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OPEN-FILE REPORT

GEOLOGY OF THE OGOTORUK CREEK AREA, NORTHWESTERN ALASKA

By Reuben Kachadoorian, R. H. Campbell, C. L. Sainsbury, and D. W. Scholl

Trace Elements Memorandum Report 976

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with a section on SURFACE WATER, OGOTORUK CREEK, ALASKA

By

M. J. Slaughter

with a section on QUALITY OF WATER OF OGOTORUK CREEK, ALASKA

By

George Porterfield

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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

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GEOLOGY OF THE OGOTORUK CREEK AREA, NORTHWESTERN ALASKA

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SUMMARY AND CONCLUSIONS

The Ogotoruk Creek area is topographically and geologically well situated for the construction of a harbor by a nuclear device. Little maintenance of the harbor will be required. Studies of the submarine topography show an offshore continuation of Ogotoruk Creek valley, which should provide an excellent natural deep-water approach channel. Locally, buoys will have to be placed to mark areas of bedrock knolls off the channel area. The channel extends to within 2,600 feet of the proposed harbor mouth.

The material to be excavated consists chiefly of mudstone, siltstone, and sandstone of the Tiglukpuk formation of Jurassic age. These rocks are frozen to probable depths of 500 to 800 feet. Holes for the device will be entirely in these frozen rocks. Locally, there may be unfrozen areas which may cause some slumping in the holes when they are drilled. Unconsolidated surficial deposits form a veneer of negligible thickness with respect to the size of the proposed excavation. Although the bedrock is relatively soft and fissile, it is doubtful that large-scale slumping into the excavation will occur as a result of the blasting and subsequent thawing of permafrost.

The low altitude of the bedrock at the mouth of Ogotoruk Creek presents one problem that can be minimized by proper placing of the excavating device. The device should be so placed that the blast will not destroy the bedrock barrier to the harbor. If this barrier is destroyed, the overlying ancient beach gravels may retreat rapidly by erosion, thereby removing the natural harbor protection of the ancient beach gravel bar.

Silting of the harbor by Ogotoruk Creek should be negligible except during flood stage such as spring run-off and summer rain storms. During periods of low flow Ogotoruk Creek carries essentially no suspended load and the bed-load is stationary. Although the creek carries a substantial load during periods of high flow, these periods are infrequent and the amount of debris contributed to the harbor area each year should be insufficient to result in a maintenance problem except in the distant future.

Longshore transport of sand and gravel by longshore currents will tend to form spits or bars across the harbor entrance. However, a comparison of the proposed size of the excavation with estimates of longshore transport and amounts of material available for longshore transport indicates that several tens of years would be required for such deposits to reach a size that would pose a maintenance problem. Even if such deposits formed, only minor intermittent dredging would be required to keep the entrance open. The amount of unconsolidated material contributed by the blast itself will add to the material already available for longshore transport. This factor, however, will be very minor.

The construction and maintenance of facilities such as docks, warehouses, roads, airfields, and living quarters will require some precautions for frost heaving and the thawing of permafrost. If the structures are placed on unconsolidated deposits some frost heaving of the structures will occur, and heated buildings may settle due to thawing of permafrost. Roads and airstrips should be placed on areas that are not susceptible to frost action and that do not contain appreciable perennial ice. If it is necessary to place structures, roads, and airstrips on areas susceptible to frost heaving and thawing of permafrost, construction techniques should be adopted to minimize these actions. Fortunately, the unconsolidated deposits are only a few feet thick and the foundations of structures can easily be placed on bedrock.

Dock facilities and other installations at the water's edge in the harbor should be constructed so damage from ice thrusting during the winter months will not occur. Damage from ice thrusting of the facilities can be prevented by placing the structures in sheltered locations.

The best source of fresh water is Ogotoruk Creek. A dam placed on this creek would provide storage for a water supply and possibly flood alleviation if a suitable reservoir site could be found.

INTRODUCTION

General statement

A project to use the immense energy concentrated in a nuclear device to construct an experimental deep-water harbor has been proposed by the Atomic Energy Commission and is referred to as Project Chariot; it is one phase of AEC Project Plowshare. The northwestern coast of Alaska from Point Barrow to Nome was originally selected for the site of the experimental harbor, because of the lack of both harbors and large population centers. In the early spring of 1958 the U. S. Geological Survey was asked by the Atomic Energy Commission to undertake a study to evaluate the geologic and oceanographic factors relevant to the selection of a site between Point Barrow and Nome. Later, an area between Cape Seppings and Cape Thompson was selected and the U. S. Geological Survey prepared a report on this 20-mile area (Péwé, Hopkins, and Lachenbruch, written communication, 1958). Péwé, Hopkins, and Lachenbruch's work was based entirely on the study of published reports, manuscripts, field notes, unpublished maps in the files of the U. S. Geological Survey, interviews with geologists who had visited the area, and the geologic interpretation of aerial photographs. On the basis of the above sources of information, 3 sites were selected in the

20-mile coastal strip from Cape Seppings to Cape Thompson. The report suggested that geologic field investigations of the 3 sites be made to determine the most suitable site for the harbor.

A Survey field party consisting of Reuben Kachadoorian, R. H. Campbell, C. L. Sainsbury, and D. W. Scholl, geologists, and Currie Lockett, field assistant, started field work on the investigation of the 3 sites on July 7, 1958. The data collected on the 3 sites were discussed with representatives of the Atomic Energy Commission, University of California Radiation Laboratory, Sandia Corporation, U. S. Corps of Engineers, and Holmes and Narver, Inc., who visited the Survey party from July 17 to July 19 for a field conference. At that time it was decided that because of the more favorable geologic and topographic conditions the site at Ogotoruk Creek was most suitable for the location of the experimental harbor. Therefore, the Survey party spent the remainder of the field season to August 25, 1958 in the Ogotoruk Creek area.

During the field conference, Mr. Gerald Johnson of U. C. R. L. requested that the U. S. Geological Survey submit a report on the summer's investigation around the first of November 1958. This preliminary report is in response to Mr. Johnson's request. The authors wish to point out that in order to submit this report by November 1, 1958, time did not permit a complete and thorough study of many of the problems that may arise in the construction of the harbor by a nuclear device. They feel, however, that all major problems have been considered in this report. Slight revisions may be necessary when complete laboratory results have been obtained. The authors believe that these revisions will be slight and will not materially affect the conclusions expressed in this report.

Acknowledgments

Field work was greatly facilitated by the cooperation of the military and civilian personnel of the U. S. Navy icebreaker the U. S. S. Burton Island. Some of the oceanographic data shown on plate 2 are taken from fathograms furnished by the U. S. S. Burton Island. Divers from the icebreaker also furnished information about the floor of the Chukchi Sea. The topographic base for plate 3 is a reduction of a map of 1:1,200 scale furnished by Holmes and Narver, Inc. There are some minor topographic discrepancies between this map and the map shown in plate 1. They are chiefly due to the difference of scale between the two maps.

Location

The Ogotoruk Creek area lies north of the Arctic Circle in northwestern Alaska at longitude 165° 45' W. and latitude 68° 06' N. (fig. 1). The area is approximately 125 miles northwest of the town of Kotzebue and about 32 miles southeast of the town of Point Hope. Figure 2 is a photograph of the proposed harbor site.

Accessibility

The only means of access to the Ogotoruk Creek area at the present time are by boat, light aircraft, or tracked vehicle. The Alaska highway system does not extend into northwestern Alaska. The topography would permit a highway to be constructed to Corwin Bluffs, approximately 55 miles northeast of the area, and to Kotzebue. However, several large rivers would have to be bridged. Geological factors should control the location of the highway route to either of the two places.

