TEI-642

NUCLEAR EXPLOSIONS - PEACEFUL APPLICATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

ENGINEERING GEOLOGY BEARING ON HARBOR SITE SELECTION ALONG THE GULF OF ALASKA FROM POINT WHITSHED TO CAPE YAKATAGA, ALASKA*

By

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Trace Elements Investigations Report 642

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

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by Reuben Kachadoorian

ABSTRACT

An analysis of the known geologic factors in the Point Whitshed-Cape Yakataga area, Alaska, indicates that the most suitable location for a harbor to be excavated by nuclear-device techniques is a section of coastline from Point Martin to the town of Katalla.

Three sites selected in the Point Martin-Katalla area are indicated on plates 5 and 9. Site 1 at Point Martin is underlain by terrace gravel overlying sedimentary rocks of Tertiary age. The site is protected from southeast storms but not from southwest storms. Longshore transport of sediments is to the west during high tides and either lacking or to the east during low tides. The 60-foot offshore contour is within 1.5 miles of the site and the 30-foot offshore contour is within 0.4 mile.

Site 2 at Palm Point is underlain by beach gravel, terrace gravel, and muskeg deposits that overlie Tertiary sedimentary rocks. The site is protected from southwest storms but exposed to southeast storms, which are the major ones in the Point Whitshed-Cape Yakataga area. The beach at this site is being eroded actively and the sediments are carried offshore by waves that break at right angles to the beach. The 60-foot offshore contour lies within 2 miles of the site area; the 30-foot offshore contour is within 0.3 mile.

Site 3 at the town of Katalla is underlain by beach and terrace deposits overlying Tertiary sedimentary rocks. This site offers better protection than either of the other two from southeast and southwest storms. Longshore transport along a spit east of the site has filled the Katalla River channel

to within 3 feet of the surface to mean low tide. Dredging requirements at this site would be much greater than at sites 1 and 2. The 60-foot offshore contour is within 3.5 miles of Katalla and the 30-foot contour within 1 mile.

INTRODUCTION

The immense explosive energy concentrated in modern nuclear devices is capable of creating a crater that if properly located can function as a deepwater harbor. From all indications it appears that the construction of an artificial harbor by nuclear techniques would be much less expensive than by conventional explosives and earth-moving equipment.

In the spring of 1959 the Albuquerque Operations Office, U. S. Atomic Energy Commission, requested the U. S. Geological Survey to make an evaluation on the basis of known information of the geologic and oceanographic factors relevant to the selection of a harbor site along the Gulf of Alaska. This report is based on existing published reports of the Geological Survey, unpublished reports in the Survey files, and the analysis of vertical photographs and charts of the U. S. Coast and Geodetic Survey. Most parts of all the area included on plates 2, 3, and 4 have been visited on the ground by Survey geologists.

The harbor site is being considered by the Atomic Energy Commission because of the possibility of developing the Bering River Coal Field, and because no harbors exist in the immediate vicinity of the coal field.

A 140-mile strip of shoreline between Point Whitshed and Cape Yakataga (fig. 1) was selected by the Geological Survey for the study. Point Whitshed is the western terminus of the investigation because there is a harbor at Cordova, about 8 miles northeast of Point Whitshed; Cape Yakataga is the eastern terminus because of economic considerations such as the construction

