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

Lake Clark National Park and Preserve

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Lake Clark National Park and Preserve

lacl_geology.pdf

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Geologic Resources Inventory Map Document for Lake Clark National Park and Preserve

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Geologic Resources Inventory Map Document

Lake Clark National Park and Preserve, Alaska

Document to Accompany Digital Geologic-GIS Data

lacl_geology.pdf

Version: 3/8/2021

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

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.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Maps and Source Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

3) **Map Unit List** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.

4) **Map Unit Descriptions** – Descriptions for all geologic map units. If a unit is present on multiple source maps the unit is listed with its source geologic unit symbol, unit name and unit age followed by the unit's description for each source map. The geologic unit on SIM-3340 (U.S. Geological Survey Geologic Map of Alaska) that includes or represents the unit on that map is also denoted.

5) **Geologic Map of Alaska Unit Descriptions (SIM-3340)** – Descriptions for geologic units from SIM-3340 for units present in the digital geologic-GIS data.

6) **Ancillary Source Map Information** – Additional source map information presented by source map. For the SIM-3340 map this includes a link to the publication's pamphlet, GIS data and related information. For each Alaska Resource Data Files (ARDF) source this includes a link to a report and source data, as well as an index map, mineral occurrence map and references taken from the report.

7)**GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

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

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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: https://www.nps.gov/articles/gri-geodatabase-model.htm

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:

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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 Lake Clark National Park and Preserve, Alaska (LACL):

Digital Geologic-GIS Map of Lake Clark National Park and Preserve and Vicinity, Alaska (*GRI MapCode LACL*)

Digital GIS data was converted to the NPS GRI digital geologic-GIS geodatabase data model (v. 2.3) and ESRI 10.4 file geodatabase format from U.S. Geological Survey SIM-3340. For geologic units USGS NSAClass values were preserved, and for many units used to divide the unit into more detailed sub-units. The extent of the data converted includes portions of eight 1 degree x 3 degree quadrangles that cover Lake Clark National Park and Preserve.

Wilson, F.H., Hults, C.P., Mull, C.G, and Karl, S.M., 2015, Geologic Map of Alaska: U.S. Geological Survey, Scientific Investigations Map SIM-3340, scale 1:1,584,000 (Geologic Map of Alaska). (*GRI Source Map ID 76064*).

The extent of the GRI digital geologic-GIS data covers portions of the following 1' x 3' quadrangles: Dillingham, Iliamna, Kenai, Lake Clark, Lime Hills, Seldovia, Taylor Mountains, and Tyonek.

Digital data for seven Alaska Resource Data File (ARDF) reports were converted and are represented in the GRI digital geologic-GIS data. These sources are listed below.

Hudson, T.L., 2001, Alaska Resource Data File; Dillingham Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2001-192, 1:250000 scale (ARDF, 1' x 3' Dillingham Quadrangle). (*GRI Source Map ID 2205*).

Huber, J.A., 1999, Alaska Resource Data File; Kenai Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-99-393, 1:250000 scale (ARDF, 1' x 3' Kenai Quadrangle). (GRI Source Map ID 2724).

Hudson, T.L., and Millholland, M.A., 2002, Alaska Resource Data File; Lime Hills Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2002-76, 1:250000 scale (ARDF, 1' x 3' Lime Hills Quadrangle). (*GRI Source Map ID 2725*).

Millholland, M.A. and Riehle, J.R., 1998, Alaska Resource Data File; Tyonek Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-98-525, 1:250000 scale (ARDF, 1' x 3' Tyonek Quadrangle). (*GRI Source Map ID 2726*).

Bickerstaff, D., 1998, Alaska Resource Data File; Lake Clark Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-98-356, 1:250000 scale (ARDF, 1' x 3' Lake Clark Quadrangle). (*GRI Source Map ID 5204*).

Hudson, T.L., 2001, Alaska Resource Data File; Taylor Mountains Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2001-200, 1:250000 scale (ARDF, 1' x 3' Taylor Mountains Quadrangle). (*GRI Source Map ID 51666*).

Hawley, C.C., 2004, Alaska Resource Data File, Iliamna Quadrangle, Alaska: U.S. Geological Survey, Open-File Report OF-2004-1057, scale 1:250,000 (ARDF, 1' x 3' Iliamna Quadrangle). (*GRI Source Map ID 75243*).

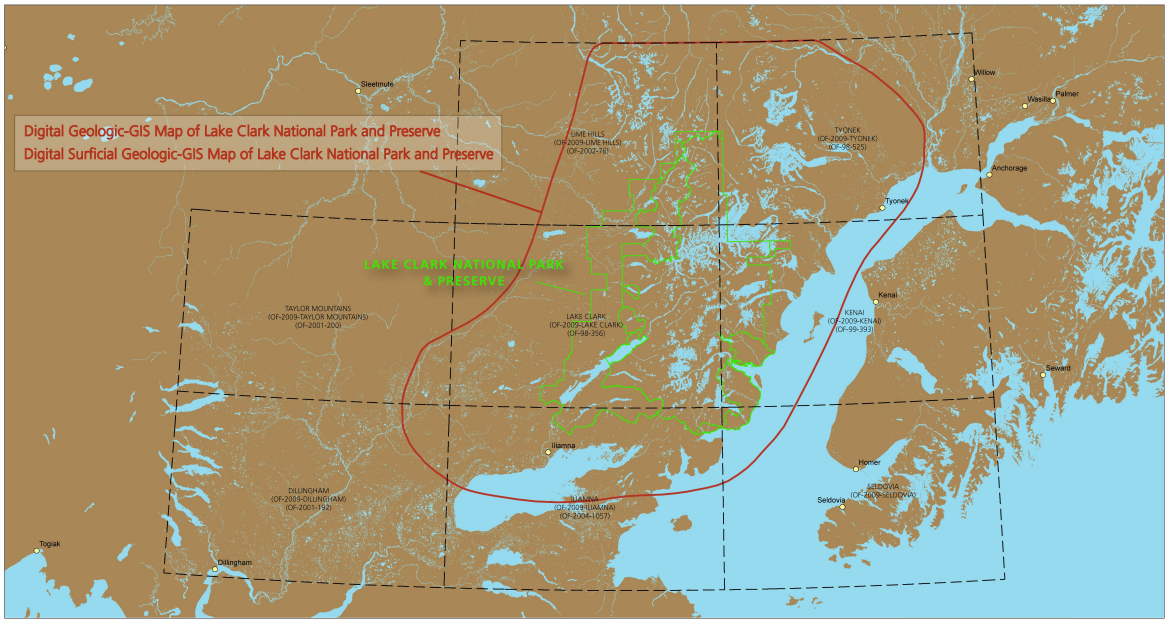
U.S. Geological Survey, 2008, Alaska Resource Data File, New and Revised Records Version 1.6: U.S. Geological Survey, Open-File Report OF-2008-1225, scale 1:250,000 (ARDF New and Revised Records). (*GRI Source Map ID 76130*).

The GRI digital geologic-GIS dataset includes a portion of the Seldovia 1' x 3' quadrangle, but no Alaska Resource Data File (ARDF) information is present within this extent, and thus the Alaska Resource Data File (ARDF) for the Seldovia 1' x 3' quadrangle was not used by the GRI.

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

Index Map

The following index map displays the extent of GRI digital geologic-GIS maps for Lake Clark National Park and Preserve. These maps include the Digital Geologic-GIS Map of Lake Clark National Park and Preserve and Vicinity, as well as the Digital Surficial Geologic-GIS Map of Lake Clark National Park and Preserve and Vicinity. Of note, both maps share the same extent. The boundary of Lake Clark National Park and Preserve (as of September, 2019) is displayed in light green. The extent and name of relevant 1' x 3' quadrangles is also shown. Surficial 1' x 3' source maps from an unpublished 2009 source are also indicated (see the source citations in the surficial geology GRI Ancillary Map Information document (lacl_surficial_geology.pdf), as are the relevant 1' x 3' Alaska Resource Data Files (ARDF) sources.



Graphic by Jake Suri, Stephanie O'Meara and Ron Karpilo (Colorado State University).

Map Unit List

The bedrock geologic units present in the digital geologic-GIS data produced for Lake Clark National Park and Preserve, Alaska (LACL) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qa - Alluvium). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (LACLUNIT) table included with the GRI geologic-GIS data.

Cenozoic Era

Quaternary Period

g - Ice fields or glaciers
Qpm - Placer and anthropogenic deposits
Qtf - Tidal flat and estuarine deposits
Qa - Alluvium
Qaf - Alluvial fan and talus deposits
Qc - Colluvium
Ql - Lacustrine deposits
Qsw - Swamp deposits
Qd - Dune deposits
Qrg - Rock glacier deposits
Qsf - Solifluction deposits
Qhg - Drift, neoglaciation
Qho - Outwash deposits, neoglaciation
Qhv - Holocene volcanic rocks
Qafd - Ash and tephra deposits
Qmf - Mudflow deposits
Qav - Volcanic avalanche deposits
Qbld - Drumlin deposits in ground moraine fields of Brooks Lake glacial deposits
Qdf - Debris-flow deposits
Qs - Surficial deposits, undifferentiated
Qls - Landslide deposits
Qt - Terrace deposits
Qb - Beach deposits
Qes - Estuarine deposits
Qmt - Marine terrace deposits
Qm - Glacial deposits, undivided
Qwu - Drift, undivided, Late Wisconsin-age glaciations
Qlv - Natural levee deposits
Qsu - Silt deposits, undifferentiated
Qsg - Superglacial drift
Qek - Esker deposits
Qoc - Channeled glacial deposits, kame and kettle
Qgme - Ground moraine modified by estuarine water
Qge - Glacio-estuarine deposits
Qbc - Bootlegger Cove Formation
Qdl - Deltaic deposits
Qewd - Drumlins associated with early glaciations
Qmi - Illinoian glaciations
Qmio - Outwash older than Wisconsin-age
Qsb - Scoured bedrock
Qv - Volcanic rocks, undivided
Qpd - Pyroclastic (ash and debris flow) deposits
Qac - Abandoned channel deposits
Qglf - Glacial outwash derived fans deposited in ephermeral glacial lakes
Qgl - Glaciolacustrine deposits

Qwr - Glacial deposits, latest Wisconsin, Iliuk, Riley Creek, and other glaciations
Qw2 - Late Wisconsin, Newhalen and other till
Qw1 - Late Wisconsin, Iliamna and other till
Qw0 - Till, Brooks Lake, Kvichak
Qwo - Outwash deposits, late Wisconsin-age glaciations
Qew - Glaciations older than Late Wisconsin
Qmhg - Early Wisconsin (Mak Hill and Iowithla) ground moraine
Qow - Older Wisconsin age outwash
Qanp - Andesite plug domes

Quaternary and Tertiary Periods
QTod - Deposits related to but peripheral to older glaciations
QTi - Intrusive rocks
QTv - Quaternary and/or Tertiary volcanic rocks, undifferentiated

Tertiary Period
Tib - Intricate Basalt
Tsu - Sedimentary rocks, undivided
Tvu - Tertiary volcanic rocks, undivided
Tsf - Kenai Group, Sterling Formation
Tkb - Kenai Group, Beluga Formation
Tty - Kenai Group, Tyonek Formation
Ta - Andesite
Thf - Hypabyssal felsic and intermediate intrusions
Tgr - Granite
Tgd - Granodiorite, undivided
Toqd - Quartz diorite and diorite
Tpgr - Peralkaline granite
Tap - Andesite plug dome
Trd - Rhyolitic and dacitic tuff
Ttyh - Kenai Group, Tyonek Formation and Hemlock Conglomerate (undivided)
Twf - West Foreland Formation
Togr - Granitic rocks
Tpag - Peralkaline granite and related rocks
Toem - Granodiorite to tonalite
Tegr - Tertiary granite and granodiorite
Tvr - Crystal and crystal-lithic ash-flow tuff
Tvba - Meshik Volcanics
Tvb - Basaltic lavas of the Meshik volcanic arc
Tvc - Block and ash deposits
Tvs - Volcanic and sedimentary rocks, undivided
Tcl - Copper Lake Formation
Tvbs - Andesite and basalt
Tfv - Intermediate to felsic biotite tuff
Tgh - Hypabyssal granitic rocks
Tpg - Granitic rocks, ranging from granite to granodiorite, mostly felsic
Thgd - Biotite-hornblende-granodiorite
Tpd - Biotite diorite
Tgl - Hornblende and pyroxene-hornblende gabbro

Cenozoic and Mesozoic Eras

Tertiary and Cretaceous Periods
TKd - Dikes and subvolcanic rocks
TKgs - Syenitic rocks

TKgb - Gabbro and dark-colored dikes and sills
TKgg - Gneissose granitic rocks
TKv - Extrusive rocks, flows, tuff, and breccia
TKgbu - Gabbro and diorite, undivided
TKgp - Hypabyssal granite porphyry dikes, sills, and plugs
TKg - Granitic rocks
TKqd - Quartz diorite and diorite dikes, stocks, and small plutons
TKgdt - Granodiorite
TKqdt - Quartz diorite
TKv - Felsic tuff
TKoegr - Granitic rocks
TKvr - Volcanic rock, light gray to pink rhyolite
TKvd - Volcanic rocks, dacite
TKmv - Mafic flows of andesite and basalt, and volcaniclastic deposits
TKgd - Mafic granitic rocks, tonalite, monzonite
TKgr - Granite and alaskite
TKgm - Quartz monzonite, granodiorite, and quartz monzodiorite
TKJg - Granitic rocks and minor monzonite

Mesozoic Era

MZPZcb - Cottonwood Bay Greenstone
MZPZk - Kakhonak Complex
MZPZb - Metabasalt and minor metachert

Cretaceous Period

Kks - Kaguyak Formation, nonmarine sedimentary rocks
Kvi - Intermediate and felsic volcanic rocks
Kgd - Granodiorite
Kqd - Quartz diorite
Kgl - Granite
Kgk - Quartz monzonite, monzonite, and syenite
Kmg - Granite
Kmqm - Quartz monzonite, monzonite, and syenite
Kmgd - Intermediate granitic rocks, granodiorite
Kivs - Intermediate volcanic and sedimentary rocks
Ksf - Feldspathic sedimentary rocks
Kesv - Turbiditic sedimentary and volcanic rocks
KJk - Kuskokwim Group, sandstone, siltstone, shale, and conglomerate

Cretaceous and Jurassic Periods

KJs - Flysch sequence
KJkr - Koksetna River sequence, Jura-Cretaceous flysch, southern part of Kahiltna terrane
KJv - Olivine basalt
KJvs - Volcanic and sedimentary rocks

Jurassic Period

Jn - Naknek Formation, undivided
Jnp - Naknek Formation, Pomeroy Arkose Member
Jnn - Naknek Formation, Northeast Creek Sandstone Member
Jns - Naknek Formation, Snug Harbor Siltstone Member
Jnc - Naknek Formation, Chisik Conglomerate Member
Js - Chinitna Formation, Paveloff Siltstone Member
Jc - Chinitna Formation, Tonnie Siltstone Member
Jtr - Trondjemite

Jgd - Granodiorite of Alaska-Aleutian Range batholith
Jqd - Quartz diorite of Alaska-Aleutian Range batholith
Jdg - Diorite and gabbro of Alaska-Aleutian Range batholith
Jqt - Quartz diorite and tonalite
Jla - Lamprophyre and mafic dikes associated with Iliamna Volcano
Jtb - Tuxedni Group, Bowser Formation
Jtt - Tuxedni Group, Twist Creek Siltstone
Jtc - Tuxedni Group, Cynthia Falls Sandstone
Jtf - Tuxedni Group, Fitz Creek Siltstone
Jtg - Tuxedni Group, Gaikema Sandstone
Jtrg - Tuxedni Group, Red Glacier Formation
Jtk - Talkeetna Formation
Jtkh - Talkeetna Formation, Horn Mountain Tuff Member
Jtkp - Talkeetna Formation, Portage Creek Agglomerate Member
Jtkm - Talkeetna Formation, Marsh Creek Breccia Member
Jgaa - Gabbroic rocks, associated with Alaska-Aleutian Range batholith

Jurassic and Triassic Periods
JTRku - Kamishak Formation, Ursus Member

Triassic Period
TRtv - Tatina River Volcanics, lower members, pillow basalt and gabbro
TRk - Kamishak Formation
TRkm - Kamishak Formation, Middle Member
TRkb - Kamishak Formation, Bruin Limestone Member
TRScg - Conglomerate and volcanic sandstone

Paleozoic Era
PZd - Dillinger sequence, undivided

Permian, Pennsylvannian, Mississippian and Devonian Periods
PDsc - Mystic stratigraphic sequence, Sheep Creek Formation and correlative siliciclastic units

Devonian Period
Dsc - Mystic stratigraphic sequence, shale and chert
Dsca - Barren Ridge limestone, calcarenite, calcareous siltstone, and limestone

Silurian Period

Stc - Dillinger sequence, Terra Cotta Mountains sandstone, sandstone and graptolitic shale

Silurian, Ordovician and Cambrian Periods
SOCpl - Post River Sandstone and Lyman Hills Formations and correlative units, silty limestone and siltstone

Unknown Age
bu - Bedrock of unknown type or age

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

g - Ice fields or glaciers (Holocene and Pleistocene)

No additional description present on source maps. Unit present on source maps: IL001, KN001, LC001, LH001, SV001, and TY001

See g unit description from SIM-3340 (Geologic Map of Alaska).

Qpm - Placer and anthropogenic deposits (Quaternary)

Qf - Other unconsolidated deposits -- artificial fill (Quaternary, Holocene)
Artificial fill at Drift River and West Foreland facilities. Unit description from source map: KN006

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qtf - Tidal flat and estuarine deposits (Quaternary)

Qfs - Alluvial deposits, Partially submerged alluvial fans (Quaternary, Recent)
Partially submerged alluvial fans consisting of sand and gravel, exposed at low tide. Unit description from source map: SV004

Qbm - Beach deposits, Salt marsh (Quaternary, Recent)
Salt-marsh, well-stratified silt and small pebbles, poorly drained. Unit description from source map: IL007

Qt - Turnagain Arm tidal deposits (Quaternary)
Turnagain Arm tidal deposits. Unit description from source map: TY001

Qtf - Modern tidal flat and estuarine deposits (Quaternary)
Well-sorted, stratified silt and some sand and local gravel deposited in shallow embayments. Sub-tidal. Unit description from source map: KN008

Qes - Estuarine silt (Quaternary, Holocene)
Consists of silt deposits exposed at low tide and lying below mean high tide. Are primarily bluish gray, clay to silt sized, extremely plastic and sticky when wet. Deposits below mean high tide coded as tidal flats rather than estuarine deposits. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qa - Alluvium (Quaternary)

Qal - Quaternary alluvium (Quaternary)
Quaternary alluvium along active rivers and streams. Unit description from source map: TY009

Qal - Alluvium (Quaternary)
Alluvium. Unit description from source map: LH009

Qal - Alluvial deposits, Flood-plain alluvium (Quaternary, Recent)
Flood-plain alluvium, poorly- to well-sorted silt, sand, pebbles, cobbles, and boulders. Mainly cobbles and boulders except near tidewater. Includes some glacial outwash. Unit description from source map: IL007

Qal - Alluvial deposits, Flood-plain alluvium (Quaternary, Recent)
Flood-plain alluvium, poorly- to well-sorted silt, sand, pebbles, cobbles, and boulders. Mainly cobbles and boulders except near tidewater. Includes some glacial outwash. Unit description from source map: KN005

Qal - Alluvial deposits, Flood-plain alluvium (Quaternary, Recent)
Flood-plain alluvium, poorly- to well-sorted silt, sand, pebbles, cobbles, and boulders. Mainly cobbles and boulders except near tidewater. Includes some glacial outwash. Unit description from source map: SV004

Qal - Alluvium (Quaternary)
Mainly gravel and coarse sand, consists in part of glacial and glaciofluvial material reworked by postglacial streams. Forms flood plains along major streams and rivers. Unit description from source map: LC005

Qaa - Active floodplain alluvium (Quaternary)
Active floodplain alluvium. Unit description from source map: TY008

Qal - Alluvial deposits, Flood-plain alluvium (Quaternary, Recent)
Flood-plain alluvium, poorly- to well-sorted silt, sand, pebbles, cobbles, and boulders. Mainly cobbles and boulders except near tidewater. Includes some glacial outwash. Unit description from source map: LC007

Qal - Alluvium (Quaternary)
Alluvium along active rivers and streams. Unit description from source map: TY007

Qal - Alluvium (Quaternary)
Mainly gravel and coarse sand, consists in part of glacial and glaciofluvial material reworked by postglacial streams. Forms flood plains along major streams and rivers. Unit description from source map: KN008

Qal - Alluvium (Quaternary)
Mainly gravel and coarse sand, consists in part of glacial and glaciofluvial material reworked by postglacial streams. Forms flood plains along major streams and rivers. Unit description from source map: DI013

Qa - Alluvium (Quaternary)
Active alluvial deposits on modern rivers and streams. Unit description from source map: TA021

Qal - Floodplain alluvium (Quaternary, Holocene)
Most extensive and abundant in the western part of the quadrangle where large volumes of glacial debris is being reworked and moved downstream. Interstratified sand and gravel constitute the bulk of materials, gravel here defined to include fragments up to 10 inches in diameter. Streams in the eastern part of the quadrangle have a high proportion of boulders, fragments greater than 10 inches in diameter and only minor sand and gravel. Silt and fine sand are much more common along low gradient western streams and can be a major part of the material in the floodplain. Unit description from source map: IL003

Qal - Alluvial deposits, Flood-plain alluvium (Quaternary, Recent)
Flood-plain alluvium, poorly- to well-sorted silt, sand, pebbles, cobbles, and boulders. Mainly cobbles and boulders except near tidewater. Includes some glacial outwash. Unit description from source

map: IL006

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qaf - Alluvial fan and talus deposits (Quaternary)

Qaf - Alluvial Fan Deposits (Quaternary)
Alluvial fans. Unit description from source map: LH009

Qaf - Quaternary alluvial fan deposits (Quaternary)
Quaternary alluvial fan deposits, not all are mapped. Unit description from source map: TY009

Qaf - Alluvial Fan Deposits (Quaternary)
Appear to be alluvial fans. Unit description from source map: LH009

Qf - Alluvial deposits, Alluvial fans and cones (Quaternary, Recent)
Alluvial fans and cones, unsorted rock talus, in part colluvial in origin. Unit description from source maps: IL007, KN005 and SV004

Qfs - Alluvial deposits, Partially submerged alluvial fans and cones (Quaternary, Recent)
Partially submerged alluvial fans consisting of sand and gravel; exposed at low tide. Unit description from source map: IL007

Qaf - Alluvial fan deposits (Quaternary)
Gravel, silt, and sand, commonly occur at mouth of small side canyons. Includes some colluvial deposits. Unit description from source map: LC005

Qaf - Alluvial fans and outwash plains (more distal) (Quaternary (Latest Pleistocene))
Alluvial fans and outwash plains. Mainly external to moraines. Unit description from source map: TY008

Qaf - Alluvial fan deposts (Quaternary)
Alluvial fan deposits. Gravel, silt, and sand, commonly occur at mouth of small side canyons. Includes some colluvial deposits. Unit description from source map: TY007

Qaf - Alluvial fan deposits (Quaternary)
Gravel, silt, and sand, commonly occur at mouth of small side canyons. Includes some colluvial deposits. Unit description from source maps: KN008, DI013 and TA021

Qf - Alluvial fans and cones (Quaternary, Holocene)
Coarser and more angular than floodplain deposits; fans and cones have distinctly convex cross-sections. Composed mainly of locally derived rocks fragments and minor glacial draft. Most are forested and gullied indicating they are being dissected. Thought to have formed mainly during the time of the Alaska Glaciation. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qc - Colluvium (Quaternary)

Qc - Colluvium (Quaternary)
Colluvium. Unit description from source map: LH009 and TY007

Qc - Colluvial deposits (Holocene)

Chiefly rubble, gravel, sand, silt, and clay. Talus and other slope debris deposits, also includes alluvium of minor streams, and locally glacial, rock glacier, and mass-wasting deposits. May include older glacial drift and locally grades into glacial deposits. Unit description from source map: LC005

Qlc - Landslide and colluvial deposits (Quaternary)
Unsorted deposits of fine to coarse rubble. Unit description from source maps: IL007, KN005 and SV004

Qc - Colluvial deposits (Quaternary, Holocene)
Chiefly rubble, gravel, sand, silt, and clay. Talus and other slope debris deposits, also includes alluvium of minor streams, and locally glacial, rock glacier, and mass-wasting deposits. May include older glacial drift and locally grades into glacial deposits. Unit description from source maps: KN008, LC005, DI013 and TA021

Qtr - Talus and rubble deposits (Quaternary, Holocene)
Sheets, fans, and cones of angular frost-riven rock fragments accumulate on steep slopes in mountainous regions. Most commonly formed in areas of granitic rock. Rubble covers flat to gently rounded hilltops and upland surfaces that stand above the limit of Late Wisconsin glaciation. Areas where rubble has developed are underlain by a variety of rock types, but are most commonly granitic or Tertiary volcanic rocks. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Ql - Lacustrine deposits (Quaternary)

Ql - Lacustrine deposits? (Quaternary)
Lacustrine deposits?. Unit description from source map: LH009

Qld - Lake deposits (Quaternary)
Lake deposits. Silt, clay, and sand. Deltaic deposits, gravel and sand shown by stipple pattern. Unit description from source map: TY008

Qac - Abandoned lacustrine deposits (Quaternary)
Abandoned lacustrine deposits, probably lake was dammed behind early debris flow from Redoubt Volcano. Lake is now drained and deposits form floodplain of the upper part of the North Fork of the Crescent River. Air photo interpretation. Unit description from source map: KN008

Ql - Lacustrine deposits (Quaternary)
Well-sorted, well-stratified clay, silt and fine sand deposited in former lake basins. Typically covered by several feet of muck and peat. Air photo interpretation. Unit description from source map: DI013

Ql - Lacustrine deposits (Quaternary, Holocene)
Lacustrine deposits in upper Crescent River valley from an older Crescent Lake. Examined on the ground by Jon Harvey of NPS. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qsw - Swamp deposits (Quaternary)

Qsw - Swamp deposits (Quaternary)
Silt, sandy silt, and bog deposits, interpreted from air photos. Unit description from source maps: LC005, KN008 and DI013

Qs - Swamp deposits (Quaternary, Holocene)
Dark-brown organic accumulation of woody and peaty material mixed with silt and fine sand. Sedge and sphagnum peat are both present. Measured thicknesses are about 2 feet but deposits are probably much thicker than has been observed. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qd - Dune deposits (Quaternary)

Qd - Eolian sand (Quaternary)
Well-sorted sand, irregularly cross-bedded, forms active and stabilized dunes on outwash plains and raised beaches. Unit description from source map: DI013

Qd - Sand dunes (Quaternary, Holocene)
Extensive area of sand dunes overlies high terraces and beach ridges at west end of Iliamna Lake. Other smaller dunes occur locally. Only partially stabilized by sparse vegetation cover, having common blowouts. Typically consist of fine-grained quartz sand or silty sand; silt absent in active layer. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qrg - Rock glacier deposits (Quaternary)

Qr - Rock glaciers? (Quaternary)
Assigned to Quat, undivided by default. Unit description from source map: LH009

Qrg - Active and recently active rock glaciers (Quaternary)
Chiefly rubble and diamicton, interpreted from air photos. Unit description from source map: LC005

Qrg - Rock glaciers (Quaternary, Holocene)
Active and recently active rock glaciers. Chiefly rubble and coarse rock debris, interpreted from air photos. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qsf - Solifluction deposits (Quaternary)

Qsf - Solifluction deposits (Quaternary)
Solifluction mantle, interpreted from airphotos. Thought to be poorly sorted sand, silt, and clay derived from local upslope bedrock sources. Unit description from source maps: LC005, KN008 and DI013

Qso - Solifluction deposits (Quaternary, Holocene)
Solifluction lobes are conspicuous features in northwestern part of quadrangle. Deposits are most common where regolith contains a considerable amount of fine material, such as loess-mantled hills and drift of the Mak Hill Glaciation. Transported material undergoes a minor amount of sorting and crude polygonal ground is formed. Fine materials are concentrated in the center and coarse fragments around the outside. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qhg - Drift, neoglaciation (Quaternary)

Qt - Quaternary till (Quaternary)
Quaternary till, likely includes Holocene Little Ice Age moraines [Need to reconcile unit with Qg]. Unit description from source map: TY009

Qgh - Moraine (Quaternary, Holocene)
Holocene glacial deposits, interpreted from Richter's (LH009) mapping. Unit description from source map: LH007

Qgtn - Glacial deposits, Tunnel Stade Alaskan Glaciation (Quaternary)
Barren moraine as much as 1-mile in front of present glaciers. Tunnel Stade, Alaskan Glaciation. Unit description from source maps: IL007, KN005 and SV004

Qgt - Glacial deposits, Tustumena Stade Alaskan Glaciation (Quaternary)
Partially dissected moraine 1-6-mile in front of present glaciers; spruce and brush covered. Tustumena Stade, Alaskan Glaciation. Unit description from source maps: IL007, KN005 and SV004
Qad - Till, Cirque glaciations (Quaternary, Holocene?)
Unsorted boulder to clay-size particles. Moraine forms locally present, restricted to cirques. Unit description from source map: LC005

Qmh - Holocene end lateral and ground moraine deposits (Quaternary)
Holocene end lateral and ground moraine deposits. Unit description from source map: TY008

Qau - Alaskan Glaciation, drift, undivided (Quaternary, Holocene)
Drift, undivided. Unit description from source map: IL006

Qgtn - Glacial deposits, Tunnel Stade Alaskan Glaciation (Quaternary)
Barren moraine as much as 1-mile in front of present glaciers. Tunnel Stade, Alaskan Glaciation. Unit description from source map: LC007

Qgt - Glacial deposits, Tustumena Stade Alaskan Glaciation (Quaternary)
Partially dissected moraine 1-6-mile in front of present glaciers; spruce and brush covered. Tustumena Stade, Alaskan Glaciation. Unit description from source map: LC007