Light single-engine aircraft can land at the site on a 700-foot airstrip built by U. S. Geological Survey personnel.

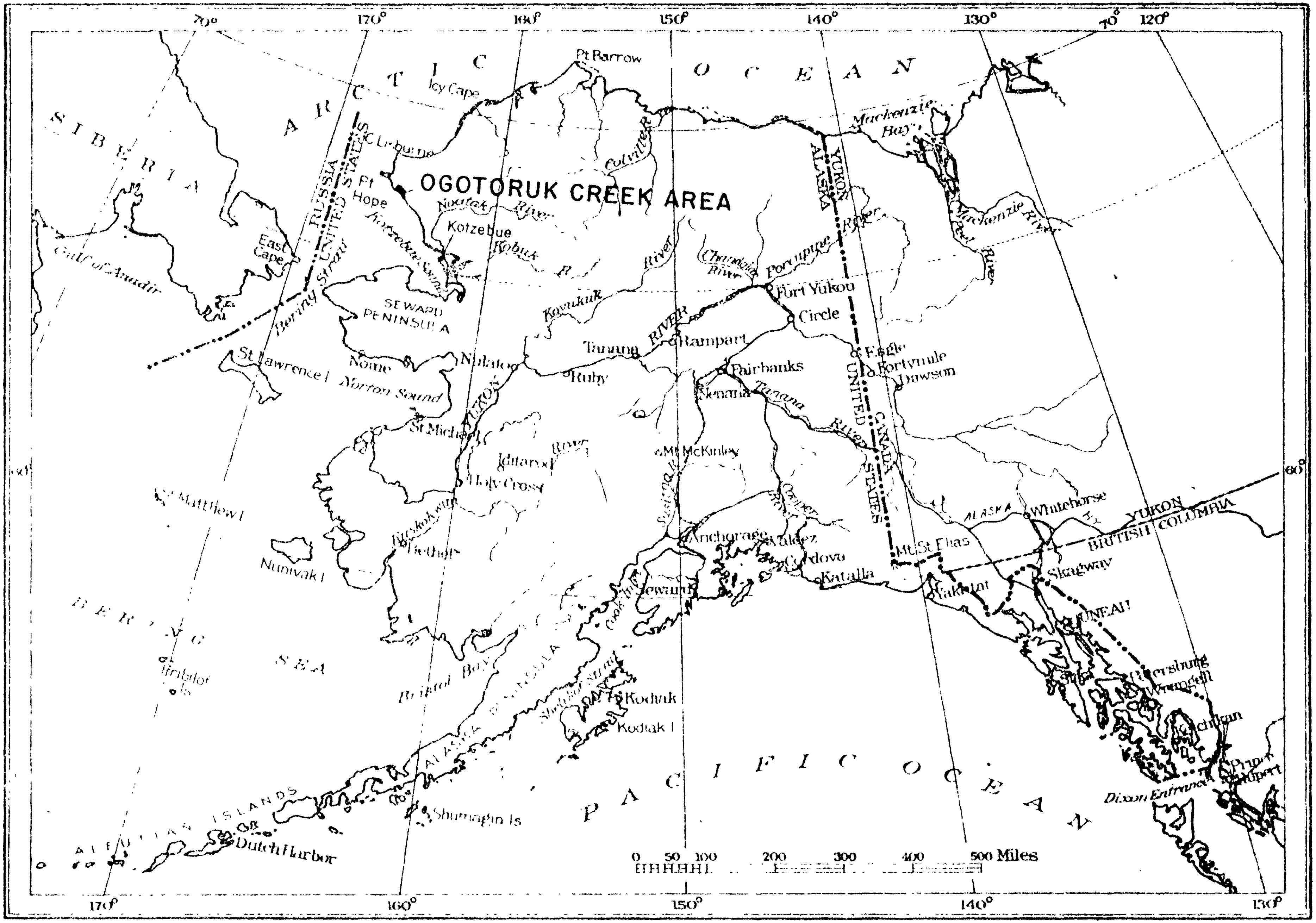

Figure 1. Index map showing location of Ogotoruk Creek area, Northwestern Alaska

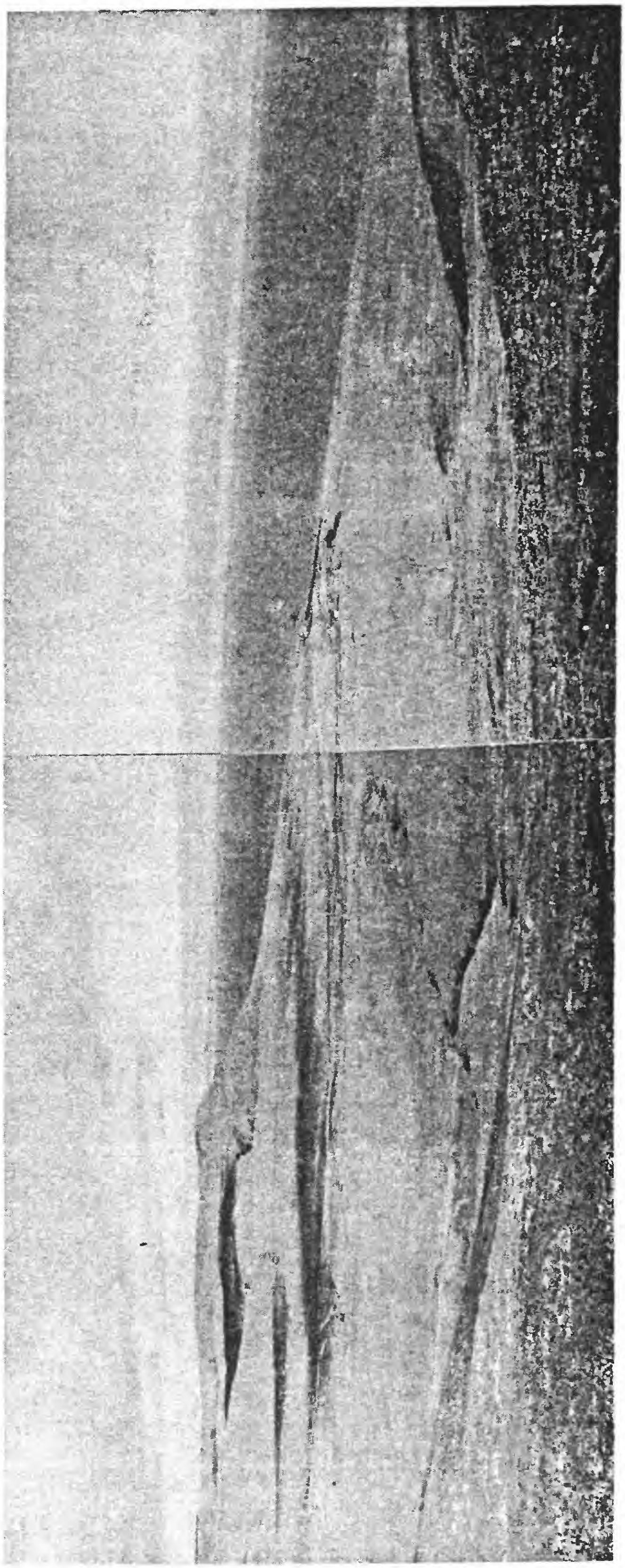

Figure 2. View of Ogotoruk Creek harbor site, looking southeast.