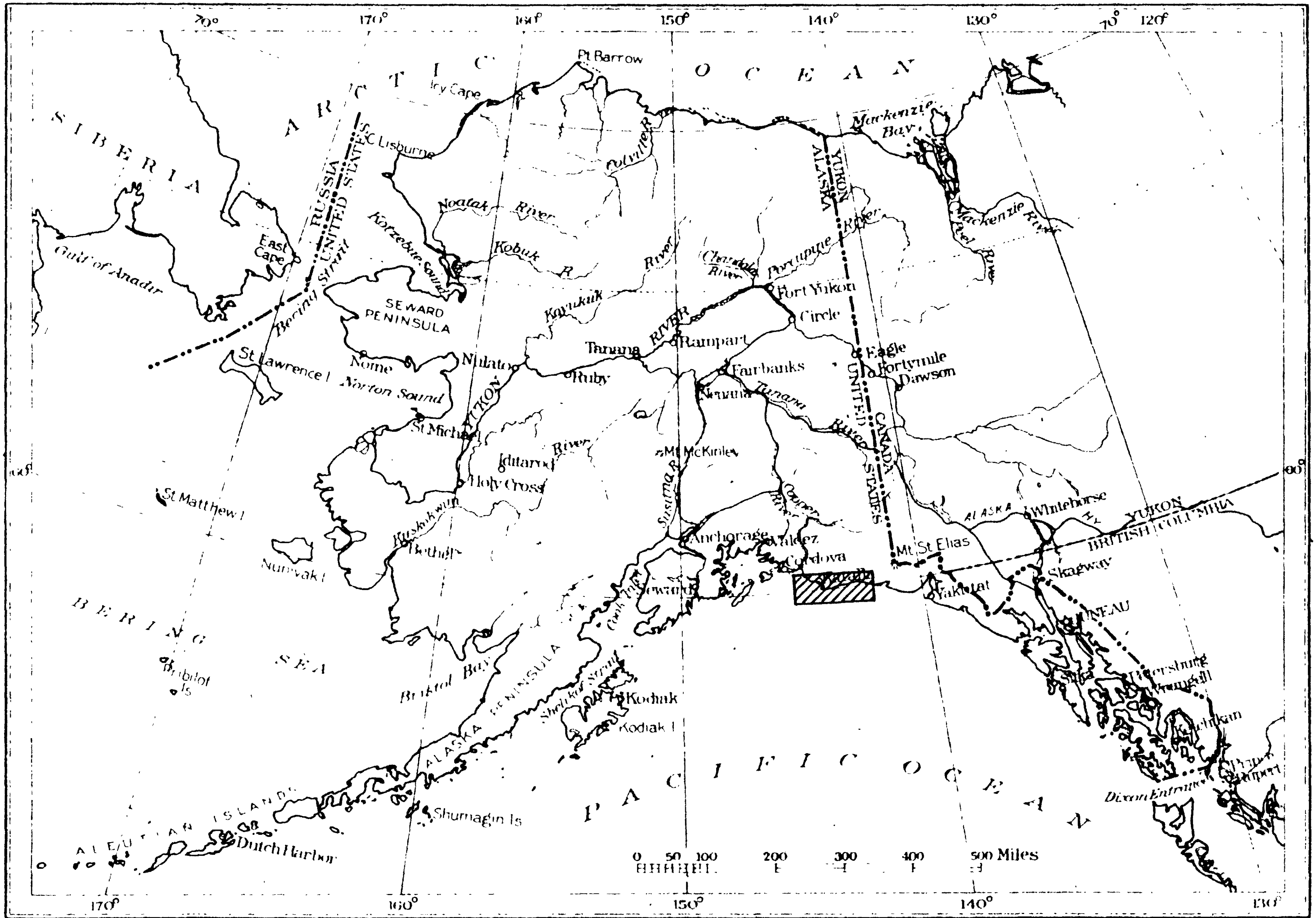


Figure 1. Index map showing location of Pt. Whitshed--Cape Yakataga area, Alaska

of roads from the proposed coal field development. The three possible sites indicated on plate 5 were chosen chiefly because of geologic and oceanographic factors such as offshore topography, the engineering characteristics of the bedrock, the direction and magnitude of storms, and to some extent because of possible economic considerations such as construction of roads.

GEOGRAPHY

Only two permanent towns, Cape Yakataga and Katalla, exist in the map area from Cape Yakataga to Point Whitshed. Cape Yakataga, located on the extreme eastern end of the map area, has a population of about 25. The town of Katalla, located approximately in the middle of the map area, can be considered a ghost town. The population in 1955 consisted of a family of four, a man and his wife operating the CAA repeater station, and Mr. Nels Larson, a longtime resident of Katalla. The author does not know what the population of Katalla is at the present time. Crystal Falls and Point Whitshed, located at the extreme western part of the map area are occupied by 25 to 30 people only during the fishing season. It is not known if anyone occupies these locations during the winter months. The town of Cordova, 8 miles northeast of Point Whitshed, is not in the map area and has a population of about 1,200.

Topography

The Point Whitshed-Cape Yakataga area lies on the south flank of the Chugach Mountains and is bounded on the south by the Gulf of Alaska. The major topographic features include northward-trending mountains and ridges interspersed with glaciers, lakes, valleys, swamps, and broad lowland areas. The mountains rise abruptly from lowland areas to altitudes of 4,000 feet.

Two large glaciers, the Bering and Martin River glaciers, occur in the area.

Vegetation

Two major floral zones are represented in the Point Whitshed-Cape Yakataga area. The coastal-forest zone extends from sea level to an altitude of approximately 1,700 feet. Areas above this altitude have alpine-tundra vegetation.

Within the coastal-forest zone swamp deposits (Qs), muskeg (Qm), and alluvial sand (Qas) are covered with grasses, sedges, mosses, and small colonies of shrubs. Willow, alder, and limited patches of Sitka spruce and western hemlock are restricted to fairly well drained ground bordering the water courses of the swamps and meadows. Vegetation on the alluvial gravel deposits (Qag) consists of willow, alder, Sitka spruce, and western hemlock. The undergrowth is devilsclub and salmonberry. The largest stands of spruce and hemlock are on moraines (Qmo), outwash (Qo), bedrock along Trout Creek (pl. 3), and along the shore between Redwood Bay and the mouth of Bering River (pl. 3). The forest floor is mantled by a thick growth of devilsclub, salmonberry, and blueberry.

In the alpine-tundra zone, above timberline, the upper slopes and summits of the hills and mountains are covered by a thick mat of moss, sedges, and herbs. Shrubs and stunted Sitka spruce and mountain hemlock grow in sheltered sites along the lower margin of the alpine zone. Vegetation-free bedrock is common on very steep slopes and on the higher summits.

Climate

The climate of the Point Whitshed-Cape Yakataga area is characterized by heavy rainfall, cloudy weather, and low summer and moderate winter temperatures. Climatological data for the Cordova Airport, approximately 7 miles north of Point Whitshed, and the CAA station at Yakataga approximately 3 miles west of Cape Yakataga (pl. 1), are shown in tables 1 and 2, respectively (U. S Weather Bureau, 1956).

GENERAL GEOLOGY

Onshore geology

The rocks exposed in the Point Whitshed-Cape Yakataga area consist of metamorphic rocks and associated intrusive rocks of pre-Tertiary age, sedimentary rocks of Tertiary age, and unconsolidated glacial and nonglacial sediments of Quaternary age.

Rocks older than Tertiary (pTm)

The sedimentary and volcanic rocks of pre-Tertiary age are slightly reconstituted and in part slightly to moderately metamorphosed and are exposed on Ragged Mountain, Wingham Island, except the extreme southeastern part, and the Heney Range (see pls. 2 and 3). The rocks consist of sandstone, graywacke, shale, and slate with some greenstone, graywacke, and minor amounts of chert, limestone, and intrusive igneous rocks (Martin, 1908, Miller, 1951). The sandstone and graywacke are massive and generally fracture into blocks less than 1 foot across. The greenstone is massive and fractures into blocks 5-8 feet across. The shales and slates have well-developed cleavage and break into thin slabs.

Pre-Tertiary rocks are closely jointed and complexly faulted and folded; they are in fault contact with Tertiary rocks on Wingham Island, and on the east flank of Ragged Mountain.

