U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Gates of the Arctic National Park and Preserve

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Gates of the Arctic National Park and Preserve

gsur_geology.pdf

Version: 9/6/2013

Geologic Resources Inventory Map Document for Gates of the Arctic National Park and Preserve

Table of Contents

Geologic Resources Inventory Map Document

Gates of the Arctic National Park and Preserve, Alaska

Document to Accompany Digital Geologic-GIS Data

gsur_geology.pdf

Version: 9/6/2013

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Gates of the Arctic National Park and Preserve, Alaska (GSUR).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

For information about the status of GRI digital geologic-GIS data for a park contact:

Tim Connors
Geologist/GRI Mapping Contact
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2093
fax: (303) 987-6792
email: Tim_Connors@nps.gov

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
1201 Oak Ridge Drive, Suite 200
Fort Collins, CO 80525
phone: (970) 491-6655
fax: (970) 225-3597
e-mail: stephanie.omeara@colostate.edu

About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park (s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: http://www.nature.nps.gov/geology/inventory, or contact:

Bruce Heise
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2017
fax: (303) 987-6792
email: Bruce_Heise@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS map for Gates of the Arctic National Park and Preserve, Alaska (GSUR):

Digital Surficial Geology Map of Gates of the Arctic National Park and Preserve and Vicinity, Alaska (*GRI MapCode GSUR*)

Hamilton, T.D. and Labay, K.A., 2012, Surficial Geologic Map of the Gates of the Arctic National Park and Preserve, Alaska, U.S. Geological Survey, Scientific Investigations Map SIM-3125, 1:300,000 scale. (SIM-3125). (*GRI Source Map ID 2283*).

*** U.S. Geological Survey GIS data were converted to GRI data model and all geologic features were checked against the U.S. Geological Survey published PDF of the map for attribute accuracy and symbol rotation. Map symbology was digitized from the U.S. Geological Survey PDF of the map.*

Additional information pertaining to each source map is also presented in the GRI Source Map Information (GSURMAP) table included with the GRI geology-GIS data.

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Gates of the Arctic National Park and Preserve, Alaska (GSUR) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., g - Glaciers). Units are generally listed from youngest to oldest. Information about each geologic unit is also presented in the GRI Geologic Unit Information (GSURUNIT) table included with the GRI geology-GIS data.

Cenozoic Era

Quaternary Period

g - Glaciers
Qav - Avalanche tracks and deposits
Qpr - Protalus rampart deposits
Qnd - Drift of neoglacial age
Qnd2 - Drift of late neoglacial age
Qnd1 - Drift of early neoglacial age
Qno - Outwash of neoglacial age
Qds - Dune sand
Qb - Beach deposits
Qsi - Organic silt deposits
Qdg - Debris glaciers
Qrg - Rock-glacier deposits, undifferentiated
Qrga - Rock-glacier deposits, active
Qrgi - Rock-glacier deposits, inactive
Qfl - Flow deposits
Qls - Landslide deposits
Ql - Lacustrine deposits
Qaf - Steep alpine fan deposits
Qafi - Steep alpine fan deposits, inactive
Qf - Fan deposits
Qfi - Fan deposits, inactive
Qfs - Silt fans
Qfsa - Sand fans
Qfda - Fan-delta deposits, active
Qfdi - Fan-delta deposits, inactive
Qfd - Fan-delta deposits
Qtr - Talus rubble
Qtra - Talus rubble, active
Qtri - Talus rubble, inactive
Qal - Alluvium, undivided
Qal/Qsa - Alluvium, undivided over sand deposits
Qal2 - Modern alluvium
Qal1 - Low alluvial-terrace deposits
Qalsa - Alluvium, sand facies
Qs - Solifluction deposits
Qs/Qsd - Solifluction deposits over drift of Sagavanirktok River age
Qdt - Deltaic deposits
Qdti - Deltaic deposits, inactive
Qm - Muskeg deposits
Qus - Upland silt deposits

Qrs - Retransported silt deposits
Qc - Colluvium, undivided
Qtd2 - Terrace deposit, low-level
Qim - Meltwater deposits of late Itkillik II age
Qsa - Sand deposits
Qigl - Glacial-lake deposits of Itkillik age
Qigl3 - Glacial-lake deposits of late Itkillik II readvance
Qigl2 - Glacial-lake deposits of Itkillik II age
Qigl1 - Glacial-lake deposits of Itkillik I age
Qidt - Deltaic deposits of Itkillik age
Qid - Drift of Itkillik age, undifferentiated
Qik - Kame and kame-terrace deposits
Qid3 - Drift of late Itkillik II readvance
Qik3 - Kame and kame-terrace deposits, late Itkillik II readvance
Qid2 - Drift of Itkillik II age
Qik2 - Kame and kame-terrace deposits, Itkillik II age
Qid1 - Drift of Itkillik I age
Qik1 - Kame and kame-terrace deposits, Itkillik I age
Qid1B - Drift of Itkillik I age, differentiated (Itkillik Phase IB)
Qid1A - Drift of Itkillik I age, differentiated (Itkillik Phase IA)
Qio - Outwash of Itkillik age
Qio3 - Outwash of late Itkillik II readvance
Qio2 - Outwash of Itkillik II age
Qio2B - Outwash of Itkillik II age, differentiated (Itkillik Phase IIB)
Qio2A - Outwash of Itkillik II age, differentiated (Itkillik Phase IIA)
Qio1 - Outwash of Itkillik I age
Qio1B - Outwash of Itkillik I age, differentiated (Itkillik Phase IB)
Qio1A - Outwash of Itkillik I age, differentiated (Itkillik Phase IA)
Qii/Qid - Inwash of Itkillik age over drift of Itkillik age, undifferentiated
Qii3 - Inwash of late Itkillik II readvance
Qii2 - Inwash of Itkillik II age
Qii1 - Inwash of Itkillik I age
QTpg - Piedmont gravel
Qtd1 - Terrace deposit, high-level
QTtg - Terrace gravel, undivided
Qtg3 - Pleistocene terrace gravels, younger
Qtg2 - Pleistocene terrace gravels, older
QTtg1 - Pleistocene terrace gravels, oldest
Qsgl - Glacial-lake deposits of Sagavanirktok River age
Qsdt - Deltaic deposits of Sagavanirktok River age
Qsd - Drift of Sagavanirktok River age
Qsd2 - Younger drift of Sagavanirktok River age
Qsd1 - Older drift of Sagavanirktok River age
Qso - Outwash of Sagavanirktok River age
Qso2 - Younger outwash of Sagavanirktok River age
Qso1 - Older outwash of Sagavanirktok River age
QTgr - Gravel, undifferentiated
Qgrfn - Fine gravel
Qad - Drift of Anaktuvuk River age
Qao - Outwash of Anaktuvuk River age

Tertiary Period

Ttg - Tertiary terrace gravels
Tgmd - Drift of Gunsight Mountain age

Age Unspecified

B - Bedrock, undifferentiated
Bg - Bedrock, glacier-scoured
Bs - Bedrock, silt-covered
Bp - Bedrock, pediment-like erosion surface near north flank of Brooks Range
Bu - Bedrock, upland erosion surface near head of Alatna Valley

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. Units referenced within the unit description retain their source unit symbol, and thus do not have a "Q" or "T" at the beginning of the unit symbol. In the GIS data, units shown in parentheses, such as (Qs), indicate thin and generally discontinuous distribution of a unit. Compound map units shown with slashes, such as Qal/Qsa, indicate deposits of the first unit above known or inferred subsurface deposits of the second unit. Units queried where uncertain, such as Qnd?, are indicated with a question mark.

g - Glaciers (Holocene)

No unit description available.

Qav - Avalanche tracks and deposits (late Holocene)

Angular unsorted unstratified loose rock rubble, commonly with intermixed woody plant debris. Forms tongues and fans along lower walls of mountain valleys. Associated with tracks and chutes where soil and vegetation are generally absent and that commonly are bordered by zones of battered trees or shrubs from which bark and branches have been partly stripped (Luckman, 1978). Recognized only in deep mountain valleys in southwestern part of map area (Survey Pass, Ambler River, and Hughes quadrangles). (SIM-3125). (*GRI Source Map ID 2283*).

