REPORT OF INVESTIGATION 2017-5
DeRaps and others, 2017
SHEET 1 OF 1
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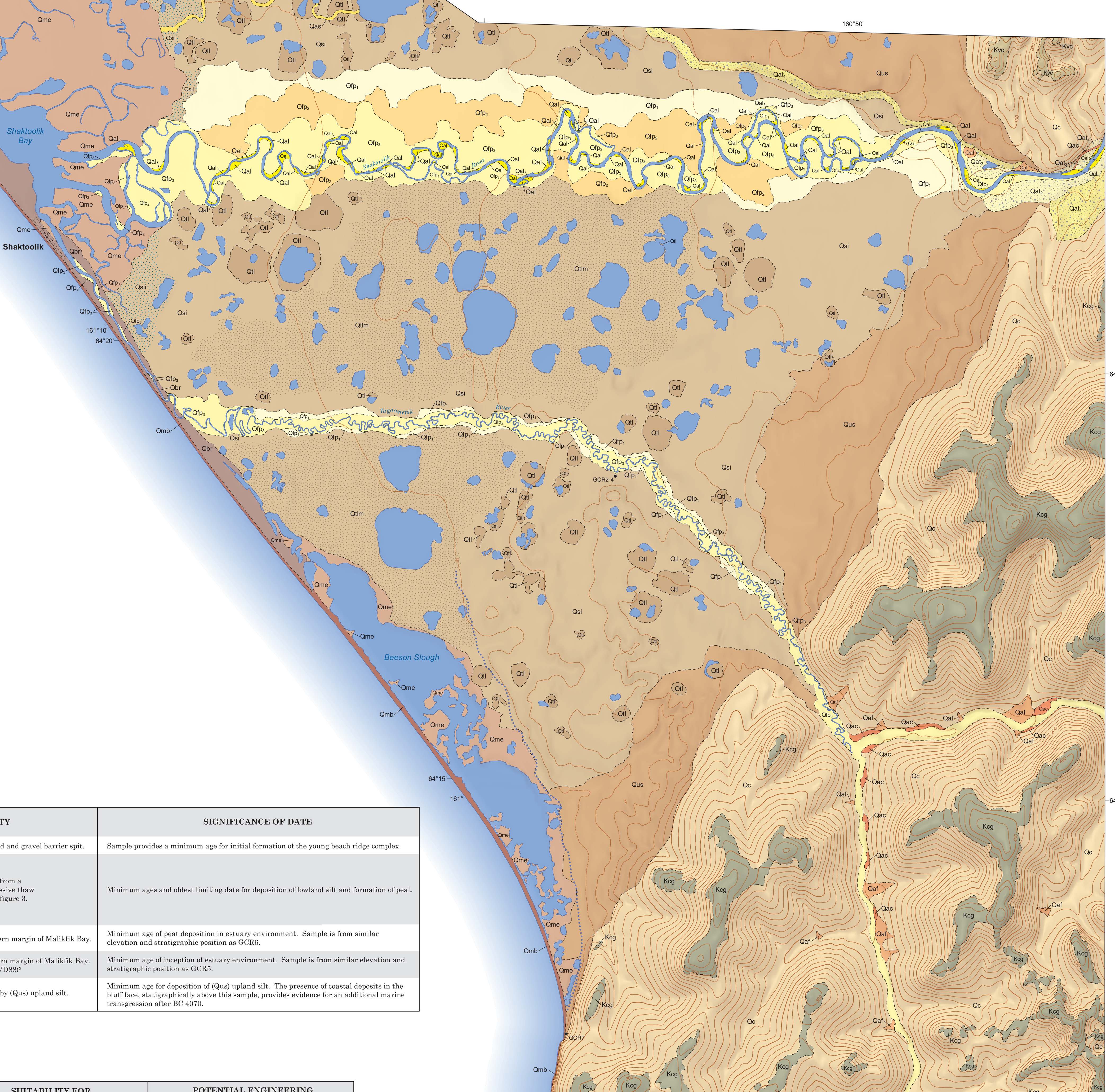
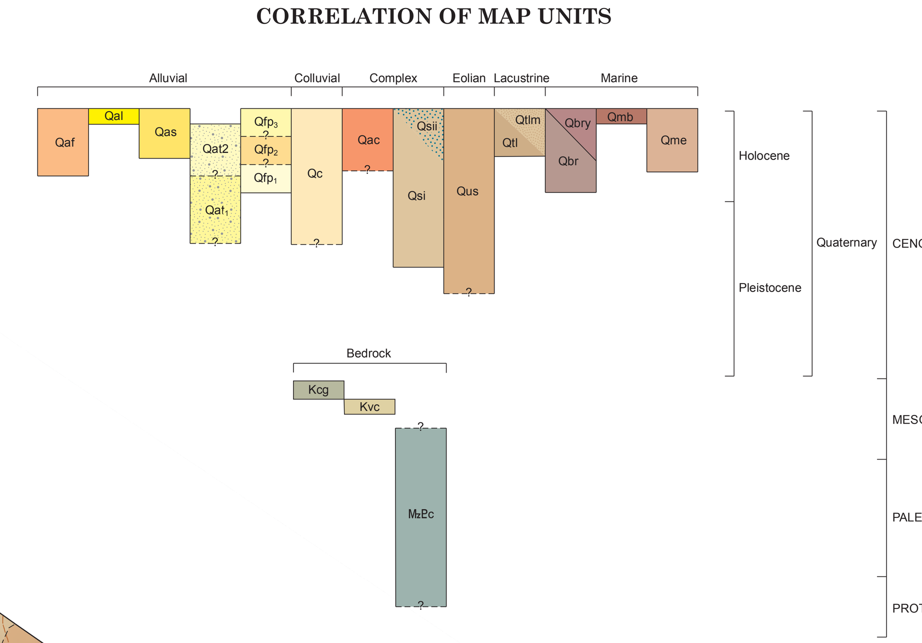