Methods of field work

Onshore field work by the Geological Survey consisted of a series of foot, tracked vehicle, and boat traverses, during which geological data were collected and plotted on vertical aerial photographs of 1:12,000 and 1:40,000 scales. The information was later transferred to topographic maps of 1:12,000, and 1:4,800 scales (plates 1 and 3, respectively). Information concerning the depth to permafrost and thickness of ice wedges was obtained through the use of hand augers and shovels.

Data regarding submarine topography, marine geology, and oceanography were principally collected from a small boat equipped with an outboard motor. These data were augmented by sonic soundings and bathythermograph readings (from 4 to 15 miles offshore) provided by the civilian and military personnel of the icebreaker, U. S. S. Burton Island. Qualified divers (geologists) from the Burton Island also supplied pertinent data regarding the nature of the sea floor.

Climate

The climate of the Ogotoruk Creek area is characterized by long cold winters and short cool summers. Data from weather stations at Kotzebue airport, and Cape Lisburne about 70 miles north of Ogotoruk Creek, are shown on tables 1 and 2. Additional data for dates of freeze-up and break-up of ice are available for Kivalina, 30 miles southeast of Ogotoruk Creek, and Point Hope, and are shown on table 3. These data indicate that the proposed harbor would be ice-free for about 4 months of the year.

The only weather data available for the Ogotoruk Creek area were collected during the present investigation. Wind direction, maximum and minimum temperatures, and precipitation were recorded. The summary of these data is shown on table 4.

Table 1.--Climatological Data for Kotzebue Airport, Alaska [1/]

Month	Average temperature °F.	Average precipitation inches
January	-6.6	.47
February	-4.7	.32
March	-1.6	.27
April	13.8	.36
May	29.6	.33
June	43.3	.49
July	52.6	1.53
August	50.7	1.95
September	40.9	.94
October	25.5	.58
November	7.5	.43
December	-3.7	.35
Annual	20.6	8.02

[1/] U. S. Weather Bureau, 1958, Climatological Data, Alaska Annual Summary, 1957, v. XLIII, no. 13

Years of record:
Precipitation, 15 years
Temperature, 15 years

Table 2.--Climatological Data for Cape Lisburne, Alaska [1]

Month	Average temperature °F.		Average precipitation inches	
January	-9.5		.27	
February	-10.6		.13	
March	-8.7		.25	
April	20.9		.21	
May	30.3		.02	
June	41.6		.44	Partly estimated
July	46.0		2.12	Partly estimated
August	44.9		3.50	Partly estimated
September	35.8		2.61	Partly estimated
October	28.2		1.94	
November	5.9		.44	
December	-8.2	(1-10 days record missing)	.12	
Annual	19.7		12.05	Partly estimated

[1] U. S. Weather Bureau, 1958, Climatological Data, Alaska Annual Summary, 1957, v. XLIII, no. 13

Years of record:
Precipitation, 3 years
Temperature, 4 years

Table 3.--Miscellaneous climatological data for Kotzebue, Cape Lisburne, Point Hope, and Kivalina, Alaska, 1957 1/

Station	Rivers and harbors	Date unsafe for man	Break-up	Departure 2/	First ice	Date safe for man	Departure 2/	Highest temp.	Date	Lowest temp.	Date	Total snowfall	Freezing temp.		Number of days temperature			
													Last date in spring	First date in autumn	Max. 70°F or above	Max. 32°F or below	Min. 32°F or below	Min. 0°F or below
Kotzebue	Kotzebue Sound	May 25	May 26	-6	Sept. 25	Oct. 31	+8	81	June 8	-47	Dec. 26	77.2	May 31 (30°)	Sept. 19 (32°)	5	183	243	90
Cape Lisburne	--	3/	3/	3/	3/	3/	3/	72	July 11	-37	Feb. 13	30.3	June 20 (32°)	Sept. 17 (28°)	1	195	247	104
Kivalina	Walik River	4/	4/	4/	Oct. 4	Oct. 8	-18	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
Point Hope	Marit Inlet	May 30	June 9	4/	Sept. 26	Oct. 3	-8	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/

1/U. S. Weather Bureau, 1958, Climatological Data, Alaska Annual Summary, 1957, v. XLIII, no. 13.
2/Departures are days from average date of breakup or average date safe for man based on five or more years of record. Earlier-than-average dates are indicated as minus and later-than-average dates are indicated as plus.
3/No data reported by Weather Bureau.
4/No record.

Table 4.--Summary of weather data for the Ogotoruk Creek area collected from July 7, 1958 to August 27, 1958.

	July 7-31, 1958	August 1-27, 1958
Total precipitation	0.4 inches	4.4 inches
Maximum precipitation in 24 hours	0.2 inches (July 9)	1.0 inches (Aug. 10 & 11)
Number of days of rain	8	11
Maximum temperature	80°F (July 10)	70°F (Aug. 27)
Average maximum daily temperature	63.5°F	60.2°F
Minimum temperature	35°F (July 27)	34°F (Aug. 19)
Average minimum daily temperature	44.4°F	42.7°F
Average daily wind velocity	14 mph	17 mph
Maximum wind velocity	30 mph SE	60 mph N
Average daily cloud cover	60%	65%
Number of essentially cloudless days	7	7

Most of the winds blew from the north, northwest, and west during July, and from the north during August. The average velocities were about 14 miles per hour during July and 17 miles per hour during August. A maximum velocity of 60 miles per hour from the north was recorded on August 14.

GEOLOGY

General geology

The geology of the Ogotoruk Creek area is shown on plates 1, 2, and 3. Plates 1 and 3 show the onshore geology; plate 2 shows the marine topography and geology.

Onshore geology

Sedimentary rocks.--The sedimentary rocks of the area consist of consolidated clastic and chemical sediments of marine and brackish-water origin. They include shale, limestone, chert, argillite, slaty mudstone, siltstone, and medium- to fine-grained sandstone. The rocks range from Mississippian to Jurassic(?) in age and are exposed in about 40 percent of the map area (pl. 1). Except where wave or stream erosion is active, the areas of bedrock are mantled by a few inches to a few feet of rubble produced chiefly by frost action. Undisturbed outcrops are essentially confined to sea cliffs and stream cuts.

The oldest rocks exposed in the area are limestone, chert, and shale of the Lisburne group of Mississippian age (Bowsher and Dutro, 1957, p. 3). Two distinct lithologic units are shown on plate 1: a lower unit (herein termed "middle Lisburne") of interbedded thin gray limestone and black sandy shale; and an upper unit (herein termed "upper Lisburne") of thick- to thin-bedded light-gray limestone and dolomite with variable amounts of gray to black chert as thin interbeds, as minute angular patches, and as irregular nodules. The "middle Lisburne" is exposed in the western and southwestern part of the map area. To the east along the sea cliffs in the vicinity of Cape Crowbill it is in apparent conformable contact with the "upper Lisburne" and both units are overturned. The contact of the Lisburne with the overlying younger rocks is nowhere exposed but is believed to be a high-angle reverse fault in the southwestern part of the area and a thrust fault in the west central part of the area.

A sequence of argillite and chert beds overlying the Lisburne group is probably correlative with the Siksikpuk formation of probable Permian age as described in the Brooks Range by W. W. Patton, Jr. (1957, p. 41-43).

