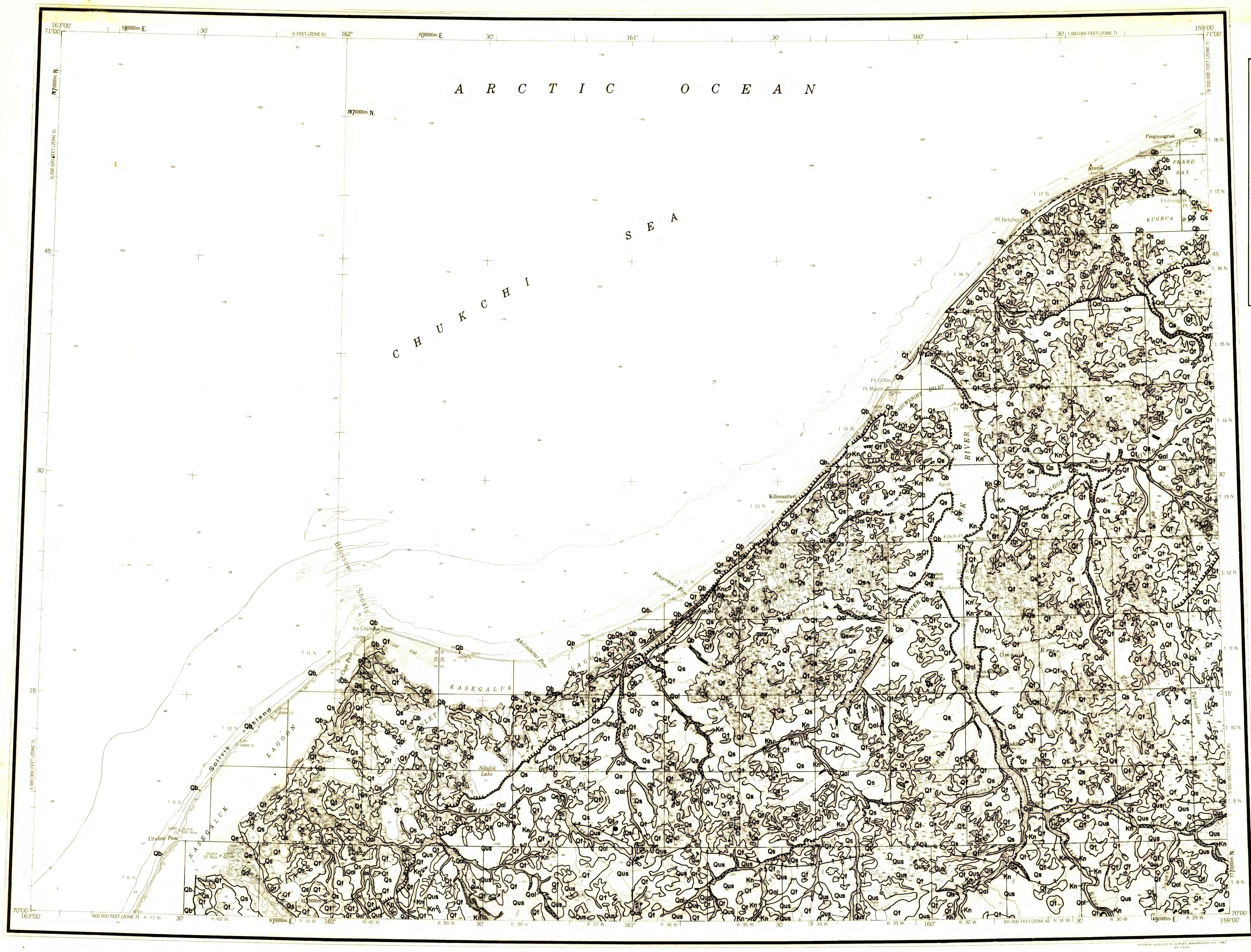
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

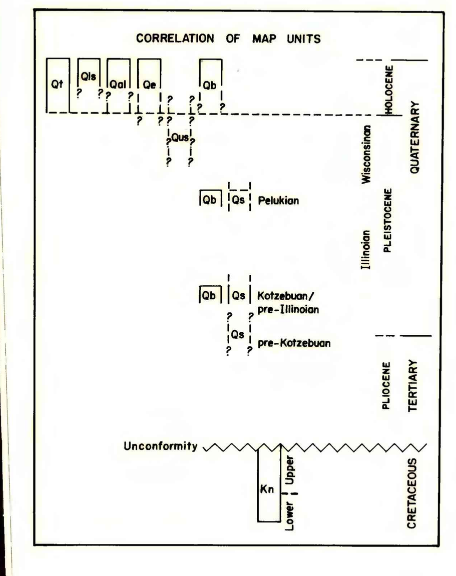
OPEN-FILE REPORT
83-457
PLATE 1



Base from USGS 1:250,000
WAINWRIGHT, 1955, 1961

SCALE 1:250 000

Geology mapped in 1977-78.