CORRELATION OF MAP UNITS



INTRODUCTION

This map depicts the distribution of unconsolidated deposits and generalized bedrock in the vicinity of Shaktoolik, Alaska, including parts of the Norton Bay B-6, B-5, B-4, and A-4 quadrangles (fig. 1). It was completed as part of the Alaska Division of Geological & Geophysical Surveys (DGGS) Coastal Geohazard Evaluation and Geologic Mapping for Coastal Communities project, funded by the Federal Coastal Impact Assistance Program (CIAP). The primary objective of this map is to describe the distribution of unconsolidated geologic deposits, identify local geologic hazards, and provide information about the depositional environment and basic engineering properties of common surficial-geologic materials in and around Shaktoolik.

Map units are the result of combined field observations and aerial imagery interpretation. A suite of local ground observations were collected over a two-week period in July 2011 by a helicopter-supported team of DGGS geologists and collaborators. Field investigations included soil test pits, sample collection, soil and rock description, oblique aerial photography, and documentation of landscape morphology. Best available orthorectified aerial photographs and satellite imagery (fig. 2) were used to interpret surficial-geologic units and delineate contacts at a scale of 1:50,000 or smaller. Organic samples were radiocarbon dated to provide constraints on the age of unconsolidated deposits and understand the sequence of depositional events (fig. 3).

Radiocarbon ages for selected samples from surficial-geologic units are included in Table 1. Generalized engineering-geologic properties typical of the surficial-geologic units found in this map area are summarized in Table 2. The properties outlined in this table are intended as a general guide; detailed geotechnical investigations should be conducted before any of these deposits are used for construction purposes.

DESCRIPTION OF MAP UNITS

Unconsolidated Deposits

ALLUVIAL DEPOSITS

Qaf — ALLUVIAL FAN DEPOSITS—Poorly sorted, subangular gravel, sand, silt, and scattered boulders deposited by ephemeral streams, forming fans or aprons at transitions between higher- and lower-gradient landscape surfaces.

Qal — ALLUVIUM IN ACTIVE CHANNELS—Elongate deposits of moderately- to well-sorted, well-stratified, fluvial gravel, sand, and silt with scattered to numerous boulders, deposited in active stream channels. Clasts generally rounded. Deposit is medium to thick bedded, locally crossbedded, and contains fining-upward cycles.