In the map area the Siksikpuk is not well exposed and the lithology is not well known. Good exposures west of the mapped area, however, show more than 160 feet of chert and argillite of the Siksikpuk formation overlying rocks of the Lisburne group. The bottom of the Siksikpuk formation has not been observed. The lower 80 feet of the exposed Siksikpuk consist of green argillite; locally the argillite has green and red banding. The upper 80 feet consist of chert beds ranging in thickness from 3 inches to 1 foot. The chert beds are interbedded with argillite beds as much as 3 inches thick. More commonly, the argillite beds are about 1 inch to 1-1/2 inches thick. The top 30 feet of this chert unit contain nodules as much as 6 inches in diameter.

The rocks that overlie the Siksikpuk are probably correlative with the Shublik formation of Triassic age described by Leffingwell (1919, p. 115-118) in the Canning River area. The Shublik formation consists of three mappable units. The lowermost unit, about 160 feet thick, grades from thin-bedded black shale at the base to brown to gray bedded chert at the top. This lower unit grades into a light-brown thin-bedded fossiliferous limestone zone about 15 to 30 feet thick, containing minor amounts of interbedded shale and chert. Fossils, chiefly <u>Entomonotis</u> are abundant. Because of its distinctive lighology and fauna, this zone is an important marker bed that is useful in attempts to interpret complex structure in areas of poor exposures west of Ogotoruk Creek. The fossiliferous limestone is overlain by about 40 feet of thick-bedded green argillite with a few thin interbeds of chert. This green argillite is lithologically very similar to the argillite in the Siksikpuk formation.

Exposures of Mississippian, Permian, and Triassic rocks are confined to the western part of the Ogotoruk Creek area. The central and eastern parts of the area are underlain by slaty to shaly grayish-black mudstone and siltstone with variable amounts of interbedded very fine- to medium-grained gray to brown graywacke. These rocks are tentatively assigned to the Tiglukpuk formation of Jurassic age (Patton, 1956). In a few exposures the mudstone appears unstratified and fracture cleavage is the only observed planar structure. More commonly, thin interbeds of siltstone and sandstone are prominent. Graywacke interbeds generally increase in abundance and thickness eastward, and near the eastern boundary of the map (pl. 1) these rocks grade imperceptibly into undifferentiated Jurassic-Cretaceous rocks which locally contain calcareous sandstone. As the Jurassic rocks have been highly deformed, no accurate thickness could be measured. The absence of exposures of older rocks for several miles across the structural grain indicates that several thousand feet of Jurassic rocks are represented in the Ogotoruk Creek area. Consideration of the thickness of the Tiglukpuk and the general geologic structure in the Ogotoruk Creek area indicates that the proposed harbor would be excavated almost entirely in rocks of the Tiglukpuk formation. Drill holes and shafts will probably not penetrate other rocks unless driven to depths greater than 500 feet.

Structure.--Nearly all of the beds in the Ogotoruk Creek area strike north-northeast to east-northeast. Most of the beds dip west and stratigraphic and other criteria indicate that in many places the beds are overturned. From west to east the beds form a nearly parallel series of north-trending belts of progressively younger rocks. Minor folds overturned to the east are common. The largest overturned fold is exposed along the sea cliff in the southwest corner of the map area (pl. 1) where several thousand feet of Lisburne rocks dip to the west. The rocks have been further disturbed by north-northeastward trending high-angle reverse faults and imbricate thrust faults. These faults bring the older, more resistant Lisburne rocks into contact with Permian and younger rocks on the eastern flank of the north-trending ridge about a mile west of Ogotoruk Creek.

The major folding and faulting probably developed about contemporaneously after Early Cretaceous time.

Unconsolidated deposits.--Unconsolidated deposits of Quaternary age overlie the bedrock in about 60 percent of the map area included in plate 1. They consist of ancient beach deposits (Qab), terrace deposits (Qt), silt and sand (Qss), colluvium (Qco), alluvial fan deposits (Qaf), talus (Qta), swamp deposits (Qs), floodplain deposits (Qfp), and modern beach deposits (Qb). Although the unconsolidated deposits are locally as much as 30 feet thick, they are generally only a thin veneer from 5 to 12 feet thick.

Ancient beach deposits (Qab) and modern beach deposits (Qb) consist of subangular to rounded pebbles generally about 3 to 4 inches in diameter. Locally, boulders as much as 20 inches in diameter occur. The average diameter of the beach gravels, however, is about 1 inch. Gravel derived from the Jurassic Tiglukpuk formation rocks is generally subangular to subrounded; the rounded gravel consists chiefly of Mississippian, Permian, and Triassic rocks. The matrix of these deposits is silt and clay. These ancient beach deposits are at least 18 feet thick and locally may be as much as 30 feet thick.

Terrace deposits (Qt) consist of subrounded to rounded gravel generally smaller than 3 inches in diameter and averaging from 1 to 2 inches in diameter. Locally, the deposit may consist chiefly of coarse-grained sand with minor amounts of gravel. The matrix of the terrace deposits is medium- to coarse-grained sand with local pockets of fine-grained sand. The thickness of terrace deposits is unknown, but they are probably less than 15 feet thick.

Colluvium (Qco) consists of angular fragments about 4 inches across with local boulders as much as 2 feet across with a matrix of fine-grained sand and silt. Locally, the colluvium contains talus and stream gravels. The colluvium in the extreme eastern part of the area shown on plate 1 is as much as 60 feet thick. In the Ogotoruk Creek valley, however, the blanket-like colluvium deposits are more commonly 15 feet or less in thickness.

Alluvial fan deposits (Qaf) consist of subangular to subrounded gravel generally less than 4 to 5 inches in diameter, in a matrix of coarse- to medium-grained sand. The thickness of this deposit is unknown but is believed to be less than 10 feet in most places.

Talus deposits (Qta) consist of angular blocks as much as 5 feet across and averaging about 2 feet across. Locally, these deposits are intermingled with colluvium and contain a substantial amount of fine sand and silt. More commonly, however, they do not have a sand and silt matrix. The thickness of the talus deposits is estimated to range from 8 to 10 feet.

Floodplain deposits (Qfp) range from subrounded to rounded gravel as much as 4 inches in diameter at the mouths of the creeks, to angular and subangular boulders as much as 1 foot across at the heads of the streams. The matrix of the deposit at the stream mouths consists of coarse-grained sand which may be as much as 50 percent of the deposit. At the heads of the creeks, the matrix is also coarse-grained sand but is about 10 percent of the deposit. The maximum thickness of floodplain deposits was not determined but may be as much as 10 feet.

Silt and sand (Qss) is an accumulation of windblown material generally less than 8 feet thick. In the northwestern part of the map area (pl. 1), however, windblown material as much as 30 feet thick was noted. Locally, silt and sand deposits grade into colluvium.

Swamp deposits (Qs) occur in areas of impeded drainage and consist of accumulations of grasses, sedges, and fine-grained windblown sand and silt.

The thickness of accumulations of swamp deposits is not known but is probably less than 3 to 4 feet.

Marine geology

Oceanography.--From July 8 to August 25, 1958 the surface water temperature in the vicinity of the proposed harbor ranged from 42°F to 60°F. July and August surface water temperatures averaged 55.7°F and 51.2°F, respectively. At depths greater than 50 feet the recorded water temperatures fell below 51°F and ranged down to 42°F at a depth of 100 feet. This 42°F water at the surface suggests upwelling of deep cold water during sustained strong northwesterly winds. These upwelling currents of cold water would tend to inhibit or reverse the prevailing offshore current which generally transports suspended silt to the northwest.