Qhg - Holocene end lateral and ground moraine deposits (Quaternary)
Holocene end lateral and ground moraine deposits. Unit description from source map: TY007

Qag - Alaskan glaciation, till, Cirque glaciations (Quaternary, Holocene?)
Unsorted boulder to clay-size particles. Morainal landforms common as are till deposits along the margins of modern glaciers. Unit description from source map: KN008

Qad - Till, Cirque glaciations (Quaternary, Holocene?)
Unsorted boulder to clay-size particles. Moraine forms locally present, restricted to cirques. Unit description from source map: LC005

Qau - Alaskan Glaciation, drift, undivided (Quaternary, Holocene)
Deposits represent an event beginning about 4,500 to 4,800 years BP and continuing until about 200 years BP. Modern glaciers are remnants from this advance. Restricted to higher parts of mountains along Cook Inlet. Unit description from source map: IL003

Qat - Alaskan Glaciation, Tunnel Stade (Quaternary, Holocene)
A minor resurgence of the Alaskan Glaciation, dating from about 1200 years BP, these deposits are from alpine-valley glaciers that extended no more than .5 to 1.5 miles from the cirque headwall, except at Iliamna Volcano. In contrast to the earlier Tustumena Stade deposits, the Tunnel Stade deposits are more extensive in the north and less so in the southern part of the quadrangle. Most

localities show end moraines of two advances. These deposits may represent the "Little Ice Age" in Alaska in part. Unit description from source map: IL003

Qatt - Alaskan Glaciation, Tustumena Stade (Quaternary, Holocene)
Oldest of the Alaskan Glaciation moraines, these deposits are from alpine-valley glaciers that extended no more than 2.5 miles from the cirque headwall in the southern part of quadrangle and less than 1.5 miles in the northern part of quadrangle. However, glaciers derived from icefields on Iliamna Volcano were much more extensive, extending more than 15 miles. Most localities show end moraines of two advances, separated by one third to one half miles, locally there is the suggestion of a third advance between the two prominent moraines, represented by faint deposits, which conversely may indicate a recessional event. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qho - Outwash deposits, neoglaciation (Quaternary)

Qaoh - Outwash? (Quaternary, Holocene?)
Probable Holocene outwash, interpreted from Richter's (LH009) mapping. Unit description from source map: LH007

Qo - Outwash deposits (Quaternary)
Poorly- to well-sorted silt, sand, and gravel in terraces and outwash fans plains. Unit description from source maps: IL007, KN005 and SV004

Qno - Outwash deposits (Quaternary, Holocene)
Poorly- to well-sorted silt, sand, and gravel in terraces and outwash fans plains, interpreted from air photos. Unit description from source map: LC005

Qoh - Older Holocene outwash fans and plains (Quaternary)
Older Holocene outwash fans and plains. Unit description from source map: TY008

Qao - Alaskan Glaciation, outwash (Quaternary, Holocene)
Outwash deposits associated with modern and Holocene glaciers. Unit description from source maps: KN008 and TY007

Qao - Alaskan Glaciation, outwash (Quaternary, Holocene)
Outwash deposits locally mapped along West Glacier and Middle Glacier Creeks, but also occur elsewhere in patches too small to map. Composed of fragments of volcanic rock. Outwash continues to be deposited by existing glaciers. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qhv - Holocene volcanic rocks (Quaternary)

Qv - Andesitic lava and tuff of Iliamna Volcano (Quaternary)
Light gray andesitic lava and yellowish-gray, opalized tuff. Unit description from source map: LC002

Qvh - Quaternary volcanics, Hayes volcano (Quaternary (Holocene))
Quaternary volcanic rocks, Hayes volcano. Unit description from source map: TY009

Hv - Holocene volcanics (Quaternary (Holocene))
Holocene volcanic rocks associated with Mt. Spurr, prior to Crater Peak vent. Unit description from source map: TY009

Hvcp - Holocene volcanics, Crater Peak (Quaternary (Holocene))
Holocene volcanic rocks associated with the Crater Peak vent of Spurr Volcano. Unit description from source map: TY009

Qil - Iliamna Lava flows (Quaternary)
Light-gray hypersthene-augite andesitic lava, breccia, and associated pyroclastic debris. Unit description from source maps: IL007, SV004 and LC007

Qv - Volcanic rocks at Mt. Spurr (Quaternary)
Volcanic rocks at Mt. Spurr. Unit description from source map: TY008

Qtv - Lava flows, North and South Twin volcanic center (Quaternary)
Lava flows from the North and South Twin volcanic center. Probably andesitic. Unit description from source map: IL008

Qhv - Holocene volcanic rocks (Quaternary, Holocene)
Holocene volcanic rocks, primarily associated with Redoubt Volcano. Unit description from source map: KN008

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qafd - Ash and tephra deposits (Quaternary)

Qvf - Ashflow (Quaternary)
Ashflow. Unit description from source map: TY008

Qca - Ash-rich colluvium (Quaternary, Holocene)
Consists of tephra-rich colluvium in the vicinity of and west of Redoubt volcano. Similar to other volcanoes, these deposits probably consist of ash and larger-sized pyroclasts. On the flank of Redoubt Volcano, these deposits mantle and are incorporated in deposits that reflect Holocene glaciation. West of the volcano, they mantle bedrock and older glacial deposits. East of the volcano, they apparently cover one long low ridge -- this is apparently an erosional remnant as other ridges to the east do not seem to have these deposits. Unit description from source map: KN008

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qmf - Mudflow deposits (Quaternary)

Qdr - Drift River delta mudflow deposits, undifferentiated (Quaternary, Holocene)
Areas of mudflow deposits, not easily separatable into the Younger and Older events. Unit description from source map: KN008

Qdr2 - Older Drift River delta mudflow deposits (Quaternary, Holocene)
Areas of mudflow deposits, tending to be more heavily vegetated and tending to control location of Drift River channels. Unit description from source map: KN008

Qdr1 - Younger Drift River delta mudflow deposits prior to 1957 (Quaternary, Holocene)
Areas of mudflow deposits, tending to be minimally vegetated and relatively close to channel of Drift River. Unit description from source map: KN008

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qav - Volcanic avalanche deposits (Quaternary)

Qda - Debris-avalanche deposits (Quaternary, Holocene)
Volcanic avalanche deposits consisting of poorly sorted mixture of angular sand, cobbles, and boulders. All deposits contain clasts of grey andesitic lava and yellow-orange hydrothermally altered rocks. Estimated age is less than 1,000 years and some may be historic (< 200 years). Unit description from source maps: IL008 and KN011

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qbld - Drumlin deposits in ground moraine fields of Brooks Lake glacial deposits (late Quaternary)

Qbld - Glacial deposits of the Brooks Lake glaciation -- drumlins (Late Quaternary)
Drumlin deposits in ground moraine fields of Brooks Lake glacial deposits. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qdf - Debris-flow deposits (Quaternary)

Qvd - Debris flow and or debris avalanche (Quaternary)
Debris flow and or debris avalanche. Unit description from source map: TY008

Qdfn - Debris flow deposits, younger Redoubt flows (Quaternary, Holocene)
Debris flow deposits on the north flank of Redoubt Volcano in the Drift River valley. Unit description from source map: KN008

Qm - Debris-flow deposits (earliest Holocene or late Pleistocene)
No additional description present on source maps. Unit present on source map: KN018

Qm - Debris flow deposits (Quaternary, Holocene)
Debris flow deposits of Crescent River valley. Includes several small (older?) deposits in the upper valley and the 3,500-year-old debris flow in the lower valley. Unit description from source map: LC005

Qdf2 - Debris flow deposits, oldeest? Redoubt flows (Quaternary, Holocene)
Debris flow deposits of North Fork, Crescent River. Deposits of multiple debris flows off the west and southwest flanks Redoubt Volcano. Oldest(?) deposit is derived from west flank of Redoubt. Next oldest deposit appears derived from presently glaciated valley draining to the southwest off Redoubt. These deposits are of relatively limited extent. They may have dammed the North Fork of the Crescent River, creating a temporary lake in the valley. Unit description from source map: KN008

Qdf1 - Debris flow deposits, younger Redoubt flows (Quaternary, Holocene)
Debris flow deposits of North Fork, Crescent River. Deposits of the youngest, most extensive, and probably most fluid debris flow derived from southwest flank of Redoubt Volcano. Flow was apparently derived from a presently glacier free valley draining south from Redoubt. This debris flow has been dated at 3,500 yrs. BP, young enough to possibly explain lack of glaciers in the source valley, as all surrounding valleys have extensive glaciers and glacial deposits. This debris flow extends to coast of Cook Inlet and back flowed up the main fork of the Crescent River, creating Crescent Lake. Unit description from source map: KN008

Qdf - Debris flow deposits (Quaternary, Holocene)
Debris flow deposits of North Fork, Crescent River. Deposits of multiple debris flows off the west and southwest flanks Redoubt Volcano. Oldest(?) deposit is derived from west flank of Redoubt. Next oldest deposit appears derived from presently glaciated valley draining to the southwest off Redoubt. Unit description from source map: KN008

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qs - Surficial deposits, undifferentiated (Quaternary)

Qs - Surficial deposits (Quaternary (Holocene and Pleistocene))
Unsorted to well-sorted alluvial, colluvial, glacial, glaciofluvial, lacustrine, marine, and eolian deposits. Unit description from source map: IL002

Qa - Undifferentiated Quaternary surficial deposits (Quaternary)
Unit description from source map: LH002

Qu - Undifferentiated surficial deposits (Quaternary)
Mainly unsorted gravel, sand, and silt produced and deposited by action of wind, water, frost, and solifluction. Unit description from source maps: LC005, DI005 and TA021

Qs - Undifferentiated surficial deposits (Quaternary)
Mainly unsorted gravel, sand, and silt produced, deposited, and reworked by action of wind, water, glaciers, and frost, including solifluction. In many areas of the map, this unit is a mixture of surrounding surficial deposit units that could not be readily sub-divided. In the vicinity of the Drift River delta, this unit contains a significant proportion of volcanic debris derived from airfall, mudflows and lahars from Mt. Redoubt. Unit description from source maps: KN008 and TY007

Q - Alluvial, colluvial, and glacial deposits (Quaternary)
Alluvial, colluvial, and glacial deposits. Unit description from source map: LC012

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qls - Landslide deposits (Quaternary)

Qls - Landslide deposits (Quaternary)
Landslide deposits. Unit description from source map: LC005

Ql - Landslides (Quaternary)
Landslides, mainly massive and complex. Massive blocks shown by pattern. Smaller slides represented by point. Unit description from source map: TY008

Ql - Landslides (Quaternary)
Landslides. Unit description from source map: TY007

Qls - Landslide deposits (Quaternary)
Chiefly rubble, gravel, sand, silt, and clay. Most extensive in Jurassic sedimentary rock northeast of Mount Iliamna. Unit description from source map: KN008

Qls - Landslide deposits (Quaternary, Pleistocene and Holocene)
Consist of large angular blocks of bedrock and minor amounts of surficial material. Most slides appear to be stabilized by vegetation. Slides are most common in Jurassic sedimentary rocks and Tertiary volcanic rocks. Slides in the Jurassic sedimentary rocks along the Iniskin Peninsula involve millions of

tons of rock and may be as much as 2 miles long. Landslide have a wide variety of ages; some are partially overridden by Pleistocene glacial deposits, whereas others happen as recently as the 1950's No landslides occurred as a result of the 1964 Great Alaska earthquake. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qt - Terrace deposits (Quaternary)

Qtg - Terrace deposits (Quaternary)
Terrace gravels in outwash above modern floodplains. Air photo interpretation. Unit description from source map: LC005, KN008 and DI013

Qa - Alluvium in low terraces and alluvial fans (Quaternary)
Alluvium in low terraces and alluvial fans. Unit description from source map: TY008

Qa - Alluvium in low terraces (Quaternary)
Alluvium in low terraces. Unit description from source map: TY007

Qtgo - Older terrace deposits (Quaternary)
Terrace gravels in outwash above modern floodplains. These particular polygons are at a second, higher level than areas having CLASS codes of 510. Air photo interpretation. Unit description from source map: LC005

Qt - Terrace deposits (Quaternary)
Terrace gravels in outwash above modern floodplains. Air photo interpretation. Unit description from source map: TA021

Qt2 - Terrace deposits (Quaternary)
Higher level terrace gravels in above modern floodplains and younger terraces. Air photo interpretation. Unit description from source map: TA021

Qtg - Terrace deposits (Quaternary)
Terrace gravels in outwash above modern floodplains. These particular polygons are at a second, higher level than areas having CLASS codes of 5110. Air photo interpretation. Unit description from source map: DI013

Qts - Stream terrace deposits (Quaternary, Pleistocene and Holocene)
Crudely stratified deposits of gravel and sand having level or gently sloping upper surfaces form terraces found along virtually all streams in the quadrangle. Many streams show a complex series of multiple terraces and the deposits that form the terraces are locally more than 100 feet thick. Consist mainly of poorly stratified, well-round pebbles and cobbles having interbeds and lenses of sand and silt. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qb - Beach deposits (Quaternary)

Qbe - Beach deposits, Elevated beach ridges (Quaternary, Recent)
Elevated beach ridges, well-sorted well-stratified, well-drained sand and gravel. Unit description from source maps: IL007, KN005 and SV004

Qb - Beach deposits (Quaternary, Holocene and Pleistocene)
Moderately well-stratified and sorted sand and gravel on beaches. Unit description from source maps: LC005 and KN008

Qb - Beach deposits, sand and gravel (Quaternary, Holocene)
Beach deposits, sand and gravel, inferred from air photo interpretation. Unit description from source map: TA021

Qb - Beach deposits (Quaternary, Holocene)
Primarily well-round pebbles and cobbles derived from glacial deposits along most lakes. Sandy beaches only common at west end of Iliamna Lake. Cook Inlet shore is mainly bordered by rocky cliffs, though a result of recent uplift. Unit description from source map: IL003

Qb - Beach deposits (Quaternary, Holocene and Pleistocene)
Moderately well-stratified and sorted sand and gravel on beaches. Older elevated beaches. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qes - Estuarine deposits (Quaternary)

Qbm - Beach deposits, Salt marsh (Quaternary, Recent)
Salt- marsh, well-stratified silt and small pebbles, poorly drained. Unit description from source map: SV004

Qt - Turnagain Arm tidal deposits (Quaternary)
Turnagain Arm tidal deposits. Unit description from source map: TY008

Qeo - Older estuarine deposits (Quaternary, Holocene)
Older estuarine deposits, at higher levels than younger deposits, are not subject to tidal activity, but commonly marshy or occupied by numerous lakes. Locally include thin beds of peat, driftwood, and other organic material, and some windblown material. Beach ridges present locally, mainly sand and minor gravel with some driftwood. Thickness a few to few tens of meters. Unit description from source map: TY008

Qes - Estuarine deposits (Quaternary)
Well-sorted, stratified silt and some sand deposited in shallow embayments, supra-tidal, hence probably uplifted. Unit description from source map: KN008

Qsm - Salt marsh deposits (Quaternary, Pleistocene and Holocene)
Salt marsh deposits consist of fine silt containing vegetation layers and peat. Typically lie above water but are inundated when extreme high tides occur during storms. Special variety of estuarine deposits. Unit description from source map: IL003

Qes - Estuarine deposits (Quaternary)
Well-sorted, stratified silt and some sand deposited in shallow embayments, supra-tidal, hence probably uplifted. Separate, more recently uplifted deposits. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qmt - Marine terrace deposits (Quaternary)

Qtm - Marine terrace deposits (Quaternary, Pleistocene and Holocene)
Marine terrace deposits. Unit description from source map: KN008

Qtm - Marine terrace and beach ridge deposits (Quaternary, Pleistocene and Holocene)
Uplift along Cook Inlet has produced terraces containing beach deposits and wave-cut bedrock platforms. Wave-cut platforms are well developed 90 and 50 feet above modern sea level; beach deposits overlie these platforms. Lower and younger beach ridges are found below the 50-foot level. Unit description from source map: IL003

Qtl - Lake terrace and beach ridge deposits (Quaternary, Pleistocene and Holocene)
Prominent lacustrine terraces occur along much of Lake Iliamna. Multiple terraces on the north and west sides of the lake are at 40, 80, 100, and 130 above the present lake level, which is 47 feet. Other less well developed terraces also occur. The 40 and 80-foot terraces are best preserved and most continuous. They are generally 1,000 to 3,000 feet wide but locally as much as 5,000 feet wide. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qm - Glacial deposits, undivided (Quaternary)

Qg - Moraine? (Quaternary)
Glacial deposits. Unit description from source map: LH009

Qg - Glacial Deposits (Holocene and Pleistocene)
Undifferentiated glacial and related deposits. Sand, gravel, and boulders. Includes moraines. Also includes colluvium, talus, landslide debris, alluvium, and local silt. Unit description from source map: LC005

Qd - Glacial deposits -- Undifferentiated glacial drift (Quaternary)
Undifferentiated glacial drift. Unit description from source map: KN008

Qm - Glacial Deposits (Holocene and Pleistocene)
Undifferentiated glacial and related deposits. Sand, gravel, and boulders. Includes moraines. Also includes colluvium, talus, landslide debris, alluvium, and local silt. Unit description from source map: DI013

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qwu - Drift, undivided, Late Wisconsin-age glaciations (Quaternary)

Qgn - Glacial deposits, Naptowne Glaciation (Quaternary)
Moderately weathered moraine along shoreline; heavily spruce and brush covered; Naptowne Glaciation. Unit description from source maps: KN005 and SV004

Qbl - Glacial deposits of the Brooks Lake glaciation (Quaternary)
Loop, recessional, lateral, and medial moraine of the Brooks Lake glaciation. Unit description from source map: LC005

Qm - Late Pleistocene end, lateral, and ground moraine (Quaternary (Late Pleistocene))
Late Pleistocene end, lateral, and ground moraine. Prominent lateral and end moraines shown by line symbol, two letter name designation on ice side of line. Unit description from source map: TY008

Qg - Glacial deposits, Last Glacial Maximum (Quaternary, Late Pleistocene)
Along slopes of major valleys. Unit description from source map: LH007

Qm - Late Pleistocene end, lateral, and ground moraine (Quaternary (Late Pleistocene))
Late Pleistocene end, lateral, and ground moraine. Prominent lateral and end moraines. Unit description from source map: TY007

Qbl - Glacial deposits of the Naptowne glaciation (Quaternary)
Loop, recessional, lateral, and medial moraine and other deposits of the Brooks Lake glaciation. Unit description from source map: KN008

Qbu - Brooks Lake drift, undivided (Quaternary, Pleistocene)
Broadly distributed glacial deposits; generally assigned to individual late Wisconsin advances. Unit description from source map: IL003

Qbg - Brooks Lake drift, ground moraine (Quaternary, Pleistocene)
Deposits that lie immediately behind end moraines in western part of quadrangle, not associated with end moraines in eastern part of quadrangle. consist of unsorted till in the form of irregularly shaped, nondirectional mounds and knobs a few feet to tens of feet high. Most formed under moving ice though some undoubtedly formed by ablation during melting of glaciers. Unit description from source map: IL003

Qbl - Glacial deposits of the Naptowne glaciation - ground moraine? (Quaternary)
Probably ground moraine deposits of the Brooks Lake glaciation. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qlv - Natural levee deposits (Quaternary)

Qlv - Natural levee deposits (Quaternary)
Natural levee deposits on deltaic or fan delta deposits. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qsu - Silt deposits, undifferentiated (Quaternary)

Qp - Peat bog deposits (Quaternary)
Peat bog deposits. May include pond deposits especially in areas of Qm. Unit description from source map: TY008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qsg - Superglacial drift (Quaternary)

Qmi - Moraine on ice (Quaternary)
Superglacial and englacial till on present glaciers. Unit description from source maps: IL007 and LC007

Qsg - Moraine on ice (Quaternary)

Superglacial and englacial till on present glaciers. Unit description from source map: LC005

Qsg - Superglacial drift (Quaternary)
Consists of unsorted boulder to fine-grained debris on the surface of modern glaciers. In the vicinity of Mount Redoubt and Mount Iliamna, may include a significant component of ash and other air-fall debris from eruptions. Unit description from source map: KN008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qek - Esker deposits (Quaternary)

Qek - Esker deposits (Quaternary)
Esker deposits, interpreted from air photos. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qoc - Channeled glacial deposits, kame and kettle (Quaternary)

Qoc - Ground moraine, channeled (Quaternary)
Distinctive surface form subdivided from Weber(1961) unit 13. Thought to emulate her 13f in eastern part of quadrangle. 13f description: Deposit of unsorted, unstratified boulders, pebbles, sand, silt, and a small amount of clay, up to 250 feet thick. Locally, boulders exposed on surface may exceed 5 feet in diameter. Components vary greatly in composition depending on lithologies present in source areas -- granitic rocks volcanic rocks, argillite, chert, limestone, quartz, quartzite, graywacke, slate -- generally the most resistant rocks persist. Many small boulders and pebbles are well-rounded. Till is gray and covered in most places with 2 to 5 feet of reddish clay, silt, and sand. Five to 20 feet of thick veneer of ground moraine deeply cut by channels, the bottom of which contain coarse boulders, gravel, and sand overlying various types of bedrock. Unit description from source map: TY007

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qgme - Ground moraine modified by estuarine water (Quaternary)

Qmm - Ground moraine modified by estuarine water (Quaternary)
Ground moraine modified by estuarine water. Unit description from source map: TY008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qge - Glacio-estuarine deposits (Quaternary)

Qh - Hood Lake deposits (Quaternary)
Hood Lake deposits. Sand, commonly underlain by Bootlegger Cove formation. Unit description from source map: TY008

Qh+stipple - Hood Lake deposits, higher level (Quaternary)
Hood Lake deposits, higher level. Sand, commonly underlain by Bootlegger Cove Formation. Higher level deposits, probably not underlain by Qbc shown by stipple pattern. Unit description from source map: TY008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qbc - Bootlegger Cove Formation (Quaternary)

Qbc - Bootlegger Cove Formation (Quaternary)
Bootlegger Cove Formation. Unit description from source map: TY008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qdl - Deltaic deposits (Quaternary)

Qdl - Deltaic deposits (Quaternary)
Deltaic deposits, including outwash and alluvial deposits. Unit description from source map: KN008

Qdl - Deltaic deposits (Quaternary)
Deltaic deposits, including outwash and alluvial deposits. Unit description from source map: TY007

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qewd - Drumlins associated with early glaciations (Quaternary)

Qmhd - Glacial deposits of the Mak Hill glaciation -- drumlin (Quaternary)
Drumlin deposits, composed chiefly of gravelly till of glaciations preceding the Mak Hill glaciation. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qmi - Illinoian glaciations (Quaternary)

Qum - Unnamed glacial deposits -- moraine (Quaternary)
Loop and recessional moraine, composed chiefly of glacial and glaciofluvial materials. Extensively mantled by colluvium, silt, muck, and peat. Moraine topography, where recognizable is much subdued and modified. Most likely derived from the east. Unit description from source map: TA021

Qim - Glacial deposits of unnamed older glaciation -- moraine (Quaternary)
Loop, recessional, lateral, and medial moraine, composed chiefly of coarse gravel and coarse gravelly till, with silty clay matrix of the Iowithla glaciation Extensively mantled by several feet of silt, muck, and peat, except on knolls and ridges. May be equivalent to Johnson Hill on Alaska Peninsula. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qmio - Outwash older than Wisconsin-age (Quaternary)

Qio - Glacial deposits of unnamed older glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons. May be equivalent to Johnson Hill of the Alaska Peninsula. Unit description from source map: LC005

Quo - Unnamed glacial deposits -- outwash (Quaternary)

Stratified gravel and sand of outwash aprons. Possibly equivalent to Johnson Hill glaciation of Detterman (1986). Unit description from source map: TA021

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qsb - Scoured bedrock (Quaternary)

Qsb - Scoured bedrock (Quaternary)
Glacially scoured bedrock; may be covered with thin glacially derived deposits; air-photo interpretation. Unit description from source map: LC005

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qv - Volcanic rocks, undivided (Quaternary)

Qv - Quaternary volcanic rocks, undivided (Quaternary)
Quaternary volcanic rocks, undivided. Unit description from source map: TY009

Qvc - Volcanic rocks (Quaternary)
"Chick deposits"?. Unit description from source map: TY008

Qv - Volcanic rocks, undivided (Quaternary)
Consists of volcanic rocks and deposits associated with Iliamna, Redoubt, and Double Glacier volcanoes. Typically restricted to immediate vicinity of these volcanic centers, however locally, debris flows and air-fall material may be somewhat distal. Locally subdivided. Unit description from source map: KN008

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qpd - Pyroclastic (ash and debris flow) deposits (Quaternary)

Qjgdt - Johnson Glacier dome tephra deposits (Quaternary)
Dome tephra. Unit description from source map: LC010

Unit compiled into Qv on SIM-3340 (Geologic Map of Alaska).

Qac - Abandoned channel deposits (Quaternary)

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits in outwash above modern floodplains. Air photo interpretation. Unit description from source map: LC005

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits in outwash above modern floodplains. Air photo interpretation. Unit description from source map: LH007

Qo - Outwash in meltwater channels (Quaternary (Later Pleistocene))
Outwash in meltwater channels. Mainly later Pleistocene, within moraines. Unit description from source map: TY008

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits in outwash above modern floodplains. Air photo interpretation. Unit description from source map: KN008

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits in outwash above modern floodplains. Air photo interpretation. Unit description from source map: TY007

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits in outwash above modern floodplains. Air photo interpretation. Unit description from source map: DI013

Qac - Abandoned channel deposits (Quaternary)
Abandoned channel deposits. Unit description from source map: TA021

Qc - Abandoned channel deposits (Quaternary, Pleistocene)
Broad channels incised into moraines of the Brook Lake Glaciation containing stratified and graded deposits of silt, sand, and gravel. Most channel occupied by underfit streams, locally no streams are present. Channels reflect drainage during maximum melting of the glaciers. Position of abandoned channels suggest numerous occurrences of stream piracy as well as shift channels in response to changing base level. Unit description from source map: IL003

Qac - Mak Hill Glaiciation, abandoned channel deposits (Quaternary, Pleistocene)
Mak Hill Glaciation, abandoned channel deposits. Deposits in broad channels incised into ground moraine and originating from a lobe of the end moraine. Channel floor is usually flat where a modern stream is not present; where modern streams are present, they are clearly underfit. Channel range in width from about 200 to 4000 feet. Deposits within are mainly stratified gravel and sand containing lenses of silt; cut and fill structures are common. Top layer commonly silt that may have been carried into the channel from the loess mantle after abandonment. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qglf - Glacial outwash derived fans deposited in ephermeral glacial lakes (Quaternary)

Qglf - Glaciolacustrine fan (Quaternary)
Glacial outwash derived fans deposited in ephemeral glacial lakes. Unit description from source map: LC005

Qdf - Brooks Lake hanging delta and outwash fan deposits (Quaternary, Pleistocene)
Deposits of gravel, sand and silt, these are the result of streams draining into ancestral Lake Iliamna. Typically deltaic and consist of stratified layers of cobbles, pebbles, sand, silt, and glacial lake clay. Mostly associated with outwash of the Kvichak and Iliamna stades. Are at two levels, coarser ones are at the higher level, generally above 200 feet and larger, being 2 to 4 miles long and as wide in a triangular shape. Deltas of lower set are commonly narrow and more linear, up to 4 miles long and and rarely more than 1/4 to 1/2 mile wide; these tend to be 100 to 150 feet in elevation and most sand and silt. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qgl - Glaciolacustrine deposits (Quaternary)

Qgl - Glaciolacustrine deposits (Quaternary)
Ephemeral glacial lake deposits. Well-sorted, well-stratified clay, silt and fine sand deposited in ephemeral preglacial and postglacial lakes. Typically covered by several feet of muck and peat. Air photo interpretation. Unit description from source map: LC005

Qlb - Proglacial lake bottom sediments (Quaternary, Pleistocene)
Proglacial lake bottom sediments underlying terraced and channeled surfaces between major morainal belts in lowland and mountain valleys. Unit description from source map: TY008

Qglf - Glaciolacustrine deposits (Quaternary)
Ephemeral glacial lake deposits. Well-sorted, well-stratified clay, silt, and fine sand deposited in ephemeral glacial and postglacial lakes. Thought to be typically covered by several feet of muck and peat. Unit description from source map: KN008

Qgl - Glaciolacustrine deposits (Quaternary)
Well-sorted, well-stratified clay, silt and fine sand deposited in ephemeral preglacial and postglacial lakes. Typically covered by several feet of muck and peat. Air photo interpretation. Unit description from source map: IL013

Qgl - Glaciolacustrine deposits (Quaternary)
Ephemeral glacial lake deposits. Well-sorted, well-stratified clay, silt and fine sand deposited in ephemeral preglacial and postglacial lakes. Typically covered by several feet of muck and peat. Air photo interpretation. Unit description from source maps: TA021 and LC005

Qgl - Proglacial lake deposits (Quaternary, Pleistocene)
These deposits are almost entirely silt- and clay-size, though locally sand and pebbles occur near ground moraine exposures. Silt and clay is light-gray to tan, locally laminated and as much as 20-50 feet thick. Upper layers are rich in organic material. Lenses of interstitial ice are present and relict permafrost (Periglacial) features are common. Proglacial lake deposits have a characteristic topographic expression, nearly flat and covered by myriad small ponds, remnants of larger ponds and the intervening areas covered by quaking bogs. Unit description from source map: IL003

Ql - Lacustrine deposits (Quaternary, Pleistocene)
Main area of deposition was in glacial Lake Iliamna below highest terrace level. Consist of silt and clay and a few interbeds of coarse sand and gravel. Poorly drained and swampy with common organic layers. Probably formed in a periglacial environment and consist mainly of glacially transported material, although some fluvial deposits are incorporated. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qwr - Glacial deposits, latest Wisconsin, Iliuk, Riley Creek, and other glaciations (Quaternary)

Qw4 - Brooks Lake drift, Iliuk Stade (Quaternary, Pleistocene)
Brooks Lake drift, Iliuk Stade. Unit description from source map: LC005