Table 1: Climatological data for Cordova Airport, Alaska[1]

Month	Average Temperature[1] (°F)	Average total precipitation[2] (inches)
January	25.4	7.05
February	26.1	5.27
March	30.1	5.92
April	36.4	5.07
May	42.9	6.44
June	49.3	4.19
July	53.3	6.44
August	53.4	9.72
September	48.0	15.47
October	40.8	15.56
November	31.1	10.55
December	26.6	6.96
Annual average	38.6	98.64

[1] Based on 13-year record from 1944 through 1956

[2] Based on 14-year record from 1943 through 1956

Table 2: Climatological data for Yakataga station, Alaska[1/]

Month	Average temperature (°F)	Average total precipitation (inches)
January	27.0	11.11
February	29.0	5.31
March	31.7	6.13
April	36.1	6.67
May	42.9	6.62
June	49.0	4.99
July	53.2	5.63
August	52.5	7.11
September	48.5	15.93
October	41.6	16.52
November	34.3	13.18
December	30.0	12.71
Annual average	39.7	111.91

[1/] Based on 12-year record from 1945 through 1956

The age of these rocks has not been clearly established. The degree of deformation and alteration, the structural relationship to the Tertiary rocks exposed in the area, and the lithologic similarity to the more accurately dated rocks in adjacent parts of Alaska suggest that the bedded metamorphosed rocks of the Point Whitshed-Cape Yakataga area are of Mesozoic age (Miller, 1951, p. 12).

Rocks of Tertiary age (Tss)

Sedimentary rocks of Tertiary age underlie most of the area included on plate in the Suckling Hills, Nichawak Mountain and Mount Campbell, and the ridge of mountains north of Cape Yakataga shown on plate 4. These rocks do not crop out in the area included in plate 2. The sedimentary rocks consist chiefly of sandstone, shale, argillite, siltstone, and conglomerate and have been subdivided into several mappable units. The rocks considered to be of Tertiary age in this report consist of the Stillwater, Kushtaka, Tokun, and Katalla formations of Eocene to Oligocene and possibly Miocene age, and undifferentiated sequences of rocks of probable early Tertiary age (Miller, 1951, p. 13-23). Since the engineering characteristics of most of the various units are essentially similar, however, the sedimentary rocks are considered as one unit in this report.

West of Ragged Mountain the Tertiary sedimentary rocks consist chiefly of massive, hard, fine- to medium-grained sandstone interbedded with argillite, siltstone, and conglomerate that contains cobbles and boulders. East of Ragged Mountain the Tertiary sedimentary rocks consist of thick-bedded medium- to coarse-grained sandstone interbedded with fine-grained, thin-bedded sandstone and minor amounts of mudstone, siltstone, claystone, and fine-grained calcareous sandstone interbedded with shale and siltstone.

Locally, east of Ragged Mountain, small exposures of arkose occur.

Joints in the thick- and thin-bedded sandy and shaly sedimentary rocks commonly are 2-4 feet apart; locally they are spaced 4-8 feet apart.

Structure of pre-Tertiary and Tertiary rocks

The rocks of the Point Whitshed-Cape Yakataga area have been intensely folded and cut by many faults. The folds and major faults are the result of uplift resulting from compressive forces that were normal to either the Chugach Mountain front or the east face of Ragged Mountain (Miller, 1951, p. 42). The fold axes trend northeastward in the area included in plate 3 and trend eastward in the area included in plate 4.

A fault, which has a surface trace along the east flank of Ragged Mountain places pre-Tertiary metamorphic rocks in contact with the Tertiary sediments (see cross-sections, pl. 5). This fault strikes approximately north and dips about 70°W. The original relative displacement on the fault was up on the west side. Linear scars in talus cones along the east face of Ragged Mountain indicate that the west block of the fault has been displaced downward as much as 30 feet in Recent time.

Deposits of Quaternary age

With the exception of glacial outwash (Qo) and glacial moraine (Qmo) the unconsolidated deposits in the Point Whitshed-Cape Yakataga area are of nonglacial origin. Deposits associated with two minor glacial advances of Recent age are recognized in the area; a few small deposits of till-like material on the northeast side of Whale Island (pl. 3) may represent a third, much older glacial advance, but as other evidence of such an advance is inconclusive, the material has been mapped as Recent terrace deposits

(Kachadoorian, 1956). Outwash and morainal complexes (end, lateral, and ground moraines) are restricted to areas within 5.5 miles of present glaciers. The nonglacial sediments, however, vary widely in composition (fig. 2) and are scattered throughout the Point Whitshed-Cape Yakataga area. The nonglacial sediments consist of landslides (Qls), talus (Qta), alluvial sand (Qas), swamp deposits (Qs), muskeg deposits (Qm), alluvial gravel deposits (Qag), beach deposits (Qbd), dune sand (Qsd), and terrace deposits (Qt).

The Quaternary unconsolidated deposits are generally a thin mantle over bedrock and will not greatly affect the selection of a proposed harbor site as the excavation will be principally in bedrock. Therefore, they are not fully discussed in this report. Kachadoorian has discussed these deposits more fully in an earlier report (1956).

End, lateral, and ground moraines (Qmo)

End, lateral, and ground moraines underlie areas of rough topography consisting of ridges 20-100 feet high, separated by swales and undrained depressions. Kettle holes ranging from shallow panlike depressions 10 feet deep and 100 feet wide to steep-walled pits 50 feet deep and 100-500 feet across are common. Lakes are common in the kettle holes and in depressions dammed by till that was plastered at the base of moving ice, or was dumped without reworking at the point where ice finally melted.

Sandy till is generally the predominant material comprising moraine complexes and consists of 58- to 72-percent gravel, 24- to 36-percent sand, and less than 6-percent silt and clay (fig. 2, curves D and E). It is present everywhere in the moraines at depth, and crops out at the surface in long ridges that are the chief element in the morainal topography. The dominant exposed material of the moraine that dams Kushtaka Lake (pl. 3), however, is not sandy till but cobbles and boulders.

Outwash (Qo)

Outwash is glacial debris that has been reworked and deposited by meltwater streams. It consists of well-sorted sand and gravel, commonly stratified. Deposits of outwash large enough to map occur chiefly in areas included in plates 2, 3, and 4.

Outwash is characterized by nearly flat surfaces with local relief of 3-15 feet consisting of low escarpments, bars, and swales, marking the courses of abandoned stream channels.