Qpr - Protalus rampart deposits (late Holocene)

Unsorted, unstratified, coarse angular rock debris forming arcuate low ridges. Associated with persistent snowbanks in shaded sites, most commonly at bases of cirque headwalls. Subject to rockfalls during spring thaw. (SIM-3125). (*GRI Source Map ID 2283*).

Qnd - Drift of neoglacial age (late Holocene)

Unsorted unstratified coarse to fine angular rubble; forms lobes and arcuate ridges with moderate to steep frontal slopes. Clasts unweathered to slightly weathered; generally unvegetated except by lichens. Generaly restricted to cirques at higher altitudes, commonly near valley heads. Designates drift remnants of uncertain neoglacial age or composite drift bodies too small for subdivision. (SIM-3125). (*GRI Source Map ID 2283*).

Qnd2 - Drift of late neoglacial age (late Holocene)

Angular rubble, as described in unit nd; forms lobes and arcuate ridges of ice-cored drift with steep, unstable frontal slopes. Unvegetated, unweathered to slightly weathered, and with lichens sparse to absent. Restricted to cirques, and generally associated with active glaciers. (SIM-3125). (*GRI Source Map ID 2283*).

Qnd1 - Drift of early neoglacial age (late Holocene)

Angular rubble, as described in unit nd. Forms more subdued lobes and ridges with stable frontal slopes; generally eroded by axial streams. Generally in cirques, but locally may extend into upper valleys. Weathered and lichen encrusted, with partial sod cover in some localities. Ice cores generally absent. (SIM-3125). (*GRI Source Map ID 2283*).

Qno - Outwash of neoglacial age (late Holocene)

Moderately well sorted and stratified sandy coarse gravel forming modern floodplains and low (1–3 m) vegetated terraces that extend downvalley from modern glaciers and from end moraines of neoglacial age. Forms mappable unit only in some higher valley heads of Killik River and Survey Pass quadrangles; too small to be designated separately elsewhere. (SIM-3125). (*GRI Source Map ID 2283*).

Qds - Dune sand (Holocene)

Moderately well sorted medium to fine sand commonly containing shale chips and with thin interbeds of sandy peat; grass rootlets may be abundant. Forms extensive parabolic and longitudinal dunes along Killik River near north flank of Brooks Range. Also present in Survey Pass quadrangle, where it forms series of subparallel ridges as much as 6.5 m high on Alatna River floodplain south of Takahula Lake. (SIM-3125). (*GRI Source Map ID 2283*).

Qb - Beach deposits (Holocene)

Moderately well sorted, coarse to medium sand containing schist chips, interbedded with platy fine gravel; ranges to poorly sorted, gravely sand and sandy fine gravel where mixed by ice shove during spring breakup period. Mapped within Survey Pass quadrangle around Iniakuk Lake and at south end of Walker Lake, where series of raised beach ridges rise to heights of 12–16 m and 18–24 m, respectively. Also mapped around shores of lakes or former lakes in Bettles, Chandler Lake, Hughes, and Philip Smith Mountains quadrangles. (SIM-3125). (*GRI Source Map ID 2283*).

Qsi - Organic silt deposits (Holocene and late Pleistocene)

Weakly stratified sandy silt, organic silt, and silty peat, containing abundant ice in form of lenses, wedges, and interstitial grains. Formed largely of loess, with admixed organic and solifluction deposits. Fills thaw basins, valleys of underfit streams, and other poorly drained depressions beyond limits of Anaktuvuk River drift north of Brooks Range in Killik River and Chandler Lake quadrangles. Forms smaller and more localized deposits on younger surfaces farther south, but generally is absent from deposits of Itkillik or younger age. High ice content may be largely due to Holocene ice-wedge growth. (SIM-3125). (*GRI Source Map ID 2283*).

Qdg - Debris glaciers (Holocene and late Pleistocene)

Tabular rock rubble in abundant ice-rich matrix of generally micaceous sand and silt with wood fragments, humic soil material, and other organic detritus commonly present (Daanen, 2009). Commonly highly elongate, extending down valley walls below forest limits. Subject to slow and perhaps intermittent

downslope motion. Common in southern valleys of central Brooks Range, where they are most numerous on phyllite, siltstone, shale and schist bedrock. Also present on limestone with siltstone or phyllite interbeds. (SIM-3125). (*GRI Source Map ID 2283*).

Qrg - Rock-glacier deposits, undifferentiated (Holocene and late Pleistocene)

Very poorly sorted, unstratified, coarse angular rock debris with matrix of silt and fine rubble; Active and inactive components (described separately below) either undetermined or too small to be mapped separately. Fed by talus cones and aprons, which commonly are too small to show on map. Form lobate deposits along bases of valley walls and tongue-shaped deposits within cirques. (SIM-3125). (*GRI Source Map ID 2283*).

Qrga - Rock-glacier deposits, active (late Holocene)

Coarse angular rock debris, as described in unit rg, but containing abundant interstitial ice. Upper surfaces generally unvegetated, unweathered to moderately weathered; with lichen cover sparse. Frontal slopes barren, steep (35°–38°), and highly unstable; they meet upper surfaces at abrupt angle. Tongue-shaped deposits commonly overlie stagnant glacier ice. Subject to slow downslope motion. (SIM-3125). (*GRI Source Map ID 2283*).

Qrgi - Rock-glacier deposits, inactive (Holocene and late Pleistocene)

Coarse angular rock debris, as described for unit rg, but generally lacking interstitial ice or underlying stagnant glacier ice. Upper surfaces and frontal slopes weathered, covered by lichens, and commonly partly covered by sod and vegetation. Frontal slopes grade into upper surfaces without abrupt angles. (SIM-3125). (*GRI Source Map ID 2283*).

Qfl - Flow deposits (Holocene and late Pleistocene)

Very poorly sorted rock debris in abundant muddy matrix. Typically develop below arcuate detachment scars resulting from thaw of ice-rich permafrost. Collapse of those headwalls results in continual input of debris and meltwater into flow mass. Forms distinctive steep-fronted lobes that are subject to slow and continuous movement, especially during summer thaw season. These features have been variously termed tundra earthflows, retrogressive flow-slides, bimodal slope failures, or active-layer detachment slides (Brown and Kreig, 1983; Burn and Lewkowicz, 1990; French, 2007, p. 232–233). Common in Killik River quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qls - Landslide deposits (Holocene and late Pleistocene)

Unsorted, nonstratified, coarse to fine angular rubble forming tongues and lobes associated with detachment scars and slide tracks on high, steep walls of mountain valleys. Subject to episodes of rapid downslope motion and long periods of relative stability. Most common in upper mountain valleys that supported active glaciers during late Itkillik II time. Although some recent landslides have been reported (for example, Yeend, 1972), most landslide activity probably took place on oversteepened slopes soon after deglaciation.

Subunit (ls) designates incipient landslides marked by fractures and sagging rock masses on mountain slopes. Recognized only in Ambler River and Survey Pass quadrangles. (SIM-3125). (*GRI Source Map ID 2283*).

Ql - Lacustrine deposits (Holocene and late Pleistocene)

Well stratified clay, silt, and silty fine sand, grading into sand and gravelly sand near former shorelines and sandy fine gravel near former stream mouths. Include beach deposits too small to be designated separately. (SIM-3125). (*GRI Source Map ID 2283*).

Qaf - Steep alpine fan deposits (Holocene and late Pleistocene)

Coarse, very poorly sorted, nonstratified to weakly stratified, subangular to subrounded silty sandy gravel at mouths of avalanche chutes and steep canyons. Common in upper mountain valleys. Upper segments generally channeled, with levees of angular to subangular coarse debris. Subject to snow avalanches during winter, slushflows during spring snowmelt, and debris flows during summer. Surface gradients generally 12°–25°, intermediate between those of alluvial fans and talus cones. (SIM-3125). (*GRI Source Map ID 2283*).