MAP SYMBOLS

Contact approximately located from aerial photographs; queried where gradational and indefinite

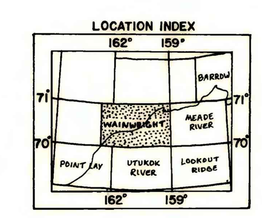
Wave-cut cliff forming inshore limit of separate marine transgressions

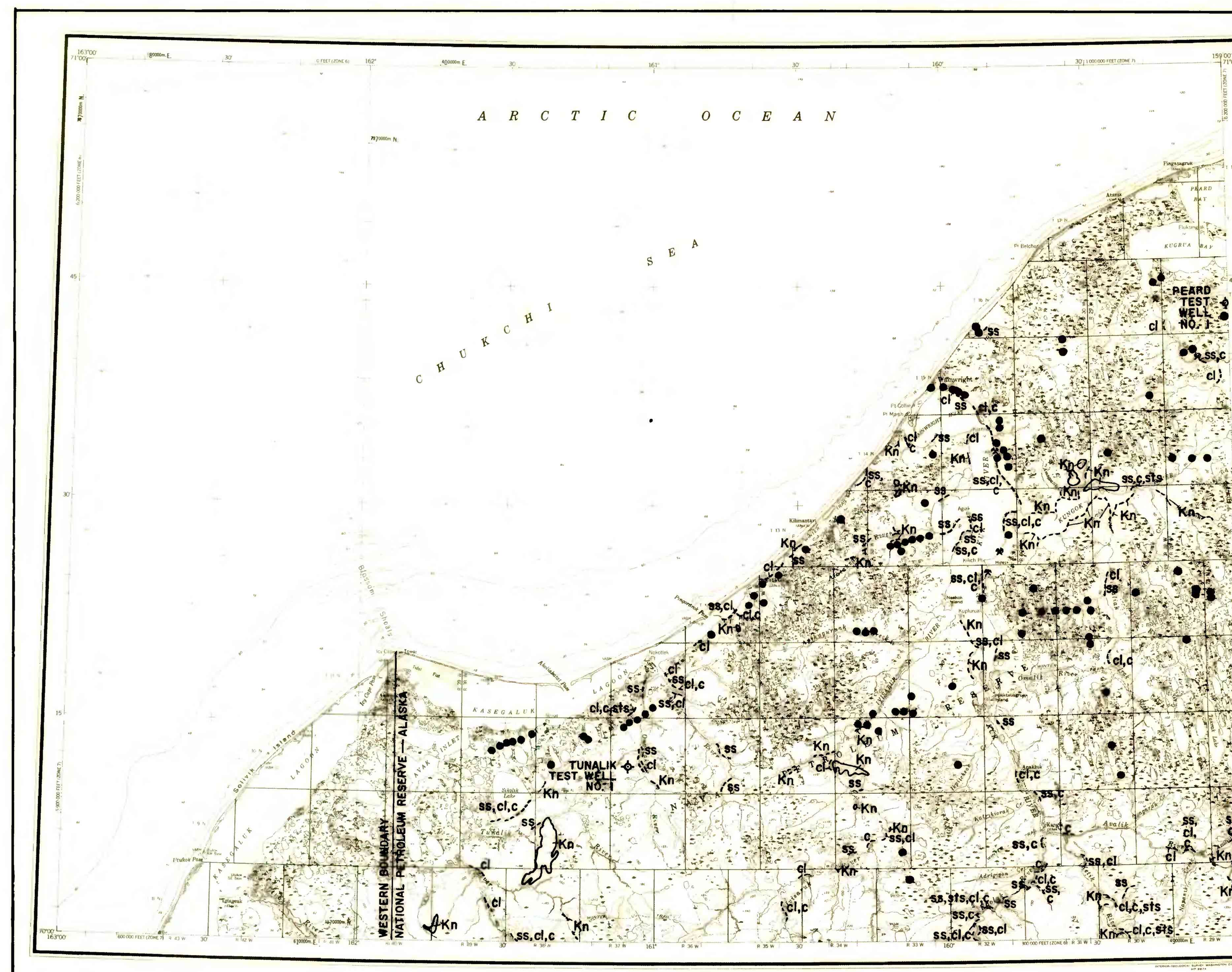
Minor escarpments at outer limit of fluvial terraces or at changes in bedrock lithology