The outwash deposits are similar to, but coarser than, the modern alluvium (Qas) in nearby streams and consist principally of well-rounded pebble and cobble gravel, sand, silt, and clay. A sample of outwash material deposited by the Kushtaka Glacier consisted of about 65 percent well-rounded pebble and cobble gravel, 30 percent clean washed sand, and less than 5 percent silt and clay (fig. 2, curve F).

Terrace deposits (Qt)

Terrace deposits are confined to the western portion of the area included in plate 3. They occur chiefly west of Katalla, along the southern end of Ragged Mountain, west of Martin Lake, and on Fox and Whale Islands.

The terraces are in large part mantled by swamp (Qs) and muskeg (Qm) deposits 3-10 feet thick. Measured thicknesses of terrace deposits range from 3 feet west of Katalla to 46 feet on Whale Island.

Sediments comprising terrace deposits consist of about 35 to 58 percent angular to rounded gravel, 25 to 54 percent sand, and 7 to 40 percent silt or clay (fig. 2, shaded area T-T').

Dune sand (Qsd)

Dune sand occurs east of Suckling Hills (pl. 4). The sand consists chiefly of medium- to coarse-grained windblown material in ridges 10-20 feet high, 20-40 feet wide, and as much as 100 feet long. Stabilization of most of the dunes is indicated by a substantial growth of vegetation which mantles practically all of them.

Beach deposits (Qbd)

All shoreline deposits, built principally by marine waves and long-shore currents and consisting of sand grains, pebbles, and boulders, are considered beach deposits (Qbd) in this report. Such deposits include barrier beaches, spits, bay-mouth bars, and cuspate forelands. Numerous offshore islands in the Point Whitshed-Cape Yakataga area are barrier beaches formed by waves breaking some distance offshore on the gently shelving bottom.

Barrier beaches and sand bars consist principally of coarse- to fine-grained sand with minor amounts of pebbles. The bay-mouth bars formed in the Katalla River valley (pl. 3) range in composition from about 68-percent gravel, 30-percent sand, and 2-percent silt and clay at the head of the valley to about 10-percent gravel, 85-percent sand, and 5-percent silt or clay at the mouth of the valley (fig. 2, curves A and B).

Alluvial gravel deposits (Qag)

Included in alluvial gravel deposits are alluvial fans and stream gravel of numerous nonglacial streams. These deposits are chiefly in the area included on plate 3. The fans have relatively little relief and stand only a foot or two higher than their stream channels. Trenches a few feet wide represent old abandoned stream channels and channels occupied only during floods.

Alluvial fans consist of interfingering lenses of clean, washed gravel and sand, with a few cobbles. The average grain size of the deposits decreases with increasing distance from the mountain slopes or sources of the material. A sample collected midway between the toe and head of the alluvial fan on the east flank of Ragged Mountain consists of approximately 55-percent gravel, 43-percent sand, and 2-percent silt or clay (fig. 2, curve C).

Muskeg deposits (Qm)

Extensive areas of muskeg occur in the area shown on plate 3. The muskeg consists of 1 foot to 10 feet of spongy material made up of grasses, sedges, mosses, fine sand, and silt. Although the material is very absorbent and generally dry on the surface, local swampy areas are abundant in the low-lying muskegs. Deep, steep-walled small pools are characteristic of the muskeg areas. With the exception of those on the mountain slopes, the muskeg areas are generally underlain by 3-12 feet of sand and gravel. On the high mountain slopes they are underlain by bedrock. The deposit that underlies the abandoned railroad grade in the Katalla River valley (pl. 3) has an average thickness of at least 8 feet.

Swamp deposits (Qs)

Large swamp deposits are scattered throughout the Point Whitshed-Cape Yakataga area and are especially abundant south of Kushtaka Lake, southeast of Bering River, west of the Martin River Glacier (pl. 3), in the Copper