Qafi - Steep alpine fan deposits, inactive (late Pleistocene)

As described in unit af. Generally weathered and covered with sod and vegetation. Commonly are periglacial relics that formed beyond limits of ice advances of last major (Itkillik II) glaciation under climate more rigorous than that of present day. (SIM-3125). (*GRI Source Map ID 2283*).

Qf - Fan deposits (Holocene and late Pleistocene)

Range from poorly sorted, weakly stratified, subangular, silty, sandy coarse gravel at mouths of steep canyons to moderately sorted and stratified subrounded sandy gravel at mouths of large tributary valleys with relatively gentle gradients. Locally subject to icings (aufeis) during winter. (SIM-3125). (*GRI Source Map ID 2283*).

Qfi - Fan deposits, inactive (Holocene and late Pleistocene)

As described in unit f. Generally weathered and covered by 0.3–0.5 m organic silt to stony silt beneath sod and vegetation. Differentiated only on large compound fans. (SIM-3125). (*GRI Source Map ID 2283*).

Qfs - Silt fans (Holocene and late Pleistocene)

Unusually fine-grained fan deposits consisting of poorly sorted silt and sandy silt. Present only in valley of Kugukpak Creek (Killik River quadrangle), where associated with widespread solifluction deposits and outcrops of Hunt Fork Shale (as mapped by Brosgé and others, 1979). (SIM-3125). (*GRI Source Map ID 2283*).

Qfsa - Sand fans (Holocene and late Pleistocene)

Fan deposits in which sand dominates. Mapped only near northeast corner of Shungnak quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qfda - Fan-delta deposits, active (late Holocene)

Alluvial fan and delta deposits, as described in unit fd. Mapped only along west side of Galbraith Lake (Philip Smith Mountains quadrangle). (SIM-3125). (*GRI Source Map ID 2283*).

Qdti - Deltaic deposits, inactive (Holocene)

Composition uncertain. Mapped upstream from active delta at north end of Lake Minakokosa in Hughes quadrangle. May be compound deposit related to multiple lake stages. (SIM-3125). (*GRI Source Map ID 2283*).

Qfd - Fan-delta deposits (late Pleistocene)

Compound units that consist of alluvial-fan facies, as described in unit f, near valley walls that grade distally into well sorted and generally well stratified sand, silt, and fine gravel of deltaic and lacustrine facies. Commonly associated with present-day or former lakes dammed behind end moraines at or near mouths of mountain valleys. (SIM-3125). (*GRI Source Map ID 2283*).

Qtr - Talus rubble (Holocene and late Pleistocene)

Angular, unsorted, unstratified rock debris, forming cones and aprons more than 2 m thick and generally sloping 30°–33° along lower flanks of mountain valleys and on lower parts of cirque headwalls. Also forms thinner and generally discontinuous sheets over many uplands mapped as bedrock. Active and inactive components (described separately below) either undetermined or too small to be mapped separately.

Active talus rubble (designated by symbol only; see Symbols) is generally unvegetated, unweathered to slightly weathered, with lichen cover sparse to absent. Subject to rockfalls from slopes above, especially during spring thaw Note: Active talus rubble and associated active rock glaciers in cirques of Arrigetch Peaks (Survey Pass quadrangle) are too numerous to label separately and are shown by a special symbol (see Symbols). (SIM-3125). (*GRI Source Map ID 2283*).

Qtra - Talus rubble, active (Holocene)

See Qtr unit description above. (SIM-3125). (*GRI Source Map ID 2283*).

Qtri - Talus rubble, inactive (Holocene and late Pleistocene)

Angular rock debris, as described in unit tra. Generally weathered and lichen covered, and with partial sod cover at some localities. Thin (less than 1–2 m) blankets of stabilized talus occur on many uplands beyond limits of Itkillik glaciation. (SIM-3125). (*GRI Source Map ID 2283*).

Qal - Alluvium, undivided (Holocene and late Pleistocene)

Moderately sorted to well-sorted, fine to medium sand, parallel bedded to slightly crossbedded, commonly with thin interbeds of sandy peat or organic silty fine sand. Deposited by slow-flowing streams within basins partly dammed by end moraines near mouths of mountain valleys. Upper 1–2 m locally reworked by wind into sand sheets and dunes. Commonly grades downward into lacustrine deposits. Readily dissected by streams, leaving low (3–5 m) paired terraces. (SIM-3125). (*GRI Source Map ID 2283*).

Qal/Qsa - Alluvium, undivided over sand deposits (Holocene and late Pleistocene)

Varies from poorly sorted, moderately well stratified, subangular coarse gravel near heads of mountain valleys to moderately well sorted gravelly sand and sandy fine gravel along slow-flowing stretches of major streams. May contain local beds and lenses of sand and sandy silt. Muddy fine gravel and gravelly mud locally present in some streams south of Brooks Range. Along smaller streams, unit includes fan, floodplain, and low terrace deposits that are too small to be designated separately.(SIM-3125). (*GRI Source Map ID 2283*).

Qal2 - Modern alluvium (late Holocene)

Gravel to gravelly mud, as described in unit al. Generally unvegetated and subject to annual flooding. Commonly subject to aufeis formation (Yoshikawa and others, 2007). Differentiated only along principal streams within major valleys. (SIM-3125). (*GRI Source Map ID 2283*).

Qal1 - Low alluvial-terrace deposits (Holocene)

Gravel to gravelly mud, as described in unit al. Mantled with 0.3–1 m of silt, sand, turf, and peat, and generally vegetated. Forms terraces generally within 3–4 m of modern stream levels. Differentiated only along principal streams. (SIM-3125). (*GRI Source Map ID 2283*).

Qalsa - Alluvium, sand facies (Holocene and late Pleistocene)

Moderately sorted to well-sorted, fine to medium sand, parallel bedded to slightly crossbedded, commonly with thin interbeds of sandy peat or organic silty fine sand. Deposited by slow-flowing streams within basins partly dammed by end moraines near mouths of mountain valleys. Upper 1–2 m locally reworked by wind into sand sheets and dunes. Commonly grades downward into lacustrine deposits. Readily dissected by streams, leaving low (3–5 m) paired terraces. (SIM-3125). (*GRI Source Map ID 2283*).

Qs - Solifluction deposits (Holocene and late Pleistocene; middle Pleistocene?)

Very poorly sorted, unstratified to weakly stratified, stony silt and organic silt; forms smoothly graded, gently to moderately sloping sheets and aprons more than 1–2 m thick. Platy to elongate stones generally oriented parallel to slope. Forms widespread thick deposits beyond limits of Anaktuvuk River drift. Successively thinner and more locally present on successively younger drift surfaces. Within Brooks Range, unusually thick and abundant deposits overlie shale-rich formations and phyllitic bedrock, and appear to be associated with some fault zones.
Subunit (s) designates thin (less than about 1.5 m) but widespread and generally continuous solifluction blankets above near-surface bedrock. (SIM-3125). (*GRI Source Map ID 2283*).

Qs/Qsd - Solifluction deposits over drift of Sagavanirktok River age (Holocene and late Pleistocene; middle Pleistocene?)

Qs - Solifluction deposits (Holocene and late Pleistocene; middle Pleistocene?)
Very poorly sorted, unstratified to weakly stratified, stony silt and organic silt; forms smoothly graded, gently to moderately sloping sheets and aprons more than 1–2 m thick. Platy to elongate stones generally oriented parallel to slope. Forms widespread thick deposits beyond limits of Anaktuvuk River drift. Successively thinner and more locally present on successively younger drift surfaces. Within Brooks Range, unusually thick and abundant deposits overlie shale-rich formations and phyllitic bedrock, and appear to be associated with some fault zones.

