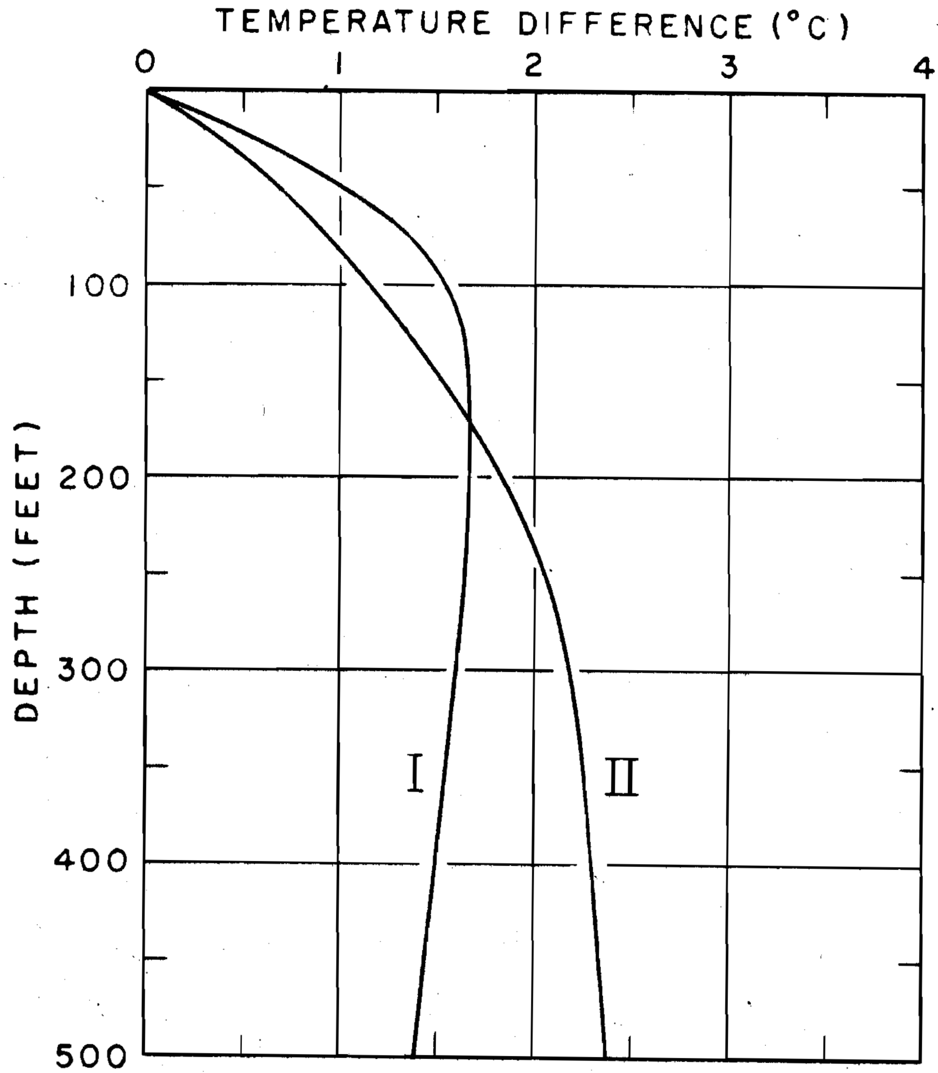

Figure 6. Curve I is the estimated difference in predrilling temperatures at Holes Able and Baker. Curve II is an estimate of what the difference would be if thermal equilibrium with present shoreline obtained.

thermal equilibrium with the present shoreline and lagoon configuration. Evidently thermal equilibrium does not exist. One logical explanation for these data is that the shoreline in general is transgressing, but that the lagoon has been filling in. However, in view of the complicated geometry and transitory nature of the lagoon, the persistence of the drilling heat, and the absence of data from the 500- to 1,000-foot interval, calculation of rates for these processes is not warranted at the present time.