Two distinct currents are present along and off this portion of the Alaska coast. The more important of these with respect to sediment transport is the longshore current, which occurs only nearshore in the area affected by surf action. Longshore currents are variable in direction because they are set up by waves striking the beach at oblique angles. These currents transport gravel along the shore and are the primary mechanism by which a harbor entrance could be filled or reduced in depth. A more thorough discussion of this problem is presented in the ENGINEERING GEOLOGY section of this report.

The second current is a prominent north-to northwest-moving mass of water which is essentially the northward continuation of the oceanic current flowing through the Bering Strait. This current is usually present a few hundred yards from shore and is characterized by surface velocities ranging from about 0.1 mile per hour to 0.6 mile per hour. These velocities are sufficient to permit transport of silt and clay size particles but not beach gravels.

Fluctuations of the Chukchi Sea were recorded at various times during the months of July and August, 1958. The tides and other free and forced oscillations of the sea were characterized by a 1/2 period of 6 to 6-1/2 hours, a height which averages about 9 inches, and a lag time of the high tide of about 20 to 30 minutes per day. When a strong onshore wind (25-40 mph) blew for two or more days sea level rose an additional 1 foot to 1-1/2 feet. Conversely, when strong offshore winds blew sea level fell between 1 foot and 2 feet below mean low water. Kindle (1909) reports that sea level can rise as much as 10 feet along the northwest Alaskan coast during violent storms in the month of October.

Throughout the time of observation, the waves varied greatly in direction, height, and period as a result of variations in wind velocity and direction. During calm days, or when winds were directly offshore, wave trains were like those of a large lake. These waves usually had a period of 2 to 3 seconds, a length of 10 to 20 feet, and a height of 3 to 6 inches. At times of strong onshore winds the waves had periods of 6 to 8 seconds, lengths of 40 to 70 feet, and heights of 1 to 5 feet. There were about eight such days of strong onshore winds during the months of July and August, 1958. Throughout the period of observation by the Survey personnel the waves averaged about 10 inches high, were 25 to 30 feet long, and had a period of 4 to 5 seconds. Most of the waves arrived from the west or west-northwest, but the largest waves came from the south and southeast.

Marine topography.--The topography of the floor of the Chukchi Sea in general reflects the seaward continuation of the land topography; the relief, however, is more subdued (pl. 2). The gentle valley of Ogotoruk Creek continues seaward and has been traced at least 15 miles offshore by Survey personnel and by acoustic soundings made by the U. S. Navy icebreaker the

U. S. S. Burton Island. This submarine valley has been cut into soft Jurassic rocks which also underlie the valley of Ogotoruk Creek. The more resistant rocks, such as the Lisburne limestone, continue seaward to form low ridges that are also extensions of land topography.

Although the submerged valley of Ogotoruk Creek forms a natural approach channel to the proposed harbor, bedrock hillocks were detected both along the sides and the axis of the valley and to the east and west of the valley. Some of these hillocks were observed visually, and others have been reported by the natives in the area. The 50-foot contour crosses the axis of the valley or depression within 8,000 feet from shore and no major navigational hazard is known that might obstruct this natural approach channel.

Marine sediments.--The distribution of unconsolidated marine sediments is shown on plate 2. This map is based upon small samples collected by a hand line attached to a bottom sampler. Samples were collected at most of the 280 stations shown on the map. The sediments are distributed in a crudely linear pattern parallel to the coast, with local disruption near the mouths of the larger creeks.

A narrow belt of well-sorted gray and green sand is almost everywhere found near shore except off precipitous sea cliffs. Seaward of the sand, the sediments generally consist of gravel with a matrix of sand and silt. The silty gravel is largely restricted to water deeper than about 35 feet. This material lies generally in submarine depressions. The gravel near shore is covered by a thin veneer of fine sand about 1 inch to 3 inches thick; farther offshore the gravel locally is overlain by 2 to 3 inches of silt. Off the sea cliffs between Cape Crowbill and Cape Thompson, the gravel is consistently free of silt for some distance offshore. At the east part of the mapped area (pl. 2), silt and sand encroaches landward, and is probably the result of silting by Kisimilowk Creek and the creeks to the east.

No quantitative data were obtained to determine the thickness of the unconsolidated marine sediments and deposits. The following evidence suggests that the sediments form a relatively thin veneer of material over bedrock: (1) observed bedrock outcrops at scattered spots offshore; (2) the drowned valleys of Ogotoruk Creek and the minor creeks indicate that extensive silting has not occurred offshore; (3) the general slope of the submerged marine platform found at a depth of about 45 feet suggests a wave-planed surface on bedrock that has not been modified appreciably by deposition of sediments; and (4) the generally thin cover of unconsolidated deposits in Ogotoruk Creek valley may indicate that its marine continuation is probably similar. Although no quantitative data were obtained to establish the thickness of the marine sediments, it is believed that they are thinner than the colluvium deposits, which are about 60 feet thick in areas of greatest accumulation. The marine sediments are believed to be generally less than 20 feet thick with local thicker accumulations.

Active transport of marine sediments is restricted to the nearshore environment with the exception of the silt- and clay-size particles which are probably transported seaward for long distances. The gravel offshore is probably derived from two sources: (1) marine reworking of older colluvium similar to that exposed to the east; and (2) ice rafting from the beach.

ENGINEERING GEOLOGY

Permafrost

Permafrost, or perennially frozen ground, exists in the Ogotoruk Creek area. The depth to permafrost is unknown in areas of bedrock and modern beach deposits (Qb), but is believed to be about 10 feet below the surface in bedrock areas and 15 to 25 feet below the surface in modern beach deposits. Permafrost is absent beneath the Chukchi Sea beyond 200 feet from shore. Within 200 feet from shore permafrost probably exists, but the depth and extent are unknown. In unconsolidated deposits, except modern beach deposits and marine sediments, permafrost lies from 1 foot to 2 feet below the surface. Locally, the frost may lie 4 to 5 feet below the surface. Ice layers or lenses as much as 3 feet thick were measured in silt and sand deposits (Qss). Test holes indicate that the fine-grained sediments such as silt and sand contain a higher percentage of ice than the coarser-grained sediments such as colluvium (Qco) and alluvial fan deposits (Qaf). Top of permafrost on the east side of Ogotoruk Creek valley is generally about 1 foot lower than on the west side of the valley. This is because the east side of the valley receives longer exposures to the afternoon sun.

In areas of bedrock, it is believed that the permafrost surface is deeper on the west-facing slopes than on the east-facing slopes. This is also due to the west-facing slopes receiving a longer exposure to the afternoon sun.

Ice wedge polygons are common throughout the area (pls. 1, 3). All of the polygonal ground is confined to silt and sand (Qss) areas. Ice wedges as much as 3 feet thick were observed along the edges of the polygons. In areas of polygonal ground the ice is only about 1 foot below the surface and locally may be as little as 3 inches below the surface.

The thickness of the permafrost zone is unknown but is believed to be from 500 to 800 feet. Locally, there may be unfrozen pockets or zones of brine with temperatures below 32°F.