Subunit (s) designates thin (less than about 1.5 m) but widespread and generally continuous solifluction blankets above near-surface bedrock. (SIM-3125). (*GRI Source Map ID 2283*).

Qsd - Sagavanirktok River drift, undifferentiated (middle Pleistocene)
Poorly sorted nonstratified till ranging in composition from silty sandy boulder gravel to clayey stony silt, with local deposits of moderately well sorted ice-contact gravel; generally oxidized and strongly jointed. Erratic boulders sparse; they commonly protrude less than 0.15 m above ground surface. Forms distinct but subdued end moraines and ground moraine with most crests and flanks covered by continuous blanket of organic silt (loess and solifluction deposits).

In northern valleys, surface boulders are composed only of a highly indurated quartzite and conglomerate of Kanayut Conglomerate (Nilsen and Moore, 1984; Moore and others, 1989). Swales and kettles generally contain more than 5 m of ice-rich organic silt (colluvial and lacustrine deposits). Some ridge crests locally lack silt cover, exposing weathered subrounded gravel of resistant lithologies. Broadly dissected (to 2–3 km width) along major rivers, with depth of erosion 25–40 m.

At and beyond south flank of Brooks Range, forms broad morainal ridges and hummocky till plains; isolated drift remnants occur beyond Itkillik drift limits elsewhere within southern mountain valleys. Generally covered by thick (more than 3 m), nonstratified to weakly stratified blanket of silt, stony silt, and organic silt (loess, solifluction, and muskeg deposits). Crests of some ridges and knolls yield limited exposures of weathered gravel consisting of subrounded pebbles, cobbles, and small boulders of resistant lithologies.

Subunit (sd) designates thin (less than 3 to 5 m) and generally discontinuous drift deposits on bedrock beyond Itkillik ice limits. (SIM-3125). (*GRI Source Map ID 2283*).

Qdt - Deltaic deposits (Holocene and late Pleistocene)

Generally well stratified sand and sandy fine gravel deposited by streams at lake margins. Commonly build outward into lake, and overlie fine-grained lacustrine deposits. Large deltas currently are forming at north ends of Narvak Lake and Lake Minakokosa near north margin of Hughes quadrangle. Other deltas in map area are too small or too intermixed with other deposits to designate individually. (SIM-3125). (*GRI Source Map ID 2283*).

Qfdi - Fan-delta deposits, inactive (Holocene and late Pleistocene)

Alluvial fan and delta deposits, as described in unit fd. Form eroded remnants around unit fda along west side of Galbraith Lake (Philip Smith Mountains quadrangle) and in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qm - Muskeg deposits (Holocene and Pleistocene)

Laminated peat composed of sedges and mosses, with scattered leaves, twigs, and other plant fragments. Occurs beneath Sphagnum and black spruce in poorly drained depressions beyond Itkillik II drift limits at and beyond south flank of Brooks Range. Most extensive across basins formerly occupied by lakes of Pleistocene age. Grades laterally into retransported silt deposits near bases of solifluction slopes. Generally contains abundant ice as lenses, wedges, and interstitial grains. (SIM-3125). (*GRI Source Map ID 2283*).

Qus - Upland silt deposits (Holocene and Pleistocene)

Poorly to moderately sorted generally unstratified silt, organic silt, and slightly clayey, sandy or stony silt on uplands of low to moderate relief beyond oldest drift limits and above highest terrace levels both north and south of Brooks Range. Formed from loess mixed by frost action with local organic matter, rock rubble, and other weathering products. Generally bears tussock cover broken by frost boils at sites north of Brooks Range; bears continuous forest cover at sites south of range. Grades laterally into solifluction deposits on slopes steeper than about 1–2 degrees. (SIM-3125). (*GRI Source Map ID 2283*).

Qrs - Retransported silt deposits (Holocene and Pleistocene)

Thick (up to 15 m) deposits of nonstratified to weakly stratified silt and organic silt containing local lenses of stony to sandy silt. Typically ice-rich. Derived from eolian silt (loess) that was eroded by debris flows, solifluction, gulley-incision, and other slope processes, and then redeposited on lower slopes and valley floors. Most deposits presently are stable and vegetated, but some in northern part of map area are subject to present-day solifluction activity. Most common in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qc - Colluvium, undivided (Holocene and Pleistocene)

Mixed solifluction deposits (unit s) and talus-rubble deposits (unit tr) in sheets and aprons more than about 1–2 m thick. Most extensive on moderate to steep slopes above and beyond limits of ice advances of Itkillik age. Also common on upper slopes below exposed or near-surface bedrock. (SIM-3125). (*GRI Source Map ID 2283*).

Qtd2 - Terrace deposit, low-level (late Pleistocene)

Compound deposit with terrace-like upper surface. Consists of outwash gravel and silty flood-plain deposits of Itkillik II advance underlain by laminated clay and silt (lacustrine) and sandy fine gravel (deltaic) of Itkillik I age. Mapped only in Hughes quadrangle, where deposit stands 8 m above Reed River near its mouth. (SIM-3125). (*GRI Source Map ID 2283*).

Qim - Meltwater deposits of late Itkillik II age (late Pleistocene)

Extensive complexes of kames, kame terraces, and eskers consisting generally of sandy gravel that formed in contact with stagnating glacier ice of late Itkillik II age on floor of Anaktuvuk River valley south of range front and on adjoining valley floor of John River (Chandler Lake and Wiseman quadrangles). (SIM-3125). (*GRI Source Map ID 2283*).

Qsa - Sand deposits (late Pleistocene)

Moderately sorted silty fine sand to medium sand, horizontally bedded to slightly crossbedded, commonly with thin interbeds of sandy peat or organic silty fine sand. Deposited initially by slow-moving streams within sedimentary basins partly dammed by end moraines near north and south flanks of Brooks Range. Upper 1–10 m locally reworked by wind into sand sheets and dunes. Commonly grades downward into lacustrine deposits (see stippled map pattern). Generally dissected by postglacial streams, forming terraces 5–15 m high that border stream channels and modern floodplains of sandy alluvium (unit alsa).

Composite unit al/sa is distinguished in many glacial valleys of the southern Brooks Range (Survey Pass and Wiseman quadrangles), where fluvial reworking of sand into sandy alluvium is more widespread across narrow valley floors. (SIM-3125). (*GRI Source Map ID 2283*).

Qigl - Glacial-lake deposits of Itkillik age (late Pleistocene)

As described in unit dt. Associated with glacial lakes of Itkillik age in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qigl3 - Glacial-lake deposits of late Itkillik II readvance (late Pleistocene)

As described in units l and igl. Associated with moraine dams or drift deposited during late Itkilllik II time. (SIM-3125). (*GRI Source Map ID 2283*).

Qigl2 - Glacial-lake deposits of Itkillik II age (late Pleistocene)

As described in units l and igl. Associated with moraine dams or drift deposits of Itkillik II age. (SIM-3125). (*GRI Source Map ID 2283*).

Qigl1 - Glacial-lake deposits of Itkillik I age (late Pleistocene)

As described in units l and igl. Associated with moraine dams or drift deposited during Itkillik I time. Most common in lower mountain valleys of Wiseman quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qidt - Deltaic deposits of Itkillik age (late Pleistocene)

As described in unit dt. Associated with glacial lakes of Itkillik age in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qid - Drift of Itkillik age, undifferentiated (late Pleistocene)

Unsorted to poorly sorted generally nonstratified compact till, ranging in composition from muddy sandy boulder gravel to clayey stony silt, with local stratified ice-contact deposits consisting of moderately sorted sand and sandy gravel. Contains faceted and striated stones up to boulder size. Designates thick (greater than 3 m) drift deposits, usually within mountain valleys, that cannot be assigned to a specific Itkillik moraine system. (SIM-3125). (*GRI Source Map ID 2283*).