Qas — SILTY ALLUVIUM—Moderately well-stratified silt containing traces of fine sand in modern channels and floodplains of streams draining silt-mantled slopes. Generally composed of retransported eolian silt. Moderately- to well-sorted and medium to thinly bedded; locally crossbedded.

Qat_2 — YOUNGER TERRACE DEPOSITS—Well-sorted, well-stratified, well-rounded to subrounded gravel and sand with trace to some silt and rare to numerous boulders forming stream terraces adjacent to and above modern floodplains. Mantled by up to 1 m of eolian and retransported silt. Terrace treads are approximately 40–60 m above modern stream elevation. Surface morphology is smooth except for scattered low scarps.

Qat_1 — OLDER TERRACE DEPOSITS—Well-sorted, well-stratified, well-rounded to subrounded gravel and sand with trace to some silt and rare to numerous boulders forming stream terraces at elevations well above modern zones of alluvial deposition. Mantled by up to 1 m of eolian and retransported silt. Terrace treads are approximately 70–80 m above modern stream elevation. Surface morphology is smooth except for scattered low scarps.

Qfp_3 — YOUNG FLOODPLAIN DEPOSITS—Elongate deposits of moderately- to well-sorted, well-stratified, fluvial gravel, sand, and silt with scattered to numerous boulders comprising recent and modern floodplains. Clasts generally rounded. Deposits may reflect former channels and flow regimes. Medium to thick bedded, locally crossbedded, and includes fining-upward cycles. Commonly mantled by thin layer of silty overbank deposits. Low-lying surfaces may be flooded during periods of high stream discharge. Surface typically well vegetated with extensive willow and alder thickets. Characteristic landforms include recent bars, oxbow lakes, meander scrolls, and abandoned channels.

Qfp_2 — FLOODPLAIN DEPOSITS OF INTERMEDIATE AGE—Elongate deposits of moderately- to well-sorted, well-stratified, fluvial gravel, sand, and silt with scattered to numerous boulders. Clasts generally rounded. Deposits reflect former channels and flow regimes. Medium to thick bedded, locally crossbedded, and includes fining-upward cycles. Commonly mantled by thin layer of silty overbank deposits, generally thicker than on Qfp_3 deposits. Characteristic landforms include modified bars, oxbow lakes, meander scrolls, abandoned channels, and other evidence of past floodplain activity.

Qfp_1 — OLD FLOODPLAIN DEPOSITS—Elongate deposits of moderately- to well sorted, well-stratified, fluvial gravel, sand, and silt with scattered to numerous boulders. Clasts generally rounded. Deposits reflect old former channels and flow regimes. Medium to thick bedded, locally crossbedded and includes fining-upward cycles. Commonly mantled by thin layer of silty overbank deposits, generally thicker than on Qfp_2 deposits.. Surface typically well vegetated, smooth to hummocky, with local low scarps and bogs. Characteristic landforms include highly modified bars, oxbow lakes, meander scrolls, abandoned channels, and other evidence of past floodplain activity.

COLLUVIAL DEPOSITS

Qc — COLLUVIUM—Poorly sorted, heterogeneous blankets, aprons, and fans of angular to subrounded rock fragments, gravel, sand, and silt deposited on slopes, slope bases, or high-level surfaces by residual weathering and complex mass-movement processes, including rolling, sliding, flowing, soil creep (gelifluction/solifluction), and frost creep (fig. 4). Locally washed by meltwater and slope runoff. Generally unsorted to very poorly sorted. Thickness is highly variable, with thickest deposits at the bases of hillslopes. Surface morphology is smooth, lobed, or moderately terraced. Where deposit is thin, surface morphology reflects configuration of underlying bedrock surface.

COMPLEX DEPOSITS

Qac — COLLUVIAL AND ALLUVIAL VALLEY FILL DEPOSITS—Poorly sorted, heterogeneous, elongate deposits of silt, sand, and gravel derived from weathered bedrock and deposited at the margins of stream valleys by a combination of fluvial and mass-movement processes. Surface morphology is hummocky.