Harbor construction

The proposed harbor will be located entirely in highly deformed and fractured mudstone, siltstone, and graywacke of the Tiglukpuk formation of Jurassic(?) age. In the site area these rocks are from 500 to more than 1000 feet thick and the bottom of the proposed holes in which the nuclear devices are to be placed will be in these rocks. Locally, these rocks are so highly fractured that they occur as splinters 1/8 to 1/4 inch thick, 1/2 to 1 inch wide, and about 3 inches long. As already stated the mudstone, siltstone, and graywacke are frozen to depths of 500 to 800 feet with the possibility that local unfrozen pockets and lenses may exist. If these unfrozen pockets are encountered in areas of splintered bedrock when holes for the devices are drilled, slumping of the hole walls may occur. Also in the course of drilling the device holes, thawing of permafrost is probable along the walls which will result in slumping of debris into the hole. Drilling techniques should be developed to keep this hazard to a minimum. To assure minimum thawing of permafrost, it is desirable that the large-diameter holes for the devices be drilled during the same summer that the nuclear devices are detonated. Although ice wedges were not observed in the mudstone, siltstone, and graywacke rocks some small wedges may be encountered by the drill holes. It is doubtful that these ice wedges will be as large as the 3-foot wedges observed in the unconsolidated deposits.

It is doubtful that the holes will pass through a rock layer carrying a large supply of ground water. If the permafrost begins to thaw and unfrozen brine pockets are encountered, some water will accumulate in the bottom of the hole.

Harbor

The following discussion of the harbor is based on the assumption that the location and configuration of the harbor will be essentially similar to that discussed during the field conference in July 1958. The approximate outline of the harbor is indicated on plate 3.

The proposed harbor is very favorably located as to the approach and bottom characteristics of the ocean floor. Locally, however, there are knolls and bedrock knobs on the ocean floor. Such areas may have to be marked by buoys.

The chief problem to be considered is the closure of the harbor entrance by longshore transport of beach materials. Prior to the present investigation very little data were available regarding currents, directions of prevailing winds and waves, strength of currents, and the general climatic condition of the Ogotoruk Creek area. The following conclusions are based upon data collected by the Survey for a period of approximately 2 months, and may not be valid for longer periods.

Climatological data collected during the summer of 1958 indicate the direction and velocity of the winds are extremely variable off Ogotoruk Creek. The strongest winds blew from the north and northeast, reaching gust velocities of 60 miles per hour. Such offshore winds, however, exert little influence on longshore transport of material. Thunder showers generally approached from the east; the heavy storms generally from the southeast or southwest. Storms that originated with southeasterly winds usually veered southwesterly for variable periods during the storm. Longshore transport was most active during such storms because the waves struck the beach at oblique angles and the fetch was sufficient to create waves of moderate wave-length and height that actively eroded the beach and transported material longshore. The direction of longshore transport was variable, but easterly transport was predominant during our observations.

Data on direction of beach transport were collected throughout the field season. Volumetric measurements, however, were restricted to times of (1) lateral extensions of beaches below rocky sea cliffs, and (2) development of bars and spits across creek mouths. The data on longshore transport rates are valid only for weather conditions such as discussed above. It should be realized that during a severe storm the rates of longshore transport could be many times greater than those observed. A severe storm occurred the day after all technical personnel left the site area, and according to reports of semi-professional observers, the waves overrode the beach to a point 5 to 7 feet vertically above, and 100 feet beyond, the position of previously observed storm waves. Rate of longshore transport undoubtedly increased several fold during this storm.

Filling of the harbor would be most rapid by longshore transport of material across the harbor entrance roughly parallel to the present shoreline. Computations based on oral information obtained from the University of California Radiation Laboratory personnel indicate that a 100 kiloton shot placed at a depth of 500 feet at the shore line would remove approximately 21,800,000 cubic yards of material. At the observed transport rates, a moderate storm would transport material into the harbor entrance at a rate of about 5 cubic yards per hour. At this rate of transport, it would require approximately 23 years of continuous moderate storms to transport 1,000,000 yards of material into the harbor (fig. 3). Wave action is negligible during the months of November through May because of sea ice and the freezing of beach deposits. However, Eskimos report that occasional winter storms blow the ice away from shore for short periods of time and some

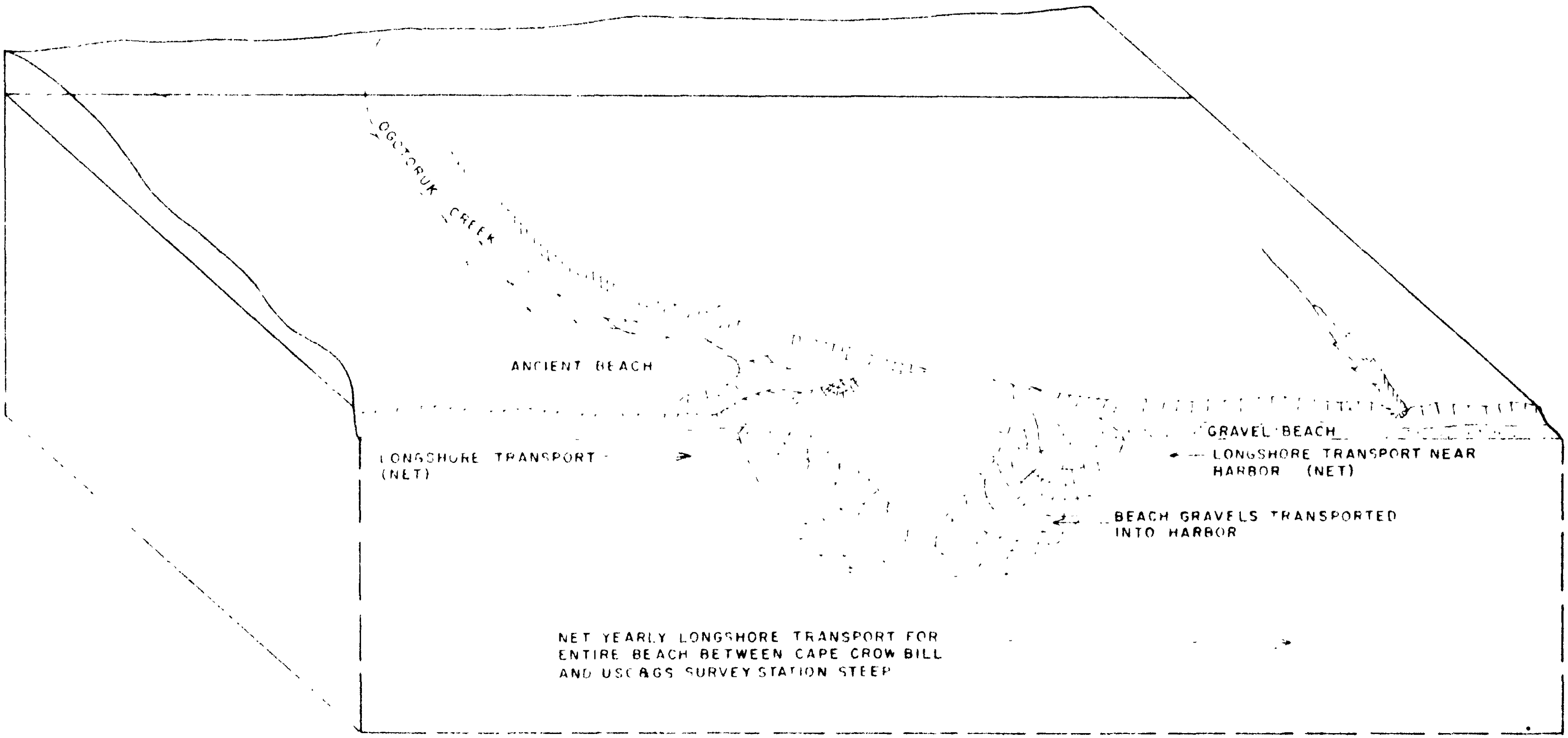

Figure 3. Schematic drawing illustrating development of spits at harbor entrance by longshore transport to initial shot crater

longshore transport may occur at such times. Many calm days were observed during the field season and it is probably safe to assume that these calm days will compensate for the periods of heavy violent storms. Therefore, it is unlikely that the rate of 5 cubic yards per hour will be exceeded on a long-term basis.