12 - End moraine, undifferentiated (Quaternary)
Heterogeneous deposit of unstratified, well-graded sediments composed of varying percentages of clay, silt, sand, pebbles, and boulders, locally covered with a layer of peat or silty peat up to 2 feet thick. Unit description from source map: TY016

Qw4 - Brooks Lake drift, Iliuk Stade (Quaternary, Pleistocene)

Brooks Lake drift, Iliuk Stade. Unit description from source map: KN008

Qw4g - Brooks Lake drift, Iliuk Stade (Quaternary, Pleistocene)
Brooks Lake drift, Iliuk Stade, ground moraine. Unit description from source map: LC005

Qbi - Brooks Lake drift, Iliuk Stade (Quaternary, Pleistocene)
Little modified, showing fresh knob-and-kettle topography. Contains a less heterogeneous assemblage of rock types than older moraines, indicating localized sources. Ice-polished and striated erratics are common on surface of the moraines. Well-preserved lobate end moraines can be followed for many miles; recessional moraines are less preserved, being partially covered by glaciofluvial deposits. Kettle ponds are for most part undrained and retain the irregular shapes left by melting ice blocks. Vegetational cover varies widely, but is not a criteria for determining age of a moraines; it is more a function of climatic zones. Some of the youngest moraines are locally heavily forested, whereas the oldest moraines at comparable elevations may be only tundra covered. These end moraines extend no more than 10 to 20 miles beyond their source cirques, yet are about the same distance behind Newhalen end moraines. Many cirques have been little modified by Holocene glaciations; locally one recessional moraine is mapped; others may have been covered by Holocene readvances. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qw2 - Late Wisconsin, Newhalen and other till (Quaternary)

Qmw-4 or Qgt-6 - Till of Middle Farewell II Glaciation (Quaternary)
Unsorted to poorly sorted, clay, silt, sand, gravel and diamicton deposited by glacial ice. Abundant erratics are polyhedral, striated, and subrounded, relatively fresh granitic boulders up to 6.5 feet (2.0 m) in diameter derived from 1) the Revelation Batholith; 2) Tired Pup, two-mica Pluton (southern edge of Revelation Mountains, and 3) hornblende rich tonalite which are collectively granitic types making up the core of the Alaska Aleutian Range Batholith. Prominent moraines are not dissected by small second and third order streams, but cut by the Swift, Stony, and Big Rivers. Irregular craggy Moraines contain from 7-15 kettles per km2. In Big River, the terminal ice position is marked by a prominent granitic boulder field in a restricted 4-mile-long canyon, about 8 miles (12 km) below the confluence of Lyman Fork and Big River. Distinctive lateral moraines ranging from 1,600 to 2,400 feet (490670 m) in elevation mark Qmw-4 moraines in the valleys of Stony, Swift, and Big Rivers as they break out onto the piedmont west of the mountain front. A large pro-glacial lake deposit (Qgl), is damned up behind Qmw-4 moraines in the valley of Stony River; the 1214 mile long (19-22 km), ancestral lake is centered on the mouth of the Telequana River where it enters Stoney River. Bundtzen and others (1994) show Qmw-4 deposits in Lime Hills C-5 quadrangle as Qgt-2 deposits of Late Wisconsin age. Qmw-4 deposits are probably equivalent to either the Newhalen or Iliuk stades of the Brooks Lake Glaciation as defined by Detterman (1986). Qmw-4 is also equivalent to the terminal ice position that damned up glacial Lake Telequana in Lake Clark Quadrangle (unit Qw3 of Wilson, 2004, unpublished). Unit description from source map: TY013

Qbln - Brooks Lake, Newhalen moraine (Quaternary, Pleistocene)
End moraine of the Newhalen advance of the Brooks Lake glaciation. Unit description from source map: LC005

Qbln - Brooks Lake, Newhalen moraine (Quaternary, Pleistocene)
End moraine of the Newhalen advance of the Brooks Lake glaciation. Unit description from source map: KN008

Qbln - Brooks Lake, Newhalen moraine (Quaternary, Pleistocene)
Ground moraine of the Newhalen advance of the Brooks Lake glaciation. Unit description from source map: LC005

Qbn - Brooks Lake drift, Newhalen Stade (Quaternary, Pleistocene)
Little modified, showing fresh knob-and-kettle topography. Contains a less heterogeneous assemblage of rock types than older moraines, indicating localized sources. Ice-polished and striated erratics are common on surface of the moraines. Well-preserved lobate end moraines can be followed for many miles; recessional moraines are less preserved, being partially covered by glaciofluvial deposits. Kettle ponds are for most part undrained and retain the irregular shapes left by melting ice blocks. Some of the youngest moraines are locally heavily forested, whereas the oldest moraines at comparable elevations may be only tundra covered. Apparently a large gap in time occurred between the older Iliamna stade and the Newhalen advance. The Newhalen advance was an alpine advance where for the most part, individual glaciers did not coalesce. The alpine glaciers extended no more than 20 to 30 miles from their source areas; at least 3 recessional moraines have been identified, best developed along Lower Tazimina Lake in the north and Moraine Creek in the south. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qw1 - Late Wisconsin, Iliamna and other till (Quaternary)

Qblil - Brooks Lake, Iliamna moraine (Quaternary, Pleistocene)
End moraine of the Iliamna advance of the Brooks Lake glaciation. Unit description from source map: LC005 and KN008

Qblil - Brooks Lake, Iliamna moraine (Quaternary, Pleistocene)
Ground moraine of the Iliamna advance of the Brooks Lake glaciation. Unit description from source map: LC005

Qbil - Brooks Lake drift, Iliamna Stade (Quaternary, Pleistocene)
Little modified, showing fresher knob-and-kettle topography than Kvichak moraines. Contains a heterogeneous assemblage of rock types indicating multiple sources of tributary glaciers. Ice-polished and striated erratics are common on surface of the moraines. Well-preserved lobate end moraines can be followed for many miles; recessional moraines are less preserved, being partially covered by glaciofluvial deposits. Kettle ponds are for most part undrained and retain the irregular shapes left by melting ice blocks, locally loess and vegetation are infilling the kettles. Some of the youngest moraines are locally heavily forested, whereas the oldest moraines at comparable elevations may be only tundra covered. These end moraines lie 20 to 60 miles beyond the Newhalen end moraines and a complex system of recessional moraines indicate at least three major stillstands. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qw0 - Till, Brooks Lake, Kvichak (Quaternary)

Qg - Glacial deposits (Quaternary)
Glacial drift deposited during the last three glacial advances. Sand, gravel, and boulders. Includes moraines. Also includes colluvium, talus, landslide debris, alluvium, and local silt. Unit description from source map: TA002

Qblk - Brooks Lake, Kvichak moraine (Quaternary, Pleistocene)
End moraine of the Kvichak advance of the Brooks Lake. Unit description from source maps: LC005 and TA021

Qblk - Brooks Lake, Kvichak moraine (Quaternary, Pleistocene)
Type end moraine of the Kvichak advance of the Brooks Lake. Unit description from source map:

DI013

Qblk - Brooks Lake, Kvichak ground moraine (Quaternary, Pleistocene)
Ground moraine of the Kvichak advance of the Brooks Lake. Unit description from source maps: DI013 and LC005

Qbk - Brooks Lake drift, Kvichak Stade (Quaternary, Pleistocene)
Little modified, showing relatively fresh knob-and-kettle topography. Contains a heterogeneous assemblage of rock types indicating multiple sources of tributary glaciers. Ice-polished and striated erratics are common on surface of the moraines. Well-preserved lobate end moraines can be followed for many miles; recessional moraines are less preserved, being partially covered by glaciofluvial deposits. Kettle ponds are for most part undrained and retain the irregular shapes left by melting ice blocks, locally loess and vegetation are infilling the kettles. Some of the youngest moraines are locally heavily forested, whereas the oldest moraines at comparable elevations may be only tundra covered. Kvichak moraines are 5 to 20 beyond those of the Iliamna stade and 200 to 400 higher in elevation. Generally only one prominent end moraine though in the headwaters region of the Koktuli River, a complex system of recessional moraines is present. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qwo - Outwash deposits, late Wisconsin-age glaciations (Quaternary)

Qbo - Glacial deposits of the Brooks Lake glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons and plains of the Brooks Lake glaciation. Unit description from source map: TA002

Qao - Outwash? (Quaternary)
Outwash?. Unit description from source map: LH009 and TY007

Qblo - Glacial deposits of the Brooks Lake glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons and plains of the Brooks Lake glaciation. Unit description from source map: LC005

Qaf - Alluvial fans and outwash plains (Quaternary (Latest Pleistocene))
Alluvial fans and outwash plains. Mainly external to moraines. Unit description from source map: TY008

Qblo - Outwash, Brooks Lake glaciation, undivided (Quaternary, Pleistocene)
Outwash, Brooks Lake glaciation, undivided. Unit description from source map: KN008

Qblo - Glacial deposits of the Brooks Lake glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons and plains of the Brooks Lake glaciation. Unit description from source map: DI013 and TA021

Qbloo - Glacial deposits of the Brooks Lake glaciation -- older outwash (Quaternary)
Older stratified gravel and sand of outwash aprons and plains of the Brooks Lake glaciation. Unit description from source map: LC005

Qbo - Brooks Lake outwash plains, kame terrace and pitted outwash deposits (Quaternary, Pleistocene)
Glaciofluvial deposits bordering moraine fronts of the Kvichak and Iliamna advances, commonly 1.5 to 2 miles wide and many miles long. Thought to be so extensive because of protracted stillstands of the glacial advances.Deposits form great plains, dipping 25 to 50 feet per miles and showing shallow braided channels scars due to rapidly shifting streams. Pitted outwash border the moraines where outwash cover ice blocks and ultimately melted out, leaving depressions as much as 50 feet deep. At

west end of Iliamna lake, outwash is 65 feet thick, composed of alternating layers of silt and gravel and containing lenses of cobbles. A well-developed kame terrace extends along south side of Kvichak moraine west from Kukaklek Lake. It is 300 to 800 feet wide and the inner (ice) margin is a scrap 25-50 feet high. Outwash locally mantles morainal deposits of the Mak Hill and older Brooks Lake advances. Unit description from source map: IL003

Qbm - Brooks Lake terraced and modified morainal deposits (Quaternary, Pleistocene)
Brooks Lake terraced and modified morainal deposits. Originally deposited as ground moraine, but subsequently modified by streams emerging from later glaciers. In many places, deposits are adjacent to outwash plains or hanging deltas and may be partially covered by these deposits. A thin layer of loess, derived from braided stream channels in front of glaciers overlies the deposit. Terraces created by runoff streams issuing from glaciers. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qew - Glaciations older than Late Wisconsin (Quaternary)

Qmh - Glacial deposits of the Mak Hill glaciation -- moraine (Quaternary)
Loop, recessional, lateral, and medial moraine, composed chiefly of gravelly till of the Mak Hill glaciation. Unit description from source map: LC005 and DI013

Qmo - Older moraine deposits (Quaternary)
Older moraine deposits. Areas of mainly bedrock rubble with scattered erratics. Unit description from source map: TY008

Qew - Glacial deposits of the Mak Hill glaciation -- moraine (Quaternary)
Loop, recessional, lateral, and medial moraine, composed chiefly of gravelly till of the Mak Hill glaciation. Unit description from source map: TA021

Qmu - Mak Hill Glaiciation, drfit, undivided (Quaternary, Pleistocene)
Mak Hill Glaciation, drift, undivided. Unit description from source map: IL003

Qmk - Mak Hill Glaiciation, Kulakeklek Stade, drfit, moraine of Kukaklek Lake (Quaternary, Pleistocene)
Mak Hill Glaciation, drift, moraine of Kukaklek Lake. Considerably modified and subdue, but locally lobate. Kettle basins mainly drained or filled. Surface drainage moderately integrated, but stream valley contain sluggish, meandering, underfit streams. Generally, swampy and poorly drained. A thin loess cover blankets deposits. Silt and clay-size material abundant. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qmhg - Early Wisconsin (Mak Hill and Iowithla) ground moraine (Quaternary)

Qmhg - Glacial deposits of the Mak Hill glaciation -- ground moraine (Quaternary)
Ground moraine, includes some organic and lacustrine material, of the Mak Hill glaciation. Unit description from source maps: LC005 and DI013

Qmg - Glacial deposits of the Mak Hill glaciation -- ground moraine (Quaternary)
Ground moraine, includes some organic and lacustrine material, of the Mak Hill glaciation -- air photo interpretation. Unit description from source map: TA021
Qkg - Mak Hill Glaiciation, Kulakeklek Stade, drfit, ground moraine (Quaternary, Pleistocene)
Mak Hill Glaciation, drift, ground moraine. Along Stuyahok River, only unmodified remnants of

formerly extensive deposits. Unsorted nature indicates they were formed under a moving glacier. Unit description from source map: IL003

Qkm - Mak Hill Glaiciation, Kulakeklek Stade, terraced and modified morainal deposits (Quaternary, Pleistocene)
Mak Hill Glaciation, terraced and modified morainal deposits. Found several miles behind moraine front; most probably deposited as ground moraine, subsequently modified by meltwaters from later Brooks Lake glaciation and by loess deposition. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qow - Older Wisconsin age outwash (Quaternary)

Qmo - Glacial deposits of the Mak Hill glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons and plains of the Mak Hill glaciation. Unit description from source maps: LC005 and DI013

Qewo - Glacial deposits of the Mak Hill glaciation -- outwash (Quaternary)
Stratified gravel and sand of outwash aprons and plains of the Mak Hill glaciation. Unit description from source map: TA021

Qko - Mak Hill Glaiciation, Kulakeklek Stade, outwash deposits (Quaternary, Pleistocene)
Gently sloping plain graded to end moraine of Kulakeklek stade. Mass wasting and loess obliterate anastomosing stream pattern and pitted surface of younger outwash. Consists largely of gravel and minor silt and sand. Unit description from source map: IL003

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

Qanp - Andesite plug domes (Quaternary)

Qv - Quaternary volcanic rocks (Quaternary, Pleistocene)
Composite dome complex consisting of medium- to coarsely porphyritic hornblende andesite and dacite. Unit description from source map: KN009

Qjgd - Johnson Glacier dome complex (Quaternary)
Dome complex. Unit description from source map: LC010

Unit compiled into QTi on SIM-3340 (Geologic Map of Alaska).

QTod - Deposits related to but peripheral to older glaciations (Quaternary or late Tertiary, Pliocene)

Qkd - Kaloa deposits (Quaternary or late Tertiary, Pliocene)
Kaloa deposits. Unit description from source map: TY008

Unit compiled into Qs on SIM-3340 (Geologic Map of Alaska).

QTi - Intrusive rocks (Quaternary and Tertiary)

QTi - Basaltic andesite porphyry dikes and sills (Quaternary and Tertiary)
Basaltic andesite porphyry dikes and sills. Unit description from source map: IL007

Unit compiled into QTi on SIM-3340 (Geologic Map of Alaska).

QTv - Quaternary and/or Tertiary volcanic rocks, undifferentiated (Pleistocene or Pliocene)

QTv - Volcanic rocks, undivided (Pleistocene or Pliocene)
Scoriaceous olivine basalt on Seven Sisters and possibly andesite at West Glacier Creek. Unit description from source map: IL002

Unit compiled into QTv on SIM-3340 (Geologic Map of Alaska).

Tib - Intricate Basalt (Tertiary)

Tib - Intricate Basalt (Tertiary -- Pliocene)
Glassy to porphyritic black to dark-green olivine-augite basalt, largely in the vicinity of Intricate Bay, but also occurs south of Gibraltar Lake. Unit description from source map: IL002

Unit compiled into Tpv on SIM-3340 (Geologic Map of Alaska).

Tsu - Sedimentary rocks, undivided (Pliocene or Miocene)

Ts - Sedimentary rocks, undivbided (Pliocene or Miocene)
Mainly light- to medium-gray and light-tan, fine- to medium-grained tuffaceous feldspathic to arkosic wacke and siltstone containing scattered pebbles and lenticular beds of pebble conglomerate. Micaceous clay and silt having moderately abundant glass shards constitutes 40 to 60 percent of this moderately indurated rock unit. Rock and pumice fragments as well as a few volcanic bombs were reported from the wackes. Unit description from source map: IL002

Unit compiled into Tsu on SIM-3340 (Geologic Map of Alaska).

Tvu - Tertiary volcanic rocks, undivided (Tertiary, late? to middle)

Tf - Lava flows (Tertiary, middle to late?)
Andesitic to basaltic lavas and associated pyroclastic rocks. Unit description from source maps: IL007 and KN005

Tv - Volcanic(?) rocks (Tertiary(?))
Volcanic rocks based on photo correlation with areas of known volcanic rocks. Unit description from source map: DI005

Unit compiled into Tvu on SIM-3340 (Geologic Map of Alaska).

Tsf - Kenai Group, Sterling Formation (Tertiary)

Tks - Tertiary, Kenai Group, Sterling Formation (Tertiary)
Sterling Formation. Unit description from source map: TY009

Unit compiled into Tkn on SIM-3340 (Geologic Map of Alaska).

Tkb - Kenai Group, Beluga Formation (Tertiary)

Tkb - Beluga Formation (Tertiary)
Unit taken from Magoon?. Unit description from source map: TY008

Unit compiled into Tkn on SIM-3340 (Geologic Map of Alaska).

Tty - Kenai Group, Tyonek Formation (Tertiary)

Tty - Tyonek Formation (Tertiary)
No additional description present on source map. Unit present on source map: TY009

Tty? - Tyonek Formation? (Tertiary)
Tyonek Formation?. Unit description from source map: TY009

Tkt - Tyonek Formation (Tertiary)
Unit taken from Magoon?. Unit description from source map: TY008

Unit compiled into Tkn on SIM-3340 (Geologic Map of Alaska).

Ta - Andesite (Tertiary)

Tvf - Mafic to intermediate flows (Tertiary)
Mafic to intermediate flows of unit Tv where they constitute separate mappable entities. Unit split into flows likely to be part of the Meshik Arc and assigned an NSACLASS of 1082 and the less certain age unit which are assigned NSACLASS of 1003. Unit description from source maps: LC002 and LC005

Unit compiled into Tvu on SIM-3340 (Geologic Map of Alaska).

Thf - Hypabyssal felsic and intermediate intrusions (Tertiary)

Tai - Tertiary andesitic intrusive (Tertiary)
No additional description present on source map. Unit present on source map: TY009

Tif - Felsic dikes (Tertiary)
Undeformed felsic dikes which in some cases can be traced for several kilometers. Generally light gray, commonly orange-weathering, fine-grained to aphanitic. Unit present on source map: TY004

Unit compiled into Thi on SIM-3340 (Geologic Map of Alaska).

Tgr - Granite (Tertiary)

Ti13 - Tertiary intrusive rocks -- Unit 13 Granite (Tertiary)
Multiphase, hypabyssal leucocratic grayish-pink biotite granite. Unit description from source map: LC002

Ti18 - Tertiary intrusive rocks -- Unit 18 Granite (Tertiary)
Small area of fractured biotite granite containing as much as 40 percent potassium-feldspar. Unit description from source map: LC002

Ti19 - Tertiary intrusive rocks -- Unit 19 Aplite (Tertiary)
Light-gray, fine-grained xenomorphic granular aplite stock. Younger than Ti -- unit 17. Unit description from source map: LC002

Unit compiled into Tgw on SIM-3340 (Geologic Map of Alaska).

Tgd - Granodiorite, undivided (Tertiary)

Ti - Intrusive rocks (Tertiary)
Fine- to medium-grained granodiorite and quartz diorite, includes volcanic necks, sills, and dikes. Unit description from source map: IL002

Unit compiled into Tod on SIM-3340 (Geologic Map of Alaska).

Toqd - Quartz diorite and diorite (Tertiary)

Ti6 - Tertiary intrusive rocks -- Unit 6 Quartz monzodiorite (Tertiary)
Small irregular body of quartz monzodiorite cutting metamorphic rocks and containing abundant mafic inclusions. Unit description from source map: LC002

Ti14 - Tertiary intrusive rocks -- Unit 14 Quartz monzodiorite (Tertiary)
Heterogeneous, intensely sheared and locally altered medium- to fine-grained rocks ranging from tonalite to monzodiorite. Intruded by Ti unit 13 and intrudes Mesozoic metavolcanic rocks. Unit description from source map: LC002

Ti15 - Tertiary intrusive rocks -- Unit 15 Tonalite (Tertiary)
Compositionally variable medium-grained, slightly foliated tonalite and quartz diorite. Unit description from source map: LC002

Unit compiled into Tod on SIM-3340 (Geologic Map of Alaska).

Tpgr - Peralkaline granite (Tertiary)

Ti3 - Tertiary intrusive rocks -- Unit 3 Peralkaline granite (Tertiary)
Mostly medium-grained hypidiomorphic granular granite containing subhedral to euhedral perthite. Only peralkaline granite associated with Alaska-Aleutian Range batholith and probably not related to calc-alkaline rocks of the batholith. Unit description from source map: LC002

Unit compiled into Tpg on SIM-3340 (Geologic Map of Alaska).

Tap - Andesite plug dome (Tertiary?)

Ta - Andesite plug (Tertiary(?))
Small andesite plug intruding hornfelsed siltstone. Contact metamorphism is not associated with andesite plug. Also includes isolated andesite plug in southeast corner of D-1 quadrangle. Unit description from source map: DI005

Unit compiled into Tvm on SIM-3340 (Geologic Map of Alaska).

Trd - Rhyolitic and dacitic tuff (Tertiary?)

Tv3 - Seabee volcanic rocks (Tertiary)
Predominantly crystal and crystal-lithic ash-flow tuff and lesser interbedded lava flows and local volcaniclastic sedimentary rocks. Unit description from source map: LH002

Tv5 - A-2 volcanic rocks (Tertiary?)
Chiefly crystal-lithic tuff and lesser volcaniclastic rocks, lava flows, and lahar/debris flows. Unit description from source map: LH002

Tv4 - Snowcap volcanic rocks (Tertiary)
Chiefly crystal-lithic ash-flow tuff and lesser interbedded lava flows and local volcaniclastic sedimentary rocks. Unit description from source map: LH002

Tv1 - North volcanic center (Tertiary?)
Chiefly crystal-rich ash-flow tuff and lesser lithic-crystal ash-flow tuff and lava flows. Two lahar deposits have been included in unit as well as a small hypabyssal porphyritic intrusion. Lithic fragments in tuff are graywacke and argillite derived from Kahiltna terrane. Unit description from source map: LH002

Tv2 - Styx River Volcanics (Tertiary?)
Chiefly crystal-lithic ash-flow tuff and subordinate lava flows and local volcaniclastic rocks south of Jimmy Lake Pass. Lithic fragments in tuff are chiefly volcanic and sedimentary rock fragments. Sedimentary rock fragments are graywacke and siltstone derived from Kahiltna terrane. Unit description from source map: LH002

Unit compiled into Tev on SIM-3340 (Geologic Map of Alaska).

Ttyh - Kenai Group, Tyonek Formation and Hemlock Conglomerate (undivided) (Miocene and Oligocene)

Tkth - Tyonek Formation and Hemlock Conglomerate (undivided) (Tertiary, Miocene and Oligocene)
Sandstone, conglomerate, and siltstone. Unit description from source map: KN002

Unit compiled into Tkn on SIM-3340 (Geologic Map of Alaska).

Twf - West Foreland Formation (Tertiary)

Twf - West Foreland Formation (Tertiary)
West Foreland Formation. Unit description from source map: TY009

Tk - Kenai Formation (Tertiary, Miocene and Oligocene(?))
Tan to light-yellow-brown conglomerate, sandstone, and laminated siltstone; few thin coal beds. Unit description from source map: SV004

Twf - West Foreland Formation (Tertiary)
Unit taken from Magoon?. Unit description from source map: TY008

Twf? - West Foreland Formation (Tertiary, Eocene and Paleocene)
Conglomerate, sandstone, and siltstone; mostly tuffaceous, inferred from air photos, covered by thin glacial deposits. Unit description from source map: KN008

Twf - West Foreland Formation (Tertiary, Eocene and Paleocene)
Conglomerate, sandstone, and siltstone; mostly tuffaceous. Unit description from source map: KN002

Unit compiled into Ttk on SIM-3340 (Geologic Map of Alaska).

Togr - Granitic rocks (middle Tertiary)

Tnep - Northeast Prong, Tired Pup pluton (middle Tertiary)
Large fine- to coarse-grained seriate, biotite or biotite-amphibole granite pluton. Unit description from source map: LH002

Unit compiled into Togr on SIM-3340 (Geologic Map of Alaska).

Tpag - Peralkaline granite and related rocks ((middle) Tertiary)

Twf - Windy Fork pluton (middle Tertiary)
Peralkaline granite in two distinct phases, an alkali feldspar granite and granite. Overlaps into McGrath quadrangle. Anomalous U and Th near northern margin of pluton. Unit description from source map: LH002

TKqc - Quartz Crystal pluton (middle Tertiary?)
Fine- to medium-grained, seriate, peralkaline granite to alkali feldspar granite. Unit description from source map: LH002

Tbr - Big River pluton, McKinley sequence(?) granites (Tertiary?)
"Medium- to coarse-grained, seriate, biotite granite. CI, 3-8. Similar to, and possibly apophysis of, the 56.7 to 58.69 Ma Tired Pup pluton (Ttp) that is exposed about 1.25 km to south. Unit description from source map: LH012"

Unit compiled into Tgw on SIM-3340 (Geologic Map of Alaska).

Toem - Granodiorite to tonalite ((middle) Tertiary)

Tmpg - Merrill Pass intermediate phases (middle Tertiary?)
Highly variable intrusions spatially associated with Merrill Pass pluton. Ranges from quartz diorite to granite, northern samples typically granodiorite and granite. Larger plutonic bodies exposed in south. Unit description from source map: LH002

Ttg - Telequana Pass pluton (middle Tertiary)
Medium- to coarse-grained, seriate, biotite-hornblende granodiorite having a hypidiomorphic-granular texture. Originally mapped as part of Merrill Pass pluton, separated because of higher color index and presence of hornblende. Unit description from source map: LH002

Ti16 - Tertiary intrusive rocks -- Unit 16 Granodiorite (Tertiary)
Medium-gray, medium-grained hypidiomorphic-granular biotite-hornblende granodiorite. According to Reed and Lanphere, is part of Merrill Pass sequence. Biotite granite and biotite-hornblende granite

and granodiorite. Possibly two population, uniformly grayish-white, coarse-grained biotite granite containing light-pink perthite phenocrysts north of Township 9 N. In T. 9 N and south, rocks are less uniform and include two medium- to fine-grained phases of biotite-hornblende granite and granodiorite. Unit description from source map: LC002

Tmr - Mount Rich pluton (Tertiary)
Fine- to medium-grained, seriate granodiorite to tonalite. Presumably intrudes stock of McKinley sequence granite. Contains subordinate phase is fine- to medium-grained granite. Unit description from source map: LH002

Tsr - Stony River granodiorite (middle Tertiary)
Fine- to medium-grained, seriate, hypidiomorphic granular granodiorite to quartz monzodiorite. Unit description from source map: LH002

Unit compiled into Toegr on SIM-3340 (Geologic Map of Alaska).

Tegr - Tertiary granite and granodiorite ((middle) Tertiary)

Tmp - Merrill Pass pluton (middle Tertiary)
Elongate pluton that is chiefly biotite- or biotite-hornblende granite. Unit description from source map: LH002

Ti4 - Tertiary intrusive rocks -- Unit 4 Granodiorite (Tertiary)
Medium- to coarse-grained biotite-hornblende granodiorite. Unit description from source map: LC002

Ti12 - Tertiary intrusive rocks -- Unit 12 Granite and granodiorite (Tertiary)
North of Currant Creek, consist of grayish-white coarse-grained biotite granite; south of Currant Creek consist of medium- to coarse-grained granodiorite. Unit description from source map: LC002

Ti17 - Tertiary intrusive rocks -- Unit 17 Granite (Tertiary)
Biotite granite and biotite-hornblende granite and granodiorite. Possibly two populations, uniformly grayish-white, coarse-grained biotite granite containing light-pink perthite phenocrysts north of Township 9 N. In T. 9 N and southward, rocks are less uniform and include two medium- to fine-grained phases of biotite-hornblende granite and granodiorite. Unit description from source map: LC002

Tt - Tlikakila pluton (Tertiary)
Small pluton having two phases, quartz diorite and granodiorite. Quartz diorite is fine- to medium-grained, seriate. Granodiorite is fine- to medium-grained, subequigranular. Unit description from source map: LH002

Ti17 - Tertiary intrusive rocks -- Unit 17 Granite (Tertiary)
Biotite granite and biotite-hornblende granite and granodiorite. Possibly two populations, uniformly grayish-white, coarse-grained biotite granite containing light-pink perthite phenocrysts north of Township 9 N. In T. 9 N and southward, rocks are less uniform and include two medium- to fine-grained phases of biotite-hornblende granite and granodiorite. Glacially scoured, added from airphotos. Unit description from source map: LC005

Unit compiled into Toegr on SIM-3340 (Geologic Map of Alaska).

Tvr - Crystal and crystal-lithic ash-flow tuff ((early) Tertiary, (Oligocene and older?, Eocene))

Tvt - Volcanic rocks, undivided, tuff (Tertiary, Oligocene and older?)
Gray, green, and purple bedded lithic, crystal, and vitric tuff; light-gray to tan welded crystal and lithic tuff most common. Unit description from source map: IL002

Tev - Tertiary, Eocene volcanic rocks (Tertiary (Eocene))
No additional description present on source map. Unit present on source map: TY009

Toa? - Tertiary, Oligocene andesite (Tertiary (Oligocene))
No additional description present on source map. Unit present on source map: TY009

Tft - Felsic volcanic rocks, tuff(?) (Early Tertiary)
Cream to light-gray to green layered volcanic rocks. Layering suggests rocks are tuffaceous. Unit description from source map: DI005

Tvt - Volcanic rocks (Tertiary)
Rhyolitic breccia, ash-flow tuff, and flows. Cream, light-gray, green, and purple bedded lithic, crystal, and vitric tuff; light-gray to tan welded crystal and lithic tuff most common. Unit description from source map: LC005

Unit compiled into Tev on SIM-3340 (Geologic Map of Alaska).