Boundary between modern beach ridges of different elevations

Pingo

Bedrock exposed in vertical sections along rivers, lakes, and the ocean





EXPLANATION

The entire quadrangle is underalin by the Nanushuk Group of Early and Late Cretaceous age, consisting of the following major rock types: sandstone, siltstone, clay shale (clay, bentonite, bentonitic clay, and carbonaceous shale), and coal

SYMBOLS

Outcrop in river, lake banks, and in sea cliffs

- ss sandstone
- sts siltstone
- cl clay, bentonite, bentonitic clay, clay shale, and carbonaceous shale
- Kn undifferentiated rocks of Nanushuk Group

Seismic shot hole in coal of Nanushuk Group (Martin and Callahan, 1978)

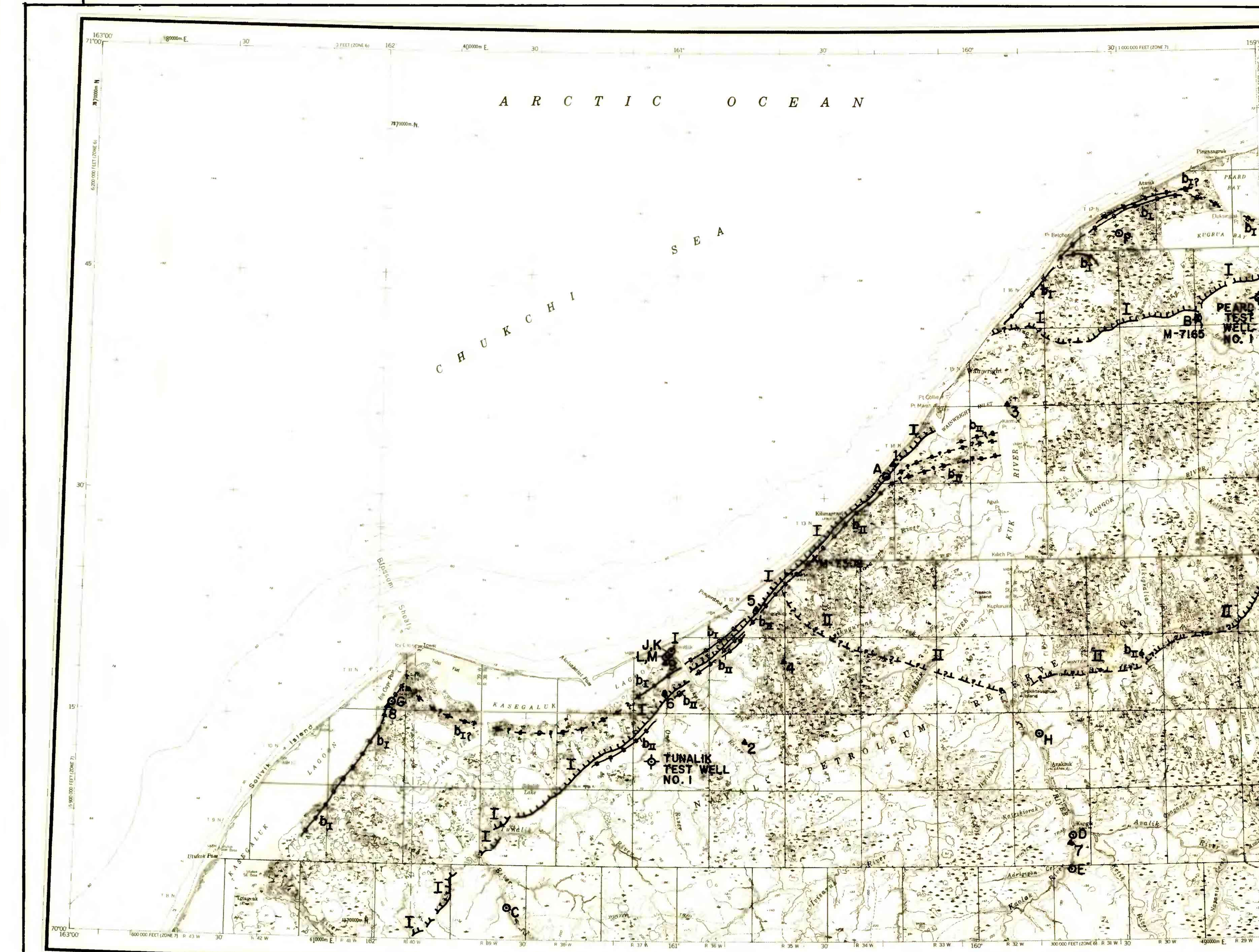
Test well in which Nanushuk Group is uppermost bedrock formation