Qsi — LOWLAND SILT—Homogeneous blankets of poorly to moderately stratified silt and organic silt deposited by eolian processes and extensively reworked by lacustrine processes and the formation, thawing, and redevelopment of ice-rich permafrost. Variable in thickness and saturated and locally refrozen with variable ice content. Thermokarst features are common and include low-centered ice wedge polygons, retrogressive thaw slumps, beaded streams, thaw lakes, and drained thaw lakes. Dating of organic silt exposed in a retrogressive thaw slump at a depth of 1.2 m indicates a minimum age of initial accumulation of this unit of 9,610 +/- 45 radiocarbon years BP (GCR3 in table 1). Surface morphology is generally smooth to hummocky and characterized by numerous shallow, interconnected channels and small lakes (figs. 3 and 5).

Qsii — LOWLAND SILT, INTERMITTENTLY INUNDATED—Poorly to moderately stratified silt and organic silt of Qsi that is intermittently inundated by salt water during large storm events in the Late Holocene. Surface expression is characterized by a slightly greater abundance of interconnected channels and small lakes. Landward extent of modern inundation delineated by the inland limit of wave-deposited driftwood (fig. 6).

EOLIAN DEPOSITS

Qus — UPLAND SILT—Blankets and aprons of massive, generally homogeneous silt deposited by eolian processes with subsequent minor to extensive reworking by fluvial and colluvial processes such as mudflows, slopewash, gelifluction, and frost action. Thickness is highly variable, with thickest deposits along the base of slopes. Deposit is locally frozen with variable ice content. A dated organic layer from a coastal bluff exposure yielded a minimum age of 5,390 +/- 40 radiocarbon years BP (GCR7 in table 1). Surface morphology is generally smooth to gently sloping with numerous interconnected channels.

LACUSTRINE DEPOSITS

Qtl — THAW LAKE DEPOSITS—Circular, subcircular, or irregularly shaped deposits of moderately stratified, heterogeneous silt and organic silt filling small, commonly interconnected basins resulting from thawing of ice-rich permafrost (fig. 7). Formed by recently drained thaw lakes.

Qtlm — MULTI-GENERATION THAW LAKE DEPOSITS—Silt and organic silt of Qtl that has undergone repeated cycles of thaw lake formation, draining, and redevelopment. Characterized by overlapping circular, subcircular, or irregularly shaped deposits of stratified, heterogeneous silt and organic silt. Multiple generations of thaw lake deposits may overlap to such an extreme degree that identification of individual drained thaw lake boundaries is difficult. Locally includes Qsi.

MARINE DEPOSITS

Qbr — OLDER BEACH RIDGE COMPLEX, UNDIFFERENTIATED—Elongate, narrow mounds and ridges of well-sorted, well-stratified, medium sand to coarse gravel comprising inactive beach deposits, vegetated primarily by dune grass and small shrubs. Deposits are several meters thick and form sub-parallel beach ridges in orientations that reflect the beach geometry at the time of deposition. Swale-to-crest heights are typically less than 1 m.

Qbry — YOUNG BEACH RIDGE COMPLEX—Elongate, narrow mounds and ridges of well-sorted, well-stratified, medium sand to coarse gravel comprising recently active beach deposits, vegetated primarily by sparse dune grass. Deposits are several meters thick and form a recurved beach ridge complex that indicates northwest progradation of the Shaktoolik barrier spit. This ridge complex is more shore-parallel than the older recurved beach complex it crosscuts. Dating of a shell hash layer at 60 cm depth gives a minimum age for the deposit of 1,470 +/- 25 radiocarbon years BP (GCR1 in table 1). Swale-to-crest height is up to 2 m.

Qmb — MODERN BEACH DEPOSITS—Elongate, shore-parallel littoral deposits of well-sorted fine sand to very coarse gravel. Well rounded gravels with elongate pebbles are common. Sediment size increases to cobbles and boulders in proximity to cliffs in the southern and northern portions of the mapped coastline. Storm overwash deposits and tidal flats are present in areas of lower elevation and are laterally extensive along the Beeson Slough barrier. Driftwood up to 25 cm diameter is common along the entire coastline. Locally capped by salt-resistant vegetation, primarily dune grass, where surface has been undisturbed by recent wave activity (fig. 1).