Tvba - Meshik Volcanics (Tertiary (Oligocene and older?))

Tv - Volcanic rocks (Tertiary)
Rhyolitic breccia, ash-flow tuff, flows, and intrusive rocks and subordinate mafic and intermediate flows. Unit is thought to encompass entire Tertiary and may include Jurassic rocks of the Talkeetna Formation. Unit description from source map: LC002

Tv - Volcanic rocks, undivided (Tertiary, Oligocene and older?)
Includes basalt, andesite, tuff, volcanic rubble, and breccia. Unit description from source map: IL002

Tv - Volcanic rocks (Tertiary)
Undifferentiated volcanic mafic and felsic flows, tuff flow breccias. Interpreted from air photos. Unit description from source map: LC005

Tv - Volcanic rocks (Tertiary)
Rhyolitic breccia, ash-flow tuff, flows, and intrusive rocks and subordinate mafic and intermediate flows. Unit is thought to encompass entire Tertiary and may include Jurassic rocks of the Talkeetna Fm. Interpreted from airphotos. Unit description from source map: LC005

Tf - Felsic porphyry (Tertiary)
Felsic porphyry. Unit description from source map: TA015

Tvba - Volcanic rocks, undivided, basalt and andesite (Tertiary, Oligocene and older?)
Dark-gray to green glassy to porphyritic basaltic andesite and andesite lava flows. Locally, basalt, dacite, and rhyolite are common. Many of the rocks are associated with eruptive centers. Unit inferred from adjacent Iliamna quadrangle geologic map. Unit description from source map: DI005

Unit compiled into Tmv on SIM-3340 (Geologic Map of Alaska).

Tvb - Basaltic lavas of the Meshik volcanic arc (Tertiary (Oligocene and older?))

Tvf - Mafic to intermediate flows (Tertiary)
Mafic to intermediate flows of unit Tv where they constitute separate mappable entities. Unit split into flows likely to be part of the Meshik Arc and assigned an NSACLASS of 1082 and the less certain age unit which are assigned NSACLASS of 1003. Unit description from source map: LC002

Tvba - Volcanic rocks, undivided, basalt and andesite (Tertiary, Oligocene and older?)
Dark-gray to green glassy to porphyritic basaltic andesite and andesite lava flows. Locally, basalt, dacite, and rhyolite are common. Many of the rocks are associated with eruptive centers. Unit description from source map: IL002

Tvf - Mafic to intermediate flows (Tertiary)
Mafic to intermediate flows of unit Tv where they constitute separate mappable entities. Unit split into flows likely to be part of the Meshik Arc and assigned an NSACLASS of 1082 and the less certain age unit which are assigned NSACLASS of 1003. Inferred from air photos. Unit description from source map: LC005

Unit compiled into Tmv on SIM-3340 (Geologic Map of Alaska).

Tvc - Block and ash deposits (Tertiary, Oligocene and older?)

Tvr - Volcanic rocks, undivided, volcanic rubble and breccia (Tertiary, Oligocene and older?)
Volcanic rubble and breccia, including some agglomerate; may include deposits of lahars. Unit description from source map: IL002

Unit compiled into Tmv on SIM-3340 (Geologic Map of Alaska).

Tvs - Volcanic and sedimentary rocks, undivided (Tertiary, Eocene or younger)

Tevs - Volcaniclastic sedimentary rocks (Tertiary, Eocene or younger)
Light green to gray bedded volcaniclastic sedimentary rocks, with some beds containing volcanic breccia clasts. Volcanic rock clasts have light greenish color. LA-ICPMS detrital zircon dates from this unit have youngest grain ages of 55-58 Ma (Paul O'Sullivan, Apatite to Zircon, written commun., 2007). Unit description from source map: TY009

Unit compiled into Tvs on SIM-3340 (Geologic Map of Alaska).

Tcl - Copper Lake Formation (Eocene and Paleocene (?))

Tclu - Copper Lake Formation -- Upper conglomerate member (Eocene and Paleocene(?))
Red-weathering pebble-cobble conglomerate consisting mainly of volcanic rock clasts and containing minor tuff. Unit may be agglomerate rather than conglomerate; ranges from 50 to 100 percent fresh-appearing volcanic rock. Quartzite, schist, greenstone, rose quartz, limestone, and granitic clasts are present in lower parts of member. Nonmarine unit. Unit description from source map: IL002

Tcls - Copper Lake Formation -- Sandstone and siltstone member (Eocene and Paleocene(?))
Sandy facies is chiefly fine- to medium-grained medium- to greenish-gray, lithic graywacke containing locally abundant tuffaceous and carbonaceous material. Fragments include abundant quartz, schist,

volcanic, and granitic rock fragments. Interbedded siltstone is similar in color and composition to the sandy facies whereas claystone interbeds are mainly micaceous clay containing a small amount of montmorillonite. Nonmarine unit?. Unit description from source map: IL002

Tcll - Copper Lake Formation -- Lower conglomerate member (Eocene and Paleocene(?))
Red-weathering pebble-cobble conglomerate consisting mainly of volcanic rock clasts and containing minor tuff. Volcanic clasts constitute about 25 percent and appear to be derived for the Talkeetna Formation and not fresher-appearing Tertiary volcanic units. Unit description from source map: IL002

Unit compiled into Tcl on SIM-3340 (Geologic Map of Alaska).

Tvbs - Andesite and basalt (early Eocene)

Tbo - Olivine basalt (Tertiary (early Eocene))
Massive columnar jointed olivine basalt flows in the southwestern D-1 quadrangle (T.4 S., R.41 W.); overlies alaskite (unit TKga) and graywacke of probable Jurassic age (unit Jkw). Newly determined Ar-Ar isochron age is 53.70 +/- 0.62 Ma. SiO2 content is approximately 48 to 49 percent. Unit description from source map: DI005

Unit compiled into Tev on SIM-3340 (Geologic Map of Alaska).

Tfv - Intermediate to felsic biotite tuff (Paleocene)

Tpv - Intermediate to mafic volcanic rocks (Tertiary, Paleocene)
Consists of massive welded tuff beds greater than several meters thick generally of andesitic and dacitic composition. Includes the Porcupine Butte andesite of Solie and Layer (1993), which consists of columnar jointed andesite forming the neck of a Paleocene volcanic center. Solie and others (1991) originally called Porcupine Butte dacite but on the basis of chemistry, revised the composition to porphyritic andesite. Some welded tuff of probable Cretaceous age appears similar in texture and composition, which we distinguish by their more greenish color. The only basalt in this unit lies between the Trimble and Hayes Glaciers and includes rocks mapped by Solie and others (1991) as unit TMzb. The basalt was mapped by Solie and others (1991) in contact with the shale, siltstone and limestone unit (KJsl) of Solie and others (1991); in the vicinity of the basalt they reported their KJsl unit may underlie the basalt and their KJcs unit. Unit description from source map: TY009

Unit compiled into Tpt on SIM-3340 (Geologic Map of Alaska).

Tgh - Hypabyssal granitic rocks (Tertiary)

Tgh - Hypabyssal granitic rocks (Tertiary)
Granitic rocks commonly containing miarolitic cavities, beta quartz, or granophyric texture. Medium- to fine-grained and usually porphyritic containing few mafic minerals. Miarolitic cavities commonly contain native sulfur. Commonly reddish weathering. Age likely to be Paleocene, although none of the best examples of these granitic rocks have been dated. The granite porphyry of Dickason Mountain (Solie and others, 1991) is is included here as one of these hypabyssal intrusive bodies. Unit description from source map: TY009

Tpgp - Granite porphyry of Dickason Mountain (Tertiary (Paleocene))
Granite porphyry of Dickason Mountain. Unit description from source map: TY009

Unit compiled into Tpgr on SIM-3340 (Geologic Map of Alaska).

Tpg - Granitic rocks, ranging from granite to granodiorite, mostly felsic (Tertiary)

Ti7 - Tertiary intrusive rocks -- Unit 7 Granite (Tertiary)
Coarse- to medium-grained granite. Unit description from source map: LC002

Ti10 - Tertiary intrusive rocks -- Unit 10 Granite (Tertiary)
Medium-grained composite pluton of granite and granodiorite which forms western border of Alaska-Aleutian Range batholith from Little Lake Clark southwestward into the Iliamna quadrangle. Unit description from source map: LC002

Tpg - Tertiary, Paleocene granitic rocks (Tertiary (Paleocene))
No additional description present on source map. Unit present on source map: TY009

Tpg? - possible Tertiary, Paleocene granitic rocks (Tertiary (Paleocene))
No additional description present on source map. Unit present on source map: TY009

Tpgs? - ??? (Tertiary (Paleocene))
No additional description present on source map. Unit present on source map: TY009

Tpqm - Tertiary, Paleocene quartz monzonite (Tertiary (Paleocene))
No additional description present on source map. Unit present on source map: TY009

Ti10 - Tertiary intrusive rocks -- Unit 10 Granite (Tertiary)
Medium-grained composite pluton of granite and granodiorite which forms western border of Alaska-Aleutian Range batholith from Little Lake Clark southwestward into the Iliamna quadrangle. Unit description from source map: IL006

Unit compiled into Tpgr on SIM-3340 (Geologic Map of Alaska).

Thgd - Biotite-hornblende-granodiorite (Tertiary)

Ti1 - Tertiary intrusive rocks -- Unit 1 Granodiorite (Tertiary)
Compositionally variable, medium-grained hypidiomorphic granular igneous rock, which depending on perthite content ranges from granodiorite to tonalite. Unit description from source map: LC002

Ti2 - Tertiary intrusive rocks -- Unit 2 Quartz monzodiorite (Tertiary)
Medium- to fine-grained hypidiomorphic granular hornblende-biotite quartz monzodiorite. Cut by Ti unit 10. Unit description from source map: LC002

Ti8 - Tertiary intrusive rocks -- Unit 8 Granodiorite (Tertiary)
Largely medium-grained, equigranular hornblende-biotite silicic granodiorite but ranges from granite to quartz monzodiorite. Intrudes Jurassic and Cretaceous rocks of Alaska-Aleutian Range batholith. Unit description from source map: LC002

Ti9 - Tertiary intrusive rocks -- Unit 9 Granodiorite (Tertiary)
Medium-grained, equigranular hornblende-biotite granodiorite. Intrudes Jurassic unit 2. Unit description from source map: LC002

Ti11 - Tertiary intrusive rocks -- Unit 11 Granodiorite (Tertiary)
Medium-grained composite body largely of granodiorite but including granite and quartz monzodiorite. Locally includes rocks of Ti10. Unit description from source map: LC002

Tpgd - Granodiorite (Tertiary (Paleocene))
Granodiorite. Unit description from source map: TY009

Ti9 - Tertiary intrusive rocks -- Unit 9 Granodiorite (Tertiary)
Medium-grained, equigranular hornblende-biotite granodiorite. Intrudes Jurassic unit 2. Unit description from source map: IL006

Unit compiled into Tpgr on SIM-3340 (Geologic Map of Alaska).

Tpd - Biotite diorite (Paleocene)

Tpd - Biotite diorite (Tertiary, Paleocene)
Diorite, quartz diorite, quartz monzodiorite and quartz monzonite in a large compositionally variable pluton which outcrops over an area of about 7 square miles (11 km2) (Solie and others, 1991). Generally coarse- to medium-grained, a fine-grained variant is also found. More mafic phases contain olivine, both clino- and orthopyroxene, and biotite, whereas more quartz- and potassium-feldspar-rich phases contain amphibole and/or biotite (Solie and others, 1991). Unit description from source map: TY009

Unit compiled into Tpgr on SIM-3340 (Geologic Map of Alaska).

Tgl - Hornblende and pyroxene-hornblende gabbro ((early) Tertiary)

Tgl - A-2 Gabbro (Early Tertiary)
Dark-colored hornblende and pyroxene-hornblende fine- to medium-grained gabbro. Two varieties, one foliated (cumulate?) and a non-foliated variety. Unit description from source map: LH002

Ti5 - Tertiary intrusive rocks -- Unit 5 Gabbronorite (Tertiary)
Small, coarse-grained stock of hornblende and biotite-bearing olivine gabbronorite cutting Mesozoic sedimentary rocks. Unit description from source map: LC002

Tlpg - Leucogabbro (Tertiary)
Leucogabbro, probably Paleocene. Unit description from source map: TY009

Unit compiled into Tgbw on SIM-3340 (Geologic Map of Alaska).

TKd - Dikes and subvolcanic rocks (Tertiary or Cretaceous)

TKd - Dike swarm (southern area) (Tertiary or Cretaceous)
Two areas of dike swarms consisting of felsic and mafic (southern area) or felsic (northern area) dikes. Unit description from source map: LH002

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKgs - Syenitic rocks (Tertiary or Cretaceous)

TKgn - Northern pluton (Tertiary or Cretaceous)
Medium-grained biotite monzogranite to syenogranite found in the mountains immediately south of the Koktuli River. Biotite is the only mafic mineral and orthoclase has moderate development of string perthite. SiO2 of analyzed samples has a narrow range of 65.5 to 65.7 percent and K2O is relatively

high (>4.80 percent) relative other plutons in the map area. Chemistry suggests rock unit is high-potassium granodiorite, a number of samples that are corundum normative. Unit description from source map: DI009

Unit compiled into TKg on SIM-3340 (Geologic Map of Alaska).

TKgb - Gabbro and dark-colored dikes and sills (Tertiary or Cretaceous)

TKm - Goldpan Peak Gabbro (Tertiary or Cretaceous)
Small intrusion of fine- to medium-grained to fine- to coarse-grained, seriate, hypidiomorphic granular gabbro. Intruded by and completely surrounded by Merrill Pass pluton. Unit description from source map: LH002

TKtp - Tex Peak Mafic intrusion (Tertiary or Cretaceous)
Fine-grained, equigranular, or fine- to medium-grained seriate gabbro. Unit description from source map: LH002

TKmg - Mount Estelle Gabbro (Tertiary or Cretaceous)
Very fine- to fine-grained, sub-equigranular gabbro. Unit description from source map: LH002

TKkm - Unnamed quartz monzonite pluton (Tertiary or Cretaceous)
Fine- to medium-grained seriate quartz monzonite. Unit description from source map: LH002

Mzm - Unassigned mafic rocks (Mesozoic)
Chiefly diorite and olivine and/or hornblende gabbro. Occurs as inclusions in Tertiary intrusive rocks. Locally may be metamorphosed equivalent of unit Mzi. Unit description from source map: TY003

TKmi - Mafic intrusive rocks, undivided (Tertiary to Cretaceous)
Mafic intrusive rocks, undivided. Unit description from source map: TY009

TKsg - Sled Pass gabbro (Tertiary or Cretaceous?)
Fine- to medium-grained, seriate, hypidiomorphic-granular gabbro. Highly variable mineral composition; contains plagioclase, biotite, amphibole±quartz, orthopyroxene, clinopyroxene, olivine, and as much as 6 percent opaque oxides and 4 percent apatite. CI, 21-40. Unit description from source map: LH012

Unit compiled into TKgb on SIM-3340 (Geologic Map of Alaska).

TKgg - Gneissose granitic rocks (Tertiary or Cretaceous)

TKgs - Gneiss (Tertiary or Cretaceous)
Gneiss, possibly Mesozoic (Mzg)?. Unit description from source maps: LH002, TY007

Unit compiled into TKgg on SIM-3340 (Geologic Map of Alaska).

TKv - Extrusive rocks, flows, tuff, and breccia (Tertiary and/or Cretaceous)

TKft - Felsic tuff (Tertiary to Cretaceous)
Light greenish grey felsic tuffs, crystal tuffs and lapilli tuffs. Crystals include quartz, felspar and minor hornblende. Lapillis are grey to green; lithic fragments are of sedimentary origin. Unit may include some fine-grained porphyritic felsic flows. Age uncertain, but may be extrusive equivalent of Dickason

granite porphyry (TKdgp) and /or TKqm, due to proximity. Also includes light grey lithic crystal tuff in lower Spring Creek. Unit description from source map: TY004

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKgbu - Gabbro and diorite, undivided (Tertiary or Cretaceous?)

TKm - Goldpan Peak Gabbro (Tertiary or Cretaceous)
Small intrusion of fine- to medium-grained to fine- to coarse-grained, seriate, hypidiomorphic granular gabbro. Intruded by and completely surrounded by Merrill Pass pluton. Unit description from source map: LH002

TKtp - Tex Peak Mafic intrusion (Tertiary or Cretaceous)
Fine-grained, equigranular, or fine- to medium-grained seriate gabbro. Unit description from source map: LH002

TKmg - Mount Estelle Gabbro (Tertiary or Cretaceous)
Very fine- to fine-grained, sub-equigranular gabbro. Unit description from source map: LH002

TKkm - Unnamed quartz monzonite pluton (Tertiary or Cretaceous)
Fine- to medium-grained seriate quartz monzonite. Unit description from source map: LH002

Mzm - Unassigned mafic rocks (Mesozoic)
Chiefly diorite and olivine and/or hornblende gabbro. Occurs as inclusions in Tertiary intrusive rocks. Locally may be metamorphosed equivalent of unit Mzi. Unit description from source map: TY003

TKmi - Mafic intrusive rocks, undivided (Tertiary to Cretaceous)
Mafic intrusive rocks, undivided. Unit description from source map: TY009

TKsg - Sled Pass gabbro (Tertiary or Cretaceous?)
Fine- to medium-grained, seriate, hypidiomorphic-granular gabbro. Highly variable mineral composition; contains plagioclase, biotite, amphibole±quartz, orthopyroxene, clinopyroxene, olivine, and as much as 6 percent opaque oxides and 4 percent apatite. CI, 21-40. Unit description from source map: LH012

Unit compiled into TKgb on SIM-3340 (Geologic Map of Alaska).

TKgp - Hypabyssal granite porphyry dikes, sills, and plugs (Tertiary and/or Cretaceous)

TKi7 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 7 Rhyolite dikes (Tertiary and (or) Cretaceous)
Rhyolite dikes containing phenocrysts of sanidine and high temperature quartz. Unit description from source map: LC002

TKd - Dike swarm (northern area) (Tertiary or Cretaceous)
Two areas of dike swarms consisting of felsic and mafic (southern area) or felsic (northern area) dikes. Unit description from source map: LH002

Ti - Felsic hypabyssal rocks (Tertiary(?))
The larger of scattered occurrences of felsic hypabyssal rocks. Occurs as dikes and small plugs. Unit description from source map: DI005

Unit compiled into TKhi on SIM-3340 (Geologic Map of Alaska).

TKg - Granitic rocks (Tertiary and/or Cretaceous)

TKg - Northern Intermediate plutons (Tertiary or Cretaceous)
Biotite-amphibole granite to quartz monzonite; diorite also present. Unit description from source map: LH002

TKg - Tertiary, Cretaceous granitic rocks (Tertiary to Cretaceous)
No additional description present on source map. Unit present on source map: TY009

TKg - Granitic rocks (Tertiary or Cretaceous)
Granitic rocks. Largely inferred from air photos. Unit description from source map: TA015

TKgm - Granitic rocks and mixed hornfels and dikes (Tertiary and Cretaceous)
Fine-, medium-, and coarse-grained, light- to dark-gray, plutonic granitic rocks mixed with felsic dikes and contact metamorphosed volcanic or sedimentary rocks. Outcrop area is south of the Northern pluton, at much lower elevation, suggesting that it may indicate the roof area of another pluton. However SiO2 (67.5 percent), K2O (4.50 percent), and other characteristics, including age (65.26 +/- 0.06 Ma on biotite) are similar to the Northern pluton. Unit description from source map: DI009

TKg - Granitic rocks of Tertiary and (or) Cretaceous age (Tertiary and (or) Cretaceous)
Granitic rocks. Unit description from source map: LC005

Unit compiled into TKg on SIM-3340 (Geologic Map of Alaska).

TKqd - Quartz diorite and diorite dikes, stocks, and small plutons (Tertiary and/or Cretaceous)

TKi1 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 1 Diorite (Tertiary and (or) Cretaceous)
Altered pyroxene gabbro and hornblende-pyroxene diorite. Assigned Tertiary or Cretaceous age, however, Jurassic age can not be ruled out. Unit description from source map: LC002

TKi3 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 3 Quartz diorite (Tertiary and (or) Cretaceous)
Predominantly fine- to medium-grained altered hornblende-biotite quartz diorite and less commonly granodiorite. Unit description from source map: LC002

TKi6 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 6 Diorite (Tertiary and (or) Cretaceous)
Numerous small diorite intrusions in central part of quadrangle. Unit description from source map: LC002

TKqd - Tertiary, Cretaceous quartz diorite (Tertiary to Cretaceous)
No additional description present on source map. Unit present on source map: TY009

TKqm - Diorite (Tertiary (Paleocene) or Late Cretaceous)
Diorite. Unit description from source map: LC012

Teg - Tertiary, Eocene granitic rocks (Tertiary (Eocene))
Tertiary, Eocene granitic rocks - includes granitic rocks of variable composition. Recoded polygons south of fault because of age and compositional differences based on data from Biff Reed. Unit

description from source map: TY007

TKpd - Dioritic rocks (Tertiary(?) or Cretaceous(?))
Monzodioritic rocks of Pike Creek-Largely medium-grained quartz monzodioritic and dioritic rocks in the southeast D-1 quadrangle. SiO2 content ranges between 57.4 and 61.4 percent; as with other rocks in this region, alkalis tend to be higher that normal for rocks of this silica content (LeMaitre, 1976). Rocks are typically dark green, have sparse biotite and abundant amphibole and clinopyroxene, and locally show evidence of contact metamorphism. Unit description from source map: DI009

TKqd - Monzontic rocks (Tertiary(?) or Cretaceous(?))
Coarse- to fine-grained monzogranitic to monzodioritic rocks in the southeast D-1 quadrangle. Rocks are typically dark green, have sparse clinopyroxene, and locally show evidence of contact metamorphism. Amphibole dominant mafic, tends to be green pleochroic and partially altered to chlorite. Unit description from source map: DI009

Unit compiled into TKgd on SIM-3340 (Geologic Map of Alaska).

TKgdt - Granodiorite (Tertiary and/or Cretaceous)

TKi8 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 8 Monzodiorite (Tertiary and (or) Cretaceous)
Medium-grained, hypidiomorphic-seriate textured monzodiorite, contains subequal hornblende and clinopyroxene. Unit description from source map: LC002

Ki11 - Cretaceous intrusive rocks -- Unit 11 Granodiorite (Cretaceous)
Medium- to coarse-grained subporphyritic granodiorite. Unit description from source map: LC002

Ki14 - Cretaceous intrusive rocks -- Unit 14 Granodiorite (Cretaceous)
Porphyritic granodiorite having phenocrysts of quartz, plagioclase, biotite, and glomeroporphyritic clusters of pale-green amphibole in a groundmass of quartz and mostly potassic feldspar. Unit description from source map: LC002

Kgd - Cretaceous granodiorite (Cretaceous)
No additional description present on source map. Unit present on source map: TY009

Kg - Granodiorite (Cretaceous)
Called granodiorite tentatively based on mode. Chemistry suggests diorite probably -- most similar to diorite field of LeMaitre (1976). More probably proper name might be quartz diorite. Unit description from source map: TA015

Ki11 - Cretaceous intrusive rocks -- Unit 11 Granodiorite (Cretaceous)
Medium- to coarse-grained subporphyritic granodiorite. Polygons added based on air photo interpretation of scoured bedrock. Unit description from source map: LC005

Kg - Cretaceous granitic rocks (Cretaceous)
Plutons just west of Susitna River in east central part of quadrangle. Granodiorite to quartz diorite. Unit description from source map: TY007

Unit compiled into Klgr on SIM-3340 (Geologic Map of Alaska).

TKqdt - Quartz diorite (Tertiary and Cretaceous)

Ki12 - Cretaceous intrusive rocks -- Unit 12 Quartz diorite (Cretaceous)
Locally foliated, seriate hornblende-biotite quartz diorite. Biotite-hornblende ration is quite variable although color index remains constant. Deuteric epidote common. Extension from adjacent Lake Clark quadrangle. Unit description from source map: KN008

Ki12 - Cretaceous intrusive rocks -- Unit 12 Quartz diorite (Cretaceous)
Locally foliated, seriate hornblende-biotite quartz diorite. Biotite-hornblende ratio is quite variable although color index remains constant. Deuteric epidote common. Unit description from source map: LC002

Ku - Plutonic rocks, undivided (Late Cretaceous)
Plutonic rocks, undivided. Unit description from source map: KN009

Kgd - Quartz dioritic rocks (Tertiary and Cretaceous)
Quartz diorite, and diorite. Revised from Haeussler unit. Unit description from source map: TY007

Unit compiled into Klgr on SIM-3340 (Geologic Map of Alaska).

TKv - Felsic tuff (Cretaceous to Tertiary)

TKft - Felsic tuff (Tertiary to Cretaceous)
Light greenish grey felsic tuffs, crystal tuffs and lapilli tuffs. Crystals include quartz, felspar and minor hornblende. Lapillis are grey to green; lithic fragments are of sedimentary origin. Unit may include some fine-grained porphyritic felsic flows. Age uncertain, but may be extrusive equivalent of Dickason granite porphyry (TKdgp) and /or TKqm, due to proximity. Also includes light grey lithic crystal tuff in lower Spring Creek. Unit description from source map: TY004

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKoegr - Granitic rocks ((Cretaceous) to (middle) Tertiary)

Tsf - South Fork stocks (middle Tertiary?)
Several small stocks consisting of fine- to medium-grained, seriate to subporphyritic, hypidiomorphic-granular biotite granite. Unit description from source map: LH002

Tsc - Snowcap Central (middle Tertiary)
Fine- to medium-grained, seriate, biotite-hornblende granite to granodiorite. Unit description from source map: LH002

Tcpi - Crowded Porphyry (Tertiary)
Porphyritic hypabyssal intrusive rock containing 40-50 percent phenocrysts. Phenocrysts are cheifly plagioclase feldspar and subordinate biotite and quartz. Aphanitic siliceous groundmass. Unit description from source map: LH002

Tmpb - Merrill Pass breccia (Tertiary)
No additional description present on source map. Unit present on source map: LH002

Tgd - Necons River pluton (middle Tertiary)
Large multiphase pluton consisting of medium- to coarse-grained, seriate, hypidiomorphic granular granite to granodiorite and lesser gabbro. Unit description from source map: LH002

Tus - Unnamed stock (Tertiary)
Small hypabyssal stock consisting of a silicic(?), biotite and hornblende-bearing porphyry. Unit description from source map: LH002

TKg - Tertiary, Cretaceous granitic rocks (Tertiary to Cretaceous)
Pluton at west end of Chakachamna Lake. Unit description from source map: TY007

Unit compiled into Toegr on SIM-3340 (Geologic Map of Alaska).

TKvr - Volcanic rock, light gray to pink rhyolite (Tertiary (Paleocene) or (Late) Cretaceous)

TKr - Rhyolite flows and tuff (Tertiary or Cretaceous)
Rhyolite flows and tuff, includes some dikes. Unit description from source map: LC012

TKr - Rhyolite flows and tuff (Tertiary (Paleocene) or Late Cretaceous)
Sericitically altered rhyolite flows and tuff, includes some dikes. Unit description from source map: LC012

TKr - Rhyolite flows and tuff (Tertiary (Paleocene) or Late Cretaceous)
Rhyolite flows and tuff, includes some dikes. Inferred on basis of Eakins and others (1978). Unit description from source map: LC005

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKvd - Volcanic rocks, dacite (Tertiary (Paleocene) or Late Cretaceous)

TKd - Dacite flows and pyroclastic rocks (Tertiary (Paleocene) or Late Cretaceous)
Dacite flows and pyroclastic rocks, includes some hypabyssal intrusions. Unit description from source map: LC012

TKd - Dacite flows and pyroclastic rocks (Tertiary (Paleocene) or Late Cretaceous)
Dacite flows and pyroclastic rocks, includes some hypabyssal intrusions. Added from air-photos. Unit description from source map: LC005

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKmv - Mafic flows of andesite and basalt, and volcaniclastic deposits (Tertiary (Paleocene) or Late Cretaceous)

TKb - Basalt flows (Tertiary (Paleocene) or Late Cretaceous)
Basalt flows. Unit description from source map: LC012

TKb - Basalt flows (Tertiary (Paleocene) or Late Cretaceous)
Basalt flows. Added from air-photos. Unit description from source map: LC005

Unit compiled into TKv on SIM-3340 (Geologic Map of Alaska).