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

Figure 1

Bedrock map of the Wainwright quadrangle



EXPLANATION

Prominent wave-cut escarpments of former marine shorelines approximately located from aerial photographs; queried where indefinite or indistinct. Roman numeral denotes escarpments, as referred to in text and listed below:

- I Wave- cut cliff indicating sea level 20 m or less above present sea level; correlated with Pelukian shoreline (McCulloch, 1967)
- II Wave-cut cliff indicating sea level from 20 m to 30 m above present sea level; correlated with pre-Illinoian (McCulloch, 1967) or Kotzebuan shoreline (Hopkins, 1967)

Prominent beaches, offshore bars, and barrier island chains related to shorelines I and II as referred to in text and listed below; dashed and queried where inferred

- b_I Beaches, offshore bars, and barrier islands related to wave-cut cliff I, the Pelukian shoreline
- b_{II} Beaches and offshore bars related to wave-cut cliff II, the pre-Illinoian or Kotzebuan shoreline

Abandoned and plugged test well

x M-7165
Location and U.S. Geological Survey identification number of fossil collection described in table 1

▲7
Location and number of ice-rafted erratic boulders in marine sediments of Quaternary age described in table 2

⊙E
Location of and letter identifying radiocarbon-dated organic material in deposits of Quaternary age described in table 3

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

Figure 2

Location of wave-cut cliffs and related beaches, offshore bars, and barrier island chains; test wells; fossil collections, erratic boulders, and radiocarbon-dated samples