Qik - Kame and kame-terrace deposits (late Pleistocene)

Unusually extensive and thick (generally greater than 30 m) deposits of moderately well to well sorted sand, gravelly sand, and sandy gravel within undifferentiated drift of Itkillik age. Forms generally steep-sided knobs or knob complexes on drift sheets of Itkillik age and sharply defined terraces along their margins. (SIM-3125). (*GRI Source Map ID 2283*).

Qid3 - Drift of late Itkillik II readvance (late Pleistocene)

Till and stratified ice-contact deposits, as described in unit id. Forms sharp-crested end moraines, irregular ground moraine, and steep-sided ice-contact stratified drift deposits in many upper mountain valleys of southern Brooks Range. Forms usually subdued moraines of silty till (probable redeposited lacustrine sediments) near mouths of large mountain valleys along north flank of Brooks Range. Loess cover generally absent, and exposed stones very slightly weathered; oxide penetration to only 20–30 cm depth in most permeable deposits. (SIM-3125). (*GRI Source Map ID 2283*).

Qik3 - Kame and kame-terrace deposits, late Itkillik II readvance (late Pleistocene)

Unusually extensive and thick deposits of sand and sandy gravel, as described in unit ik, usually with less than 0.2 m cover of silt, organic silt, and sod. Formed within and marginal to drift of late Itkillik II readvance. (SIM-3125). (*GRI Source Map ID 2283*).

Qid2 - Drift of Itkillik II age (late Pleistocene)

Till and stratified ice-contact deposits, as described in unit id, with ice-contact deposits very abundant in most valleys. Forms prominent end moraines and associated glacial deposits north of Brooks Range in major valleys, along both range flanks in other valleys, and in upper Noatak River valley (Ambler River quadrangle). Drift lobes sharply defined, with narrow (generally 1–3 m) morainal ridges, prominent knob and kettle morphology, and conspicuously channeled outwash trains. Crests and upper slopes lack loess and solifluction cover, and exposed boulders and cobbles exhibit slight to moderate weathering; oxidation has penetrated 30–50 cm into better drained deposits. Most swales lack solifluction deposits, and abandoned meltwater channels commonly are floored with lichen-covered coarse gravel. Unstable kettles with actively caving gravel rims beyond north flank of Brooks Range indicate that residual glacier ice may persist locally. (SIM-3125). (*GRI Source Map ID 2283*).

Qik2 - Kame and kame-terrace deposits, Itkillik II age (late Pleistocene)

Thick and extensive gravel deposits, as described in unit ik, within and marginal to drift of Itkillik II age. (SIM-3125). (*GRI Source Map ID 2283*).

Qid1 - Drift of Itkillik I age (late Pleistocene)

Till and stratified ice-contact deposits, as described in unit id. In northern valleys, forms closely nested concentric end moraines with flanking slopes up to 20° and subdued knob and kettle topography; associated with outwash trains partly obscured by solifluction. Moraine crests generally 3–10 m wide and partly bare of loess; upper slopes are blanketed by 0.5 to 2 m of stony organic silt (loess and colluvium). Cobbles and boulders exposed at surface are moderately to heavily weathered; stones in soil profiles are etched, pitted, and oxidized to depth of about 1 m. Swales partly filled with 1–3 m of ice-rich organic silty solifluction deposits. Shallow earthflows common on steep slopes. *At and beyond south flank of Brooks Range*, forms broad, heavily forested piedmont lobes with large kettle lakes and extensive outwash terraces. Eroded arcuate end moraines and lateral embankments extend from glaciated main valleys of southern Brooks Range into lower courses of unglaciated tributaries.

Subunit id1A designates outer moraine belt in drift sheets where conspicuous inner moraines (designated id1B) represent local readvances of Itkillik I glaciers during interval of general ice wastage.

Subunit (id1) designates thin deposits of Itkillik I drift above bedrock. On hillslopes or lower valley walls, these deposits commonly are mixed with silt, rock rubble, and organic detritus, and hence become a compound (glacial-colluvial) unit. (SIM-3125). (*GRI Source Map ID 2283*).

Qik1 - Kame and kame-terrace deposits, Itkillik I age (late Pleistocene)

Unusually thick and extensive sand and gravel deposits, as described in unit ik, within and marginal to drift of Itkillik I age. Occurrence within outwash train associated with Itkillik I glacial advance west of Anaktuvuk River (Chandler Lake quadrangle) suggests persistence of residual glacier ice from Sagavanirktok River glaciation at time of Itkillik I glacial advance. (SIM-3125). (*GRI Source Map ID 2283*).

Qid1A and Qid1B - Drift of Itkillik I age, differentiated (Itkillik Phase IB) (late Pleistocene)

See Qid1 unit description above. (SIM-3125). (*GRI Source Map ID 2283*).

Qio - Outwash of Itkillik age (late Pleistocene)

Moderately well sorted and stratified sandy gravel forming aprons and valley trains in front of moraines of Itkillik age that extend into terrace remnants farther downvalley. Largest stones decrease in size from subrounded cobbles and very small boulders near moraine fronts to rounded to subrounded pebbles and granules farther downvalley. (SIM-3125). (*GRI Source Map ID 2283*).

Qio3 - Outwash of late Itkillik II readvance (late Pleistocene)

Sandy gravel, as described in unit io, generally without loess or peat cover and oxidized to only 20–30 cm depth. Forms valley trains beyond end moraines of late Itkillik II age. Terraces near moraine fronts commonly 12-15 m high; they generally are continuous downvalley and merge distally with outwash terraces of Itkillik II age. (SIM-3125). (*GRI Source Map ID 2283*).

Qio2 - Outwash of Itkillik II age (late Pleistocene)

Sandy gravel, as described in unit io, generally with thin (0.3 m or less) cover of silt and sod. Exposures in northern valleys show stones etched, fractured, and pitted to 30–40 cm below surface; oxidized to depths of 30–45 cm. Depths are slightly greater in southern valleys (30–50 cm and 40–50 cm, respectively). Forms extensive aprons and valley trains in front of Itkillik II moraines. Terraces near moraine fronts are up to 40 m high in major valleys; they generally are continuous downvalley, decreasing progressively in height to about 3–5 m.

Subunits io2A and io2B designate outwash trains associated with outer and inner moraines west of Kobuk River at south end of Walker Lake (Survey Pass quadrangle). Subunit io2B is lower than io2A, and is inset within it. (SIM-3125). (*GRI Source Map ID 2283*).

Qio2A and Qio2B - Outwash of Itkillik II age, differentiated (Itkillik Phase IIA) (late Pleistocene)

See Qio2 unit description above. (SIM-3125). (*GRI Source Map ID 2283*).

Qio1 - Outwash of Itkillik I age (late Pleistocene)

Sandy gravel, as described in unit io, generally with thin to moderate (0.3–3 m) loess and solifluction cover that contains frost-churned stones with vertical orientations. In northern valleys, upper 1–1.5 m oxidized, with silt illuviation and weathered stones. In valleys at and beyond south flank of Brooks Range, cover of silt and organic silt (loess and solifluction deposits) may be up to 4 m thick. Forms aprons and valley trains in front of Itkillik I moraines. Terraces are up to 40 m high near moraine fronts, and decrease in height progressively downvalley. Commonly incised within drift of Sagavanirktok River age and dissected in turn by Itkillik II outwash.

Subunits io1A and io1B designate outwash associated with outer and inner moraines of Itkillik I age (units id1A and id1B) at several localities beyond south flank of Brooks Range. (SIM-3125). (*GRI Source Map ID 2283*).

Qio1A and Qio1B - Outwash of Itkillik I age, differentiated (Itkillik Phase IA) (late Pleistocene)

See Qio1 unit description above. (SIM-3125). (*GRI Source Map ID 2283*).

Qii/Qid - Inwash of Itkillik age over drift of Itkillik age, undifferentiated (late Pleistocene)

Qii - Inwash of Itkillik age (late Pleistocene)
Well sorted to moderately sorted and stratified gravelly sand and sandy fine gravel, commonly grading upvalley into fan deposits and downvalley into lacustrine beds. Loess, sod, and silt cover generally thin (less than 0.2 m) to absent. Deposited near mouths of nonglaciated tributaries blocked by Itkillik-age glaciers in main valleys, forming benches and terraces that abut outer flanks of lateral moraines or outer faces of end moraines. (SIM-3125). (*GRI Source Map ID 2283*).