Permafrost distribution

An analysis of details of the distribution of permafrost must await the analysis of shoreline events and the measurement of temperatures at greater depth. Hence only a few comments will be made at this time.

Linear extrapolation of data from Hole Baker (fig. 2) indicates a permafrost depth of about 1,200 feet. The extrapolation is, in this instance, uncertain but not unreasonable. Inasmuch as the preliminary analysis indicates a marine transgression, it is unlikely that temperatures in Hole Baker are disturbed appreciably by the ocean. Thus this 1,200-foot depth, if valid, would represent a general inland value. If however, the shoreline had been stable ($t=\infty$, fig. 5), the permafrost depth at Hole Baker would have been reduced by about 250 feet.

Linear extrapolation to the $0^{\circ}C$ depth is more uncertain and less reasonable at Hole Able than at Hole Baker. It yields a local permafrost thickness of about 1,000 feet (fig. 3). At any rate it is clear that permafrost is thicker and more extensive near the shoreline than would have been anticipated from an equilibrium theory. Under the influence of a stable shoreline, permafrost thickness would have varied from about 600 feet at Hole Able to zero at the shoreline.

Recent climatic change

If temperatures at Hole Baker were in equilibrium with the current thermal regime at the surface, the profile would, in this instance, be very nearly linear below the 50-foot depth. The curvature in the upper 250 feet (fig. 2) evidently represents a distinct and systematic increase in mean annual temperature at the ground surface. A rough theoretical calculation indicates that this change, which currently amounts to about 1°C, is confined to the last century, probably the last 50 years. It is likely that it is still in progress. It is somewhat smaller but no less distinct than a contemporaneous change discovered from geothermal data at Barrow and Cape Simpson (Lachenbruch and Brewer, 1959). A more complete analysis of the problem will be undertaken when more data are available.

Although this change evidently represents a systematic climatic trend, it is not necessarily associated with an increase in mean annual air temperature. Subtle changes in any of several climatic parameters can effect a change in mean annual ground surface temperatures. These changes are often difficult if not impossible to detect from surface observations, even when continuous records are available over a period of several decades. In this problem, as in that of determining generalized mean surface temperatures or of reconstructing shoreline movements, analysis of the thermal regime at depth can yield more information about the surface than can surface observations.

References cited

Lachenbruch, A. H., 1957a, Thermal effects of the ocean on permafrost: Bull. Geol. Soc. America, v. 68, p. 1515-1530.

_______ 1957b, Three-dimensional heat conduction in permafrost beneath heated buildings: U. S. Geol. Survey Bull. 1052-B.

Lachenbruch, A. H., and Brewer, M. C., 1959, Dissipation of the temperature effect of drilling a well in Arctic Alaska: U. S. Geol. Survey Bull. 1083-C.

Lachenbruch, A. H., and Greene, G. W., 1960, Preliminary report on geothermal studies at Ogotoruk Creek, Chapter in Geologic Investigations in support of Project Chariot, Kachadoorian et al.; U. S. Geol. Survey TEI-753.

Appendix: Extension of tables of the function Υ

In computing the information summarized in figure 5 it was necessary to extend tables of the function Υ defined by

$$\Upsilon\left(\frac{x}{z}, m\right) = \frac{1}{\sqrt{\pi}} \int_{m}^{\infty} e^{-v^2} \, dv + \frac{1}{\pi} \int_{0}^{x/z} e^{-m(1+v^2)} \frac{1}{1+v^2} \, dv$$

where

x=horizontal distance from shoreline ($x<0$ inland)

z=depth beneath ground surface

α=thermal diffusivity of ground materials

t=time since shoreline movement

$m=z^2/4\alpha t$

The derivation and use of this function, and the original tabulation are explained in the Geological Society of America paper cited (1957b). With the supplementary tables that follow it is possible to treat all ranges of the parameters likely to be encountered in thermal studies at the Ogotoruk Creek Chariot test site.