Qme — ESTUARINE DEPOSITS—Fine silt and clay intermixed with fine to medium sand of marine and fluvial origin. Thinly bedded to massive, containing discontinuous peat beds that were dated at 3,630 +/- 45 radiocarbon years BP (GCR6 in table 1) in exposures along the modern beach. Includes tidal marshes segmented by complex modern strandlines. Surface morphology is generally smooth to hummocky and characterized by numerous shallow, interconnected channels and small lakes (fig. 6). Elevation is less than 8 m above local mean sea level (msl).

Figure 4: Talus cone in a colluvial deposit (Qc) along the coastal cliffs in the southern portion of the map (photograph taken 07/23/2011 by N.E.M. Kinsman).

Figure 5. Low-centered ice wedge polygons in (Qsi) lowland silt deposit, just east of Beeson Slough. Polygons range in size from 5 to 30 meters across (photograph taken 07/27/2011 by K. Ohman).

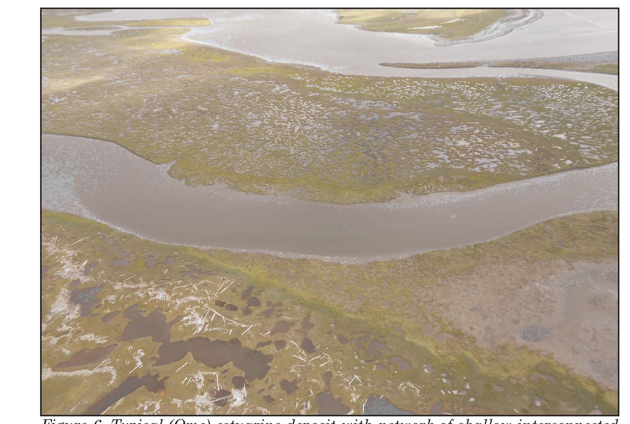


Figure 6. Typical (Qme) estuarine deposit with network of shallow interconnected channels and small lakes in tidal flat, Wave-deposited driftwood used to delineate extent of modern inundation is visible in the foreground (photograph taken 07/28/2011 by M.R. DeRaps).

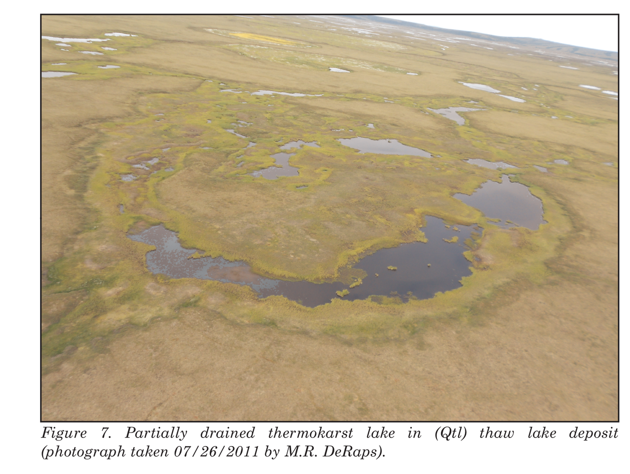


Figure 7. Partially drained thermokarst lake in (Qtl) thaw lake deposit (photograph taken 07/26/2011 by M.R. DeRaps).

BEDROCK

(Descriptions modified from Patton and others, 2009)

Kcg — CARBONATE-CLAST GRAYWACKE AND MUDSTONE (CRETACEOUS), SUBMARINE FAN DEPOSITS—Fine- to coarse-grained graywacke interbedded with finely laminated, micaceous mudstone deposits. Predominantly carbonate clasts with some quartz, chert, and volcanic rock; mica clasts also present. Interpreted to represent turbidite submarine deposits of the mid to outer fan. Outcrops of the more resistant graywacke are exposed along ridgetops while the finer-grained mudstone forms weathered slopes and valleys. Mapped extent includes outcrops, subcrops, and boulder field exposures that exhibit minimal downslope displacement.