Qid - Drift of Itkillik age, undifferentiated (late Pleistocene)
Unsorted to poorly sorted generally nonstratified compact till, ranging in composition from muddy sandy boulder gravel to clayey stony silt, with local stratified ice-contact deposits consisting of moderately sorted sand and sandy gravel. Contains faceted and striated stones up to boulder size. Designates thick (greater than 3 m) drift deposits, usually within mountain valleys, that cannot be assigned to a specific Itkillik moraine system. (SIM-3125). (*GRI Source Map ID 2283*).

Qii3 - Inwash of late Itkillik II readvance (late Pleistocene)

As described in unit ii. Forms deposits that abut drift deposited during late Itkillik II time. (SIM-3125). (*GRI Source Map ID 2283*).

Qii2 - Inwash of Itkillik II age (late Pleistocene)

As described in unit ii. Forms deposits that abut drift of Itkillik II age. (SIM-3125). (*GRI Source Map ID 2283*).

Qii1 - Inwash of Itkillik I age (late Pleistocene)

As described in unit ii. Forms deposits that abut drift of Itkillik I age. (SIM-3125). (*GRI Source Map ID 2283*).

QTpg - Piedmont gravel (middle and early Pleistocene; late Tertiary)

Moderately well sorted, rounded to subrounded pebbles of schist and quartz in abundant matrix of medium to coarse sand containing schist chips, commonly interbedded with medium to coarse sand; generally oxidized yellowish-brown (10YR 4/6) to dark yellowish-brown (10 YR 3/4). Grades laterally into fan deposits consisting of platy pebbles, small cobbles, and some large cobbles of schist and quartz in coarse sand-granule matrix. Forms hummocky erosion remnants in trough between Brooks Range and foothills to the south in Survey Pass and Hughes quadrangles. Commonly overlain by erratic cobbles and boulders of Itkillik I age, but abuts moraines of this age in places and may in part be contemporaneous with them. (SIM-3125). (*GRI Source Map ID 2283*).

Qtd1 - Terrace deposit, high-level (middle Pleistocene)

Compound deposit with alluvial surface 53–60 m above modern river level. Consists of coarse and fine gravel, strongly oxidized gravel, some sand, silt, and clay; and generally thick (up to 24 m) till deposits of Sagavanirktok River age. Capped by silt up to 7 m thick. Mapped only along Kobuk River in Hughes and Shungnak quadrangles. (SIM-3125). (*GRI Source Map ID 2283*).

QTtg - Terrace gravel, undivided (middle and early Pleistocene; late Tertiary?)

Coarse gravel to sandy fine gravel, commonly consisting of rounded to subrounded pebbles and cobbles in sandy matrix. Forms alluvial terraces of uncertain age or origin. (SIM-3125). (*GRI Source Map ID 2283*).

Qtg3 - Pleistocene terrace gravels, younger (middle Pleistocene)

Oxidized gravel, as described in unit gr, forming terraces generally 12–15 m high that are inset with within higher alluvial surfaces. Forms lower terraces or valley floors along some smaller streams that originate north of Brooks Range. Bears thick (4–8 m) cap of ice-rich organic silt in some localities. Composed of undifferentiated nonglacial alluvium plus distal outwash of Sagavanirktok River age. Designated only in Killik River quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qtg2 - Pleistocene terrace gravels, older (early Pleistocene)

Oxidized gravel, as described in unit gr, along major drainages north of Brooks Range. Forms terraces 30–45 m above rivers in Killik River quadrangle; 45–65 m above rivers in Chandler Lake quadrangle. Commonly contains residual erratic boulders derived from former deposits of Gunsight Mountain drift. Bears thick (5–10 m) cap of ice-rich silt in most localities, and commonly overlies 10–20 m of bedrock exposed by downcutting. Composed of undifferentiated nonglacial alluvium plus distal outwash of Anaktuvuk River age in Killik River quadrangle; commonly caps erosion surfaces formed within drift sheets of Anaktuvuk River age in Chandler Lake quadrangle. Lies beyond outer moraines of

Sagavanirktok River Glaciation and above outwash terraces of Sagavanirktok River age. (SIM-3125). (*GRI Source Map ID 2283*).

QTtg1 - Pleistocene terrace gravels, oldest (early Pleistocene; latest Tertiary?)

Oxidized sandy gravel, as described in unit gr. Forms terraces 80 to 110 m above modern stream levels north of Brooks Range in Chandler Lake quadrangle. Generally caps erosion surfaces that formed within drift limits of Gunsight Mountain glacial interval but lie beyond outer moraines and outwash of Anaktuvuk River Glaciation. (SIM-3125). (*GRI Source Map ID 2283*).

Qsgl - Glacial-lake deposits of Sagavanirktok River age (middle Pleistocene)

As described in units l and igl, generally with silt and (or) muskeg cover up to several meters thick. Mapped only in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qsdt - Deltaic deposits of Sagavanirktok River age (middle Pleistocene)

As described in unit dt. Associated with glacial lakes of Sagavanirktok river age in Hughes quadrangle. (SIM-3125). (*GRI Source Map ID 2283*).

Qsd - Drift of Sagavanirktok River age (middle Pleistocene)

Poorly sorted nonstratified till ranging in composition from silty sandy boulder gravel to clayey stony silt, with local deposits of moderately well sorted ice-contact gravel; generally oxidized and strongly jointed. Erratic boulders sparse; they commonly protrude less than 0.15 m above ground surface. Forms distinct but subdued end moraines and ground moraine with most crests and flanks covered by continuous blanket of organic silt (loess and solifluction deposits).

In northern valleys, surface boulders are composed only of a highly indurated quartzite and conglomerate of Kanayut Conglomerate (Nilsen and Moore, 1984; Moore and others, 1989). Swales and kettles generally contain more than 5 m of ice-rich organic silt (colluvial and lacustrine deposits). Some ridge crests locally lack silt cover, exposing weathered subrounded gravel of resistant lithologies. Broadly dissected (to 2–3 km width) along major rivers, with depth of erosion 25–40 m.

At and beyond south flank of Brooks Range, forms broad morainal ridges and hummocky till plains; isolated drift remnants occur beyond Itkillik drift limits elsewhere within southern mountain valleys. Generally covered by thick (more than 3 m), nonstratified to weakly stratified blanket of silt, stony silt, and organic silt (loess, solifluction, and muskeg deposits). Crests of some ridges and knolls yield limited exposures of weathered gravel consisting of subrounded pebbles, cobbles, and small boulders of resistant lithologies.

Subunit (sd) designates thin (less than 3 to 5 m) and generally discontinuous drift deposits on bedrock beyond Itkillik ice limits. (SIM-3125). (*GRI Source Map ID 2283*).

Qsd2 - Younger drift of Sagavanirktok River age (middle Pleistocene)

Till and ice-contact gravel, as described in unit sd. Forms subdued end moraine and ground moraine with many ridge crests bare of loess and solifluction cover. Swales and kettles more abundant and less modified than on older deposits of Sagavanirktok River age. (SIM-3125). (*GRI Source Map ID 2283*).

Qsd1 - Older drift of Sagavanirktok River age (middle Pleistocene)

Poorly exposed glacial deposits of composition probably similar to unit sd, forming distinct but very subdued and dissected moraines beyond limits of sd2 drift. Ridge crests and flanks bear generally continuous cover of organic silt. (SIM-3125). (*GRI Source Map ID 2283*).