DESCRIPTION OF MAP UNITS

Unit	Description of materials	Distribution and thickness	Topography and drainage	Permafrost	Susceptibility to frost action	Suitability for construction	Special problems
Qt Thaw-lake deposits	Consist of sediment eroded from lake banks and redistributed by currents and wave action; chiefly fine to medium sand in areas of eolian sand and alluvial deposits, silty sand in marine deposits, and silt to fine sand in upland silt. May include pebble beds and lenses or discrete pebbles where derived from alluvium and marine sand and beach deposits. Thaw-lake deposits overlying upland silt may be largely sand from underlying alluvial deposits. Contains retransported pieces of peat, sticks, as well as in situ peat beds and lenses. Commonly silty and organic rich.	Coalesced and individual thaw-lake basins, commonly oriented in N. 10° W. direction occupy 20 to 50 percent of areas underlain by marine sand east and west of Kuk River and bordering Avak River estuary where basins are less than 5 m deep; isolated basins to 30 m deep on upland silt; depth depends on thickness of permafrost having excess ice. Thaw-lake deposits generally less than 3 m thick, locally thicker than 3 m in upland silt unit.	Occupy interlocking and overlapping basins with local relief of less than 3 m, within broad basins that are less than 5 m below residual surfaces in marine sand unit. Occupy broad shallow coalesced basins where upland silt is thin, to deeply incised basins where upland silt is more than 5 m thick. Basins connected by small, meandering creeks or are undrained; drainage poorly integrated.	Permafrost extends from depth of 0.5-1.0 m to 200-300 m beneath surface except beneath lakes deeper than 2 m where a thin thaw bulb separates base of seasonal frost from top of permafrost. Upper 6-8 m of permafrost has excess ice that results in thaw settlement of 3.4 m beneath undisturbed ground, 1.2 m below ancient drained thaw lakes, 0.7 m beneath recently drained lakes, and 0.2 beneath present lakes (Hussey and Michelson, 1966) based on data from borrow. Ice-rich zone in upland silt may extend below 8 m, with resulting greater thaw settlement potential in all categories.	Thaw-lake deposits subject to frost action include silty sand, silt, and other material having more than 6 percent fines passing No. 200 sieve.	Note: Assumption is made in this column that buildings are to be constructed and roads and airfields built with state-of-the-art arctic construction techniques—piles and air space for buildings, pads of gravel/insulation for roads and airfields, to prevent thaw of permafrost. Silty and sandy foundation materials contain less excess ice (2 to 19 percent) than adjacent areas undisturbed by thaw-lake activity (55 percent, at Barrow; Hussey and Michelson, 1966), excluding wedge ice. Poor source of granular borrow. In part seasonally flooded during snowmelt period.	Although used as sites for construction of large projects, such as Pump Station 1 of TAPS, thaw-lake basins have potential for differential settlement upon thaw of permafrost that may require refrigerated foundations.
Ql Landslide deposits	Range from clayey debris flows to partially slumped outcrops of clay, sandstone, and coal. Redeposited clay is major constituent, containing lesser amounts of coal and slabs of sandstone. Clay commonly bentonitic.	Slightly hummocky accumulations beneath river-cut scarps or partially slumped rock in face of riverbanks. Thickness unknown, but probably less than 5 m.	Hummocky terrain with relief of less than 3 m having gentle slope from river-cut cliff to stream. Local debris flows in bentonitic clay deposits. Drainage poor.	Permafrost conditions unknown; probably present in most landslide deposits to within 0.5 m of surface.	Clay and bentonitic-clay component susceptible to frost action.	Landslide areas should be avoided, unless detailed study shows that deposits have been stabilized. High clay content, locally with bentonite, and other fine-grained materials poor sources of construction materials.	Subject to ground movement if disturbed by construction activity.
Qal Alluvial deposits	Stratified to lenticular deposits of gravel, sand, and silt, generally becoming finer downstream to sand and silt in deltas. Gravel is subrounded to angular, depending on source in marine deposits, fluvial gravel, or in broken and weathered bedrock. Erratic boulders occasionally as lag from marine deposits (table 2, fig. 2). Also include slabs of local bedrock of types shown in fig. 1. Silt and organic beds common, especially as overbank deposits on flood-plain and terraces.	Include flood plain and low terraces that are less than 10 m above river. Locally less than 1 m thick on streams cutting bedrock, but several meters thick elsewhere and possibly greater than 5 m thick in deltas.	