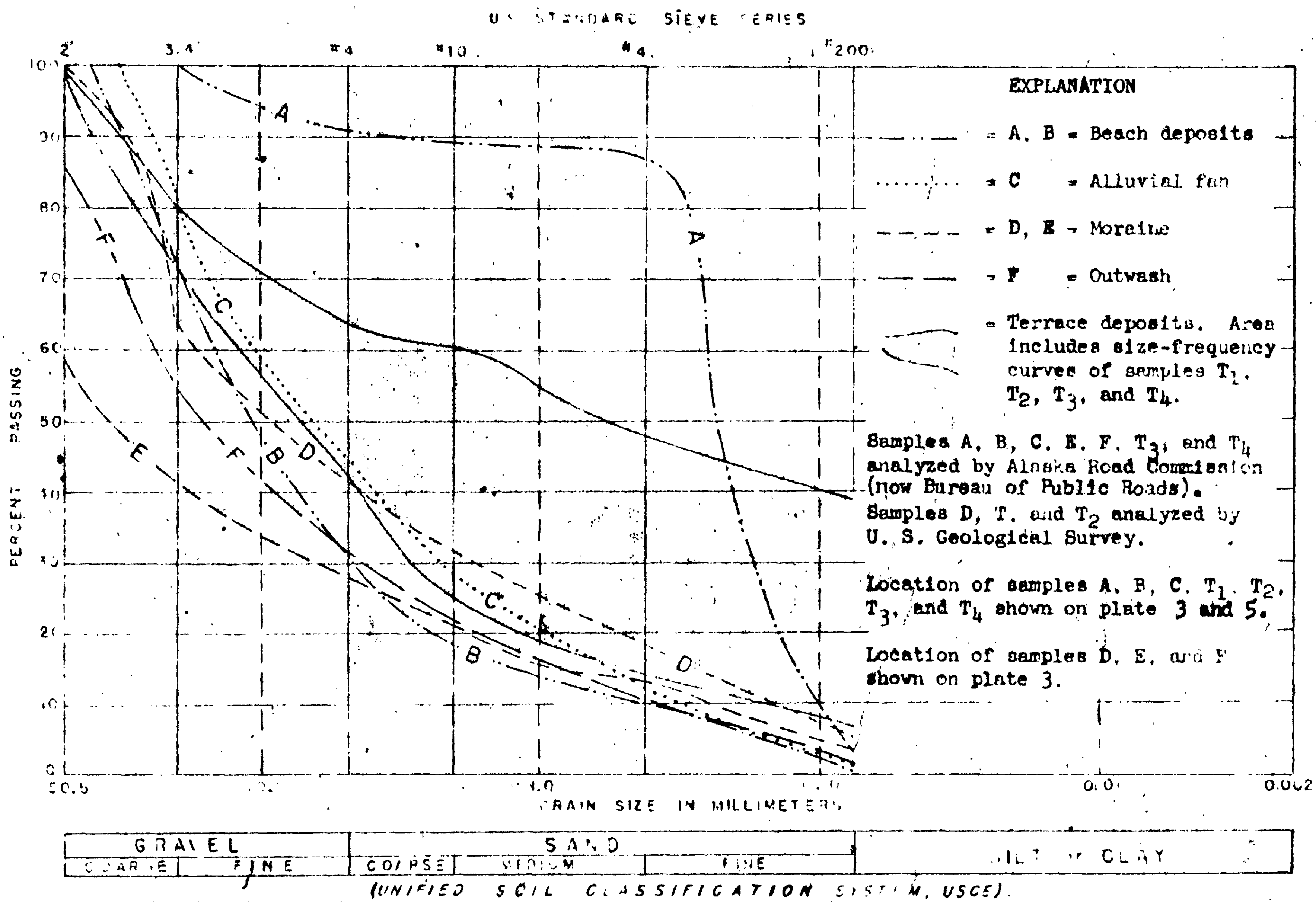


Figure 2. Cumulative size-frequency curves of deposits in the Point Whitshed--Cape Yaketaga area, Alaska

River Delta, and west of the delta (pl. 2). The features considered and mapped as swamp deposits in this report consist of areas in which drainage is impeded so that the soils are saturated throughout the year, tidal flats, and low-lying coastal areas occasionally inundated by the highest tide.

Swamp deposits consist of peat, mud, and silt as much as 3 feet thick. West of the Martin River and Bering Glaciers, swamp deposits are underlain by outwash sand and gravel. In areas of tidal flats they are underlain by clay; elsewhere they are underlain by muskeg, alluvial sand, and alluvial gravel deposits.

Alluvial sand deposits (Qas)

Extensive areas of alluvial sand underlie much of the area on plate 4, the Copper River Delta (pl. 2), and many of the glacial streams shown on plate 3.

Alluvial sand deposits vary from 1 foot to 10 feet thick and consist of clean, washed fine- to coarse-grained sand locally interbedded with gravel. The fine- to coarse-grained sand is underlain by sandy gravel as much as 30 feet thick.

Talus deposits (Qta)

Talus deposits are found along the east front of Ragged Mountain and in the steep valley east of Martin Lake (pl. 3). The talus consists of loose rock pried from bedrock cliffs by frost action and other weathering processes and deposited as aprons and cones on the gentler slopes below. The angular unsorted blocks may be as much as 50 feet thick, but more commonly they are 25-30 feet.

Landslides (Qls)

Large landslides have developed in metamorphosed rocks of pre-Tertiary age along the east flank of Ragged Mountain, north of Martin River on the south flank of the Chugach Mountains, and on the east flank of Charlotte Ridge (pl. 3). Numerous smaller slides are common throughout the area in rocks of pre-Tertiary and Tertiary age.

Offshore geology

General

An intensive study of the offshore geology of the Point Whitshed-Cape Yakataga area has not been made. The following discussion is based on (1) casual observations by Don J. Miller and Reuben Kachadoorian, geologists, U. S. Geological Survey, and (2) an analysis of Geological Survey published and unpublished maps and U. S. Coast and Geodetic Survey Charts (plate 6, Chart 8502, Cape St. Elias to Shumagin Islands, and plate 7, Chart 8513, Controller Bay).

Oceanography

Most of the large storms in the map area are from the southeast. The storm waves strike the beach at oblique angles and create longshore currents to the west. These currents transport gravel along the shore and are the primary mechanism by which spits such as Softuk Bar, Okalee Spit, and the spit closing the present channel of the Katalla River are formed. At the same time the currents that are forming the spits are eroding the area from Palm Point northward to a point approximately three-eighths of a mile south of Katalla. Locally, in this area, the waves have undermined a 50-year-old railroad grade that was originally located about 100 feet inland. More commonly, however, the beach has retreated between 25 and 36 feet in this span of 50 years. Elsewhere in the Point Whitshed-Cape Yakataga area, erosion of the coastline is much less.

Numerous offshore barrier beaches such as Kanak Island (pl. 3) occur in the area. These barriers are formed by waves breaking some distance offshore on the gently shelving bottom.

The maximum tide range that should be expected in the area is approximately 14 feet and average tide range is 9-10 feet. Fluctuations, periods of waves, and height of waves have not been recorded.

Topography

The offshore topography of the Point Whitshed-Cape Yakataga area is a gently sloping surface to the south with local relatively steep valleys. From Cape Suckling to Cape Yakataga (pl. 4) the 60-foot offshore contour is generally 3-3.5 miles offshore; from Cape Suckling to Point Martin (pl. 3) it is from 1.5 to 15 miles offshore. In the eastern part of the area included in plate 3, the 60-foot depth contour is farther offshore than in the western part of the map area. The 60-foot contour lies immediately south of Fox Island within 2 miles of shore off Palm Point.

From Point Martin to Point Whitshed (pl. 2) the 60-foot depth contour generally lies 8 miles offshore.

A broad northeast-trending submarine valley exists west of Wingham Island (pl. 3). This broad valley may be an extension of the Katalla Valley, as it strikes into the onshore valley. The submarine valley was probably cut at a time when drainage from Bering Lake flowed through the Katalla Valley instead of through its present outlet into Controller Bay, when sea level was relatively lower than it is now. It is probable that at one time the meltwater from the Kushtaka Glacier and part of the Bering Glacier flowed through the Katalla Valley without first flowing into a lake and that Bering Lake did not exist. The water was changed to its present course when alluvial fan debris blocked the flowage at a narrow place in the valley immediately southwest of the present Bering Lake.