Qso - Outwash of Sagavanirktok River age (middle Pleistocene)

Moderately well sorted and stratified oxidized sandy gravel, with largest stones generally decreasing in size from cobbles and small boulders near moraine fronts to pebbles and cobbles further downvalley. Generally overlain by 1–4 m of organic silt (loess and solifluction deposits). Commonly associated with underfit or abandoned stream courses and dissected to depths as great as 30–40 m in some valleys. (SIM-3125). (*GRI Source Map ID 2283*).

Qso2 - Younger outwash of Sagavanirktok River age (middle Pleistocene)

Sandy gravel, as described for unit so, forming outwash trains originating at outer limits of younger moraines of Sagavanirktok River age or formed within outer moraines of that age. (SIM-3125). (*GRI Source Map ID 2283*).

Qso1 - Older outwash of Sagavanirktok River age (middle Pleistocene)

Sandy gravel, as described for unit so, forming outwash trains originating at or near outer limits of older moraines of Sagavanirktok River age. (SIM-3125). (*GRI Source Map ID 2283*).

QTgr - Gravel, undifferentiated (middle and early Pleistocene; late Tertiary?)

Gravel and sandy gravel of diverse origins and composition. Generally applied to isolated, gravelly erosion remnants of uncertain origin and composition. (SIM-3125). (*GRI Source Map ID 2283*).

Qgrfn - Fine gravel (middle and early Pleistocene)

Rounded pebbles and small cobbles in matrix of slightly oxidized sand that commonly has high quartz content. Forms terrace-like erosion remnants and broader alluvial surfaces about 18–23 m above modern drainage levels in lowlands south of Norutak Hills (Hughes quadrangle). Queried where gravel present but grain size uncertain. (SIM-3125). (*GRI Source Map ID 2283*).

Qad - Drift of Anaktuvuk River age (early Pleistocene)

Bouldery glacial deposits of uncertain composition overlain by continuous cover of organic silt (loess and solifluction deposits) generally more than 2–3 m thick. Erratic boulders very sparse (generally <1 per km2); they typically protrude less than 0.2 m above ground surface and consist of only most resistant (thick-bedded and nonferruginous) facies of Kanayut Conglomerate. Forms subdued till plains and low broad morainal ridges with gentle (1°–2°) flanking slopes except where steepened by postglacial erosion. Former swales and kettles generally filled with ice-rich, silty, organic colluvial and lacustrine deposits more than 5 m thick. Deeply and broadly dissected by minor as well as major steams, with depth of dissection 45–60 m along most major valleys and to width of 6 km and depth of 100 m in Killik River valley. In smaller valleys, widths and depths of dissection are typically about 1 km and 40–60 m, respectively. North of Brooks Range, occurs beyond drift limits of Sagavanirktok River age and forms oldest and northernmost continuous drift sheets. South of Brooks Range, forms patchy drift remnants south of Kobuk River valley. (SIM-3125). (*GRI Source Map ID 2283*).

Qao - Outwash of Anaktuvuk River age (early Pleistocene)

Oxidized gravel of uncertain composition forming terrace remnants 50–60 m high that originate at outer limits of drift lobes of Anaktuvuk River age. Generally overlain by 3–5 m of organic silt (frost-churned loess and solifluction deposits). Mapped north of range front in Killik River and Chandler Lake quadrangles. (SIM-3125). (*GRI Source Map ID 2283*).

Ttg - Tertiary terrace gravels (late Tertiary)

Strongly oxidized gravel of Tertiary age, containing rounded stones to large cobble size in sandy matrix, capped by ice-rich silt as thick as 10 m containing thaw basins. Forms erosion remnants, many terracelike in form, 60–150 m above modern stream levels. Streams in some cases have downcut through gravel and then through 30–50 m of underlying bedrock. Mapped only north of Brooks Range along north margin of map area. (SIM-3125). (*GRI Source Map ID 2283*).

Tgmd - Drift of Gunsight Mountain age (late Tertiary)

Highly eroded bouldery glacial deposits of unknown initial composition, lacking primary relief and overlain by continuous cover of organic silt generally more than 2–3 m thick. Mapped only north of Brooks Range beyond limits of Anaktuvuk River drift. In Killik River quadrangle, former distribution commonly is marked by northern limits of erratic boulders incorporated in terrace deposits of early Pleistocene (tg1) age. Recognized in Chandler Lake quadrangle near Nanushuk River and near Gunsight Mountain (north of map margin), where it is associated with abundant erratics of resistant Kanayut Conglomerate facies on postglacial erosion surfaces and with rock-cut channels and benches probably eroded by glacial meltwater streams. Deeply and broadly dissected, with depth of erosion 60–80 m along most valleys. Probably eroded to depth of about 100 m along Killik River and to about 300 m along range front east of Kurupa Lake (Killik River quadrangle). (SIM-3125). (*GRI Source Map ID 2283*).

B - Bedrock, undifferentiated

Generally unweathered within Brooks Range, where glacial erosion has created steep valley walls, sharp-crested ridges, and deep cirques. More weathered and subdued in appearance in northern and

southern foothills, where it generally is covered by thin sheets of windblown silt (loess) and frost-shattered rock rubble. Lithologies as described by Moore and others, 1994, and Till and others, 2008. (SIM-3125). (*GRI Source Map ID 2283*).

Bg - Bedrock, glacier-scoured

Bedrock smoothed and abraded by overriding glacier ice. Rock surfaces generally well exposed, streamlined in direction of glacier flow (shown by arrows), and channeled by meltwater. Erratic boulders and cobbles commonly dispersed across rock surfaces. (SIM-3125). (*GRI Source Map ID 2283*).

Bs - Bedrock, silt-covered

Bedrock with cover of airborne silt (loess), 0.5 m or more thick over all but the highest and steepest slopes. Common beyond limits of late Pleistocene glaciation in foothills north and south of Brooks Range. (SIM-3125). (*GRI Source Map ID 2283*).

Bp - Bedrock, pediment-like erosion surface near north flank of Brooks Range

No unit description available.

Bu - Bedrock, upland erosion surface near head of Alatna Valley

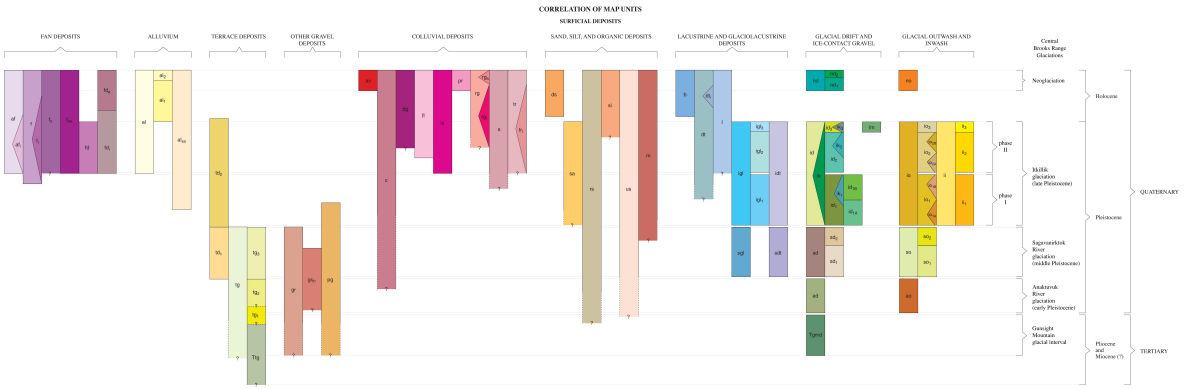
No unit description available.

Scientific Investigations Map SIM-3125

Hamilton, T.D. and Labay, K.A., 2012, Surficial Geologic Map of the Gates of the Arctic National Park and Preserve, Alaska, U.S. Geological Survey, Scientific Investigations Map SIM-3125, 1:300,000 scale. (SIM-3125). (GRI Source Map ID 2283).