Form terraced plain, part of which is occupied by stream channel and bars, the rest by terraces. Old stream meander scrolls on lower terraces have been widened by thaw-lake processes and on higher terraces the meander scroll pattern has been nearly or completely obliterated. Terrace drainage generally poor. Subject to seasonal flooding to about 4 m above low water on larger streams such as Kuk River headwaters and Avak and Kugrua Rivers and to 3 m above sea level by storm surges at mouths of rivers.	Perennially frozen except for an unfrozen zone perhaps 2 to 6 m thick beneath deep pools in river bed and lakes deeper than 2 m. Active layer about 0.5 m thick away from channels. Ice content of permafrost in granular deposits not known, but probably lower than in fine-grained materials. Ice wedges well developed on terraces.	Granular alluvium having less than 6 percent silt generally not frost-susceptible; fine-grained material such as silty sand, silt, and organic soils of overbank deposits and silty gravel are frost-susceptible.	Gravel and fine- to coarse-sand bed materials provide good foundations, except where underlain by clay, but are subject to flooding. Granular borrow quantities very limited; local gravel from beneath stream beds may be as much as 6 m beneath pools in channel. Terrace deposits offer scant gravel, mostly sand, and are frozen at shallow depth; lower terraces subject to floods.	Subject to bank erosion, channel scour, and flooding during spring thaw and storm flood peaks. Icings (aufeis) not reported. Gravel contains large amounts of coal and chert.
Qe Eolian sand	Fine to medium sand containing abundant quartz and chert with minor dark minerals. Well sorted. Stratified to massive, locally cross bedded. Non-calcareous.	Although present as a discontinuous mantle on marine sand, mapped only locally where dune forms are evident, particularly along Kuk River. Thickness less than 5 m.	Generally isolated patches of dunes less than 5 m high. Drainage of ridges good; drainage poor in interdune depressions.	Permafrost underlies unit; active layer less than 1.5 m thick in summits and less than 0.5 m thick in interdune swales. Ice content of dunes unknown, but probably less than in marine sand and interstitial ice content, underlying material may be ice rich in local areas.	Generally not frost-susceptible except where silt content exceeds 6 percent and requisite moisture is present.	Adequate for natural foundations, but requires stabilization or addition of binder for use as surfacing material or fill. Relatively easy to work and excavate with ripper in well-drained ridges. Subject to deflation by wind wherever vegetation mat is broken.	Very sensitive to wind erosion when vegetation mat is disturbed.
Qus Upland silt	Silt, silty sand, and fine sand; locally scattered pebbles and granules. Stratification indistinct. Well-sorted and calcareous. Deposits are largely wind-blown silt or silt retransported by running water. Mantles fluvial and marine (?) sand and gravel.	Lies between 30 and 64 m above sea level in an east-west trending belt at southern boundary of quadrangle. Northern border of unit is gradational and indefinitely located. A few cm to more than 13 m thick. Covers fluvial sand and fine gravel and possible marine deposits in valleys, bedrock on interfluves.	Flat to gently rolling terrain broken by bedrock hills, stream valleys, thaw-lake basins and by ravines along major streams. Drainage generally poor.	Entirely underlain by permafrost with active layer 0.5 to 1 m thick. Contains ice wedges and very high volume of ice as small interstitial grains, masses, and lenses, in some areas approaching 80 percent of volume of the subsurface materials. In thick silt deposits the high excess ice content may extend to a depth of at least 10 m as shown by deep thaw-lake basins in upland silt unit.	Silt and silty sand are frost-susceptible.	Excess ice to at least 10 m results in extreme sensitivity to disturbance of thermal regime due to construction; least suitable of all map units for foundations. Material is generally too fine for most uses; possible source of binder material.	Easily gullied by running water on slopes if vegetation is disturbed or if sheet flow is concentrated by culverts in road or airfield fill. Concentrated flow may lead to thermal erosion in combination with the gullying. For example of terrain disturbance due to construction (see Lawson, 1982).