Kvc — VOLCANIC-CLAST CONGLOMERATE, SANDSTONE, AND SHALE (CRETACEOUS), MARGINAL SHELF AND SLOPE DEPOSITS—Massive, poorly stratified pebble to boulder conglomerate consisting chiefly of andesitic volcanic clasts interbedded with dark graywacke and dark, finely laminated mudstone. Interpreted to represent debris flows and alluvial fan deposits of the marginal shelf and slope. Mapped extent includes subcrops and boulder field exposures that exhibit minimal downslope displacement.

MzPc — COMPLEX OF REINDEER HILLS (MESOZOIC TO PROTEROZOIC?)—Undivided assemblage of the Seward Terrane, consisting of both intrusive and extrusive volcanic rocks, contact metamorphosed rocks, and intruded dikes. The lithologies are complexly related and include impure marble, monzogranite, calcsilicate hornfels, alkali feldspar rhyolite, quartz-mica schist, and quartzite intruded by aplite and amphibolite dikes. Mapped extent includes outcrops, subcrops, and boulder field exposures that exhibit minimal downslope displacement.

EXPLANATION OF MAP SYMBOLS

GCR1 • Radiocarbon Sample—Sample age and description are listed in Table 1

Paleoshoreline—Elevation and location suggests formation during the Pelukian Transgression (~125,000yr) (Hopkins, 1973); beach gravels are locally present

Contact—Mapped from imagery. Identity and existence certain, location inferred

Figure 1. Oblique aerial photograph looking southeast along the open ocean coast of Shaktoolik. Two generations of driftwood deposited at high water lines are visible along the beach (photograph taken 07/26/2011 by K. Ohman).

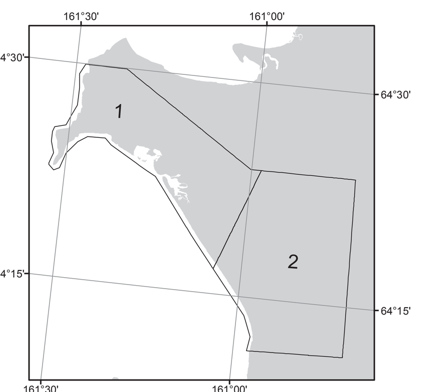


Figure 2. Mapped area with imagery sources identified:
1) Advanced Land Observation Satellite (ALOS) Prism panchromatic satellite imagery 2007-2010
2) Alaska high altitude color infrared photography (AHAP) 1978-1986

Figure 3. DGGS geologists sampling a retrogressive thaw slump in (Qls) lowland silt deposit, adjacent to the Tagoomenik River. Geochron samples GCR2, 3, and 4 were collected from this location (photograph taken 07/28/2011 by M.R. DeRaps).

TABLE 1: Results from Radiocarbon Analysis

RADIOCARBON SITE	DGGS SAMPLE ID	NOSAMS LAB ID[1]	MATERIAL ANALYZED	^{14}C AGE YR BP	95.4% (2 SIGMA) CAL AGE RANGES[2]	SAMPLE DEPTH (CM)	SAMPLE LOCALITY	SIGNIFICANCE OF DATE
GCR1	2011_SKK_NK_19B	OS-91881	Marine carbonate shell hash	1,470 ± 25	cal AD 1320 - 1580	60	Soil pit in (Qbry) beach ridge complex on sand and gravel barrier spit.	Sample provides a minimum age for initial formation of the young beach ridge complex.
GCR2	2011_SKK_NK_127A	OS-91880	Organic sediment with disseminated plant material	2,550 ± 25	cal BC 800 - 560	306	GCR2, 3, and 4 were collected from a natural exposure in a retrogressive thaw slump; (Qsi) lowland silt. See figure 3.	Minimum ages and oldest limiting date for deposition of lowland silt and formation of peat.
GCR3	2011_SKK_NK_127C	OS-91879	Peat	9,610 ± 45	cal BC 9220 - 8820	120		
GCR4	2011_SKK_NK_127D	OS-91878	Organic sediment with disseminated plant material	4,480 ± 35	cal BC 3340 - 3030	50		
GCR5	2011_SKK_KO_240B	OS-91941	Peat	100 ± 25	cal AD 1680 - 1950	40	Soil pit in (Qme) estuarine marsh from western margin of Malikfik Bay.	Minimum age of peat deposition in estuary environment. Sample is from similar elevation and stratigraphic position as GCR6.
GCR6	2011_SKK_MD_15	OS-91945	Organic sediment with disseminated plant material	3,630 ± 45	cal BC 2140 - 1890	30	Soil pit in (Qme) estuarine marsh from eastern margin of Malikfik Bay. Measured elevation of GCR6 was 2.4 m (NAVD88)[3]	Minimum age of inception of estuary environment. Sample is from similar elevation and stratigraphic position as GCR5.
GCR7	2011_SKK_JS_88A	OS-91895	Organic sediment with disseminated plant material	5,390 ± 40	cal BC 4340 - 4070	225	Soil trench into face of coastal bluff mantled by (Qus) upland silt, approximately 10 m above modern beach.	Minimum age for deposition of (Qus) upland silt. The presence of coastal deposits in the bluff face, statigraphically above this sample, provides evidence for an additional marine transgression after BC 4070.