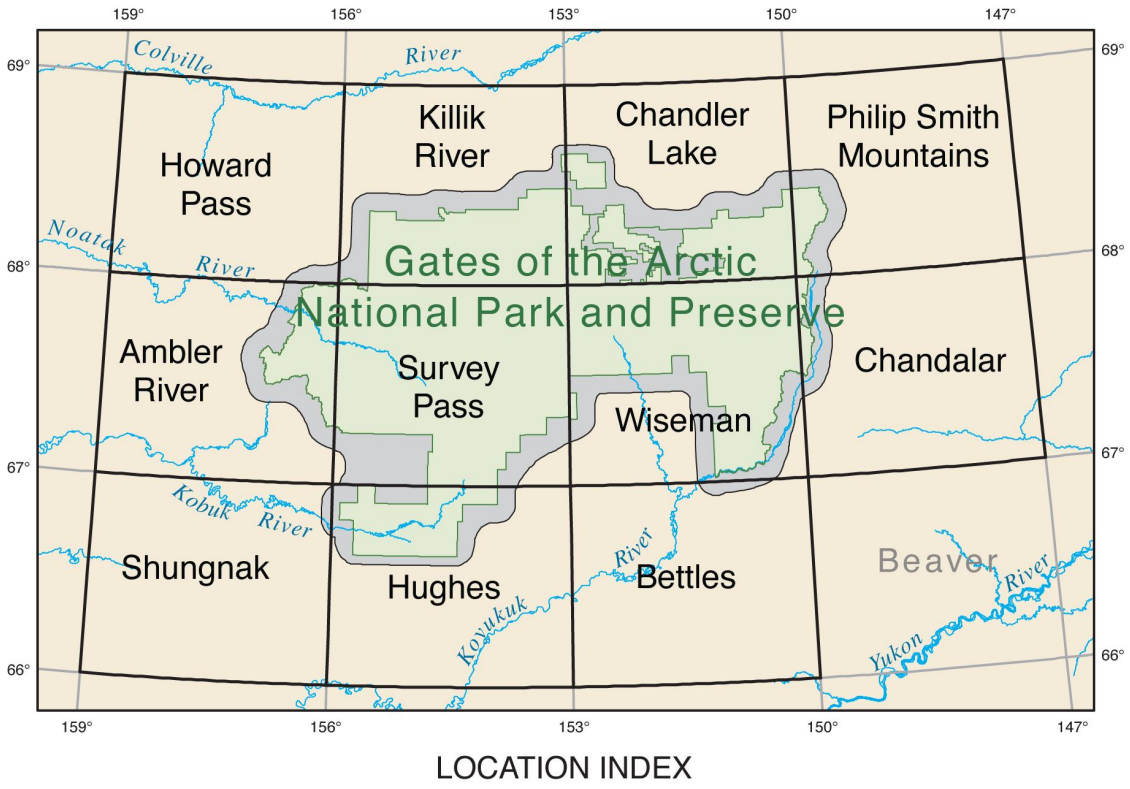
A PDF of the companion report for SIM-3125 is available at the following link: http://pubs.usgs.gov/sim/3125/sim3125_pamphlet.pdf.

Correlation of Map Units



Extracted from: (SIM-3125). (*GRI Source Map ID 2283*).

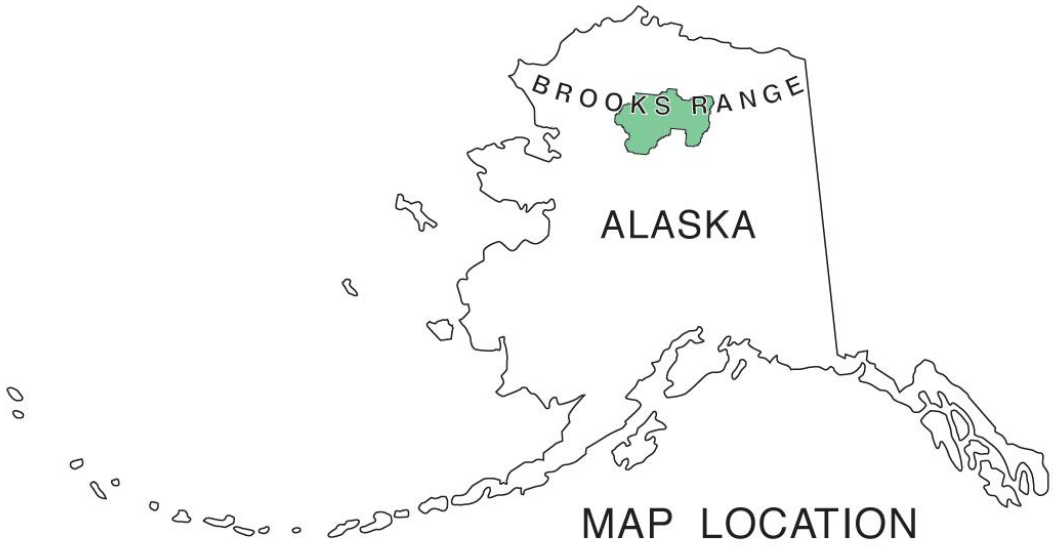
Location Index



LOCATION INDEX

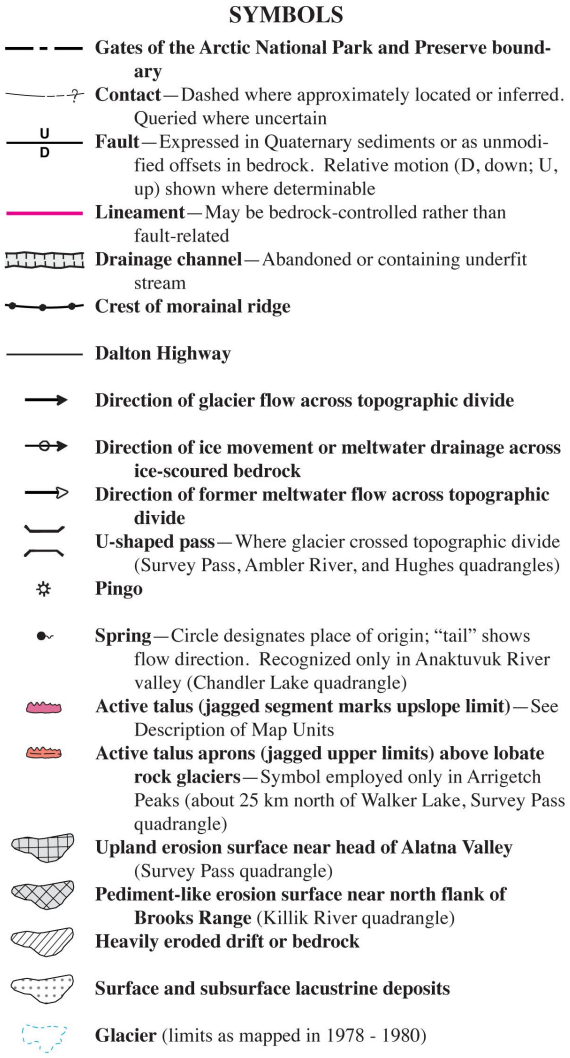
Extracted from: (SIM-3125). (*GRI Source Map ID 2283*).

Map Location



Extracted from: (SIM-3125). (*GRI Source Map ID 2283*).

Map Symbols



Extracted from: (SIM-3125). (*GRI Source Map ID 2283*).

GRI Digital Data Credits

This document was developed and completed by James Winter (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program. Quality control of this document by Ron Karpilo (Colorado State University).

The information in this document was compiled from the GRI source map, and intended to accompany the digital geologic-GIS map and other digital data for Gates of the Arctic National Park and Preserve, Alaska (GSUR) developed by Ron Karpilo (Colorado State University) with additional support and cooperation from Ric Wilson (U.S. Geological Survey, Alaska Science Center). Quality control of the GRI digital data by Jim Chappell (Colorado State University). (see the GRI Digital Map and Source Map Citation section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map).

GRI finalization by Jim Chappell (Colorado State University).

GRI program coordination and scoping provided by Bruce Heise and Tim Connors (NPS GRD, Lakewood, Colorado).