The harbor entrance would provide a collecting basin for the material transported longshore. As beach material is moved to the harbor, the shoreline will retreat. This retreat will be most rapid near the harbor, but will occur as far west as the bedrock sea cliff at Cape Crowbill, and to the east for several miles. The shore will retreat rapidly through unconsolidated sediment until it is slowed by bedrock. For maximum harbor life and protection, close control of breakage on the southwest side of the proposed harbor is required to avoid destruction of the low bedrock barrier that now underlies the unconsolidated ancient beach deposits (Qb).

The computed maximum amount of debris that can be added because of the retreating shoreline will be approximately 13,000,000 cubic yards, according to computations of the volume of unconsolidated sediment between Cape Crowbill and survey point STEEP. Approximately 15 percent of this material is silt and clay size particles. These particles would be transported seaward and little if any would be available for deposition in the channel or harbor. The amount of the remaining 11,000,000 cubic yards of material that would be transported into the harbor area is unknown. It is doubtful, however, that all of this debris will be transported to the harbor. Even if all of the debris were transported into the harbor there is insufficient material to close a harbor entrance of the size and depth proposed. If the angle of repose of the bar material were 45°, which is probably unrealistically high, about 10 million cubic yards of material would be required to bar the harbor entrance; however, it should be stated emphatically that any reduction of the harbor size by either shallow placement of device or reduction of device yield would result in greatly decreased closure time.

Filling of harbor by Ogotoruk Creek

At the present time fine sand and silt in Ogotoruk Creek is carried out to sea. Such will not be the case when the harbor is built. During low water the creek carries essentially no fine debris. During a heavy rainfall in the middle of August the creek flow increased from about 30 cubic feet per second to about 650 cubic feet per second and carried a substantial amount of fine sand and silt debris. Water samples were collected during the storm for sediment load analyses. The sediment load increased from 448 parts per million a few hours after the creek began to rise to 1,530 parts per million 25 hours later at peak discharge. Approximately 17 hours after peak discharge the creek was carrying a sediment load of 428 parts per million. On the basis that this maximum sediment load of 1,530 parts per million continued for a period of 24 hours the amount of debris that would be brought into the harbor is about 3,200 cubic yards per 24 hours. This does not consider the unknown amount of bedload that will be brought into the harbor. This bedload is believed to be small relative to the suspended load, however. This debris will be brought into a crater substantially larger than a crater excavated by a 100 kiloton device if the plans of building the harbor are similar to those discussed in the July field conference. Therefore, silting by Ogotoruk Creek will be negligible.

Shore installation

The location of roads, bridges, and other structures should be selected with care in the Ogotoruk Creek area. If improperly placed, they may heave because of frost action, subside because of thawing permafrost, or may be partially or completely destroyed because of winter ice shove. If structures are properly placed, however, the hazards will be greatly minimized.

Frost action

Frost action will heave improperly placed structures, piers, bridges, and roads. For example, U. S. C. & G. S. survey marker FEED (pls. 1, 2, and 3) has heaved 8 inches in the past 8 years. The fine-grained unconsolidated deposits such as silt and sand (Qss), colluvium (Qco), swamp deposits (Qs), and alluvial fan deposits (Qaf) are especially susceptible to frost action. In silt and sand deposits there are numerous frost scars. Although not as extensive, frost heaving also occurs in coarse-grained ancient beach deposits (Qab), flood plain deposits (Qfp), and terrace deposits (Qt).

The fine-grained sediments are not only susceptible to heaving by frost action but may flow and creep during the spring when the ice in the sediments has thawed. This flow or creep of sediments is especially characteristic of silt and sand (Qss) and colluvium (Qco) and may occur on slopes as gentle as 5 to 8 degrees.

Silt and sand, colluvium, swamp deposits, and alluvial fan deposits should be avoided as locations for roads, airfields, and structures. If possible, the structures, roads, and airfields should be placed on bedrock areas or in the case of piers and foundations they should be placed on bedrock or firmly anchored in permafrost. Construction techniques should also be adapted to minimize frost heaving.

Thawing of permafrost

As stated earlier in this report, permafrost lies close to the surface in the Ogotoruk Creek area. This will present a problem if it is not considered in the construction of the facilities, especially if the structures are placed on unconsolidated deposits. If heated structures, black-topped roads, and airfields are placed on these unconsolidated deposits containing permafrost, the perennially frozen ground will begin to thaw and the structures will begin to subside. Greatest subsidence will occur in polygonal ground areas, silt and sand (Qss) deposits, and colluvium (Qco). Maximum subsidence, as much as 3 feet, will occur in silt and sand deposits containing polygonal ground. Therefore, such areas should be avoided if possible. If it becomes necessary to construct on polygonal ground, silt and sand deposits, and colluvium deposits, the protective vegetation cover that now exists on these deposits should not be disrupted. To assure that subsidence does not occur because of thawing permafrost, buildings on the surficial deposits should be placed on piles that are driven to bedrock. Very little if any subsidence will occur in bedrock areas.

Winter shore ice

Observations on winter shore ice were not made by the Survey personnel. There is some evidence west of the map area (pl. 1) that thrusting by shore ice occurs. Ice thrusting during the months of November to May may endanger the harbor facilities, especially the piers that are in water. This factor should be considered in the design of the harbor facilities.

Seismic activity

The Ogotoruk Creek area lies in a zone of no recorded seismic activity, although there are numerous faults in the area. This does not preclude the possibility, however, that an earthquake will occur in the area. It is doubtful that special precautions are necessary to protect structures from seismic activity.

Water supply

As permafrost is at least 500 feet thick it is doubtful that an ample supply of water for a shore installation can be obtained from wells. The best source of water, therefore, is from surface flow. A sufficient supply of water can be obtained by damming the upper reaches of Ogotoruk Creek. During the winter months the reservoir will be frozen to depths of 6 to 8 feet. This factor should be considered in the design of the dam and reservoir.

SURFACE WATER, OGOTORUK CREEK, ALASKA

by M. J. Slaughter

INTRODUCTION

Location and description

Ogotoruk Creek empties into the Chukchi Sea at a point 6-1/2 miles southeast of Cape Thompson and about 32 miles southeast of Point Hope, Alaska.

The creek is approximately 10 miles long and is braided throughout most of its length. It flows westward for the first 6 miles, then southward for the remaining 4 miles. The drainage area is approximately 40 square miles. The drainage basin is about 2 miles wide near the mouth, and has a maximum width of about 5 miles. The basin boundary rises to an elevation of about 800 feet above sea level.

The stream bed consists of clean gravel and shale. The flood plain is about 1,000 feet wide and consists of gravel, shale, and sandstone.

Climate

Climatological data, from the weather stations at Kotzebue and Cape Lisburne, indicate that the total annual precipitation is 8 to 12 inches (tables 1 and 2). Freezing or subfreezing temperatures can be expected from about the middle of September to the latter part of May, and the creek will be frozen over from about mid-October to mid-May.

HYDROLOGY

Runoff

There are two high runoff periods. The first, in early June, will be due to snow melt and will be of short duration. The second, in late August and September, will be due to storms. The runoff between the second and first periods is relatively low, with winter flows extremely low.