Table 1.--The function $\Upsilon(\frac{x}{z}, m)$ for calculation of the seaward geothermal disturbance due to the ocean

$\frac{x}{z}$ \ m	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
0.0	0.327	0.264	0.219	0.186	0.159	0.137	0.118	0.103	0.090	0.079	0.069	0.061	0.053
0.2	.384	.315	.266	.228	.197	.171	.149	.131	.115	.102	.090	.079	.070
0.4	.436	.362	.308	.265	.230	.201	.177	.155	.137	.121	.107	.095	.084
0.6	.481	.401	.343	.296	.258	.225	.198	.174	.154	.136	.120	.106	.095
0.8	.518	.433	.370	.320	.278	.243	.213	.187	.165	.145	.128	.114	.101
1.0	.548	.458	.391	.337	.292	.255	.223	.195	.171	.151	.133	.118	.104
1.2	.571	.476	.405	.349	.302	.262	.229	.200	.176	.154	.136	.120	.106
1.4	.589	.490	.416	.357	.308	.267	.233	.203	.178	.156	.137	.121	.107
1.6	.603	.500	.423	.362	.312	.270	.235	.205	.179	.157	.138	.121	.107
1.8	.614	.508	.429	.366	.314	.272	.236	.205	.179	.157	.138	.121	.107
2.0	.623	.513	.432	.368	.316	.272	.236	.206	.180	.157	.138	.121	.107
2.5	.637	.521	.437	.370	.317	.273	.237	.206	.180	.157	.138	.121	.107
3.0	.646	.525	.438	.371	.3173	.273	.237	.206	.180	.157	.138	.121	.107
∞	.655	.527	.4386	.371	.3174	.2734	.237	.206	.180	.157	.138	.121	.107

Table 1.--The function $\Phi(\frac{x}{z}, m)$ for calculation of the seaward geothermal disturbance due to the ocean--continued

$\frac{x}{z}$ \ m	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.5	3.0	4.0	5.0
0.0	0.053	0.047	0.042	0.037	0.033	0.029	0.026	0.0237	0.0127	0.0072	0.0023	0.0008
0.2	.070	.062	.055	.049	.044	.039	.035	.031	.0176	.0102	.0034	.0012
0.4	.084	.075	.067	.059	.053	.047	.042	.038	.0215	.0124	.0042	.0015
0.6	.095	.084	.075	.066	.059	.053	.047	.042	.0237	.0136	.0045	.0016
0.8	.101	.089	.079	.070	.063	.056	.050	.044	.0248	.0141	.0046	.0016
1.0	.104	.092	.082	.072	.064	.057	.051	.045	.0253	.0143	.0047	.0016
1.2	.106	.093	.083	.073	.065	.058	.051	.045	.0253	.0143	.0047	
1.4	.107	.094	.083	.074	.065	.058	.051	.046	.0253	.0143		
1.6	.107	.094	.083	.074	.065	.058	.051	.046	.0253			
1.8	.107	.094	.083	.074	.065	.058	.051	.046	.0253			
2.0	.107	.094	.083	.074	.065	.058	.051	.046				
2.5	.107	.094	.083	.074	.065	.058	.051	.046				
3.0	.107	.094	.083	.074	.065	.058	.051	.046				
∞	.107	.094	.083	.074	.065	.058	.051	.046				

Table 2.--The function $\Psi(\frac{x}{z}, m)$ for calculation of the inland geothermal disturbance due to the ocean