[1]All radiocarbon ages were determined at the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) facility at the Woods Hole Oceanographic Institution with National Science Foundation sponsorship (OCE-0753487).
[2]Radiocarbon ages were calibrated to calendar years using the marine09 and intcal09 calibration data sets (Reimer and others, 2009) through the software program Calib Rev 6.1.0 (Stuiver and Reimer, 1993).
[3]GCR6 is the only organic sample where the elevation was measured with a survey-grade GNSS system.

TABLE 2: Generalized Engineering Properties of Map Units

COMPONENT GEOLOGIC UNITS	GENERAL CHARACTERISTICS	SURFACE DRAINAGE	PERMAFROST	SLOPE STABILITY	SUITABILITY FOR CONSTRUCTION	POTENTIAL ENGINEERING CONSIDERATIONS
Qmb, Qbry, Qbr	Well-sorted sand and gravel.	Good in recent deposits, may be inhibited on older, inactive surfaces where permafrost has developed or surface has been mantled by appreciable thicknesses of silt and organic materials.	Unfrozen to discontinuously frozen with low to moderate ice content. Ice-rich permafrost may be present on older, inactive surfaces mantled by appreciable thicknesses of silt and organic materials or where silt has infiltrated into gravels by percolating groundwater.	Generally stable, except for fine-grained, ice-rich deposits, which are subject to thaw instability, and areas along the coast where sudden, rapid collapse may occur due to wave erosion.	Excellent source of sand and gravel beneath fine-grained cover sediment. Excellent foundations if not within modern coastal floodplains.	Shallow permafrost may limit depth of excavation. Excavation of modern beach deposits may lead to undesirable results, for example altered patterns of beach erosion and deposition. May be subject to marine inundation during large storms.
Qal, Qfp_3, Qfp_2, Qfp_1, Qat_1, Qat_2	Well-sorted, well-stratified gravel, sand, and silt with scattered to numerous boulders.	Good in recent deposits, may be inhibited on older, inactive surfaces where permafrost has developed or surface has been mantled by appreciable thicknesses of silt and organic materials.	Unfrozen to discontinuously frozen with low to moderate ice content. Ice-rich permafrost may be present on older, inactive surfaces mantled by appreciable thicknesses of silt and organic materials or where silt has infiltrated into gravels by percolating groundwater.	Generally stable, except for areas adjacent to cutbanks or freefaces where sudden, rapid collapse may occur due to stream erosion or surface loading.	Excellent source of sand and gravel beneath fine-grained cover sediments. Excellent foundations if not within modern river floodplains.	Older deposits may have significant overburden of eolian, organic, or colluvial sediment requiring deep excavation, possibly limited by shallow permafrost. Cutbanks along active streams may fail, and therefore may not be suitable for structure sites. High potential for flooding and icing along margins of streams and rivers.
Qc, Qac, Qaf	Poorly to moderately sorted, heterogenous deposits of silt, sand, and gravel.	Generally good, decreases with increasing proportion of silt and presence of permafrost.	Unfrozen to discontinuously frozen with low to moderate ice content. Frozen ground generally more common on north-facing slopes and in older deposits. Segregated ice lenses may be prevalent in deposits with high silt and/or organic content.	Deposits with high silt content are susceptible to creep and flow, especially where saturated by near-surface groundwater. Steep colluvial deposits are generally unstable and may be subject to debris flows, slides, and rock falls. Generally thaw stable, except where silty.	May be suitable as fill. Poor foundations where blocks are loose and unstable, potentially good foundations where grain size is heterogeneous and surface slopes are low to moderate.	Slopes may be subject to debris flows, subsidence, and local liquefaction. Caution should be exercised during excavation and construction activities, which may require ripping or blasting. Saturated or over-steepened deposits may be subject to slope failure, and local thaw subsidence may occur in areas of permafrost.
Qme, Qsi, Qsii, Qtl, Qtlm, Qus, Qas	Silt and organic silt with minor to trace amounts of fine sand.	Generally very poor due to small particle size and widespread shallow ice-rich permafrost. Standing water is common and local channelized flow may be present.	Discontinuously to continuously frozen with moderate to high ice content. Ice-rich permafrost may include abundant segregated ice lenses and massive ground ice, especially in deposits with high organic content.	Thaw unstable. Subject to lateral erosion and collapse near active channels or developing thaw lakes. May be subject to slumping and earthflows in areas of low to moderate slope gradient.	Generally unsuitable as a materials source. Typically unsuitable for foundations unless permafrost is preserved (i.e., thermally buffered through pad-supported construction) and location is beyond inland extent of marine inundation.	Coastal areas may be subject to inundation during large storms. Silt-rich deposits may be subject to slump, slough, subsidence, liquefaction, and mudflows. Saturated fine-grained soils are prone to extreme frost heave and thaw subsidence. Shallow water table and presence of permafrost limit depth of excavation. Generally unsuitable as structure sites without suitable fill.
Kcg, Kvc, MzPc	Bedrock of mixed lithologies.	Generally poor except where extensively fractured.	Ice-rich permafrost generally absent, but may be present locally where rocks are extensively weathered and fractured.	Generally stable, however, rock fall or other mass-wasting processes may be present in steep terrain.	Good to excellent source of construction material where rock is not highly weathered and lithology is suitable. Igneous intrusive rocks of Reindeer Hills complex may be suitable for coastal armoring (rip-rap).	Quality of rock will vary depending on lithology, degree of weathering, and fracturing.