Prior to 1958 no runoff data are available for this stream. During the period July 17-20 the flow of Ogotoruk Creek was estimated by U. S. G. S. Water Resources Division engineers to be 20 cfs.

A gaging station was established by Survey personnel on August 27, 1958, at a site 1.2 miles upstream from the mouth at latitude 68°06'40", longitude 165°45'10". The equipment consisted of a Stevens A-35 continuous water-stage recorder housed in a timber shelter over a 30" corrugated pipe well.

One measurement was made August 27, 1958, gage height 3.43 feet, discharge 195 cfs; the second was made September 25, 1958, gage height 2.92 feet, discharge 55.8 cfs. The measurement of August 27 was made during the runoff from a storm.

A continuous gage-height chart for the period August 27 to September 25, 1958 is available to obtain the daily gage heights for this period. A rating curve was developed, based on the above two measurements and point of zero flow, to obtain the daily discharge during the period. The maximum instantaneous discharge during the period was 876 cfs September 8, maximum daily, 522 cfs same date; minimum instantaneous discharge, 36 cfs September 17, minimum daily, 42 cfs September 16. The average discharge during the period was 163 cfs. Because there were 6 storms from August 27 to September 25, the average discharge during that period is considerably higher than the annual average will be. The above data are provisional and subject to revision when additional data are collected with which to define a better rating curve.

The winter flow will be extremely low and the stream may freeze entirely. The average summer flow probably will not exceed about 30 cfs.

QUALITY OF WATER OF OGOTORUK CREEK, ALASKA

By George Porterfield

INTRODUCTION

The proposed harbor is near the mouth of Ogotoruk Creek. This creek drains a small narrow basin that consists almost entirely of tundra, has no trees, bushes, or vegetation other than the meager grasses which grow from the tundra. There is no cultivation, grazing, or other use by man to affect the chemical or physical quality of the water. The floodplain deposits are described on page 21.

COLLECTION OF SAMPLES

The first sample was collected on July 20, 1958. Samples were collected at irregular intervals during periods of low flow, and daily during 3 days of storm runoff.

All but two of the samples were depth integrated and collected with a standard U. S. DH-48 hand sampler with an intake nozzle 1/4 inch in diameter. The flow of August 11 and 12 was too high to wade and the 2 samples collected on those dates were dipped near the edge of the stream and are not entirely representative of the sediment load.

The samples collected for suspended sediment were also used for the determination of chemical quality. The samples of July 20, 25, 30, and August 8, essentially represent low base flow and were composited for one chemical analysis. The August 10 sample represents water from a rising stage and was analyzed separately. August 11, 12 are falling stage samples while August 17 represents normal flow after the flood peak has passed.

SUSPENDED SEDIMENT

The concentration of suspended sediment ranged from 6 parts per million at base flow to an observed high of 1,530 ppm at 5:10 p.m. on August 11, 1958 (table 5). The maximum sediment discharged was taken from an estimated curve, which indicated a concentration of 2,500 ppm. The concentration in low flow samples ranged from 6 to 13 ppm and are considered representative of base flow conditions. Results are not available for the spring thaw or for the runoff that occurred after August 17.

The particle size analyses made on samples collected August 10, 11, and 12 are shown in table 6. On August 10 a depth integrated sample was taken by the equal transit method and is representative of the suspended sediment discharge at that time. The stream was rising at the time of sampling and the material in suspension consisted of 8 percent clay, 31 percent silt, and 61 percent sand. The falling stage samples of August 11 and 12 were dip samples and are not necessarily representative of all the material in suspension. The size analyses on these two samples show progressively less sand and an

Table 5.--Suspended sediment concentration and water temperature of Ogotoruk Creek, Alaska

Date	Time	Method of sampling	Suspended sediment concentration (ppm)	Water temperature (°F)
1/July 10, 1958	4:00 pm	ETR	448	--
July 20	11:45 am	ETR	11	58
2/July 25	8:20 pm	ETR	107	48
July 30	3:00 pm	ETR	6	52
3/Aug. 8	10:50 am	--	6	42
4/Aug. 11	5:10 pm	dipped	1,530	47
4/Aug. 12	10:00 am	dipped	428	--
Aug. 17	--	ETR	13	51

1/ Approximately 24 hours after 0.5 inch rain; Creek rising rapidly.

2/ Six hours after light drizzle of four hours duration.

3/ Raining.

4/ Stream too high to wade.

ETR: Equal transit rate.

Table 6.--Particle-size analyses of suspended sediment, Ogotoruk Creek, Alaska, August 1958

Date of collection	Aug. 10	Aug. 11	Aug. 12
Time of collection	4:00 pm	5:10 pm	10:00 am
Concentration of sample, ppm	448	1,530	428
Concentration of suspension analyzed, ppm	270	1,710	359
Particle size (in millimeters) 1/	Percent finer than size indicated		
0.002	6	14	37
0.004	8	19	40
0,008	12	27	53
0.016	20	40	66
0.031	30	53	82
0.062	39	71	90
0.125	57	86	96
0.250	83	95	99
0.500	100	98	100
1.000	--	100	--

1/In distilled water

increasing percentage of fine material. This is a normal progression; however in this case the progression may be exaggerated because the dip samples collected near the bank probably do not contain the proper proportion of material from the lower portion of the stream or from that portion of the stream where the highest velocity occurs. Sampling during the spring thaw and summer flow of 1959 would give a better picture of the sediment discharge.

CHEMICAL QUALITY

Chemical analyses for Ogotoruk Creek are listed in table 7. The limited study shows very little change in mineral composition of the water from base flow conditions to storm runoff. The water has appreciable color at times and noticeable variation in this characteristic. The chemical quality of the water is good and is suitable for municipal and industrial use.

To date no samples have been collected to determine the radiochemical levels of the water. This project offers an opportunity to study the effects of a nuclear device on a water supply and on the recovery from this effect.

CONCLUSIONS

On the basis of the few data available, the sediment discharge from Ogotoruk Creek is indicated as minor in relation to the size of the proposed harbor. The chemical quality of the water is indicated as good and suitable for industrial and municipal use. This project offers an opportunity to study the effects of a nuclear blast on a water supply. The radiochemical levels should be determined prior to and after the blast and continued to provide basic information on recovery.

Table 7.--Chemical analyses, Ogotoruk Creek, Alaska, July to August, 1958

Parts per million

	July 20,25,30 Aug. 8	Aug. 10	Aug. 11,12	Aug. 17
Silica (SiO_2)	2.4	2.2	2.6	2.9
Iron (Fe)	.00	.07	.26	---
Manganese (Mn)	.00	.00	.00	.00
Calcium (Ca)	4.8	5.6	5.2	5.6
Magnesium (Mg)	1.9	1.9	1.6	1.9
Sodium (Na)	4.3	4.1	3.9	4.8
Potassium (K)	.6	.8	1.0	.6
Bicarbonate (HCO_3)	17	18	18	18
Sulfate (SO_4)	10	10	7.5	11
Chloride (Cl)	3.5	4.0	3.5	4.0
Fluoride (F)	.1	.1	.1	.1
Nitrate (NO_3)	.1	.5	.8	.4
Dissolved Solids: Calculated	36	38	35	40
Hardness as $CaCO_3$	20	22	20	22
Noncarbonate hardness as $CaCO_3$	6	7	4	7
Specific Conductance (Micromhos at 25 C)	68	70	62	73
pH	6.7	6.5	6.5	6.7
Color	0	30	55	30

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