$\frac{x}{z}$ \ m	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
0.0	0.327	0.264	0.219	0.186	0.159	0.137	0.118	0.103	0.090	0.079	0.069	0.061	0.053
-0.2	.271	.212	.173	.144	.121	.103	.088	.075	.065	.056	.048	.042	.037
-0.4	.218	.165	.131	.106	.087	.072	.060	.051	.043	.036	.031	.026	.023
-0.6	.173	.126	.096	.075	.060	.048	.039	.032	.026	.022	.018	.015	.013
-0.8	.137	.094	.069	.052	.040	.031	.024	.019	.015	.012	.010	.008	.006
-1.0	.107	.069	.048	.035	.025	.019	.014	.011	.008	.006	.005	.004	.003
-1.2	.084	.051	.033	.023	.016	.011	.008	.006	.004	.003	.002	.002	.001
-1.4	.066	.037	.023	.014	.009	.006	.004	.003	.002	.001	.001	.001	.0005
-1.6	.052	.027	.015	.009	.006	.003	.002	.001	.001	.0006	.0004	.0003	.0002
-1.8	.041	.019	.010	.006	.003	.002	.001	.001	.0004	.0003	.0001	.0001	.0001
-2.0	.032	.014	.007	.003	.002	.001	.001	.0003	.0002	.0001	.000	.0001	.000
-2.5	.017	.006	.002	.001	.0004	.0002	.0001	.0001	.0001	.0001	.000	.000	.000
-3.0	.009	.002	.001	.0002	.0001	.0001	.000	.000	.000	.0001	.000	.000	.000
∞	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 2.--The function $\Upsilon(\frac{x}{z}, m)$ for calculation of the inland geothermal disturbance due to the ocean--continued

$\frac{x}{z}$ \ m	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.5	3.0	4.0	5.0
0.0	0.053	0.047	0.042	0.037	0.033	0.029	0.026	0.023	0.0127	0.0072	0.0023	0.0008
-0.2	.037	.032	.028	.024	.021	.019	.017	.015	.0077	.0041	.0013	.0004
-0.4	.023	.019	.017	.014	.012	.011	.009	.008	.0039	.0019	.0005	.0001
-0.6	.013	.011	.009	.007	.006	.005	.004	.004	.0016	.0007	.0001	.000
-0.8	.006	.005	.004	.003	.003	.002	.002	.002	.0005	.0002	.000	.000
-1.0	.003	.002	.002	.001	.001	.001	.001	.001	.0001	.000	.000	.000
-1.2	.001	.001	.001	.001	.0004	.0003	.0003	.0002	.000	.000	.000	
-1.4	.0005	.0004	.0003	.0001	.0001	.0001	.0001	.0001	.000	.000		
-1.6	.0002	.0002	.0001	.000	.000	.000	.0001	.0001	.000			
-1.8	.0001	.0001	.0000	.000	.000	.000	.0001	.0001	.000			
-2.0	.000	.0001	.000	.000	.000	.000	.0001	.0001				
-2.5	.000	.0001	.000	.000	.000	.000	.0001	.0001				
-3.0	.000	.0001	.000	.000	.000	.000	.0001	.0001				
∞	.000	.000	.000	.000	.000	.000	.0001	.0001				

OBSERVATIONS OF COASTAL PROCESSES IN THE VICINITY OF CAPE THOMPSON, ALASKA, FROM MAY 3 TO MAY 9, 1960

By

George W. Moore

Introduction

A 2-man U. S. Geological Survey field team went into the Cape Thompson area in early May 1960, to make observations to ascertain the roles of winter ice and spring break-up in the coastal processes of the area. This report is based on observations made from May 3 to May 9, 1960, and is included in this supplementary Chariot Phase II report although the work was done under the Chariot Phase III program. Break-up of the larger streams and rivers had not occurred on the last day of the observations and therefore break-up information is not included in this report.

Climate

On the first two days of the observation period, the weather was clear and calm and temperatures were relatively warm. Snow was melting at the town of Kotzebue and water was running onto the margins of the sea ice. The ground surface at Kotzebue was generally free of snow although some large drifts remained where the snow had accumulated during the winter. Planes were landed and parked on the sea ice in Kotzebue Sound but it was becoming increasingly difficult to get out to them because of the belt of water about 50 feet wide and 6 inches deep that fronted the shore.