TKgd - Mafic granitic rocks, tonalite, monzonite ((early) Tertiary and/or (Late) Cretaceous)

Tse - Unnamed pluton (Tertiary)
Medium- to coarse-grained, seriate, hypidiomorphic granular quartz diorite, granodiorite, and granite. Unit description from source map: LH002

Th - Hartman Plutons (Tertiary)
Series of 4 elongate plutons, individually ranging from quartz monzonite and quartz monzodiorite to granite. In general are fine- to medium-grained seriate intrusions, chiefly granodiorite. Unit description from source map: LH002

TKi2 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 2 Granodiorite (Tertiary and (or) Cretaceous)
Medium- to locally fine-grained hypidiomorphic-granular, pinkish-gray granodiorite. Unit description from source map: LC002

TKi4 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 4 Granodiorite (Tertiary and (or) Cretaceous)
Medium- to fine-grained, light-pinkish-gray hornblende-biotite granodiorite. Unit description from source map: LC002

TKi9 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 9 Granodiorite (Tertiary and (or) Cretaceous)
Coarse- to fine-grained, hypidiomorphic-seriate textured granodiorite. Unit description from source map: LC002

TKi - Intrusive rocks (Tertiary or Cretaceous)
Chiefly medium- to coarse-grained, light-gray granodiorite, quartz monzonite, and quartz diorite plutons. Unit description from source map: IL002

TKi12 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 12 Granodioritic rocks (Tertiary and (or) Cretaceous)
Light-colored intrusive rocks, presumed granodiorite. Unit description from source map: LC002

TKi13 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 13 Granodioritic rocks (Tertiary and (or) Cretaceous)
Light-colored intrusive rocks, presumed granodiorite. Unit description from source map: LC002

TKi14 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 14 Granodiorite (Tertiary and (or) Cretaceous)
Medium-grained, hypidiomorphic granular, seriate granodiorite Biotite more abundant that hornblende. Unit description from source map: LC002

TKgd - Tertiary, Cretaceous granodiorite (Tertiary to Cretaceous)
No additional description present on source map. Unit present on source map: TY009

Tfh - Former Hartman Plutons (Tertiary)
Series of 4 elongate plutons, individually ranging from quartz monzonite and quartz monzodiorite to granite. In general are fine- to medium-grained seriate intrusions, chiefly granodiorite. These were originally thought to be part of the Hartman plutons but are not now considered part of the sequence based on mineralogy and age (chemistry too?). Unit description from source map: LH002

TKgd - (Tertiary and Cretaceous)
Unit taken from Magoon?. Unit description from source map: TY008

TKi13 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 13 Granodioritic rocks (Tertiary and (or) Cretaceous)
Light-colored intrusive rocks, presumed granodiorite. Unit description from source map: IL006

TKgd - Granodiorite, quartz diorite, and diorite (Tertiary or late Cretaceous)
No additional description present on source map. Unit present on source map: KN002

TKgd - Granodiorite, quartz diorite, and diorite (Tertiary or late Cretaceous)
No additional description present on source map. Unit present on source map: LC005

TKi9 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 9 Granodiorite (Tertiary and (or) Cretaceous)
Coarse- to fine-grained, hypidiomorphic-seriate textured granodiorite. added from airphotos. Unit description from source map: LC005

TKi12 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 12 Granodioritic rocks (Tertiary and (or) Cretaceous)
Light-colored intrusive rocks, presumed granodiorite. Added from air photos. Unit description from source map: LC005

TKu - Plutonic rocks, undivided (Tertiary and Cretaceous)
Plutonic rocks. Seem distinctive relative to surrounding rocks on airphotos. Unit description from source map: KN008

Unit compiled into TKgd on SIM-3340 (Geologic Map of Alaska).

TKgr - Granite and alaskite ((early) Tertiary and/or Cretaceous)

Tcp - Chilligan Porphyry (Early Tertiary)
Chiefly fine- to coarse-grained, biotite- or biotite-hornblende granite or granodiorite, containing alkali feldspar phenocrysts. Unit description from source map: LH002

TKi1 - Unassigned intrusive rocks (Tertiary or Cretaceous)
Chiefly granite and quartz monzonite. Rocks east of Skwentna River and south of Merrill Pass may be equivalent to Styx River batholith. Unit description from source map: TY003

Tcc - Crystal Creek pluton (Early Tertiary)
Large pluton of texturally variable, biotite +/- hornblende granite. Unit description from source map: LH002

Tsxr - Styx River Batholith (Tertiary)
Biotite granite and quartz monzonite. Weathers light brown to dark yellowish orange. Intrudes the Mount Estelle intrusive and granodiorite of the Nagshlamina River. Unit description from source map: TY003

TKi10 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 10 Granite prophyry (Tertiary and (or) Cretaceous)
Hypidiomorphic-granular granite porphyry having quartz, plagioclase and potassium feldspar phenocrysts to 4 mm in a groundmass of 1 mm plagioclase. Very little biotite, local muscovite and zircon. Unit description from source map: LC002

TKi11 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 11 Granite (Tertiary and (or) Cretaceous)
Medium-grained, xenomorphic granite, subequal biotite and hornblende. Unit description from source

map: LC002

Ttp - Tired Pup pluton (Early Tertiary)
Large granite pluton, part of McKinley sequence. Chiefly medium- to coarse-grained hypidiomorphic granular biotite- or biotite-hornblende granite. Unit description from source map: LH002

Ttp1 - Tired Pup leucogranite (Early Tertiary)
Fine- to nearly coarse-grained seriate biotite granite. Gradational contact with main phase of Tired Pup pluton. Unit description from source map: LH002

Tms - Unnamed McKinley sequence intrusions (Early Tertiary)
Leucocratic biotite granite stocks and dike swarms. Unit description from source map: LH002

Tgdn - Unnamed plutons (Tertiary or Cretaceous)
Gabbro to granite multi-phase bodies. Unit description from source map: LH002

TKgs - Granitic rocks of the eastern Stuyahok Hills (Tertiary and Cretaceous)
Largely medium- to coarse-grained, light-gray to pinkish biotite monzogranite. Large pluton widely exposed in the eastern part of the Stuyahok Hills. Typically contains large (2cm) phenocrysts of potassium feldspar (orthoclase). Biotite is dominant mafic mineral; biotite to hornblende ratio is approximately 3:1. A number of thin sections show disequilibrium mineral assemblages suggesting formation by interaction of a granitic melt with a great deal of included material. Based on chemistry, rocks of this pluton cluster about the intersection of the quartz monzonite, monzogranite, granodiorite, and quartz monzodiorite fields of Streckeisen (1975); however, visually estimated modes place the rock unit primarily in the monzogranite field. Unit description from source map: DI009

TKga - Alaskite (Tertiary(?))
Coarse- to fine-grained white to off-white alaskite (alkali-feldspar granite) consisting of white feldspar and smoky quartz. Mafic minerals and mica exceedingly sparse in this large (7 km in diameter) body on the southwestern edge of the D-1 quadrangle. Where present, biotite appears late or secondary, rare amphibole is sodic, locally cyan-blue pleochroic. Smoky quartz and pegmatitic zones are common throughout unit. SiO2 content is high, ranging from 74.8 to 75.4 percent. Unit description from source map: DI009

Unit compiled into TKg on SIM-3340 (Geologic Map of Alaska).

TKgm - Quartz monzonite, granodiorite, and quartz monzodiorite ((early) Tertiary and/or Cretaceous)

Tse - Snowcap East pluton (Tertiary)
Plutons ranging from gabbro to granite in composition, with the more mafic compositions tending to be in the southern part of the exposure. Unit description from source map: LH002

Tme - Mount Estelle pluton (Early Tertiary)
Two phases, slightly older and finer grained northern pluton consisting of medium-grained, hypidiomorphic-granular biotite- and hornblende-bearing granodiorite containing tourmaline as a characteristic accessory mineral. It is largely exposed in the Tyonek and Talkeetna quadrangles to the north. The second phase is a slightly younger, coarser-grained southern pluton consisting of medium- to coarse-grained, seriate, hypidiomorphic-granular granodiorite. It is well exposed in the Lime Hills quadrangle and also in the Tyonek quadrangle. Unit description from source map: LH002

Tn - Granodiorite of the Nagishlamina River (Tertiary)

Medium-grained hornblende-biotite granodiorite. Unit description from source map: TY003

TKi5 - Tertiary and (or) Cretaceous intrusive rocks -- Unit 5 Quartz monzonite (Tertiary and (or) Cretaceous)
Numerous small intrusive bodies of quartz monzonite in the central part of the quadrangle identified by Eakins and others (1978). Unit description from source map: LC002

TKiu - Intrusive rocks (Tertiary or Cretaceous)
Small stocks scattered throughout eastern part of Lime Hills quadrangle. Composition varies from biotite granite to hornblende-pyroxene quartz diorite. Texture varies from fine-grained equigranular to fine- to coarse-grained seriate. Unit description from source map: LH002

Teg - Tertiary, Eocene granitic rocks (Tertiary (Eocene))
Tertiary, Eocene granitic rocks - includes granitic rocks of variable composition. Unit description from source map: TY009

Tpgme - Granite, Mount Estelle (Tertiary (Paleocene))
Granite, granodiorite and quartz monzonite. Unit description from source map: TY009

TKqmd - Porphyritic quartz monzodiorite (Tertiary or Cretaceous)
Porphyritic quartz monzodiorite in a small intrusion between North and Lyman Forks of Big River in northern part of quadrangle. Intrude Paleozoic sedimentary rocks. Small gold-bearing skarn reported along northeast contact. Unit description from source map: LH002

TKqm - Quartz monzonite (Tertiary (Paleocene) or Late Cretaceous)
Quartz monzonite and minor granodiorite. Unit description from source map: LC012

TKpsw - Pike Creek plutons, southwestern unit (Tertiary and Cretaceous)
Medium- to coarse-grained, light-gray biotite monzogranite or quartz monzodiorite. Equigranular and contains more pyroxene than unit TKpnw above. Clinopyroxene, some of which containing pinkish orthopyroxene cores is common in some samples, whereas others have no pyroxene but contain sodic amphibole. Minor development of string perthite texture in orthoclase. Two major element chemical analyses have 61.5 and 61.9 percent SiO2. Unit description from source map: DI009

TKpe - Pike Creek plutons, eastern unit (Tertiary and Cretaceous)
Medium-grained, light-gray biotite monzogranite to quartz monzonite. Hornblende to biotite ratio approximately 6:4; may contain orthoclase phenocrysts and hornblende may have relict clinopyroxene cores. Major element chemical analysis indicates 63.2 percent SiO2 and very high K2O (4.70 percent). Separated from the western units of pluton complex by an inferred fault. Unit description from source map: DI009

TKgnw - Northwest pluton (Tertiary or Cretaceous)
Porphyritic amphibole-bearing monzonite. Outcrops on isolated low-relief ridge south of the Koktuli River and west of the Northern pluton. Consists of plagioclase, amphibole (kaersutite?) , and clinopyroxene phenocrysts in a fine-grained groundmass. SiO2 content ranges from 63.6 to 64.1 percent on the two samples analyzed. Alkalis are consistently high are 7.32 to 7.48 percent. Unit description from source map: DI009

TKpnw - Pike Creek plutons, northwestern unit (Tertiary and Cretaceous)
Medium-grained, light-gray hornblende-biotite monzogranite to quartz monzodiorite. May contain large phenocrysts of orthoclase; biotite to hornblende ratio approximately 2:1. Two major element chemical analyses have 67.8 and 68.2 percent SiO2. Unit description from source map: DI009

TKge - Eastern granitic rocks-Hornblende quartz monzonite (Tertiary and or Cretaceous)
Hornblende quartz monzonite. Texturally similar to the granitic rocks of the eastern Stuyahok Hills in having large (2 cm) feldspar phenocrysts, however hornblende is the more common mafic mineral in these rocks. An 40Ar-39Ar age of 61.3 +/- 0.2 Ma on hornblende is coeval with the granitic rocks of the eastern Stuyahok Hills and with some parts of the Pike Creek pluton. Unit description from source map: DI009

Unit compiled into TKg on SIM-3340 (Geologic Map of Alaska).

TKJg - Granitic rocks and minor monzonite (Tertiary and Mesozoic)

Mzi - Unassigned intrusive rocks (Mesozoic)
Chiefly sphene-bearing quartz diorite and diorite. Unit description from source map: TY003

KJi - Cretaceous(?) and Jurassic(?) intrusive rocks -- Quartz monzodiorite (Cretaceous(?) and Jurassic(?))
Medium-gray, medium-grained, hypidiomorphic granular hornblende-biotite quartz monzodiorite containing variable amounts of clinopyroxene. Flow structures locally present and hornblende and plagioclase is aligned in a north-northeast direction. Unit description from source map: LC002

Tgd - Granodioritic rocks (Tertiary)
Granodiorite and quartz diorite. Unit description from source map: KN002

Unit compiled into KJg on SIM-3340 (Geologic Map of Alaska).

MZPZcb - Cottonwood Bay Greenstone (Mesozoic or Paleozoic (Late Triassic?))

MzPzg - Greenstone (Mesozoic or Paleozoic (Late Triassic?))
Small greenstone body consisting of dark greenish-black, massive, fine-grained equigranular greenstone. May correlate with Chilikadrotna Greenstone, which has yielded Late Triassic fossils from interbedded limestone. Unit description from source map: LH002

Trc - Cottonwood Bay Greenstone (Late Triassic (pre-Norian?))
Dark-gray to dark-green porphyritic to amygdaloidal basaltic flows altered to greenstone. In general, slightly more metamorphosed than Nikolai Greenstone. Unit description from source map: IL002

Trcb? - Cottonwood Bay Greenstone (Triassic)
Greenstone. Unit description from source map: LC006

Sg - Greenstone, dark-green basalt (Silurian)
Dark-green basalt having relict pillow structures, contains minor red and black chert. Unit description from source map: LC012

Spb - Greenstone, purple basalt (Silurian)
Purple basalt and hematite rich sandstone. Unit description from source map: LC012

Trv - Mafic igneous rocks (Triassic(?))
Predominantly mafic flows and volcaniclastic rocks. May be associated with the Chilikadrotna Greenstone of Triassic age from the Lake Clark quadrangle. Unit description from source map: TA015

Sg - Greenstone, dark-green basalt (Silurian)

Dark-green basalt having relict pillow structures, contains minor red and black chert. Inferred on basis of Eakins and others (1978). Unit description from source map: LC005

Unit compiled into TRcb on SIM-3340 (Geologic Map of Alaska).

MZPZk - Kakhonak Complex (Mesozoic or Paleozoic)

Jmg - Migmatite (Middle and Early Jurassic)
Admixture of intrusive and metamorphic rocks, grading from gneissic to schistose texture, exposed along east margin of Alaska-Aleutian Range batholith. Unit description from source map: IL002

JPk - Kakhonak Complex (Jurassic, Triassic, and Permian?)
Exposed chiefly as roof pendants in Alaska-Aleutian Range batholith and consists of schist, gneiss, quartzite, marble, phyllite, argillite, and slate. Greenschist facies metamorphic grade. Metamorphic rocks are thought to equivalent to Jurassic and Triassic rocks of the map area; Permian age is only by inference based on the occurrence of Permian rocks at Puale Bay to the south. Unit description from source map: IL002

MzPzs - Sandstone and graywacke (Mesozoic or Paleozoic)
Unit supposed to continue into Lake Clark quadrangle, however no similar unit described in Lake Clark. Unit assigned to Kakhonak Complex by default. Unit description from source map: LH002

TrPztc - Tlikakila Complex (Triassic to Paleozoic)
A diverse complex of metamorphosed and highly deformed rocks, whose protoliths include cancerous to siliceous clastic rocks, limestone, thin-bedded chert, massive basalt, massive to layered gabbro and pyroxenite, and ultramafic rocks. Most of complex metamorphosed to greenschist facies but ranges from unmetamorphosed to amphibolite facies. Unit description from source map: LC003

Trm - Metamorphic rocks, undivided (Late(?) Triassic)
Metalimestone, argillite, quartzite, metatuff, greenstone, and phyllite; may in part be equivalent to the Kamishak Formation. Unit description from source maps: IL007 and KN005

TC - Tlikakila Complex (Jurassic and older?)
Complex assemblage of metamorphosed and hornfels(?) volcanic and sedimentary rocks. Unit description from source map: LC006
as - Amphibolite (Early Mesozoic(?)). Amphibolite, locally includes sedimentary rocks. Unit description from source map: KN009

Unit compiled into JPk on SIM-3340 (Geologic Map of Alaska).

MZPZb - Metabasalt and minor metachert (Mesozoic and Paleozoic)

MzPzm - Metamorphosed mafic volcanic rocks, phyllite, schist, quartzite, marble, calc-silcate rocks, serpentinite, gabbro, and chert (Mesozoic and Paleozoic)
Metamorphosed mafic volcanic rocks, phyllite, schist, quartzite, marble, calc-silicate rocks, serpentinite, gabbro, and chert. Mixed unit of varying affinity and protolith and metamorphic age. Dominant rock of unit is metamorphosed mafic volcanic rocks which may be equivalent to the Chilikradrotna Greenstone and the Talkeetna Formation. Includes unmetamorphosed siltstone and sandstone near west margin of map unit. Unit description from source map: LC002

MzPzs - Biotite-feldspar-quartz schist (Mesozoic and Paleozoic)
Biotite-feldspar-quartz schist, locally actinolite-feldspar-quartz schist or garnet-feldspar-quartz schist. Unit description from source map: LC012

MzPzm - Mafic metamorphic rocks? (Mesozoic and Paleozoic)
Mafic rocks?. Unit description from source map: LC005

Unit compiled into JPk on SIM-3340 (Geologic Map of Alaska).

Kks - Kaguyak Formation, nonmarine sedimentary rocks (Late Cretaceous)

Kk - Kaguyak Formation, nonmarine sedimentary rocks (Late Cretaceous)
Sandstone, conglomerate, siltstone and interbedded coal. Unit description from source map: SV002

Unit compiled into Kcs on SIM-3340 (Geologic Map of Alaska).

Kvi - Intermediate and felsic volcanic rocks (Cretaceous)

Kv - Intermediate and felsic volcanic rocks (Cretaceous)
Andesite, dacite, and rhyolite flows and tuff. Includes massive and crystal-rich tuff, containing either hornblende or plagioclase as phenocryst phases as well as flow-banded rhyolite. Unit description from source map: TY009

Kv? - possible Cretaceous volcanic rocks (Cretaceous)
No additional description present on source map. Unit present on source map: TY009

Unit compiled into Kvu on SIM-3340 (Geologic Map of Alaska).

Kgd - Granodiorite (Cretaceous)

Ki1 - Cretaceous intrusive rocks -- Unit 1 Granodiorite (Cretaceous)
Light- to medium-gray, medium-grained, seriate, hypidiomorphic granular granodiorite. Unit description from source map: LC002

Ki2 - Cretaceous intrusive rocks -- Unit 2 Quartz monzodiorite (Cretaceous)
Medium- to coarse-grained, locally foliated composite pluton cheifly of hornblende-biotite quartz monzodiorite. Possibly the same pluton as unit Ki3, LC002. Unit description from source map: LC002

Ki3 - Cretaceous intrusive rocks -- Unit 3 Quartz monzodiorite (Cretaceous)
Medium- to coarse-grained, medium-gray hornblende-biotite quartz monzodiorite. Possibly same pluton as Ki2, LC002. Unit description from source map: LC002

Ki7 - Cretaceous intrusive rocks -- Unit 7 Granodiorite (Cretaceous)
Medium-grained, medium-gray hypidiomorphic-granular granodiorite. Hornblende domination mafic, shows varying degrees of alteration. Biotite locally present. Locally cataclasis/mylonization. Unit description from source map: LC002

Ki9 - Cretaceous intrusive rocks -- Unit 9 Granodiorite (Cretaceous)
Ranges from silicic granodiorite to mafic tonalite and quartz diorite. Medium-grained, seriate and many show weak to strong cataclasis (probably mylonitic from description). Some have subvertical, northeast trending primary foliation. Unit description from source map: LC002

Ki10 - Cretaceous intrusive rocks -- Unit 10 Granodiorite (Cretaceous)

Medium-grained seriate, whitish-gray granodiorite. Unit description from source map: LC002

Ki13 - Cretaceous intrusive rocks -- Unit 13 Granodiorite (Cretaceous)
Primarily granodiorite but includes some granite. Notably, is generally coarse-grained. Low color index, biotite primary mafic, with traces of hornblende and muscovite in all examined thin-sections. Unit description from source map: LC002

Ki7 - Cretaceous intrusive rocks -- Unit 7 Granodiorite (Cretaceous)
Medium-grained, medium-gray hypidiomorphic-granular granodiorite. Hornblende domination mafic, shows varying degrees of alteration. Biotite locally present. Locally cataclasis/mylonization. Unit description from source map: IL006

Ki10 - Cretaceous intrusive rocks -- Unit 10 Granodiorite (Cretaceous)
Medium-grained seriate, whitish-gray granodiorite. Unit description from source map: IL006

Unit compiled into Kgu on SIM-3340 (Geologic Map of Alaska).

Kqd - Quartz diorite (Cretaceous)

Ki4 - Cretaceous intrusive rocks -- Unit 4 Quartz diorite (Cretaceous)
Composite igneous mass that includes hornblende-pyroxene gabbro and diorite, quartz diorite, tonalite, and minor granodiorite. Quartz diorite is the most abundant rock type and is medium- to coarse-grained, locally foliated, seriate and has more hornblende than biotite. Elongate mafic inclusions are common throughout unit. May be related to unit Ki5, LC002. Unit description from source map: LC002

Ki5 - Cretaceous intrusive rocks -- Unit 5 Quartz diorite (Cretaceous)
Mafic igneous rocks, chiefly quartz diorite. Medium- to locally coarse-grained and having a well developed primary subvertical foliation that trends northeast. Most samples show cataclasis (mylonization?), which is pronounced near the shear zone in southern part of unit. May be related to unit Ki4, LC002. Unit description from source map: LC002

Ki6 - Cretaceous intrusive rocks -- Unit 6 Quartz diorite (Cretaceous)
Slightly foliated, medium-grained, seriate, hornblende-biotite quartz diorite. Unit description from source map: LC002

Unit compiled into Kgu on SIM-3340 (Geologic Map of Alaska).

Kgl - Granite (Cretaceous)

Ki8 - Cretaceous intrusive rocks -- Unit 8 Granite (Cretaceous)
Coarse-grained, subporphyritic granite. Part of a granite body exposed to the south in Iliamna quadrangle. Unit description from source map: LC002

Ki8 - Cretaceous intrusive rocks -- Unit 8 Granite (Cretaceous)
Coarse-grained, subporphyritic granite. Part of a granite body exposed to the north in the Lake Clark quadrangle. Unit description from source map: IL006

Unit compiled into Klgr on SIM-3340 (Geologic Map of Alaska).

Kgk - Quartz monzonite, monzonite, and syenite (Cretaceous)

Ki - Unnamed stocks (Cretaceous)
Fine- medium-grained, seriate to porphyritic quartz monzodiorite. Unit description from source map: LH002

Ksp - Sled Pass pluton (Cretaceous)
Elongate fine- to coarse-grained, seriate pluton consisting chiefly of monzonite and monzodiorite. Locally well-developed cataclastic foliation. Unit description from source map: LH002

Kqm - Quartz monzonite (Late Cretaceous)
Massive, coarse-grained light-gray porphyritic quartz monzonite. Unit description from source map: IL002

Ki15 - Cretaceous intrusive rocks -- Unit 15 Quartz monzonite (Cretaceous)
Fine- to medium-grained hypidiomorphic seriate quartz monzonite. Unit description from source map: LC002

Kllg - Leucocratic Granite (Early Cretaceous)
Leucocratic Granite. Unit description from source map: TY009

Unit compiled into Klqm on SIM-3340 (Geologic Map of Alaska).

Kmg - Granite (Cretaceous)

Kg - Cretaceous granitic rocks (Cretaceous)
No additional description present on source map. Unit description from source map: TY009

Unit compiled into Kmgr on SIM-3340 (Geologic Map of Alaska).

Kmqm - Quartz monzonite, monzonite, and syenite (Cretaceous)

Kg - Granitic rocks (Cretaceous)
Quartz monzonite and syenite. Unit description from source map: TY007

Unit compiled into Kmqm on SIM-3340 (Geologic Map of Alaska).

Kmgd - Intermediate granitic rocks, granodiorite (Cretaceous)

Kgd - Granodiorite? (Cretaceous)
Granitic rocks associated with the Pebble Copper deposit. Unit description from source map: IL009

Unit compiled into Kmgr on SIM-3340 (Geologic Map of Alaska).

Kivs - Intermediate volcanic and sedimentary rocks (Cretaceous)

Kvs - Metamorphosed intermediate volcanic and sedimentary rocks (Cretaceous)
Volcanic, volcaniclastic, and subordinate sedimentary rocks dominantly of andesitic composition on the east side of the Tordrillo Mountains. Most exposures consist of metamorphosed and altered volcanic tuff, breccia, or agglomerate. More mafic compositions are suggested by one outcrop of

pillow lavas (small pillows, up to 30 cm in diameter). Sedimentary rocks consist of uncommon volcaniclastic turbidites and rare non-volcaniclastic turbidites. Some rocks have a light-green color, but others are light gray and unaltered and not metamorphosed. Age best constrained at a locality near Hayes River Pass where the youngest detrital zircons in volcaniclastic sedimentary rocks were dated between 136-151 Ma (Hauterivian or younger) (Richard Friedman, Univ. of British Columbia, written communication to Dwight Bradley and Peter Haeussler, 2006). As these rocks were typical of the sedimentary rocks of the unit, it seems likely they are the same age. Although the age of the remainder of the unit is not constrained, all the dated volcanic rocks (see unit Kv) are Cretaceous or younger, which suggests that these rocks are no older than Cretaceous. Magoon and others (1976) included these rocks in their undivided metasedimentary rocks unit of Jurassic and/or Cretaceous age. Unit description from source map: TY009

Unit compiled into Kvu on SIM-3340 (Geologic Map of Alaska).

Ksf - Feldspathic sedimentary rocks (Cretaceous)

Ksf - Feldspar-rich sedimentary rocks (Cretaceous)
Cretaceous sediments, feldspar-rich, as mapped by Reed and Elliott (1970). Unit description from source map: TY009

Unit compiled into Kfy on SIM-3340 (Geologic Map of Alaska).

Kesv - Turbiditic sedimentary and volcanic rocks (Early Cretaceous (Aptian or younger))

Kes - Turbiditic sedimentary and volcanic rocks (Cretaceous, Aptian or younger)
Consists largely of silty to sandy graywacke in beds up to two-meters in thickness. Sandy beds are medium- to coarse-grained, with quartz, feldspar, and chert clasts. Reed and Elliot (1970) report rocks we have assigned to this unit contain subordinate metavolcanic rocks; the outcrop near the South Twin Glacier was indicated to be dominantly volcanic rocks. This unit contains detrital zircons with youngest grain ages of 138-122 Ma based on analyses from three samples (Paul O'Sullivan, Apatite to Zircon, written communication to D.C. Bradley and P.J. Haeussler, 2007). Another sample, from the southwestern most outcrop of the unit, which lies between Emerald Creek and the Skwentna River has youngest detrital zircon grain ages of 93-84 Ma (Paul O'Sullivan, Apatite to Zircon, written communication to D.C. Bradley and P.J. Haeussler, 2007). Thus, considering the Barremian to Aptian detrital zircon ages and these younger detrital ages, it appears there are also two sequences of Cretaceous sedimentary rocks within unit Kes. This unit is mapped only where detrital zircon analyses indicate the age of the sedimentary rocks. These detrital zircon ages are consistent with others from the informally named Kahiltna assemblage reported by Kalbas and others (2007) and Hampton and others (2007). The younger detrital zircons indicate of the unit is Santonian or younger in age and suggest a long depositional history where younger part of the sequence may be age correlative with the Kuskokwim Group exposed southwest of the map area. Unit description from source map: TY009

Kesv - Sedimentary, volcanic, and volcaniclastic rocks (Early Cretaceous)
Early Cretaceous sediments, volcanics, and volcaniclastics. 'Kahiltna age", turbiditic sediments, mapped as Kes where youngest detrital zircon grain ages infer an early Cretaceous age. Unit description from source map: TY009

Unit compiled into Kfy on SIM-3340 (Geologic Map of Alaska).

KJk - Kuskokwim Group, sandstone, siltstone, shale, and conglomerate (Cretaceous and/or Jurassic)

KJs - Sedimentary rocks (Cretaceous(?) and Jurassic)
Interbedded medium-gray, medium- to fine-grained lithic graywacke, silty sandstone, black shale, and local conglomerate. Regional strike is a consistent N50E and parallel to fold axes. Rocks range from unmetamorphosed but highly indurated to local well-developed slaty cleavage and cataclasis. Assigned to Kuskokwim Group on compilation. Unit description from source map: LC002

Kk - Kuskokwim Formation, undivided (Cretaceous)
Sandstone and siltstone. Unit description from source map: LC006

KJsh - Interbedded marine volcaniclastic sandstone, siltstone, and shale -- siltstone, argillite, and shale (Late Jurassic?)
Interbedded marine volcaniclastic sandstone, siltstone, and shale -- siltstone, argillite, and shale containing important but subordinate beds of volcaniclastic sandstone. Unit description from source map: LC012

KJh - Interbedded marine volcaniclastic sandstone, siltstone, and shale -- hornfels (Late Jurassic?)
Interbedded marine volcaniclastic sandstone, siltstone, and shale -- dark gray, locally gossanized, massive, hornfelsed KJs and KJsh, contains some spotted phyllite and numerous unmappable dikes. Unit description from source map: LC012

Kk - Kuskokwim Formation, undivided (Cretaceous)
Sandstone and siltstone. Unit description from source map: LC005

Kss - Kuskokwim Group: Sandstone and siltstone (Late Cretaceous)
Deep water turbidite facies fine, medium, and coarse-grained sandstone and siltstone; part of Kuskokwim Group. Unit description from source map: LH004

Kk - Kuskokwim Group? (Cretaceous)
Inferred to be Kuskokwim Group consisting of sandstone, siltstone, shale, and conglomerate. Unit description from source map: TA015

KJsh - Interbedded marine volcaniclastic sandstone, siltstone, and shale -- siltstone, argillite, and shale (Cretaceous or Late Jurassic?)
Interbedded marine volcaniclastic sandstone, siltstone, and shale -- siltstone, argillite, and shale containing important but subordinate beds of volcaniclastic sandstone. Inferred on basis of Eakins and others (1978). Unit description from source map: LC005

Kk - Kuskokwim Group? (Cretaceous)
Inferred to be Kuskokwim Group consisting of sandstone, siltstone, shale, and conglomerate. Unit description from source map: TA015

Kk - Kuskokwim Group (Cretaceous)
Well-bedded, rhythmically interbedded dark siltstone and sandstone. Found only north of the Koktuli River. Unit description from source map: DI009

JKs - Kahiltna terrane (Cretaceous and/or Jurassic)
Graywacke and argillite. Rocks reclassified as Kuskokwim Group based on correlation to southwest. Unit description from source map: LH007

KJs - Kahiltna Assemblage: Turbidite sandstone and siltstone (Late Jurassic to Early Cretaceous)
Fine-to-coarse grained turbidite sandstone and siltstone with minor fossil-rich, prismite-rich,

limestone. Reassigned to Kuskokwim Group. Unit description from source map: LH007

Unit compiled into Kk on SIM-3340 (Geologic Map of Alaska).