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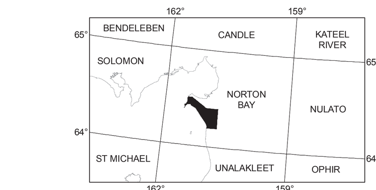

Location of Map Area

SURFICIAL GEOLOGIC MAP OF THE SHAKTOOLIK AREA, NORTON BAY QUADRANGLE, ALASKA

by

M.R. DeRaps[1], N.E.M. Kinsman[1], D.S.P. Stevens[1], and J.R. Overbeck[1]

2017

SCALE 1:50000

1 0.5 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 0.5 0 1 2 3 4 5 KILOMETERS

14°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2013

CONTOUR INTERVAL 20 METERS
SUPPLEMEMTARY CONTOUR INTERVAL 10 METERS
NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88)

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Topographic base map created from:
SPOT-5 Digital Elevation Model (CNES 2010, Distribution Spot Image S.A., France, SICORP, USA, all rights reserved)
Projection:
Universal Transverse Mercator Zone 4 North
Datum:
North American Datum of 1983
Geologic field investigations by:
N.E.M. Kinsman[1], M.R. DeRaps[1], D.S.P. Stevens[1], J.R. Overbeck[1], K. Ohman[2], and H. Smith[3] (2011)
Airphoto interpretation by:
N.E.M. Kinsman[1], M.R. DeRaps[1], and D.S.P. Stevens[1] (2011, 2012)
Geologic GIS data layers created by:
M.R. DeRaps[1] and J.R. Overbeck[1] (2011, 2012)
Cartography by:
M.R. DeRaps[1], J.R. Weakland[1] (2013), and P.E. Gallagher[1] (2013, 2016-2017)
Peer review by:
T.D. Hubbard[1] and O.K. Mason[4] (2016)

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