During the last five days of the observation period, the weather became progressively worse. The temperature was generally below freezing. Winds ranged up to about 12 miles per hour and a very light snow fell almost continuously. The snow was in the form of small pellets during the colder periods and in the form of large wet flakes during the warmer periods. Total snow fall during the five-day observation period was not more than an inch.

Sea ice

Sea ice in the vicinity of Kotzebue was almost perfectly flat. Farther seaward, however, in the Kotzebue Sound along a line between Cape Espenberg and Cape Krusenstern the ice was characterized by pressure ridges. From Cape Krusenstern north to Point Hope, the ice was generally broken and ridged. In the vicinity of Cape Thompson and the Chariot test site the ice resembled a terrazzo floor in that the individual flat sheets of ice, which were several tens of feet across, had frozen together again. In many places the sea ice contained broad areas of open water or "leads" generally a mile or more wide and located several miles offshore. Locally, the leads came fairly close to shore but there was always at least several hundred feet of ice between the leads and shore. Two large leads were noted during the May 3 to May 9, 1960 observation period. One extended along Kotzebue Sound from Cape Espenberg seaward and the other along the Arctic Coast about 10 miles offshore.

In places the sea ice had been pressed into ridges, either near the shore or in an area where large masses of ice had been blown together by the wind. When the ridges were along the shore, they were about 25-30 feet offshore where the ice was grounded on the sea floor.

Sea level

Observations indicate that sea level fluctuates as much as 1.3 feet in the area. Extending out from shore was a 25 to 30-foot area of ice bounded on the seaward side by a scarp 2-3 feet high, below which was the general level of the sea ice. It appears that the ice level was originally higher and when sea level fell, the ice near the shore grounded and therefore remained high. At the mouth of the Kukpuk River submerged bars were clearly marked by areas where ice was pushed upward 2-3 feet. Again it appears that the general level of the sea had fallen and grounded ice remained high. Numerous small fresh cracks in the ice, probably due to tidal action, extended parallel to the shore.

Two observations were made on the level of the sea ice. The level of the ice was 0.5 feet higher at 10 a.m. on May 8, 1960 than at 6 p.m. on May 7, 1960. At 4 p.m. on May 8, 1960 the surface of the sea ice was 1.3 feet above the level at which it stood at 6 p.m. on May 7, 1960.

Streams and lagoons

During the relatively warm period from May 3 to May 5, 1960, many of the streams in the area began to flow. The streams generally contained black, organic-rich water and were all largely free of ice. Water was observed flowing from muskeg areas onto the margins of the lakes and lagoons as well as in the streams. Southeast of Point Hope, water flowed slowly on the surface of the ice of the larger streams and rivers. A relatively large quantity of water flowed along the Wulik River and over the bar at its mouth. This water, as well as other water from streams flowing into the sea, accumulated on top of the sea ice in a narrow belt. At the mouth of the Kukpuk River during the warm period, the ice melted to a depth of about 6 inches around the margins of the lagoon and inlet. Later during the following cold period, the ice formed again and was about an inch thick on May 9, 1960.

The large lagoons such as the lagoon behind Cape Krusenstern, Corwin Lagoon, and Marryatt Lagoon behind Point Hope were all firmly frozen. Certain small lagoons, however, were almost entirely thawed, and may receive some water from warm springs. Tayaschek Lagoon, about 12 miles north of Cape Krusenstern, was almost entirely free of ice, and stood in sharp contrast with nearby lagoons that were frozen. The ice on the lagoons and lakes was generally not broken. Usually the ice in the center of the lagoon or lake stood a foot or so below the ice along the margins and was warped upward around the edges. The level of the ice was not measured on the lagoons with the exception of Marryatt Lagoon, where it was the same as that in the ocean.