Marine sediments

The marine sediments in the Point Whitshed-Cape Yakataga area consist chiefly of mud, clay, silt, and sand with minor amounts of small-size gravel. Locally, concentrations of gravel occur offshore of Suckling Hills, Point Martin, and Fox and Whale Islands. The clay generally underlies tidal coastal areas such as Mirror Slough and Storey Slough. The mud, silt, and sand occur throughout the Point Whitshed-Cape Yakataga area; the mud is concentrated off drainage areas of the Bering Glacier and in the Copper River Delta. Smaller areas of mud occur offshore of the area between Point Whitshed and the Copper River Delta.

The maximum thickness of marine sediments is unknown, but probably is less than 100 feet except possibly in the areas off the Copper River Delta (see cross-sections, pl. 5). Although bedrock has been mapped in the Copper River Delta, the offshore sediments may locally be more than 100 feet thick.

ENGINEERING GEOLOGY

General

The analysis of various factors to be considered in the location of a harbor between Cape Yakataga and Point Whitshed indicates that the most suitable location is in the Katalla area.

The coastline from Cape Yakataga to Suckling Hills is relatively straight and should present suitable locations for harbor sites, but there are several factors that eliminate this stretch of the coastline from consideration. The 60-foot depth contour is so far offshore that dredging the entrance channel would be a major factor in the maintenance of the harbor. The numerous rivers that flow into the Gulf of Alaska in this section of the coastline carry a large amount of sediment that would fill a harbor at a greater rate than at any other part of the Point Whitshed-Cape Yakataga area, with the exception of the Copper River Delta. Furthermore, mouths of the numerous rivers occasionally change location. The Kaliakh River in the recent past has broken through the sand barrier built by longshore currents and now flows about one-third of a mile east of its previous entrance into the Gulf of Alaska. The longshore drift of material to the west along this part of the coast is probably greater than at any other section of coastline from Point Whitshed to Cape Yakataga.

From Cape Suckling to Strawberry Point (see pls. 3 and 8) the 60-foot contour is sufficiently far offshore to rule out the location of a harbor unless the probable high maintenance cost is overshadowed by the fact that this section of the coastline will offer the best haven from storms for ships in the Point Whitshed-Cape Yakataga area with the possible exception of site 3 (see pl. 9).

The most suitable area, on the basis of geologic factors, for the location of a harbor is the area from Strawberry Point to Point Martin; more specifically, the coastline from the town of Katalla to Point Martin. This section will be discussed in more detail later in this report.

The section of coastline from Point Martin to Point Whitshed (pl. 9) does not offer any suitable location for a harbor site. The 60-foot depth contour in this area generally lies 8 miles offshore. The Copper River is presently actively constructing a large delta which will gradually push the 60-foot depth contour farther and farther offshore.

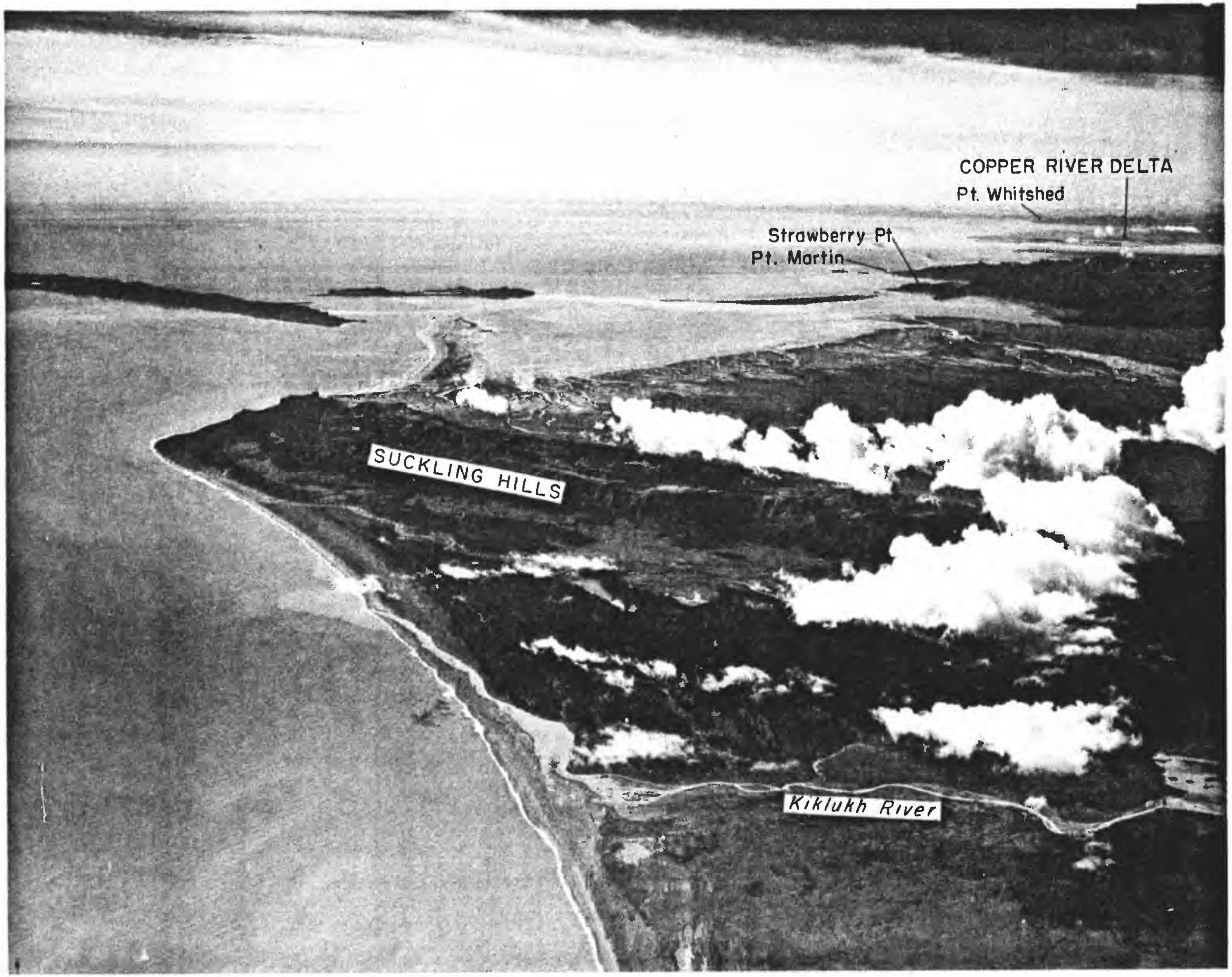
A series of offshore barrier beaches exists in this section of the coastline.