Qb Marine beach, bar, and spit deposits	Chiefly coarse to fine sand, granule and pebble gravel, gravelly sand, and, west of Kugrua Bay, medium to coarse gravel, in addition to finer material. Include local silts and organic layers and lenses with driftwood and rare erratics boulders (fig. 2, table 2) and, beneath some sea cliffs, slabs of broken bedrock. Gravel well rounded, locally polished chert, quartzite, quartz, and other rock types. Generally contain less than 6 percent silt. Contain marine shells.	Largely form modern offshore bars, beaches, spits and barrier islands within 3 m of sea level, but also include elevated beach deposits of higher stands of the sea which have been modified by thaw-lake activity and a cover of eolian sand. Probable thickness 2 to 7 m; deposits generally thin and narrow.	Form subparallel ridges in beaches, offshore bars and barrier islands. Drainage good on ridges but poor in swales between ridges. Areas below 3 m above sea level inundated during major storm surges and subject to ice push activity by pack ice along shore. Inland beach ridges well drained and not subject to flooding.	Modern beaches, barrier islands, bars, and spits have active layer as much as 2 m thick, but inland elevated beach deposits perennially frozen to within 1 to 1.5 m of surface. Many modern beach deposits have thin ice wedges along contraction cracks formed by winter freezing; elevated beaches probably have larger wedges, though total ice content is probably less than in sandy and silty deposits of other map units.	Granular materials not subject to frost action.	Granular materials suitable for fill and surfacing, but requires binder or stabilization for use as surfacing. High coal and chert content may be deleterious for use as concrete aggregate. Subject to storm surge flooding and ice shove where below 3 m above sea level.	Materials of limited volume at inland elevated beach ridges. Beaches adjacent to sea cliffs may be thin and lie on ice-rich, fine-grained deposits. Excavation of modern beaches, barrier islands, bars and spits requires evaluation of impact of effect of borrow on coastal erosional and depositional processes.
Qs Marine sand	Fine to medium sand and silty sand containing scattered pebbles and granules of chert; also contains silty clayey sand, and minor beds and lenses of organic material, especially where covered by thin eolian sand or where local fluvial deposits mapped as part of unit. Commonly covered by thin discontinuous layer of lag pebbles and granules and mantle of eolian sand that is rarely thicker than 1 m.	Forms the relatively flat seaward part of the coastal plain formerly occupied by shallow seas; deposits normally less than 10 m thick, but 15 m in Peard Test Well No. 1 and 21 m in Tunalik Test Well No. 1. Upper part of deposit reworked extensively by thaw-lake process and mantled with eolian sand.	Residual surfaces undisturbed by thaw-lake activity stand as much as 5 m above thaw-lake basins; drainage of these surfaces generally good and not subject to flooding; away from thaw-lake basins drainage is poor through beaded and meandering creeks.	Contains ice wedges and high volume of interstitial ice. Excluding wedge ice, ice content of upper 6 to 8 m of unit in excess of voids is 0 at 6 to 8 m, but 75 percent at 1 m, producing estimated thaw settlement of 55 percent, or 3.4 m if upper 6-8 m of permafrost is thawed (Hussey and Michelson, 1966; Sellmann and others, 1975; for Barrow area). Active layer generally less than 0.5 m.	Sand, generally having silt content greater than 6 percent, is frost-susceptible.	Generally contains excess ice in uppermost 6 to 8 m that causes large differential settlement on thawing (3.4 m near Barrow). Sandy materials may be suitable for fill, base course, and surfacing with proper stabilization and measures to prevent deflation by wind.	Easily eroded by running water and by wind once vegetation is removed.
Kn Bedrock	Hard to friable sandstone, shale, clay, bentonitic clay, silty shale, and coal of Nanushuk Group exposed on ridges and along riverbanks. Special symbol denotes rock exposed in vertical sections along rivers, lakes, and the ocean. Location of outcrops and lithology shown in fig. 1.	Distributed throughout map area beneath cover of unconsolidated deposits; exposed in isolated hills, in river and lake banks, and in coastal bluffs. Thickness of Nanushuk Group, the uppermost rock unit is 728 m in Peard Test Well No. 1 and 1,875 m in Tunalik Test Well No. 1.	Bedrock surface of low relief generally below sea level seaward of prominent escarpment along shore, and above sea level inland. Relief increases southward to 70 to 50 m at southern boundary of quadrangle.	Permafrost extends through unconsolidated deposits into bedrock throughout area of the quadrangle. Base of permafrost in bedrock estimated at 200 to 300 m (Osterkamp and Payne, 1981). Ice content not known.	Sandstone subject to shattering by frost action along joints and bedding planes; silty shale, shale, coal, bentonitic clay, and clay subject to frost heaving.	Quarry sites limited to river banks, and locally to ocean cliffs and lake banks, beneath frozen overburden. Best of rock is sandstone (fig. 1) which is slabby and jointed so that large pieces for riprap are difficult to obtain, wearing properties of sandstone are marginal at best for use as riprap. Other rocks generally too weak for riprap and other uses, but may be suitable for fill. Coal is subbituminous rank and can be used as fuel.	Bentonitic clay expands when wet.