KJs - Flysch sequence (Cretaceous and/or Jurassic)

JKs - Kahiltna terrane (Cretaceous and/or Jurassic)
Graywacke and argillite. Unit description from source map: LH002

Pzu - Sedimentary rocks (limey) (Paleozoic)
Sedimentary rocks. Undifferentiated shale, siltstone, argillite, and limestone. Fossils, chiefly graptolites, collected from these rocks are Late Cambrian(?), Ordovician, Silurian, and Devonian in age. Tentatively correlated with Dillinger sequence of sedimentary rocks. Unit description from LH003. Consists of selected polygons re-assigned to Kahiltna flysch sequence. Unit description from source map: LH002

Ks - Turbiditic sedimentary rocks (Cretaceous, Valanginian and Aptian or younger)
Typically consist of interbedded dark-gray to black, locally greenish-gray, sandstone, siltstone, and shale turbidites. Also locally includes granule- to boulder-conglomerate, dark-gray to black, thinly bedded and dense, cherty argillite, and limestone. Sandstone includes graywacke in beds up to 2 m thick and feldspathic sandstone. Includes rocks mapped by Reed and Elliot (1970) as their units Km, Mzu, and Mzs. Locally hornfelsed on the margin of intrusions. Three fossils were found in this unit in the Tyonek quadrangle. Coquina beds along the lower Chickak River yielded Buchia sublaevis Keyserling of Valanginian age (Solie and others, 1991). A middle Turonian Inoceramus hobetsensis Nagao and Matsumoto was also found within this unit 1 km east of the Skwentna River 3 km north of its confluence with Emerald Creek (William P. Elder, USGS, written commun., 1989 to Dwight Bradley). A float sample of chert from the headwaters of Old Man Creek contained poorly preserved Spumellariina, which yielded a not-tightly constrained age between middle Toarcian (Lower Jurassic) to upper Valanginian (Lower Cretaceous) (E.A. Pessagno, Univ. of Texas, written commun., 2006, to Marti Miller, USGS). 40Ar/39Ar age determinations (Table 1) on hornblende from igneous clasts in the conglomerate yielded Cenomanian ages. Fossils indicate the rocks are both Early and Late Cretaceous in age, and the radiometric ages on the conglomerate clasts indicate latest Early Cretaceous age igneous rocks formed a source for some of the unit. Thus, considering the Barremian to Aptian and Turonian to Santonian detrital zircon ages within unit Kes, to the southwest, it appears there are at least two sequences of Cretaceous sedimentary rocks within unit Ks, which we are unable to distinguish based upon appearance. In the Talkeetna quadrangle to the north, similar rocks were assigned a Jurassic and Cretaceous age (map unit KJs, Reed and Nelson, 1980); however, the Jurassic fossils were derived from spatially and lithologically distinct rocks which we do not consider as part of this map unit. These rocks are traditionally assigned to the informally named Kahiltna assemblage (Nokleberg and others, 1994), more recent studies by Ridgway and others (2002), Kalbas and others (2007), and Hampton and others (2007) have reported detrital zircon analyses that suggest the Kahiltna assemblage is Aptian or Albian or younger, similar to some of detrital zircon analyses reported for unit Kes below. However, these analyses are somewhat in conflict with the Valanginian fossils reported by Solie and others (1991). The Kahiltna assemblage, widespread in southern Alaska, is often the repository for miscellaneous dark-colored sedimentary rock units and as such may not represent a coherent package of rocks. In the southwest part of the Tyonek quadrangle, the nature of the transition from this unit to the Kuskokwim Group is undefined. Both units have similar lithology and character and available mapping is not sufficient to either distinguish the units or to indicate that they should be mapped as the same unit. Locally, the presence of interbedded light tuffaceous deposits indicates contemporaneous volcanism; in these same areas, extremely angular grains of oscillatory zoned plagioclase, volcanic rock fragments, hornblende, epidote, and calcite, suggest derivation from the now buried Jurassic magmatic arc to the south (Reed and Nelson, 1980). Unit as mapped in the Tyonek quadrangle includes rocks mapped by Reed and Elliott (1970) as units Km, Mzu, and Mzs. Locally subdivided. Unit description from source map: TY009

Unit compiled into Kfy on SIM-3340 (Geologic Map of Alaska).

KJkr - Koksetna River sequence, Jura-Cretaceous flysch, southern part of Kahiltna terrane (Cretaceous and/or Jurassic)

KJs - Sedimentary rocks, undivided (Jurassic or Cretaceous)
Dark-gray to green lithic metagraywacke, polymictic conglomerate, and argillite are main rock types. All are low-grade metamorphic, ranging from prehnite-pumpellyite to greenschist facies. Argillite and siltstone facies show evidence of turbidite deposition; conglomerates may represent channels. Unit description from source map: IL002

KJkr - Koksetna River sequence (Early Cretaceous (Valanginian) to Late Jurassic (Kimmeridgian))
Complexly deformed volcanic-lithic turbidites. Consists of thick monotonous sequence of thin sandstone interbedded with pelagic shale. Coarse, unsorted and chaotic matrix-supported conglomerate occurs sporadically. Unit description from source map: LC003

KJkr - Koksetna River sequence (Cretaceous and Jurassic)
Jura-Cretaceous flysch, southern part of Kahiltna terrane. Unit description from source map: LC006

KJkr? - Koksetna River sequence? (Cretaceous and Jurassic)
Jura-Cretaceous flysch, southern part of Kahiltna terrane. Unit description from source map: LC006

KJs - Interbedded marine volcaniclastic sandstone, siltstone, and shale -- sandstone (Late Jurassic?)
Interbedded marine volcaniclastic sandstone, siltstone, and shale -- volcaniclastic sandstone containing important but subordinate beds of siltstone and shale and minor beds of granule conglomerate. Unit description from source map: LC012

KJs - Sedimentary rocks (Cretaceous(?) and Jurassic)
Presence inferred on the basis of similar rocks in Dillingham quadrangle to the south and the Lake Clark quadrangle to east. Fossil collections by UNOCAL geologists in 1959, originally reported as being in the Dillingham quadrangle were most likely from the southeast corner of the Taylor Mountains quadrangle. Rocks are thought to consist of interbedded medium-gray, medium- to fine-grained lithic graywacke, silty sandstone, black shale, and local conglomerate. Regional strike is a consistent N50E and parallel to fold axes. Rocks range from unmetamorphosed but highly indurated to local well-developed slaty cleavage and cataclasis. Unit description from source map: TA015

Jkw - Sedimentary rocks, undivided (Jurassic or Cretaceous)
Small area shown as KJs by Wallace and the extension of map unit KJs from the Iliamna map to the south. Assigned to unit KJkr. Also includes a single polygon in southwest part of quadrangle that is extension of unit KJs of the Iliamna quadrangle. Presumed to match Iliamna, consisting of dark-gray to green lithic metagraywacke, polymictic conglomerate, and argillite. All are low-grade metamorphic, ranging from prehnite-pumpellyite to greenschist facies. Argillite and siltstone facies show evidence of turbidite deposition; conglomerates may represent channels. Unit description from source map: LC005

KJs - Interbedded marine volcaniclastic sandstone, siltstone, and shale -- sandstone (Late Jurassic?)
Interbedded marine volcaniclastic sandstone, siltstone, and shale -- volcaniclastic sandstone containing important but subordinate beds of siltstone and shale and minor beds of granule conglomerate. Inferred on basis of Eakins and others (1978). Unit description from source map: LC005

KJs - Sedimentary rocks (Cretaceous(?) and Jurassic)

Presence inferred on the basis of similar rocks in Dillingham quadrangle to the south and the Lake Clark quadrangle to east. Fossil collections by UNOCAL geologists in 1959, originally reported as being in the Dillingham quadrangle were most likely from the southeast corner of the Taylor Mountains quadrangle. Rocks are thought to consist of interbedded medium-gray, medium- to fine-grained lithic graywacke, silty sandstone, black shale, and local conglomerate. Regional strike is a consistent N50E and parallel to fold axes. Rocks range from unmetamorphosed but highly indurated to local well-developed slaty cleavage and cataclasis. Unit description from source map: TA015

JKs - Kahiltna terrane (Cretaceous and/or Jurassic)
Graywacke and argillite. Rocks reclassified as Koksetna River sequence based on correlation to southwest. Unit description from source map: LH007

MzPzs - Sandstone and graywacke (Mesozoic or Paleozoic)
Unit supposed to continue into Lake Clark quadrangle, however no similar unit described in Lake Clark. Unit assigned to Kakhonak Complex by default. Western part of unit assigned to Koksetna River sequence after discussions with Bruce Gamble. Unit description from source map: LH007

Jk - Graywacke and conglomerate (Middle to Late Jurassic(?))
Typically dark-green or gray massive sandstone, although coarse-pebble conglomerate is locally present. Rare fragmentary fossils are found within map area; a sample collected in 2001 yielded fragments of Buchia, suggesting a Late Jurassic or Early Cretaceous age (fossil report by Robert B. Blodgett, 2002). These rocks are correlated with a thick marine sedimentary unit referred to as the "Weary graywacke" by Hoare and others (1975) and later referred to as the "Graywacke of Kulukak Bay" by Hoare and Coonrad (1978). This unit is widely exposed in the southern Goodnews Bay and the Nushagak Bay quadrangles as well as the southeastern Dillingham quadrangle (Hoare and Coonrad, 1978). Rocks in the map area correlated with this unit are also correlated with unit KJs of the adjacent Iliamna quadrangle (Detterman and Reed, 1980). In the Goodnews Bay and Nushagak Bay quadrangles, Buchia, Inoceramus, belemnites, and rare ammonite fragments ranging from Middle to early Late Jurassic age have been found. A report of Jurassic(?) fossils found by Unocal in 1959 in the map area appears to have erroneous sample locations; these samples actually appear to have come from a part of the Taylor Mountains quadrangle, immediately north of the map area. Unit description from source map: DI009

Unit compiled into KJgn on SIM-3340 (Geologic Map of Alaska).

KJv - Olivine basalt (Cretaceous? or Jurassic?)

Olivine basalt flows and fragmental mafic volcanic rocks-Ranges in apparent composition from andesite to basalt based on field calls. Part of unit KJvs volcanic and sedimentary rocks; mapped separately only locally. Unit description from source map: DI009

Unit compiled into KTRvs on SIM-3340 (Geologic Map of Alaska).

KJvs - Volcanic and sedimentary rocks (Middle Jurassic to Early Cretaceous)

KJvs - Volcanic and sedimentary rocks (Early Cretaceous to Middle Jurassic)
Low-grade metamorphic or contact metamorphosed volcanic and lesser sedimentary rocks. Altered volcanic breccia is relatively abundant; however in the southwestern part of T.4 S., R.40 W., unit consists largely of vertically standing beds of contact-metamorphosed shale, siltstone, and lesser sandstone. In its southwestern outcrop area, locally includes unaltered fragmental volcanic rocks. Contact metamorphism evidenced in outcrop by recrystallization where weathered surfaces show textures and structures but fresh surfaces appear aphanitic. In thin-section, mafic minerals are largely replaced by chlorite and feldspars are altered in part to sericite. Inferred to correlate with a thick marine unit (KJvs) consisting of volcanic and sedimentary rocks mapped by Hoare and Coonrad (1978) in the western Dillingham and adjacent Goodnews Bay quadrangles. According to Hoare and

Coonrad (1978), "the volcanic rocks range in composition and type from mafic pillow basalts to more abundant andesitic and trachytic flows, tuff, and breccia. Interbedded with the volcanic rocks are tuffaceous siltstone, tuffaceous chert, and massive or thin-bedded argillite." . Unit description from source map: DI009

Unit compiled into KTRvs on SIM-3340 (Geologic Map of Alaska).

Jn - Naknek Formation, undivided (Late Jurassic (Oxfordian to Tithonian))

Jn - Naknek Formation (Late Jurassic -- Oxfordian to Tithonian)
Arkose, conglomerate, sandstone, siltstone, and shale. Unit description from source map: IL002

Unit compiled into Jnk on SIM-3340 (Geologic Map of Alaska).

Jnp - Naknek Formation, Pomeroy Arkose Member (Late Jurassic)

Massive light-gray arkose and arkosic conglomerate; minor interbeds of siltstone. Unit present on source maps: IL007, KN005, and SV004

Unit compiled into Jnk on SIM-3340 (Geologic Map of Alaska).

Jnn - Naknek Formation, Northeast Creek Sandstone Member (Late Jurassic)

Jnss - Naknek Formation, lower sandstone member (Late Jurassic)
Thin-bedded to massive arkosic sandstone, graywacke, and siltstone, mainly restricted to central part of region. Unit present on source maps: IL007, KN005, and SV004

Unit compiled into Jnk on SIM-3340 (Geologic Map of Alaska).

Jns - Naknek Formation, Snug Harbor Siltstone Member (Late Jurassic (Oxfordian to Kimmeridgian))

Jns - Naknek Formation, Snug Harbor Siltstone Member (Late Jurassic)
Massive to thin-bedded dark-gray to black siltstone; laminated near base. Unit present on source maps: IL007, KN005, and SV004

Jns - Naknek Formation, Snug Harbor Siltstone Member (Jurassic, Kimmeridgian to Oxfordian)

Unit added by projection from Mount Katmai quadrangle to the south. Reference section consists of more than 638 m of dark-yellowish-brown and dark-gray, thin-bedded siltstone and minor amounts of thin- to medium-bedded olive-gray sandstone. Limestone nodules are locally abundant, and limestone beds are present in some siltstone intervals. Depositional environment was interpreted by Detterman and others (1996) to have been moderately deep water, well below wave base and above carbonate compensation depth, in a basin that had restricted circulation. Unit description from source map: IL006

Unit compiled into Jnk on SIM-3340 (Geologic Map of Alaska).

Jnc - Naknek Formation, Chisik Conglomerate Member (Late Jurassic)

Massive cobble-boulder conglomerate, mainly restricted to area adjacent to Iniskin Bay and Tuxedni Bay. Unit present on source maps: IL007, and KN005.

Unit compiled into Jnk on SIM-3340 (Geologic Map of Alaska).

Js - Chinitna Formation, Paveloff Siltstone Member (Late Jurassic)

Jcp - Chinitna Formation, Paveloff Siltstone Member (Late Jurassic)
Massive to thin-bedded gray arenaceous siltstone, weathers gray, large ellipsoidal concretions and lenticular beds of limestone, massive sandstone unit at base. Unit present on source maps: IL007, KN005, and SV004

Unit compiled into Jsc on SIM-3340 (Geologic Map of Alaska).

Jc - Chinitna Formation, Tonnie Siltstone Member (Late Jurassic)

Jct - Chinitna Formation, Tonnie Siltstone Member (Late Jurassic)
Massive to thin-bedded brownish-gray arenaceous siltstone, weathers red-brown, small yellowish-brown limestone concretions in parallel bands, minor sandstone at base. Unit present on source maps: IL007, KN005, and SV004

Unit compiled into Jsc on SIM-3340 (Geologic Map of Alaska).

Jtr - Trondjemite ((Late) Jurassic)

Jtr - Trondhjemite (Late Jurassic)
Medium- to coarse-grained, light-gray muscovite bearing trondhjemite. Unit description from source map: IL002

Jth - Trondjemite (Jurassic)
Trondhjemite. Unit description from source map: LC011 and KN012

Unit compiled into Jtr on SIM-3340 (Geologic Map of Alaska).

Jgd - Granodiorite of Alaska-Aleutian Range batholith ((Late) Jurassic)

Jqm - Quartz monzonite (Late Jurassic)
Medium-grained, light-gray with a pinkish cast quartz monzonite, locally includes granodiorite and trondhjemite. Unit description from source map: IL002

Ji3 - Jurassic intrusive rocks -- Unit 3 Granodiorite (Jurassic)
Whitish-gray, medium-grained, seriate biotite granodiorite. Unit description from source map: LC002

Jqm - Quartz monzonite (Jurassic)
"Medium- to coarse-grained pink to gray granitic-textured quartz monzonite. Unit description from source map: IL007"

Jqm - Quartz monzonite (Jurassic)
"Medium- to coarse-grained pink to gray granitic-textured quartz monzonite. Unit description from

source map: KN005"

p - Pegmatite or aplite dikes (Jurassic)
Pegmatite or aplite dikes. Unit description from source map: IL007

pg - Pink quartz monzonite dikes (Jurassic)
Pink quartz monzonite dikes. Unit description from source map: LC007

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

Jqd - Quartz diorite of Alaska-Aleutian Range batholith ((Late) Jurassic)

Jqd - Quartz diorite (Late Jurassic)
Medium- to coarse-grained, light-gray quartz diorite that contains biotite and hornblende, locally includes small areas of diorite and granodiorite. Unit description from source map: IL002

Ji1 - Jurassic intrusive rocks -- Unit 1 Tonalite (Jurassic)
Medium-grained tonalite and quartz diorite, locally foliated. Two small exposures of gabbro and diorite included in unit. Unit description from source map: LC002

Jqd - Quartz diorite, diorite, and granodiorite (Jurassic)
Quartz diorite, diorite, and granodiorite. Mapped this way by Magoon and others (1976); however outcrop area has a slightly different appearance on airphotos. Unit description from source map: KN008

Jqd - Quartz diorite (Jurassic)
Mainly biotite-hornblende-quartz diorite. Unit description from source map: IL007

Jqd - Quartz diorite, diorite, and granodiorite (Jurassic)
Quartz diorite, diorite, and granodiorite. Unit description from source map: KN002

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

Jdg - Diorite and gabbro of Alaska-Aleutian Range batholith (Late Jurassic)

Jd - Diorite (Late Jurassic)
Medium- to coarse-grained diorite, locally includes small areas of quartz diorite and gabbro; numerous xenoliths. Unit description from source map: IL002

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

Jqt - Quartz diorite and tonalite (Jurassic)

Jqd - Quartz diorite (Jurassic)
"Mainly biotite-hornblende-quartz diorite. Unit description from source map: KN005"

di - Quartz diorite dikes (Jurassic)
Quartz diorite dikes. Unit description from source map: KN005

Jqd - Quartz diorite (Jurassic)
"Mainly biotite-hornblende-quartz diorite. Unit description from source map: LC007"

Ju - Plutonic rocks, undivided (Jurassic)
Plutonic rocks, undivided; chiefly tonalite and trondhjemite. Unit description from source map: KN009

JT - Tonalite (Jurassic)
Tonalite, includes hornblendite, hornblende-biotite quartz diorite, and rare granodiorite, quartz monzonite, and granite. Unit present on source maps: LC011 and KN012

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

Jla - Lamprophyre and mafic dikes associated with Iliamna Volcano (Jurassic)

la - Lamprophyre dikes (Jurassic)
Lamprophyre dikes. Unit present on source maps: IL007, KN004, and LC007

b - Basalt dikes (Jurassic)
Basalt dikes. Unit description from source map: IL007

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

Jtb - Tuxedni Group, Bowser Formation (Late and Middle Jurassic)

Jtb - Tuxedni Group, Bowser Formation (Middle and Late Jurassic)
Heterogeneous assemblage of sandstone, conglomerate, shale and siltstone characterized by rapid facies changes. Massive light- to dark-gray sandstone and conglomerate are the dominant lithologic types on the Iniskin Peninsula. The sandstone and the conglomerate matrix are coarse-grained and composed of angular fragments of feldspar and quartz, having biotite, augite, and magnetite as common accessory minerals. The light-gray sandstones are interbedded with the dark-gray sandstone and are commonly calcareous and contain numerous coquina beds composed almost entirely of the pelecypods Inoceramus and Trigonia. Clasts in the conglomerate are dominantly felsic volcanic rocks and basalt, but include about 10 percent granitic rocks. Siltstone as much as 100-m-thick occurs with the conglomerate and sandstone and north of Chinitna Bay occurs in units as much as 250-m-thick, where it forms the dominant unit in the Bowser Formation. The siltstone is massive to thin-bedded, medium- to coarse-grained, dark-brownish gray, weathering to light-brown. Lenticular limestone concretions containing ammonites are common north of Chinitna Bay. The Formation ranges in overall thickness from 380 to 560 m. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtt - Tuxedni Group, Twist Creek Siltstone (Middle Jurassic)

Soft, poorly consolidated, thin-bedded to massive siltstone and silty shale as much 125-m-thick. The siltstone is dark-gray, weathering to dark-rusty brown and contains many thin beds of volcanic ash that weather a bright orange color. Small limestone concretions commonly fossiliferous and are common throughout the unit. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtc - Tuxedni Group, Cynthia Falls Sandstone (Middle Jurassic)

Massive to thick-bedded graywacke sandstone and pebble conglomerate about 200-m-thick. The sandstone is medium- to coarse-grained, greenish-gray to dark-green, weathering mottled light-gray due to zeolites and has graded bedding. The sandstone consists mainly of angular fragments of feldspar and volcanic rocks in a compositionally similar silt-size matrix. The pebble conglomerate occurs in thin lenticular beds within the sandstone and is well sorted within individual beds. Clasts consist of "red and green felsitic volcanic rocks, aphanitic igneous rocks, and a few metasedimentary rocks that are primarily dark-gray quartzite" (Detterman and Hartsock, 1966, p. 32). Coarse-grained siltstone is interbedded with the sandstone and the siltstone may contain a few limestone concretions. The siltstone may make up 10 to 15 percent of the formation. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtf - Tuxedni Group, Fitz Creek Siltstone (Middle Jurassic)

Thick sequence of massive, bluish dark-gray, arenaceous coarse- to fine-grained siltstone that commonly weathers rusty orange and contains many small limestone concretions. Interbedded are fine-grained sandstone and, locally, conglomerate interbeds. In the upper part of the unit the siltstone could possibly be called a silty shale. The unit is coarsest in the vicinity of Gaikema Creek and rapidly becomes finer-grained in all directions away from the Gaikema Creek section. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtg - Tuxedni Group, Gaikema Sandstone (Middle Jurassic)

Resistant, cliff-forming, massive to thin-bedded graywacke sandstone and cobble conglomerate showing graded bedding. Conglomerate is confined to the Iniskin Peninsula, clasts in it consist of red and green felsic volcanic rocks, aphanitic igneous rocks and minor metasedimentary rocks, all thought to be derived from the Talkeetna Formation. Rare granitic clasts are the first appearance in the Middle Jurassic of rocks presumably derived from the Alaska-Aleutian Range batholith. Locally, thin-bedded to massive, generally coarse grained to sandy, gray to olive-gray, brownish to rusty brown weathering siltstone is as much as 40 percent of the formation, however, it constitutes generally less than 10 percent of the unit, occurring mainly as thin interbeds in sandstone. Siltstone apparently does not occur in close proximity to the conglomeratic parts of the formation. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtrg - Tuxedni Group, Red Glacier Formation (Middle Jurassic)

Thin-bedded to massive, red-brown weathering dark-gray to moderate olive-gray siltstone concentrated in the upper part of the unit and consisting of about 40 percent of the Formation. The siltstone is highly arenaceous and locally contains lenticular interbeds and concretions of reddish-gray, dense limestone and very minor coal seamlets. Underlying this is light-tan to buff arkosic sandstone making up about 25 percent of the unit and a thick black, silty to arenaceous, very fissile, shale. Unit present on source maps: IL007, KN005, and SC004

Unit compiled into Jt on SIM-3340 (Geologic Map of Alaska).

Jtk - Talkeetna Formation ((Early) Jurassic (Sinemurian to Pliensbachian))

Jtk - Talkeetna Formation (Early Jurassic -- Sinemurian to Pliensbachian)
Mainly volcanic breccia, agglomerate, lava flows, and tuff. Sedimentary rocks locally interbedded but are minor. Informally divided into three members, which correlate with formal members elsewhere. Unit description from source map: IL002

Jtku - Talkeetna Formation, undivided (Early Jurassic)
Tuff, sandstone, agglomerate, breccia and some lava flows. Unit present on source maps: IL007, KN005, SC004, and LC007

Jv - Volcanic rocks (Jurassic)
Volcanic rocks, locally includes sedimentary rocks. Unit description from source map: KN009

sv - Sedimentary and volcanic rocks (Cenozoic and Mesozoic)
Chiefly Jurassic volcanic rocks; locally includes Mesozoic and Cenozoic sedimentary and volcanic rocks. Unit description from source map: KN012

KJu - Metasedimentary rocks (undivided) (Cretaceous and (or) Jurassic)
Weakly metamorphosed slate and graywacke; locally includes volcanic and intrusive rocks, undivided. Consists of contact metamorphosed Talkeetna Formation according to Detterman and others (1976, KN010). Unit description from source map: KN002

Jtk - Talkeetna Formation (Early Jurassic)
Volcanic breccia, tuff, agglomerate, and aphanitic lava flows; as mapped, locally includes Kamishak Formation in Iliamna Quad. Unit description from source map: KN002

Jtk - Talkeetna Formation (Early Jurassic -- Sinemurian to Pliensbachian)
Mainly volcanic breccia, agglomerate, lava flows, and tuff. Sedimentary rocks locally interbedded but are minor. Informally divided into three members, which correlate with formal members elsewhere. Unit description from source map: LC005

Unit compiled into Jtk on SIM-3340 (Geologic Map of Alaska).

Jtkh - Talkeetna Formation, Horn Mountain Tuff Member (Early Jurassic)

Mottled andesitic tuff, tuffaceous sandstone, and siltstone, locally contains andesitic flows. Unit present on source maps: IL007 and KN005

Unit compiled into Jtk on SIM-3340 (Geologic Map of Alaska).

Jtkp - Talkeetna Formation, Portage Creek Agglomerate Member (Early Jurassic)

Massive pink agglomerate and some volcanic breccia; minor andesitic flows, locally metasedimentary rock. Unit present on source maps: IL007 and KN005

Unit compiled into Jtk on SIM-3340 (Geologic Map of Alaska).

Jtkm - Talkeetna Formation, Marsh Creek Breccia Member (Early Jurassic)

Massive green volcanic breccia, lava flows, in part of submarine origin, interbedded with argillite and meta tuff, low rank metamorphism mainly confined to lower part. Unit present on source maps: IL007 and KN005.

Unit compiled into Jtk on SIM-3340 (Geologic Map of Alaska).

Jgaa - Gabbroic rocks, associated with Alaska-Aleutian Range batholith (Early Jurassic)

Jm - Mafic and ultramafic plutonic rocks (Early Jurassic)
Gabbro, hornblende gabbro, hornblendite, and pyroxenite. Unit description from source map: IL002

Unit compiled into Jgr on SIM-3340 (Geologic Map of Alaska).

JTRku - Kamishak Formation, Ursus Member (Early Jurassic (?) or Late Triassic (?))

Trku - Kamishak Formation -- Ursus Member (Late Triassic(?) or Early Jurassic(?))
Thin-bedded, light-gray limestone (locally dolomitic), and minor interbedded gray chert and porcellanite and minor tuff. Limestone is fine-grained biomicrite. Depositional environment was moderate to high-energy, shallow water. Unit cut by abundant dikes and sills either related to the Cottonwood Bay Greenstone and the Talkeetna Formation. Unit description from source map: IL002

Unit compiled into TRcnk on SIM-3340 (Geologic Map of Alaska).

TRtv - Tatina River Volcanics, lower members, pillow basalt and gabbro (Late Triassic)

Trb - Tholeiitic pillow basalt (Late Triassic)
Tholeiitic pillow basalt; part of Farewell Composite terrane and Mystic subterrane and equivalent to Tatina River Volcanics of Bundtzen and others, 1997. Unit description from source map: LH004

Unit compiled into JTRmv on SIM-3340 (Geologic Map of Alaska).

TRk - Kamishak Formation (Triassic)

St - Limestone (Silurian)
Highly fractured dark-gray limestone and chert. Unit description from source map: LC012

Unit compiled into TRcnk on SIM-3340 (Geologic Map of Alaska).

Unit age revised and assigned to Kamishak Formation by Wilson et al. 2006.

Reference citation:
Wilson, F.H., Mohadjer, Solmaz, Labay, K.A., Shew, Nora, Blodgett, R.B., Blome, C.D., Preller, C.C., Klimasauskas, E.P., Gamble, B.M., and Coonrad, W.L., 2006, Preliminary integrated geologic map databases for the United States: digital data for the reconnaissance bedrock geologic map for the

northern Alaska Peninsula area, southwest Alaska: U.S. Geological Survey Open-File Report 2006-1303. https://pubs.usgs.gov/of/2006/1303/

TRkm - Kamishak Formation, Middle Member (Late Triassic (middle to late Norian))

Thin- to medium-bedded, dark-gray to black limestone and calcilutite (locally dolomitic), and minor black chert and gray tuff. Limestone is fine-grained microsparite. Calcite is locally altered to chert, suggesting a deep-basin environment. Unit cut by abundant dikes and sills either related to the Cottonwood Bay Greenstone and the Talkeetna Formation. Age correlates with McCarthy Fm. Unit description from source map: IL002

Unit compiled into TRcnk on SIM-3340 (Geologic Map of Alaska).

TRkb - Kamishak Formation, Bruin Limestone Member (Late Triassic (Norian))

Massive to thin-bedded, light- to dark-gray limestone; coral and echinoid bioherms, banded green and white chert. Environment was apparently high energy, shallow water. Unit cut by abundant dikes and sills either related to the Cottonwood Bay Greenstone and the Talkeetna Formation. Possibly age equivalent to Nizina Limestone. Unit description from source map: IL002

Unit compiled into TRcnk on SIM-3340 (Geologic Map of Alaska).

TRScg - Conglomerate and volcanic sandstone (Triassic and Silurian)

Ssh - Gray shale and gray volcaniclastic sandstone (Silurian)
Gray shale and gray volcaniclastic sandstone. Unit description from source map: LC012

Trsh - Gray shale and gray volcaniclastic sandstone (Triassic)
Gray shale and gray volcaniclastic sandstone. Inferred on basis of Eakins and others (1978). Unit description from source map: LC005

Unit compiled into TRcb on SIM-3340 (Geologic Map of Alaska).

PZd - Dillinger sequence, undivided (Paleozoic)

Pzu - Sedimentary rocks (limey) (Paleozoic)
Sedimentary rocks. Undifferentiated shale, siltstone, argillite, and limestone. Fossils, chiefly graptolites, collected from these rocks are Late Cambrian(?), Ordovician, Silurian, and Devonian in age. Tentatively correlated with Dillinger sequence of sedimentary rocks. Unit description from LH003. Unit description from source map: LH002

Pzdu - Dillinger subterrane, undivided (Paleozoic)
Dillinger subterrane, undivided; part of Farewell Composite terrane. Unit description from source map: LH004

Unit compiled into DCd on SIM-3340 (Geologic Map of Alaska).