Katalla to Point Martin section

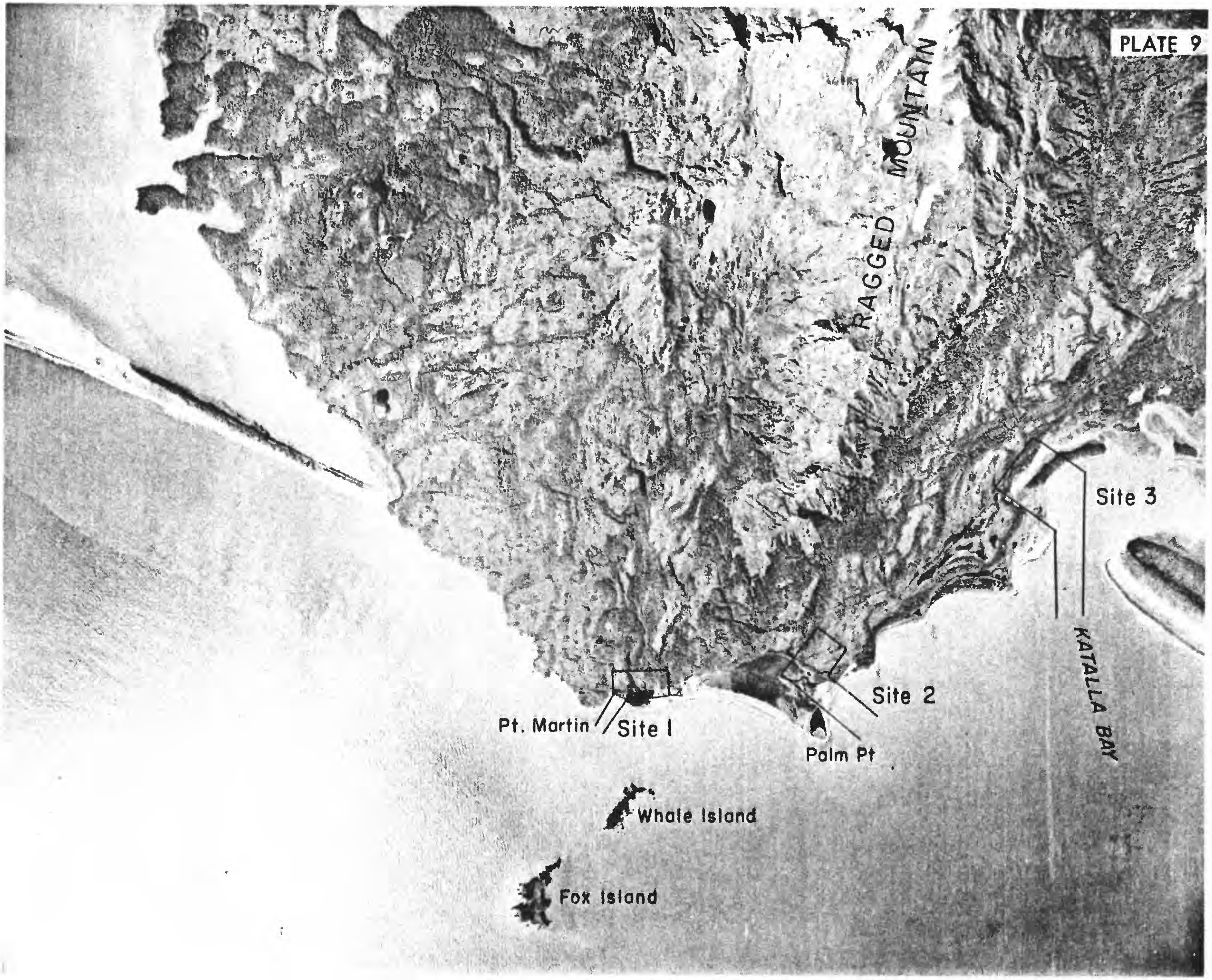
The most suitable location for a harbor in the Point Whitshed-Cape Yakataga area is between Point Martin and the town of Katalla (pl. 5). There is a natural offshore valley that strikes into the onshore Katalla Valley west of Wingham Island. The 60-foot submarine contour is within 4 miles of Katalla, within 1.5 miles of Point Martin, and within 2 miles of Palm Point. The 30-foot contour lies within 1 mile of Katalla, within 0.3 mile of Palm Point, and within 0.4 mile of Point Martin.

Three possible harbor sites between Point Martin and Katalla have been selected for discussion in this report (pl. 5). The selection of these sites was based on the onshore geologic factors plus what is known of the offshore topography, oceanography, and marine stratigraphy. The final selection of the site should be based on a more detailed examination of the area to determine the amount of longshore drift of sediments, the actual submarine topography, and the extent and nature of the marine sediments.

PLATE 8



VIEW LOOKING WEST FROM KIKLUKH RIVER TO PT. WHITSHED



VERTICAL AERIAL PHOTOGRAPH (1:60,000) OF SITES I, 2, AND 3

Site 1

Site 1 (pl. 5) is located at Point Martin and is underlain by terrace deposits overlying Tertiary sedimentary rocks. The thickness of the terrace gravel is unknown but probably is less than 10 feet. The Tertiary rocks consist of massive, hard, fine- to medium-grained sandstone interbedded with argillite, siltstone, and conglomerate that contains cobbles and boulders.