Table 1

Description of fossil collection sites and check list of marine fossils collected in 1977-1978.

Description of collection sites

M-7165: South bank Kugrua estuary near base of prominent shoreline. Shells collected from pea gravel containing driftwood about 2 m below ground surface and 1.3 m above top of underlying brown to black (Cretaceous?) clay which is 2.6 m above river level.

M-7308: Collected from open-work marine beach gravel 23 to 27 m above sea level (according to topographic map contours).

Check list of marine fossils

	M-7165	M-7308
GASTROPODA		
Natica (Tectonatica) janthostoma Deshayes		x
Neptunea (Neptunea) heros heros (Gray)		x
Neptunea (Neptunea) lyrata leffingwelli (Dall)		x
PELECYPODA		
Clinocardium sp.		x
Cyclocardia crebricostata (Krause)		x
Macoma balthica (Linnaeus)	x	
Mya (Arenomya) arenaria Linnaeus	x	

Identification by L. N. Marincovich, Jr., U.S. Geological Survey, Menlo Park, California.

Table 2
Description of erratic boulders

Map location number (fig. 2)	Description	Source of information
1	Boulders of red quartzite, foliated amphibolite, brown quartzite to 0.3 m in diameter eroding out of bank.	Hopkins, D. M., unpublished field notes, 1976
2	Large rounded boulder of chert conglomerate.	Author
3	Pink granite boulder 1 m in diameter near beach.	Brigham, J. K., unpublished field notes, 1981
4	Conglomerate boulder 30 cm across in lake; ferruginous sandstone slab 50 cm across and 3 cm thick on tundra.	Hopkins, D. M., unpublished field notes, 1981
5	Two cobbles of granite, one each of norite and conglomerate at top Pingoraruk Hill.	Hopkins, D. M., unpublished field notes, 1976
6	Rectilinear norite boulder, 70 cm across, Ongorakvik Creek	Hopkins, D. M., unpublished field notes, 1976
7	Boulders of hornfels and quartzite to 5 cm about 10 m above Kaolak River.	Hopkins, D. M., unpublished field notes, 1976
8	Rounded, rotten granitic erratic containing feldspar crystals; boulder 20-25 cm in diameter.	Hopkins, D. M., unpublished field notes, 1976
9	Red and gray granite, 8.5 m above stream.	Hopkins, D. M., unpublished field notes, 1976

Note: Smith and Mertie (1930, p. 242) reported large angular blocks of red granite and pink quartz as much as 1.8 m in diameter and many smaller ones to 0.2 m in diameter at many points along Wainwright Inlet all the way to the head of the Kuk River. Most were found along the beach, but a few were found as high as 10 m above sea level. They noted the similarity of these boulders to those reported from the Canning River region of the Beaufort Sea coast by Leffingwell, and concluded that these boulders had been ice-rafted from some remote source. Similar erratics were also found along the shores of Peard Bay, and southward along the coast to Point Lay.

Table 3
Radiocarbon dates

Map letter identification	Laboratory number	Age	Collector or reference to publication	Significance of date
A	I-10,368	9,180 ± 150	Hopkins and Robinson,	Dates basal sediments of an older thaw lake; ice wedges 1979, p. B4470-250 cm wide formed since lake drained.
B	I-10,272	40,000	Williams, coll. 1977	Dates driftwood in beach gravel 2.4 to 5.5 m above Kugrua River estuary.
C	I-11,373	10,200 ± 200	Williams, coll. 1977	Peat and twigs in overbank terrace deposits on terrace gravel, about 5 m above Avak River.
D	USGS-500	1,170 ± 45	Hopkins and Robinson, 1979, p. B44	Dates 3-m storm surge affecting valleys draining into Wainwright Inlet (Hopkins and others, 1979).
E	USGS-499	1,730 ± 40	Hopkins and Robinson, 1979, p. B44	Dates alluviation to form lowest terrace of Kaolak River.
F	I-11,125	8,295 ± 135	Williams, coll. 1978	Dates sediments deformed by ice wedge and provides maximum age for formation of ice wedge.
G	USGS-506	490 ± 50	Hopkins and Robinson, 1979, p. B44	Dates detrital peat from ice-wedge pseudomorph at base of thaw-lake deposits; dates existence of the lake.
H	USGS-517	10,600 ± 180	Hopkins and Robinson, 1979, p. B44	Detrital peat in ice-wedge pseudomorph at base of thaw-lake sediments dates early Holocene warm period; contains willow stems at least 5 cm in diameter.
I	I-10,332	8,435 ± 160	Hopkins and Robinson, 1979, p. B45	Dates basal 10 cm of 1.5-m thick thaw-lake deposits within 50 m of edge of lake basin; ice wedges 35-125 cm wide formed since lake was drained.
J	I-10,330	8,275 ± 135	Hopkins and Robinson, 1979, p. B44	Dates 5 cm of basal peat in low-center ice-wedge polygons; provides minimum date for formation of wedge ice.
K	I-10,331	9,535 ± 160	Hopkins and Robinson, 1979, p. B45	Same section as sample J, but 25 cm lower in ice-wedge disturbed peaty silt; provides maximum age for ice-wedge formation.
L	I-10,328	9,125 ± 150	Hopkins and Robinson, 1979, p. B44	Dates basal peat in lower and older of two successive thaw lakes at this site; with date M dating base of younger thaw lake, shows that older thaw lake lasted less than 3,000 years.
M	I-10,329	6,234 ± 135	Hopkins and Robinson, 1979, p. B44	Dates basal 10 cm of 60-cm detrital peat deposited in younger of two successive thaw lakes at this site, the older thaw-lake deposits being dated by sample L. Ice wedges 20 to 70 cm wide formed since younger lake was drained.

Explanatory text accompanies map

ENGINEERING - GEOLOGIC MAPS OF NORTHERN ALASKA, WAINWRIGHT QUADRANGLE

By
John R. Williams

1983