PDsc - Mystic stratigraphic sequence, Sheep Creek Formation and correlative siliciclastic units (Middle Devonian to Permian)

lPDs - Siltstone and sandstone (Pennsylvanian to Devonian)
Brown siltstone and sandstone of Sheep Creek Formation after Bundtzen and others (1997) ; part of Farewell Composite terrane and Mystic subterrane. Unit description from source map: LH004

Unit compiled into PDsc on SIM-3340 (Geologic Map of Alaska).

Dsc - Mystic stratigraphic sequence, shale and chert (Devonian (Givetian to Frasnian))

Dsc - Shale and chert (Devonian (Givetian to Frasnian))
Shale and chert; contains SEDEX barite deposits; part of Farewell Composite terrane and Mystic subterrane. Unit description from source map: LH004

Unit compiled into PDsc on SIM-3340 (Geologic Map of Alaska).

Dsca - Barren Ridge limestone, calcarenite, calcareous siltstone, and limestone (Silurian to Devonian)

DSl - Barren Ridge Limestone (Silurian to Devonian)
Barren Ridge Limestone after Churkin and Carter (1996) and Bundtzen and others (1997); part of Farewell Composite terrane and Dillinger subterrane. Unit description from source map: LH004

Unit compiled into DSbr on SIM-3340 (Geologic Map of Alaska).

Stc - Dillinger sequence, Terra Cotta Mountains sandstone, sandstone and graptolitic shale ((middle) Silurian)

mSs - Terra Cotta Sandstone (Middle Silurian)
Terra Cotta Sandstone after Churkin and Carter (1996) and Bundtzen and others (1997); part of Farewell Composite terrane and Dillinger subterrane. Unit description from source map: LH004

Unit compiled into Stc on SIM-3340 (Geologic Map of Alaska).

SOCpl - Post River Sandstone and Lyman Hills Formations and correlative units, silty limestone and siltstone (Cambrian to Silurian)

SOsh - Post River Formation (Ordovician to Silurian)
Post River Formation after Churkin and Carter (1996) and Bundtzen and others (1997); part of Farewell Composite terrane and Dillinger subterrane. Unit description from source map: LH004

OCls - Lyman Hills Formation (Ordovician to Cambrian)
Lyman Hills Formation after Bundtzen and others (1997); a separate mappable, lime rich zone (class 7582) is shown separately; part of Farewell Composite terrane and Dillinger subterrane. Unit description from source map: LH004

Unit compiled into SCpl on SIM-3340 (Geologic Map of Alaska).

bu - Bedrock of unknown type or age (unknown)

unmapped
High mountain area shown as unmapped in eastern central part of quadrangle. Unit description from source map: LC002

Not labeled
High mountain area shown adjacent to unmapped area. in eastern central part of quadrangle. Polygon not labeled, probably plutonic rocks of some variety. Unit description from source map: LC002

bu - Possible bedrock of unknown character
Areas that air photo interpretation suggest as being underlain by bedrock. Typically are of higher elevation than surrounding glacial deposits and show hints of structure. In one case, an apparent strike and dip of bedding is perceptible on air photos. Unit description from source maps: LC005 and DI005

bu - Undifferentiated bedrock
Areas of apparent bedrock or areas of known bedrock that appear different than surrounding outcrops. In some cases, this will be areas in otherwise surficial deposits that show unusual high relief or possible bedding. In areas of known bedrock, this may indicate contact metamorphism, intrusive rocks or some other indeterminate change in appearance. Unit description from source map: TA015

See bu unit description from SIM-3340 (Geologic Map of Alaska).

Geologic Map of Alaska Unit Descriptions (SIM-3340)

Unit descriptions from SIM-3340 are provided for units present in the GRI digital geologic-GIS data. As previously mentioned, many units on SIM-3340 are subdivided based on USGS NSAClass values into two or more units in the GRI digital geologic-GIS data. For example, unit Qs (on SIM-3340, see listing and description below) is divided into units Qpm, Qtf, and many other units, whereas unit QTv (on SIM-3340, see listing and description below) is represented by just one unit, QTv. The descriptions for the SIM-3340 units present in the LACL map area are presented below. Following each unit description is a list of the GRI subdivided units. Of note, unit symbols (e.g., QTi) mentioned in the following SIM-3340 unit descriptions are relevant to that publication, and may not match or even be present in the GRI unit listing and/or GRI digital geologic-GIS data. In addition, the age of a unit (as listed in SIM-3340) may differ from the age of a unit in the GRI digital geologic-GIS data, and the Map Unit List and Map Unit Description sections of this document, as these unit ages reflect a unit's age as per its 1' x 3' source map(s), and not the compiled SIM-3340 unit age.

g - Ice fields or glaciers (Holocene and Pleistocene)

No additional description present on source map.

This unit is g in the GRI digital geologic-GIS data.

Qs - Unconsolidated surficial deposits, undivided (Quaternary)

Unconsolidated, poorly to well-sorted, poorly to moderately well-stratified deposits; consist predominantly of alluvial, colluvial, marine, lacustrine, eolian, and swamp deposits. Also includes widespread glacial and periglacial deposits that consist of end, lateral, and ground moraine, outwash, rock glacier deposits, and other glacial and periglacial deposits as well as glacially scoured bedrock that may be covered with thin, glacially derived deposits. These glacial deposits are of Holocene and Pleistocene age and may include small areas of potentially latest Tertiary deposits. Map unit locally includes reworked volcanic debris as well as block and ash flows. On generalized map, included as part of unit QTs.

This unit is divided into units Qpm, Qtf, Qa, Qaf, Qc, Ql, Qsw, Qd, Qrg, Qsf, Qhg, Qho, Qbld, Qs, Qls, Qt, Qb, Qes, Qmt, Qm, Qwu, Qlv, Qsu, Qsg, Qek, Qoc, Qgme, Qge, Qbc, Qdl, Qewd, Qmi, Qmio, Qsb, Qac, Qglf, Qgl, Qwr, Qw2, Qw1, Qw0, Qwo, Qew, Qmhg, Qow and QTod in the GRI digital geologic-GIS data.

Qv - Youngest volcanic rocks (Quaternary and latest Tertiary?)

Volcanic rocks ranging in composition from rhyolite to basalt. Along the Aleutian magmatic arc and the Wrangell Mountains, the rocks are predominantly andesite and lesser dacite and basalt of calc-alkaline and tholeiitic affinity in lava flows, volcanic breccia, lahar deposits, and debris-flow deposits. Lava flows and clasts in other volcanic deposits of unit are porphyritic, typically glassy, gray to black, and commonly vesicular. Unit also includes basaltic, basaltic andesite, and dacite parasitic cinder and spatter cones. Unit typically forms volcanic edifices; it also forms isolated outcrops that cap ridges, providing a good example of topography reversal, which results from erosion of surrounding country rocks, leaving exposed more erosion-resistant flows that formerly had occupied valleys. Individual flows are locally as thick as 30 m and are laterally continuous over large areas. Includes Edgecumbe Volcanics (basalt, andesite, and dacite) on Kruzof Island (Loney and others, 1975; Riehle and others, 1989) and unnamed basaltic to rhyolitic rocks on islands west of Prince Wales Island (Eberlein and others, 1983), and on Zarembo, Kuiu, and Kupreanof Islands (Brew and others, 1984). Rocks of Holocene age were recognized east of Wrangell Island (Elliott and others, 1981) and on Kruzof Island

(Loney and others, 1975), and basaltic rocks of Holocene and (or) Pleistocene age are found on southern Kupreanof Island (Brew and others, 1985). On Revillagigedo Island and mainland to the east in the Ketchikan quadrangle (Berg and others, 1978, 1988) and at many other localities in southeast Alaska (Karl and others, 2012), this extrusive unit consists of alkaline-olivine basalt that forms volcanic cones, columnar jointed lava flows, and rubble flows that contain pumice and scoria; it also includes lenses of ash and lapilli a few centimeters to a few meters thick—too small to show on the map. Includes postglacial flows and pyroclastic deposits that overlie glacial deposits and landforms. On generalized map, included as part of unit QTvi.

This unit is divided into units Qhv, Qafd, Qmf, Qav, Qv and Qpd in the GRI digital geologic-GIS data.

QTi - Young shallow intrusive rocks (Quaternary or late Tertiary)

Hypabyssal plugs, domes, and subordinate flows that range in composition from rhyolite to basalt at Quaternary volcanic centers along the Aleutian magmatic arc and are associated with the volcanoes of the Wrangell Mountains. In the Aleutian Islands, compositions tend to be dacite to basaltic andesite; along the Alaska Peninsula the full range in composition is present; and in the Wrangell Mountains, compositions more typically range from rhyolite to dacite. Included are quartz keratophyre dikes on widely separated parts of Attu Island. Dikes consist of chalky white euhedral feldspar (albite) crystals and glassy quartz in a bluish-gray to light-gray groundmass of fine-grained albite, quartz and minor sericite, calcite, epidote, chlorite, magnetite, and apatite (Gates and others, 1971, p. 748). Unit also includes rhyolite domes at Mount Edgecumbe in the Sitka quadrangle (Riehle and others, 1989). Unit tends to be best exposed at older volcanic centers. On generalized map, included as part of unit QTvi.

This unit is unit Qanp and QTi in the GRI digital geologic-GIS data.

QTv - Young volcanic rocks, undifferentiated (Quaternary or Tertiary)

In western Alaska, from Nunivak Island and northward to the Seward Peninsula, these rocks are dominantly alkaline and tholeiitic basalt and locally contain ultramafic inclusions (Hoare, 1975; Cox and others, 1976). Analysis of rocks of this unit from the Pribilof Islands and Nunivak Island were used to establish the radiometric time scale for geomagnetic reversals (Cox and others, 1968). Unit includes numerous alkali basalt, basanite, and hawaiite cones, short flows, and maar craters. Cones and flows have little or no vegetative cover and still preserve some primary flow structures (Patton and others, 2009). Includes tholeiitic basalt of Binakslit Bluff on Nunivak Island (Hoare and others, 1968); massive, columnar-jointed flows; normally polarized flows of Gauss polarity epoch as well as normally and reversely polarized flows older than Gauss polarity epoch. Multiple samples yielded K/Ar ages between 5.01±0.15 and 3.24±0.10 Ma. Also includes alkalic basalt of Ahzwiryuk Bluff on Nunivak Island: nubbly mottled flows and pyroclastic ejecta that also includes both normally and reversely polarized rocks older than Gauss polarity epoch (Hoare and others, 1968). Two samples from this unit yielded K/Ar ages of 6.28±0.18 and 5.19±0.15 Ma. Additionally, unit includes vesicular and dense basalt and olivine basanite flows and sills in the Pribilof Islands (Barth, 1956). Along the Alaska Peninsula and in the Aleutian Islands, unit includes a wide range of volcanic products, similar to unit Qv; the main distinction is that this unit includes rocks where the age is not unequivocally Quaternary. As such, this unit includes the Pochnoi Volcanics of Semisopochnoi Island (Coats, 1959b), as well as volcanic rocks of ancestral Mount Kanaton volcano on Kanaga Island (Coats, 1956b; Miller and others, 2003), the Massacre Bay Formation of Attu Island (Gates and others, 1971), the Williwaw Cove Formation of Little Sitkin Island (Snyder, 1959), the flows and tuff-breccia of olivine-, hypersthene-, and hornblende-bearing andesite associated with Andrew Bay volcano on Adak Island (Coats, 1956a), and agglomerate on Kanaga Island (unit Tva of Coats, 1956b). On Great Sitkin Island, unit includes flows and agglomerate of the Sand Bay Volcanics (units Tsl and Tsa of Simons and Mathewson, 1955). Locally, also includes sandstone from reworked pyroclastic deposits,

as well as the pyroclastic rocks and lava flows (unit QTpl of Coats, 1959b) and crystalline vent plugs (unit QTp of Coats, 1959b) on Semisopochnoi Island. Includes interbedded flows, pyroclastic deposits, sedimentary rocks, and fine-grained dikes and sills on Tanaga, Kanaga, and Unalga Islands (unit QT of Fraser and Barnett, 1959), andesitic and basaltic tuff and tuff-breccia on Shemya Island (unit QTt of Gates and others, 1971), and Quaternary or Tertiary basaltic rocks of Bobrof Island as reported by Coats (1956c). On Little Sitkin Island, this unit locally contains areas of kaolinized, silicified, and pyritized rock (Snyder, 1959). Undated columnar-jointed flows of fine-grained tholeiitic and alkaline-olivine basalt in the western Holy Cross quadrangle (Csejtey and Keith, 1992) are included here because of similarity to volcanic rocks in the adjacent quadrangles to the north, west, and southwest. Unit includes Pliocene rocks of the Wrangell volcanic field in the Gulkana, Nabesna, Valdez, and McCarthy quadrangles (Nichols and Yehle, 1969; Richter, 1976; Richter and others, 2006; MacKevett, 1978; Winkler and others, 1981; W. Nokleberg, written commun., 1997). On generalized map, included as part of unit QTvi.

This unit is unit QTv in the GRI digital geologic-GIS data.

Tpv - Basalt and tuff (Tertiary, Pliocene)

Olivine basalt lava flows as thick as 10 m and locally diabasic intrusive rocks are found in the northwest corner of the Taylor Mountains quadrangle. These columnar-jointed flows, which form a large tilted plateau, yielded K/Ar ages of 4.62±0.14 Ma (from plagioclase) and 4.72±0.1 Ma (whole rock) (Reifenstuhl and others, 1985); D.C. Bradley (written commun., 2010) reported a whole rock 40Ar/39Ar plateau age of 4.63±0.07 Ma. An outcrop of olivine basalt at Kazik Hill in the northeast Taylor Mountains quadrangle is undated, but also included here. Map unit also includes the Intricate Basalt of Detterman and Reed (1980) in the Iliamna quadrangle, a glassy to porphyritic black to dark-green olivine-augite basalt, which occurs largely in the vicinity of Intricate Bay, but also occurs south of Gibraltar Lake and includes mafic dikes not shown here. Detterman and Reed (1980) reported K/Ar whole rock dates of 4.4±0.5 and 5.1±1.0 Ma on an olivine basalt dike that cuts the Naknek Formation. Unit also includes Gibraltar Lake Tuff, which has an upper nonwelded member of light-gray to white crystal ash-flow tuff that has a maximum thickness of 152 to 182 m; locally capped by basalt flows of Intricate Basalt. Lower member is at least 300 m thick, consists of light- to medium-gray and tan rhyolitic crystal and lithic welded tuff; locally, interbedded porphyritic rhyolite flows. Detterman and Reed (1980) had little age control; however, based on geomorphic character and comparison with other Tertiary age units, they suggested that the age was more likely Pliocene than Oligocene. On generalized map, included as part of unit Tvpm.

This unit is unit Tib in the GRI digital geologic-GIS data.

Tsu - Sedimentary rocks, undivided (Tertiary)

Widely distributed around Alaska, unit typically consists of nonmarine, moderately to poorly consolidated deposits of variable composition that range from conglomerate to sandy gravel, gravelly sand, sand, and pebbly mud. Locally, in northern Alaska (Reiser and others, 1971), may include some marine beds and, in southeast Alaska, includes marine calcareous sandstone and siltstone (Gehrels and Berg, 1992). Unit is lithologically similar to unit Tcb below except coal is generally not reported. In the Healy quadrangle, consists of poorly consolidated fluvial dark-gray shale, yellowish-gray sandstone, siltstone, and pebble conglomerate of possible Eocene to Miocene age (Csejtey and others, 1992). In the Mount Hayes quadrangle, (Nokleberg and others, 1992a), unit consists of brown sandstone and graywacke and interbedded conglomerate and argillite of possible Oligocene to Pliocene age, and light-colored, fine-grained, poorly sorted sandstone of Eocene to Miocene age, which locally contains interbedded siltstone, pebbly sandstone, pebble to cobble conglomerate, and sparse, thin coal layers, as well as poorly sorted, crudely bedded to massive, polymictic conglomerate and subordinate sandstone. In the Circle quadrangle (Foster and others, 1983), unit consists of gray

or tan conglomerate that grades into gray, tan, or iron-oxide-stained sandstone. In the Big Delta quadrangle (Weber and others, 1978), unit consists of light-gray, poorly consolidated, poorly bedded, fine to very coarse conglomerate, olive-gray, brown, or orange-brown coarse- to fine-grained sandstone and olive-gray siltstone. In the Talkeetna Mountains quadrangle (Csejtey and others, 1978), unit consists of fluvial conglomerate, sandstone, and claystone greater than 160 m thick, which contains a few interbeds of lignitic coal. These rocks lithologically resemble the Chickaloon Formation (included in unit Ttk here), which outcrops to the south, but lack fossil evidence for definitive correlation (Csejtey and others, 1978). In the McGrath quadrangle (Bundtzen and others, 1997a), consists of thick- to thin-bedded, moderately indurated sandstone interbedded with poorly indurated, laminated, fissile, carbonaceous shale and fine-grained sandstone as well as limestone conglomerate. Age range from unit inferred to be Paleocene to Miocene, but is largely Eocene.

This unit is Tsu in the GRI digital geologic-GIS data.

Tvu - Volcanic rocks of southern Alaska (Tertiary, Pliocene? and older)

Widely distributed throughout southern Alaska, unit is composed of andesite, basalt, and dacite lava flows, tuff, lahar deposits, volcanic breccia, and hypabyssal intrusions, typically poorly age constrained, and all locally hydrothermally altered or hornfelsed. Rocks of this unit tend to fall within two groups on the basis of age, where it has been determined. In south central Alaska, unit includes subaerial flows and associated pyroclastic rocks that range in composition from rhyolite to basalt. These rocks tend to be dominantly moderately altered rhyolite and basalt, but andesite, dacite, and latite also occur. Similar volcanic rocks are mapped in the Anchorage and Talkeetna Mountains quadrangles (unit Tv, Winkler, 1992; Csejtey and others, 1978, respectively), where they also include small lenses of fluvial conglomerate. Flows possibly correlative with this unit occur within the Arkose Ridge Formation (included in unit Ttk here) and yield K/Ar ages that range from 56.2±1.7 to 39.2±2.4 Ma (Csejtey and others, 1992; Winkler, 1992). A crude stratification is described (Csejtey and others 1978; Winkler, 1992), where felsic rocks and pyroclastic rocks occur stratigraphically lower and basaltic and andesitic flows occur in the upper part of the section. Unit includes rhyolitic breccia, ash-flow tuff, flows, and intrusive rocks and subordinate mafic and intermediate flows in the Lake Clark quadrangle and is thought to encompass entire Tertiary and may include Jurassic rocks of the Talkeetna Formation. Much of this unit was included in map unit Tv of Nelson and others (1983), but those rocks that we believe correspond in age with the Oligocene to Eocene Meshik Arc (Wilson, 1985) were placed within map unit Tmv here. In the Sleetmute quadrangle, brownish black olivine basalt that locally displays columnar jointing and possibly pillow structures (Miller and others, 1989) is included here, as well as olivine basalt in the Livengood, Fairbanks, and Lime Hills quadrangles. On Kavalga, Ogliuga, Ulak, and Skagul Islands (Fraser and Barnett, 1959), basaltic or andesitic lava and pyroclastic deposits were undivided in mapping; however, K/Ar age determinations suggest a bimodal age distribution of these rocks. Dates on altered rock samples from Ulak Island were 33.9±1.1 Ma and 43.4±4.6 Ma (DeLong and others, 1978; Marvin and Cole, 1978), whereas samples from Skagul and Kavalga Islands yielded 5.2±0.9 Ma and 6.2±0.4 Ma on andesite (Marvin and Cole, 1978). Marine deposits of volcanic breccia, tuff, and a few pillow lava flows, all of basaltic composition, with a few interbeds of conglomerate and sandstone of similar material are found on Kiska Island (Coats and others, 1961). Samples from flows, a dike, and a basalt boulder within the Vega Bay Formation yielded K/Ar ages that range from 55.3 to 14.7 Ma (DeLong and others, 1978; Marvin and Cole, 1978); the oldest age is inconsistent with the presumed stratigraphic position of the Vega Bay Formation and is therefore viewed as incorrect. The next oldest age of 29.2±4.4 Ma is on an olivine-basalt boulder within the sedimentary rocks of the unit and clearly indicates a protolith age. An age of 17.8±1.1 Ma was determined on a dike cutting the unit, presumably suggesting a minimum age for the unit; however, a flow within the unit yielded an age of 14.7±1.2 Ma, resulting in some doubt as to the age of the unit. Scattered outcrops of felsic to mafic volcanic rocks and related shallow intrusive bodies in the northwest part of the Talkeetna Mountains quadrangle (unit Tv of Csejtey and others, 1978) are also included here; other parts of Csejtey and others' (1978) unit Tv have been assigned to unit Tepv. Finally, includes "basaltic pyroclastic and flow rocks, including minor pillowed lava flows; locally interbedded with marine sedimentary rocks, including tuffaceous or glauconitic strata, probably

related genetically to mafic dikes, sills, and plugs on Middleton Island" (Winkler and Plafker, 1993). On generalized map, included as part of unit Tv; locally subdivided into the following seven units Twv, Tpv, Tvm, Tob, Tca, Tmv, and Tev.

This unit is Tvu and Ta in the GRI digital geologic-GIS data.

Thi - Hypabyssal intrusions (Tertiary)

Typically shallow dikes, sills, and stocks that range in composition from basalt to porphyritic, hornblende-bearing andesite to rhyolite, widely distributed in southern and central Alaska and the Aleutian Islands. Minor propylitic alteration is characteristic of these rocks. In the Middleton Island quadrangle, a prominent very pale-gray, very dense, conspicuously jointed dacite plug complex forms Cape Saint Elias and Pinnacle Rock at the southwestern end of Kayak Island (Plafker, 1974). On southern Adak and Kagalaska Islands dikes and small intrusive bodies consist largely of basalt and andesite (Coats, 1956a; Fraser and Snyder, 1959). Unit also includes a basalt dome older than caldera of ancestral Mount Kanaton on Kanaga Island (Coats, 1956b). On Kavalga, Ogliuga, and Skagul Islands, the unit consists of columnar-jointed porphyritic andesite sills and andesite and basalt dikes (units Tp, Tpi, and Tab of Fraser and Barnett, 1959). Also includes rocks associated with the Kiska Harbor and Vega Bay Formations on Kiska Island (Coats and others, 1961). Includes, on the eastern third of the Agattu Island, dacite porphyry cutting both the basement rocks and the Krugloi Formation and several of the diabase and gabbro bodies (Gates and others, 1971). Dikes of dacite, rhyolite, andesite, and rare basalt intrude rocks of the Valdez Group (unit Kaf) and McHugh Complex (unit Kumc) (Bradley and others, 1999). In the Dillingham quadrangle, this unit includes the larger of scattered occurrences of felsic hypabyssal rocks that occur as dikes and small plugs. In the Taylor Mountains quadrangle, unit includes felsic porphyritic rocks that occur in the northwest corner and along the southeastern margin. Analyzed samples of dikes throughout Alaska yield a wide range of ages. A basaltic-andesite dike intruding McHugh Complex yielded an 40Ar/39Ar hornblende plateau age of 115±2 Ma, but either the age or the sample setting must be considered suspect because this is significantly older that the unit it intrudes; an intermediate-composition dike yielded an 40Ar/39Ar isochron(?) age of 57.0±0.22 Ma (C.W. Clendenin, South Carolina Geological Survey, written commun., cited in Bradley and others, 1999) and felsic dikes mapped by Nelson and others (1999) yielded 40Ar/39Ar isochron ages as young as 31.1±0.2 Ma on potassium feldspar. Hypabyssal rocks from the Anchorage quadrangle yielded whole-rock K/Ar ages of 54.8±2.7 to 40.9±1.6 Ma and zircon fission track ages between 41.3±6.0 and 36.8±4.8 Ma (Silberman and Grantz, 1984; Winkler, 1992). An 40Ar/39Ar plateau age on amphibole from an andesite dike yielded an age of 58.64±0.52 Ma. Unit also includes unit TJds of Winkler (1992), which yielded widely different whole-rock K/Ar ages of 130 ±6 Ma and 38±2 Ma. The subvolcanic hornblende dacite of Jumbo Dome in the Healy quadrangle yielded a K/Ar age as young as 2.79±0.25 Ma (Csejtey and others, 1992). Other determinations yielded ages throughout the Tertiary.

This unit is Thf in the GRI digital geologic-GIS data.

Tod - Granodiorite, quartz diorite, and diorite (Tertiary, Oligocene and late Eocene)

Compositionally variable suite of medium- to coarse-grained, grayish-white, mafic granitic rocks exposed along the southern coastal region of the state. Unit occurs as far west as the Seguam quadrangle to as far east as the Ketchikan quadrangle and as far north as the McCarthy quadrangle. Commonly granodiorite and quartz diorite; also includes diorite and tonalite. Along the west side of Cook Inlet, the plutons are considered part of the Tertiary phase of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972) and tend to be exposed along its western margin. On the Alaska Peninsula, these plutons are associated with the Meshik magmatic arc and, in the Aleutian Islands, with the "Lower Series" magmatic rocks of Vallier and others (1994). In the eastern Gulf of

Alaska area and northern southeast Alaska, associations are not as readily apparent; plutons of this age and composition intrude a variety of terranes. Potassium-argon ages for these plutons range from about 39 to 25 Ma. Hornblende diorite in the Skagway quadrangle is undated but may be Oligocene in age (Gilbert and others, 1987). On generalized map, included as part of unit Toeg.

This unit is Tgd and Toqd in the GRI digital geologic-GIS data.

Tpg - Peralkaline granite (Tertiary, Paleocene?)

Mostly medium-grained hypidiomorphic granular granite containing subhedral to euhedral perthite (Nelson and others, 1983) in the Lake Clark quadrangle. This peralkaline granite is spatially associated with the Alaska-Aleutian Range batholith. Alternatively, this pluton may be associated with plutons of unit Tgw. Also included here is the Middle Fork granite, the perthite-arfvedsonite-granite phase of the Middle Fork plutonic complex in the McGrath quadrangle (Gilbert and others, 1988a; Solie, 1988) which yields K/Ar ages of 57.7±1.7 and 55.6±1.7 Ma. This map unit may correlate with other peralkaline granite bodies in the Dillingham quadrangle (included in map unit TKg) that generally yielded 40Ar/39Ar ages from 64 to 60 Ma. On generalized map, included as part of unit TKgi.

This unit is Tpgr in the GRI digital geologic-GIS data.

Tvm - Volcanic rocks of the Aleutian Islands and Alaska Peninsula (Tertiary, Miocene)

Widely distributed throughout southern Alaska, unit is composed of andesite, basalt, and dacite lava flows, tuff, lahar deposits, volcanic breccia, and hypabyssal intrusions, typically poorly age constrained, and all locally hydrothermally altered or hornfelsed. Rocks of this unit tend to fall within two groups on the basis of age, where it has been determined. In south central Alaska, unit includes subaerial flows and associated pyroclastic rocks that range in composition from rhyolite to basalt. These rocks tend to be dominantly moderately altered rhyolite and basalt, but andesite, dacite, and latite also occur. Similar volcanic rocks are mapped in the Anchorage and Talkeetna Mountains quadrangles (unit Tv, Winkler, 1992; Csejtey and others, 1978, respectively), where they also include small lenses of fluvial conglomerate. Flows possibly correlative with this unit occur within the Arkose Ridge Formation (included in unit Ttk here) and yield K/Ar ages that range from 56.2±1.7 to 39.2±2.4 Ma (Csejtey and others, 1992; Winkler, 1992). A crude stratification is described (Csejtey and others 1978; Winkler, 1992), where felsic rocks and pyroclastic rocks occur stratigraphically lower and basaltic and andesitic flows occur in the upper part of the section. Unit includes rhyolitic breccia, ash-flow tuff, flows, and intrusive rocks and subordinate mafic and intermediate flows in the Lake Clark quadrangle and is thought to encompass entire Tertiary and may include Jurassic rocks of the Talkeetna Formation. Much of this unit was included in map unit Tv of Nelson and others (1983), but those rocks that we believe correspond in age with the Oligocene to Eocene Meshik Arc (Wilson, 1985) were placed within map unit Tmv here. In the Sleetmute quadrangle, brownish black olivine basalt that locally displays columnar jointing and possibly pillow structures (Miller and others, 1989) is included here, as well as olivine basalt in the Livengood, Fairbanks, and Lime Hills quadrangles. On Kavalga, Ogliuga, Ulak, and Skagul Islands (Fraser and Barnett, 1959), basaltic or andesitic lava and pyroclastic deposits were undivided in mapping; however, K/Ar age determinations suggest a bimodal age distribution of these rocks. Dates on altered rock samples from Ulak Island were 33.9±1.1 Ma and 43.4±4.6 Ma (DeLong and others, 1978; Marvin and Cole, 1978), whereas samples from Skagul and Kavalga Islands yielded 5.2±0.9 Ma and 6.2±0.4 Ma on andesite (Marvin and Cole, 1978). Marine deposits of volcanic breccia, tuff, and a few pillow lava flows, all of basaltic composition, with a few interbeds of conglomerate and sandstone of similar material are found on Kiska Island (Coats and others, 1961). Samples from flows, a dike, and a basalt boulder within the Vega Bay Formation yielded K/Ar ages that range from 55.3 to 14.7 Ma (DeLong and others, 1978; Marvin and Cole, 1978); the oldest age is inconsistent with the presumed stratigraphic position of the Vega Bay

Formation and is therefore viewed as incorrect. The next oldest age of 29.2±4.4 Ma is on an olivine-basalt boulder within the sedimentary rocks of the unit and clearly indicates a protolith age. An age of 17.8±1.1 Ma was determined on a dike cutting the unit, presumably suggesting a minimum age for the unit; however, a flow within the unit yielded an age of 14.7±1.2 Ma, resulting in some doubt as to the age of the unit. Scattered outcrops of felsic to mafic volcanic rocks and related shallow intrusive bodies in the northwest part of the Talkeetna Mountains quadrangle (unit Tv of Csejtey and others, 1978) are also included here; other parts of Csejtey and others' (1978) unit Tv have been assigned to unit Tepv. Finally, includes "basaltic pyroclastic and flow rocks, including minor pillowed lava flows; locally interbedded with marine sedimentary rocks, including tuffaceous or glauconitic strata, probably related genetically to mafic dikes, sills, and plugs on Middleton Island" (Winkler and Plafker, 1993). On generalized map, included as part of unit Tv; locally subdivided into the following seven units Twv, Tpv, Tvm, Tob, Tca, Tmv, and Tev.