Late in the summer season when the quantity flow in the rivers diminishes greatly the balance between the energy of the river and wave energy moves in the direction of the wave, thereby causing the mouths of even the largest rivers to begin to close by alongshore sediments carried by the waves. The mouth of the Wulik River was entirely closed and the mouth of the Kukpuk River was made substantially smaller by waves late in the summer season of 1959.

Wind erosion

The strong winter winds ranging up to 50 miles per hour have important sediment-transporting properties in the area. The sea ice was discolored by windblown sand and silt to distances of as much as a quarter of a mile offshore. Within 30-40 feet from shore, layers of silt and sand as much as 6 inches thick overlay the sea ice. Near the shore, the grain size of the windblown debris ranged up to 2 millimeters. Bottles and fish net floats stranded on the shore were frosted by the windblown material on their exposed parts.

Preliminary conclusions

From the evidence obtained during the observation period between May 3 to May 9, 1960, it appears that a disruption of beach material above the waterline is insignificant due to ice push. Along those parts of the coast where ice ridges are formed near the shore, their location is always 25-30 feet offshore. This action probably does, however, disrupt the sediments where the ice is grounded approximately 6 feet below the sea level.

The chief conclusion derived from these observations is that winter processes in the vicinity of the Cape Thompson area affect the beach material very little, except locally to disturb the sediments at a depth of approximately 6 feet below the sea level. The chief effect of the winter freezing is generally to arrest the coastal processes. Observations during the break-up have not been made and its effect upon the coastal processes cannot be commented upon at this time. It is very likely that occurrences during the spring break-up may have a more significant effect upon the beaches than the winter sea ice.

WINTER GROUND WATER INVESTIGATIONS IN THE VICINITY OF CAPE THOMPSON, ALASKA

By

Roger M. Waller

Ogotoruk Creek Valley

The flood plain and creek channel of the lower reach of Ogotoruk Creek were observed several times during the winter of 1959-1960 for evidence of ground water occurrence. After the winter freeze-up, the creek still maintained a flow which was derived from ground water influent from adjacent channel and flood plain deposits. The flow was observed beneath an 18-inch ice cover in mid-November. Several icing sheets and creek-ice fissures were created as the water became confined by the downward encroachment of the ice cover. The presence of flowing water beneath the ice cover continued for an unknown length of time thereafter, but is believed to have stopped about mid-December when the creek bed probably became frozen. It was not possible to determine whether ground water remained all winter in the gravel beneath the frozen creek bed in the lower reach of the stream. Snow cover was negligible during the winter; therefore, the seasonal frost penetration probably was very deep.

Covreruk Springs

The springs near Cape Seppings, which were named Covreruk Springs, maintained a flow throughout the winter. The temperature of the water at one of the springs was 38°F. on April 7, 1960, as compared to 38.5°F. on September 9, 1959. The total discharge of the springs, however, had decreased from 22.7 cfs (cubic feet per second) on September 9, 1959, to 6.17 cfs on April 7, 1960. A water sample was taken to determine any changes in the chemical quality of the water from that of previous analyses. The analysis has not been obtained as yet and therefore is not included in this report.

The decrease in discharge of the springs is coincident with the normal decrease in stream flow in northern Alaska during the winter months. The correlation of the decreasing winter discharge suggests that the springs probably derive their supply from a surface stream of substantial flow. The discharge of the springs is expected to increase as precipitation and meltwater replenish the streams and spring systems in the summer.

Springs in Igichuk Hills

Several springs were reported in the Igichuk Hills, about 100 miles southeast of Ogotoruk Creek. One was easily accessible and was visited in early April 1960. A water sample was taken from the associated stream about half a mile downstream from the spring. The water and surrounding air had a noticeable sulfur odor. The stream temperature was 38°F, whereas the air was about 0°F. The spring probably has a slightly higher water temperature than that of Covreruk Springs.

Covreruk Springs and the springs in the Igichuk Hills indicate that ground water exists the year round within the permafrost region in this part of Alaska.