North of the harbor site a fault is mapped as the contact between the Tertiary and pre-Tertiary rocks. The fault has not been observed, but is inferred from geologic relationships of the rock units. Whether any movement on this fault might take place when the device, or devices, are detonated cannot be forecast at this time.

The location of site 1 offers protection from the major southeast storms in the Point Whitshed-Cape Yakataga area. It does not, however, offer much protection from southwest storms.

The direction and amount of longshore transport of debris at this site is unknown. At high tide, the transport is undoubtedly to the west; during low or medium tides, however, longshore transport, if any, may be to the east.

The sediments on the sea floor probably consist of gravel with local areas of exposed bedrock within a mile of shore. Farther offshore the sediments probably consist of mud, sand, and gravel with local exposed bedrock areas.

The 60-foot offshore contour is within 1.5 miles of the site and the 30-foot offshore contour within 0.4 mile.

Site 2

Site 2 (pl. 5) is located at Palm Point and is underlain by beach gravel, terrace gravel, and muskeg deposits. These unconsolidated deposits are only a thin veneer of material less than 10 feet thick overlying Tertiary sedimentary rocks which consist of massive, hard, fine- to medium-grained sandstone interbedded with argillite, siltstone, and conglomerate that contains cobbles and boulders.

The northwest part of the turning basin at this site would overlie the fault on the east flank of Ragged Mountain. Past activity along this fault has resulted in upthrow of the west side. In talus deposits north of Katalla displacement as much as 30 feet indicates that the most recent movement, however, has resulted in downthrow of the west side.

The location of site 2 offers protection from southwest storms. There is no protection, however, from southeast storms, which are the major storms in the area. Southeast storms are actively eroding the beach at the site area and bedrock is exposed at Palm Point and for a few hundred feet offshore during low tides. Within the past 50 years the beach in this area has retreated approximately 50 feet. The bedrock exposures at Palm Point and offshore are definite barriers to a higher erosion rate and should not be destroyed. If they were, the rate of erosion of the beach would be materially accelerated.

Sediment transport at this site generally consists of reworking the eroded debris. Storms strike the beach at right angles and very little if any lateral transport should be expected. Even so, dredging of the channel would be necessary because of deposition of sediments carried by the Katalla River, and sediments carried by storm waves from Strawberry Point. Dredging would be a relatively minor factor in the maintenance of the harbor.

Within a few hundred feet of the shoreline the sea floor consists of angular boulders and exposed bedrock; farther offshore, the materials are fine-grained sand and silt.

The 60-foot offshore contour is within 2 miles of the site area, and the 30-foot contour within 0.3 mile.

Site 3

Site 3 (pl. 5) is located at the town of Katalla and is underlain by beach and terrace deposits less than 10 feet thick. The unconsolidated deposits are underlain by complexly folded and faulted massive, fine-grained sandstone interbedded with argillite, siltstone, and conglomerate of Tertiary age.

The fault along the east flank of Ragged Mountain is approximately one mile west of this site. The characteristics of this fault have been considered in the discussion of site 2.

This site offers the most protection of the 3 proposed sites from southeast and southwest storms but several other factors should be considered. The present channel of the Katalla River has practically been closed by longshore transport of sediments from Strawberry Point. Local residents report that the spit across the river from Katalla has grown rapidly within the past 50 years. At one time large boats were able to enter Katalla Slough during high tide; although the actual size of the boats is unknown the residents estimate that the drafts of the boats were about 16 feet. The present channel is now only 3 feet deep during mean low tide. If this site were selected, dredging of the channel would be necessary. Of the 3 sites discussed, dredging at site 3 would be the most extensive.

Offshore from the channel of the Katalla River, the depth of the water increases rapidly. The 60-foot offshore contour is within 3.5 miles of Katalla and the 30-foot contour within 1 mile.

The marine sediments in Katalla Bay consist chiefly of mud and fine sand. The thickness of these sediments is unknown but probably is less than 50 feet in the bay; they may be as much as 100 feet farther offshore (see cross-section, pl. 5).

Seismic activity

Sites 1, 2, and 3 lie in a zone of major seismic activity. Moderate and severe earthquakes have been reported at Katalla, at Cordova (pl. 1), and at Yakataga. On May 14, 1908, an earthquake with an intensity of VII on the Rossi-Forel scale was reported to have had its epicenter at Katalla. Tarr and Martin (1912, p. 98) quote the description of the earthquake taken from the Katalla Herald (May 16, 1908) as follows: "Two earthquake shocks occurring in quick succession at 11:07 o'clock Thursday night, set every building in town rocking, moved furniture about rooms, knocked dishes from shelves, and caused many of the people in town, many of whom had retired, to take to the streets.

"According to the statements of a number of people, the shocks, of which there were two in almost instantaneous succession, lasted from 10 to 17 seconds. No damage was done. The shocks were accompanied by a vibratory motion pretty nearly north and south. In the Herald office the machinery and fixtures swayed perceptibly, while the building rocked as if it had been struck by a cyclone."

Recent earth movement in the area is indicated by a 30-foot displacement of the talus deposits along the fault on the eastern flank of Ragged Mountain. It is doubtful that all of this 30-foot displacement occurred during the 1908 earthquake.

Recurrence of earthquakes of intensities as great as that of the 1908 earthquake is probable in the Katalla area. Therefore, manmade structures in the area must be made earthquake resistant.

REFERENCES

Kachadoorian, Reuben, 1956, Engineering geology of the Katalla district, Alaska: U. S. Geol. Survey open-file report.

Martin, G. C., 1908, Geological and mineral resources of the Controller Bay region, Alaska: U. S Geol. Survey Bull. 335.

Miller, D. J., 1951, Preliminary report on the geology and oil possibilities of the Katalla district, Alaska: U. S Geol. Survey open-file report.

Tarr, R. S., and Martin, Lawrence, 1912, The earthquakes at Yakutat Bay, Alaska, in September 1899: U. S. Geol. Survey Prof. Paper 69.

U. S. Weather Bureau, 1956, Climatological data, Alaska: Annual summary, 1955, v. 41, no. 13.