This unit is Tap in the GRI digital geologic-GIS data.

Tkn - Kenai Group, undivided (Tertiary, Miocene to Oligocene)

Coal-bearing clastic unit in vicinity of Cook Inlet that consists of, in descending stratigraphic order: Sterling, Beluga, and Tyonek Formations and Hemlock Conglomerate. According to Calderwood and Fackler (1972), unit is at least 8,000 m thick in the subsurface of Cook Inlet. Individual formations are typically estuarine and nonmarine clastic sedimentary rocks. Sterling Formation is interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, lignite coal, and minor volcanic ash. Beluga Formation is similarly nonmarine, interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, coal, and minor volcanic ash (Bradley and others, 1999). Calderwood and Fackler (1972) reported that a distinctive feature of the Beluga Formation is its lack of massive sandstone beds and massive coal seams that characterize the underlying Tyonek Formation; however, lignitic to subbituminous coal seams can be as thick as 4 m, though more typically are 2 m thick or less in the upper part of Beluga Formation. The contact between Beluga and overlying Sterling Formation may be an unconformity, but in any case can be difficult to pinpoint (Calderwood and Fackler, 1972; Turner and others, 1980). Tyonek Formation is carbonaceous nonmarine conglomerate and subordinate sandstone, siltstone, and coal (Winkler, 1992; Bradley and others, 1999) and is identified by massive sandstone beds and lignitic to subbituminous coal beds as much as 9 m thick (Calderwood and Fackler, 1972). Hemlock Conglomerate consists of fluvial conglomeratic sandstone and conglomerate that contains minor interbeds of siltstone, shale, and coal and is lithologically transitional with Tyonek Formation, leading to some confusion; Hemlock Conglomerate is best known from the subsurface. Calderwood and Fackler (1972) included West Foreland Formation within the Kenai Group; however, it was separated as a distinct unit by Magoon and others (1976). Swenson (1997) has proposed an alternative stratigraphic column for Cook Inlet basin that recognizes the time-transgressive nature of the units, wherein all units of Kenai Group and West Foreland Formation overlap somewhat in age. Dallegge and Layer (2004) suggested that the age range of the stratigraphic units be revised based on 40Ar/39Ar dating of tephra from within Kenai Group. In particular, they document the time-transgressive nature of the formations and that the Tyonek Formation may be as old as 49 Ma (early Eocene, Ypresian) in the Matanuska Valley, making its lower part age-equivalent with the Hemlock Conglomerate and West Foreland Formation. According to R.G. Stanley (written commun., 2009) the type sections for West Foreland Formation and the subdivisions of Kenai Group are not in outcrop but rather in the subsurface located in several different wells, both onshore and offshore. These wells, in turn, are located many miles from each other in an area of complicated structure and lateral facies changes; therefore, correlation of these subsurface type sections with the surface outcrops is poorly documented, difficult, and controversial. On generalized map, included as part of unit Tknt.

This unit is Tsf, Tkb, Tty and Ttyh in the GRI digital geologic-GIS data.

Ttk - Nearshore and nonmarine sedimentary rocks (Tertiary, Eocene to Paleocene)

Unit includes several similar formations in southern Alaska. These include the Tolstoi Formation of the southwestern Alaska Peninsula, the West Foreland Formation of the Cook Inlet region, the Wishbone, Arkose Ridge, and Chickaloon Formations of the Matanuska Valley, and scattered other occurrences. Sandstone is the dominant lithology of the Tolstoi Formation; sandstone intervals grade upward from light gray to olive-gray and tend to become more thin-bedded. Siltstone intervals in section are consistently thin bedded and are usually light olive-gray. Plant debris, including well preserved leaves, is present throughout unit, whereas megafauna are only reported from the lower 280 to 290 m of type section. Lithic clasts in conglomerate and conglomeratic sandstone are dominantly granitic and arkosic detritus but also include as much as 30 percent volcanic clasts. Most volcanic clasts are altered or weathered, which is in sharp contrast to most overlying units (Detterman and others, 1996); additionally, presence of granitic and arkosic detritus suggests a Mesozoic source rather than derivation from contemporaneous magmatic activity. Rocks of Tolstoi Formation are characteristic of a shallow marine environment succeeded northward and stratigraphically upward by rocks characteristic of nonmarine delta-plain and fluvial deposits, mainly reflecting braided streams (Detterman and others, 1996). West Foreland Formation is exposed only on west side of Cook Inlet, where unit consists of tan to light-yellow-brown cobble conglomerate interbedded with lesser sandstone, laminated siltstone, and silty shale (Detterman and Hartsock, 1966). Thin coal beds are interbedded with the siltstone and shale. Conglomerate clasts are mainly rounded to subrounded quartz diorite, volcanic rock, argillite, sandstone, siltstone, quartzite, tuff, and coal fragments. Intrusive and volcanic rock fragments each make up about 35 percent of the clasts in conglomerate. Medium- to coarse-grained arkosic sandstone forms the conglomerate matrix and forms distinct lenticular beds. Siltstone and shale interbedded with conglomerate is very fine-grained subarkosic equivalent of the sandstone. Unit assigned Oligocene age by Kirschner and Lyon (1973) and later reassigned early Eocene and late Paleocene age by Magoon and others (1976), presumably on the basis of plant fossils. Zircon from an interbedded tuff about 1 m thick yielded an age of 43 Ma, middle Eocene (P.J. Haeussler, written commun., 2008). Unit may be equivalent to Arkose Ridge Formation and represent a transtensional basin along the Castle Mountain Fault System. Arkose Ridge Formation is fluvial and alluvial feldspathic and biotitic sandstone, conglomerate, siltstone, and shale that contains abundant plant fragments (Csejtey and others 1977; Winkler, 1992). Coarsening-upward sequence was deposited on alluvial fans and by braided streams carrying sediment derived from rapid erosion of uplifted mountains to the north (Winkler, 1992). Thickness is as much as 700 m. Age control is largely based on late Paleocene fossil plants and radiometric ages on locally associated volcanic flows and dikes. Age is considered broadly coeval with Chickaloon Formation and is based on whole rock K/Ar ages from volcanic rocks that range from 56 to 46 Ma in lower part of formation and a whole rock K/Ar age on basalt dike from the middle of formation of 46.1±2.8 Ma, as well as the presence of late Paleocene plant fossils (Silberman and Grantz, 1984; Winkler, 1992). Chickaloon Formation is more than 1,500 m thick and is predominantly fluvial and alluvial carbonaceous mudstone, siltstone, conglomeratic sandstone, and polymictic conglomerate (Winkler, 1992).

Locally, upper and middle parts of unit contain numerous beds of bituminous coal (Winkler, 1992). Upper part of Chickaloon Formation contains a diverse fossil assemblage of Eocene age, including abundant leaf imprints, petrified tree trunks, and large mammal track ways (Barnes and Payne, 1956; Winkler, 1992). Lower part of unit is largely conglomerate and lithic sandstone derived from erosion of the Talkeetna Formation (Winkler, 1992). Unit includes a strongly deformed, “southerly derived, green-weathering, noncarbonaceous basal sequence of poorly sorted, massive to crudely stratified cobble and boulder conglomerate * * *” which grades “upward into well-stratified, thick-bedded sandstone and conglomerate with a chloritic matrix” (Winkler, 1992). Little (1988, 1990, cited in Winkler, 1992) interpreted this sequence as a prograding alluvial fan derived from uplift and erosion of the Chugach accretionary complex (Chugach terrane) to the south (Winkler, 1992). Age control for the Chickaloon Formation is derived from the presence of Paleocene fossil leaves (Wolfe and others, 1966; Triplehorn and others, 1984) and from K/Ar and fission-track determinations on ash partings within coal beds, which range from 56 to 52 Ma (Triplehorn and others, 1984; Winkler, 1992). Unnamed rock units from other areas also included within this unit include an intercalated fluvial

sequence of conglomerate, sandstone, siltstone, and mudstone, and a few thin, interlayered flows of basaltic andesite found in the Healy quadrangle (Csejtey and others, 1992), fluviatile conglomerate, sandstone, and claystone with a few interbeds of lignitic coal in the Talkeetna Mountains quadrangle (Smith and others, 1974; Csejtey and others, 1978), and brown-weathering sandstone and shale, pebble to granule conglomerate associated with the Holokuk Basalt of southwest Alaska. Unit also includes a similar unit in the McGrath quadrangle (unit Tvs, volcaniclastic sandstone and lacustrine silt of Bundtzen and others, 1997a). On generalized map, included as part of unit Tknt.

This unit is Twf in the GRI digital geologic-GIS data.

Togr - Granite and granodiorite (Tertiary, Oligocene)

Largely consists of granite and lesser granodiorite distributed around the Gulf of Alaska, from the Lime Hills quadrangle in the west to as far as the Ketchikan quadrangle in southeast Alaska. Rocks tend to be light-gray, medium- to coarse-grained, leucocratic biotite granite and granodiorite. Larger stocks commonly grade from marginal zones containing more biotite (and locally hornblende) to more leucocratic zones inward; large parts of some intrusions are porphyritic and contain orthoclase phenocrysts in a medium-grained groundmass (Tysdal and Case, 1979; Nelson and others, 1999). Common textures are allotriomorphic granular and hypidiomorphic granular. In southeast Alaska, consists of biotite ± hornblende ± pyroxene granite, alkali granite, quartz monzonite, and subordinate syenite, granodiorite, and diorite (Berg and others, 1988; S.M. Karl, unpub. data). Radiometric ages range from about 37 to 23 Ma. On generalized map, included as part of unit Toeg.

This unit is Togr in the GRI digital geologic-GIS data.

Tgw - Granite, southwest Alaska and Aleutian Islands (Tertiary, Oligocene, or older)

Consists of several distinct plutons. The Windy Fork pluton (Bundtzen and others, 1997a; Gamble and others, 2013) in the McGarth and Lime Hills quadrangles consists of light-gray or grayish-pink biotite granite or aplite and peralkaline granite. The Windy Fork pluton yields K/Ar ages of 30.9±0.9 Ma (biotite), 29.7±0.9 Ma (hornblende) (Reed and Lanphere, 1972) and 23.5±0.7 Ma (pyroxene) (Gilbert and others, 1988a) and U/Pb ages on zircon are 31.8±0.6 and 30.9±0.4 Ma (D.C. Bradley, written commun., 2014); granite in the Lake Clark quadrangle (Nelson and others, 1983) is undated. Zircon dates on the Big River pluton of the Lime Hills quadrangle (Gamble and others, 2013) indicate an age of about 31 Ma (Jones and others, 2014). These plutons are included in the Tertiary phase of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). The second part of this map unit consists of albite granite found on Attu Island (Gates and others, 1971). The granite is gray, pale-pink, or purplish, has widely variable grain size, and locally contains euhedral gray-green feldspar (albite) phenocrysts up to 5 mm long. Quartz makes up about 20 percent of rock and, locally, granite may have as much as 5 percent green amphibole (Gates and others, 1971). The albite granite is surrounded by a halo of albitized and silicified basement rocks (unit TMzzu, here) that is as much as 2 miles wide. Age control is limited; albite granite blocks occur within keratophyric tuff in the basement rocks although the main intrusions cut through the basement rocks. Diabase dikes cut the granite, and boulders of the granite occur in the conglomeratic Chirikof Formation (unit Tms) on Attu Island, suggesting that the granite may be largely pre-Miocene. The granite on Attu Island was placed in the Attu Basement Series by Yogodzinski and others (1993). On generalized map, included as part of unit Toeg.

This unit is Tgr and Tpag in the GRI digital geologic-GIS data.

Tmv - Meshik Volcanics and similar rock units (Tertiary, Oligocene to Eocene)

Typically consists of coarse andesitic and basaltic volcanic rubble, lahar deposits, andesite and basalt lava flows, tuff, hypabyssal basalt and andesite plugs, lesser dacite and rare rhyolite, and minor amounts of volcaniclastic sedimentary rocks. Includes the Meshik Volcanics of the Alaska Peninsula, the Mount Galen Volcanics of central Alaska (Decker and Gilbert, 1978), the Ship Creek, Windy Fork, and Terra Cotta volcanic fields of the McGrath quadrangle (Bundtzen and others, 1997a), and the Finger Bay Volcanics of the Aleutian Islands (Coats, 1956b). Also includes the Rat Formation (Lewis and others, 1960), Amchitka Formation (Powers and others, 1960; Carr and others, 1970), and other rocks included in the “Lower Series” (Vallier and others, 1994) of the Aleutian Islands, as well as other unnamed volcanic rocks. The Meshik Volcanics represent the early phase of the Aleutian magmatic arc, named the Meshik Arc, and correspond to the “Lower Series” rocks in the Aleutian Islands. Unnamed equivalent rocks extend as far north as the Lake Clark quadrangle. The sedimentary rocks are equivalent in age and lithology to the Stepovak and Andrew Lake Formations (unit Tarcs). As described by Detterman and Reed (1980), in many cases eruptive centers can be identified, either as volcanic necks of eroded volcanoes or as caldera complexes. Potassium-argon ages on multiple samples of the Meshik Volcanics and rocks in the Aleutian Islands range from about 42 Ma to about 25 Ma (Wilson and others, 1999, 2006b, 2015); the vast majority of age determinations are between 40 and 30 Ma. Megafauna fossil collections from the Meshik Volcanics are rare, but existing collections are Eocene and Oligocene in age. The Mount Galen Volcanics, originally considered part of the Cantwell Formation (Decker and Gilbert, 1978), can be considered the northernmost part of this magmatic arc. They consist of andesite and basalt flows, tuff, and breccia of calc-alkaline affinity. The Finger Bay Volcanics of Adak and Kagalaska Islands and most of the Andreanof Islands east of Adak Island (Coats, 1956a; 1956b; Fraser and Snyder, 1959), and similar rocks on southeastern Great Sitkin Island (Simons and Mathewson, 1955; Waythomas and others, 2003) are basalt flows, hornblende- basalt tuff, flow breccia, agglomerate, basalt dikes, and subordinate rhyolite tuff and quartz porphyry dikes, intruded by large masses of gabbro and small masses of rhyolite (Coats, 1956b). The Rat Formation of Hawadax (formerly “Rat”) Island (Lewis and others, 1960) consists of flows and flow breccia of porphyritic andesite and minor conglomerate composed of andesitic debris. Altered pyroclastic deposits, pillow lavas, and minor sedimentary rocks on Ulak Island (Coats, 1956a) are included here as well. Also included is the Amchitka Formation (Powers and others, 1960; Carr and others, 1970), which is mainly volcanic agglomerate, tuff-breccia, tuff, and pillow lava flows of andesitic to latitic composition. In the McGrath quadrangle, the Ship Creek, Windy Fork, and Terra Cotta volcanic fields of Bundtzen and others (1997a) include gray-green andesite flows, light- to medium-gray, porphyritic, hornblende-bearing massive dacite and potassium-feldspar porphyritic rhyodacite flows, and a similar chemical range of tuff and lahar deposits. Rocks in these volcanic fields have yielded K/Ar ages ranging between 45.5±1.4 and 37.2±2.9 Ma (Solie and others, 1991a). On generalized map, included as part of unit Tvme.

This unit is Tvba, Tvb and Tvc in the GRI digital geologic-GIS data.

Tvs - Volcanic and sedimentary rocks, undivided (Tertiary, Oligocene and Eocene)

An isolated unit in the western Tyonek quadrangle, unit consists of light-green to gray, bedded volcaniclastic sedimentary rocks; some beds contain volcanic breccia clasts. Volcanic rock clasts are light green. LA-ICPMS detrital zircon dates have youngest grain ages of 58 to 55 Ma (D.C. Bradley, written commun., 2008). On generalized map, included as part of unit Tvcs.

This unit is Tvs in the GRI digital geologic-GIS data.

Tcl - Copper Lake Formation (Tertiary, Eocene to Paleocene)

Clastic nonmarine sedimentary rocks 1,025 m thick in a measured section that consists of upper and lower conglomerate members bounding a middle sandstone and siltstone member on the northern Alaska Peninsula (Detterman and Reed, 1980; Detterman and others, 1996). Upper conglomerate unit consists of red-weathering pebble-cobble conglomerate that consists mainly of volcanic rock clasts and contains minor tuff (Detterman and Reed, 1980). This upper member may be an agglomerate rather than conglomerate; clasts are 50 to 100 percent fresh-appearing volcanic rock. Clasts of quartzite, schist, greenstone, rose quartz, limestone, and granitic rocks are present in lower parts of this upper conglomerate member. Sandstone and siltstone intervals vary from thin-bedded to massive and are typically dark- to medium- gray; they are fine- to medium-grained lower in section and become medium- to coarse-grained toward top. Middle member is chiefly medium-gray to greenish-gray lithic graywacke sandstone and siltstone. More fine-grained clastic parts of formation contain considerable carbonaceous debris and minor coaly material. Grains in the sandstone include abundant quartz, schist, volcanic, and granitic rock fragments. Interbedded siltstone is similar in color and composition to the sandy facies, whereas claystone interbeds are mainly micaceous clay and contain a small amount of montmorillonite. Lower conglomerate member is red-weathering pebble-cobble conglomerate that consists mainly of volcanic rock clasts and contains minor tuff. Volcanic clasts constitute about 25 percent of member, and these appear to be derived from the Talkeetna Formation rather than the Tertiary volcanic units, which have a fresher appearance. Copper Lake Formation was derived from erosion of a Mesozoic source area and is terrestrial. In the southern part of its exposure area, the source area is underlain by the Alaska-Aleutian Range batholith (Reed and Lanphere, 1973) and associated Mesozoic sedimentary and metamorphic rocks. Towards the north, Copper Lake Formation undergoes transition from rocks of Mesozoic provenance to fresh volcanic clasts of probable Tertiary age (Detterman and Reed, 1980, p. B47). Age of the Copper Lake Formation is poorly constrained; sparse megaflora in type section and abundant megaflora on the Alaska Peninsula are restricted to sandstone and siltstone intervals in middle part of unit (Detterman and others, 1996). Detterman and others (1996) correlated the Copper Lake Formation with the Tolstoi Formation of the southwest Alaska Peninsula, where an early Eocene megaflora was collected from a section of sandstone and siltstone. Beneath the sandstone and siltstone, a basal conglomerate contains a late Paleocene flora; beds overlying the sandstone and siltstone contain a middle Eocene flora. By analogy, a Paleocene(?) to early Eocene age was assigned to the Copper Lake Formation. Parrish and others (2010) proposed a new formation they named the Ketavik [sic] Formation whose rocks, we believe, more properly belong to the Copper Lake Formation; the lithology and age assignment they gave to the Ketavik is consistent with the age of the Copper Lake Formation. Upper and lower contacts of the Copper Lake Formation are disconformities with Hemlock Conglomerate and Kaguyak Formation, respectively.

This unit is Tcl in the GRI digital geologic-GIS data.

Tev - Felsic volcanic rocks of southwest Alaska (Tertiary, Oligocene? and Eocene)

Primarily felsic tuff and subordinate flows and hypabyssal intrusive rocks exposed across southwest Alaska. In the Iliamna quadrangle, unit consists of cream, light-gray, green, and purple bedded lithic, crystal, and vitric tuff (Detterman and Reed, 1980). Also includes distinctive light-colored horizons of felsic tuff interlayered with olivine basalt in the northeast Dillingham quadrangle (Wilson and others, 2003). A sample from the northeast Dillingham quadrangle yielded a 40Ar/39Ar age determination of 45.1±0.19 Ma, whereas a sample from the southern Dillingham quadrangle yielded a 40Ar/39Ar age of 41.62±0.18 Ma, consistent with the age of the Meshik Volcanics (unit Tmv). Includes two areas of massive columnar-jointed olivine basalt flows in the northeast Dillingham quadrangle (Wilson and others, 2003). The younger of these flows ranges from 3 to 10 m thick, are interbedded with felsic tuff, and yielded a 40Ar/39Ar age of 44.47±0.41 Ma. The older olivine basalt may, in part, be a sill—locally it is overlain by contact-metamorphosed rocks of unit KTRs, marine volcaniclastic sandstone, conglomerate, and argillite; it yields a 40Ar/39Ar isochron age of 53.71±0.61 Ma. Similar tuff and

subordinate flows and hypabyssal intrusive rocks of apparently felsic composition occur in small exposures in the eastern Lime Hills and the Melozitna quadrangles, as well as in local accumulations of volcaniclastic sedimentary rocks. In some areas of the Lime Hills quadrangle, rocks range from andesite to dacite in composition, but in general the composition was not reported (Gamble and others, 2013). Farther west in the Bethel quadrangle, Box and others (1993) mapped moderately altered rhyolite flows, domes, and ash-flow tuff. Rhyolite of the main volcanic field contains phenocrysts of sanidine, riebeckitic amphibole, and rare quartz. An 40Ar/39Ar total-fusion age on riebeckite was 54.7±1.6 Ma. Also includes andesite to basalt plugs, volcanic rubble and breccia, including some agglomerate; may include deposits of lahars (Detterman and Reed, 1980). Many of the rocks of this map unit are associated with eruptive centers. An isolated andesitic plug in northeast Dillingham quadrangle yielded a 40Ar/39Ar isochron age of 47.95±1.39 Ma. Overall, dates on rocks of this map unit range from the 54.7±1.6 Ma age mentioned above to 33.6±3.4 Ma. On generalized map, included as part of unit Tvme.

This unit is Trd, Tvr and Tvbs in the GRI digital geologic-GIS data.

Tpt - Pyroclastic rocks (Early Eocene or Paleocene)

Tuffaceous rocks distributed in several areas of Alaska. The largest area of exposure is a belt in the Bettles, Tanana, and Melozitna quadrangles where light-gray to pink rhyolite tuff, welded(?) tuff, flows, and breccia and subordinate pumice, dark vitrophyre, and obsidian constitute the unit (Patton and others, 2009). Obsidian chips and artifacts found in archeological sites in northwest Alaska may have originated from this unit. In southwest Alaska in the northeast Dillingham quadrangle, unit includes crystal tuff that contains variable amounts of biotite and feldspar crystals and varies in general appearance from crystal tuff to porphyritic plutonic rock (Wilson and others, 2003), but in all cases the groundmass is tuffaceous. The proportion of tuff appears to increase from east to west. Wallace and others (1989) report K/Ar ages of 58.6±1.8 Ma (biotite) and 57.9±1.7 Ma (hornblende) for this unit, whereas multiple $^{40}Ar/^{39}Ar$ age determinations on biotite yield a tight age range between 59.69±0.05 and 59.25±0.05 Ma (Iriondo and others, 2003). On the northern part of Saint Matthew Island in the Bering Sea, unit is chiefly rhyolite and dacite welded tuff, tuff breccia, and dark rhyolite vitrophyre (Patton and others, 1975) and also includes minor intercalated andesite and basalt flows and dikes. On southwestern part of island, unit is chiefly light-colored rhyolite and dacite hypabyssal rocks (Patton and others, 1975). These felsic rocks appear to overlie mafic flows and volcaniclastic rocks and may be extrusive and hypabyssal cogenetic equivalent of granodiorite on the island (Patton and others, 1975). Age thought to be Eocene or Paleocene (see Wittbrodt and others, 1989). Tuffaceous rocks of similar age are known from the interior of Alaska in the Tanana (Reifenstuhl and others, 1997) and Big Delta quadrangles (Weber and others, 1978; Day and others, 2007); described by Reifenstuhl and others (1997) as “white and pink, purple and white, light-orange and pink, glassy-aphanitic to very fine-grained, flow-banded rhyolite, rhyolite tuff breccia, ignimbrite, and potassium feldspar-porphyritic rhyolite. The rock types present suggest that the rhyolite was emplaced as flows, domes, tuffs, breccia, and rare obsidian, and suggest extrusion over a significant period of time.” Bacon and others (1990) described areas of tuffaceous rocks in east-central Alaska that they interpreted as caldera complexes. In the easternmost Big Delta quadrangle, a complex that they called “Slate Creek,” another complex they called “EC” in the easternmost Tanacross quadrangle, and additional exposures along Taylor Highway in the Eagle quadrangle have yielded a range of K/Ar and U/Pb ages that date these rocks to the Paleocene and Eocene, between 61.6±2.0 and 54.6±1.6 Ma (Foster and others, 1979; Bacon and others, 1990). In the northern Tyonek quadrangle, more mafic andesite to dacite welded tuff occurs, where it consists of massive welded tuff in beds thicker than several meters (P.J. Haeussler, written commun., 2007). Unit also includes the Porcupine Butte andesite of Solie and Layer (1993), which consists of columnar jointed andesite forming the neck of a Paleocene volcanic center (Solie and others, 1991a). Pyroclastic volcanic rocks are also found in southeast Alaska in the Juneau and Taku River quadrangles and range from tuff to coarse block-and-ash-fall breccia, which are recognized as part of the Sloko Group of Canada. They include minor sedimentary rocks, andesite, trachyte, dacite, rhyolite, and minor andesite and basalt flows. Age in inferred from the intimate association of the volcanic rocks with granodiorite of the Coast plutonic

complex of Brew and Morrell (1979b). On generalized map, included as part of unit Tkpr.

This unit is Tfv in the GRI digital geologic-GIS data.

Tpgr - Undivided granitic rocks (Tertiary, late Paleocene)

Predominantly medium-grained composite plutons of granite and quartz monzonite and lesser granodiorite and quartz syenite. Biotite is the chief mafic mineral and hornblende is locally present, especially in the granodiorite phases. Muscovite is a common component of the granite. Unit is widespread, although the bulk of the exposure is in the western Alaska Range and Tyonek quadrangle or spatially associated with the Alaska-Aleutian Range batholith of Reed and Lanphere (1973) in the Lake Clark and Iliamna quadrangles. It is primarily distinguished from unit Tkg by age determinations. Unit includes the Styx River batholith of Reed and Elliott (1970), rocks of map units Ti7, Ti10, and Ti11 of Nelson and others (1983), much of the McKinley series of Reed and Nelson (1980) and unit Tbgd of Csejtey and others (1978). Outliers occur in Unalakleet and Table Mountain quadrangles. In the Lime Hills and western Tyonek quadrangles, it is difficult to distinguish between this map unit and unit TKg; without additional mapping and data, the density of lithologically similar plutons makes distinction of these two units especially difficult. On generalized map, included as part of unit TKgi.

This unit is Tgh, Tpg, Thgd and Tpd in the GRI digital geologic-GIS data.

Tgbw - Gabbro, southwest Alaska (Tertiary, Paleogene?)

Unit occurs as small plutons in the McGrath, Lime Hills, Lake Clark, and Tyonek quadrangles. Dark-colored hornblende and pyroxene-hornblende fine- to medium- grained gabbro (McGrath quadrangle: Bundtzen and others, 1997a; Lime Hills quadrangle: Gamble and others, 2013) or hornblende and biotite-bearing olivine gabbronorite (Lake Clark quadrangle: Nelson and others, 1983). On generalized map, included as part of unit Tgb.

This unit is Tgl in the GRI digital geologic-GIS data.

TKv - Volcanic rocks in southern Alaska (Late Cretaceous to Early Tertiary)

Primarily consists of basalt and andesite, but ranges from basalt to rhyolite, largely exposed in southwest Alaska. A common association is with rocks of the Kuskokwim Group (unit Kk), however, this volcanic rock unit is somewhat more widespread in southwest Alaska. Unit varies compositionally across exposure area and incorporates the full lithologic range of flows, tuff, and breccia and minor interbedded sandstone and shale in the Ruby, Iditarod, and Ophir quadrangles (Cass, 1959; Chapman and Patton, 1979; Chapman and others, 1985; Miller and Bundtzen, 1994). In the Iditarod quadrangle, includes that part of the Iditarod Volcanics that overlies the Kuskokwim Group. Andesite and basalt flows and volcaniclastic rocks are widely exposed in the central part of the Holy Cross quadrangle and in a small area in the north-central part of the Russian Mission quadrangle between the Yukon and Kuskokwim Rivers. Flows are generally porphyritic and are composed of phenocrysts of plagioclase and pyroxene in a groundmass of plagioclase microlites. Some of the flows are columnar jointed and locally vesicular. Volcaniclastic rocks in this unit include breccia, tuff, and agglomerate. The andesitic and basaltic rocks commonly are interlayered with or intruded by small bodies of dacite and rhyolite (Patton and others, 2006). In the southwest part of Talkeetna quadrangle, Reed and Nelson (1980) mapped interbedded medium- to coarse-grained greenish-gray crystal-lithic lapilli tuff and mafic volcanic rubble flows in units as much as 150 m thick, as well as associated sandstone, shale, and minor calcareous mudstone. In the McGrath, Melozitna, Unalakleet, Tanana, and Medfra quadrangles (Patton and others, 1978; Patton and others, 1980; Bundtzen and

others, 1997a), unit consists of dacite, rhyolite, and trachyandesite lava flows, domes, sills, dikes, and interlayered breccia and tuff. In the Bethel quadrangle, unit includes felsic rocks of the Swift Creek, Tulip, and Eek volcanic fields of Box and others (1993) as well as rhyolitic rocks in the Ruby (Cass, 1959), Denali (Bela Csejtey, Jr., written commun., 1993), Tanana (Chapman and others, 1982), and Kantishna River quadrangles (Chapman and others, 1975); unit also includes felsic tuff in the Tyonek quadrangle (Solie and others, 1991a). Locally, in Unalakleet and Medfra quadrangles, tuff at the base of unit TKv contains interbeds of quartz-chert-pebble conglomerate, sandstone, siltstone, and thin coaly layers that contain abundant plant fossils. Palynflora collected from coaly layers at the base of the unit in the Medfra quadrangle are latest Cretaceous in age. Unit overlaps compositionally and spatially with units Tpt and TKwt, described below. Where known, age determinations generally range between approximately 70 and 50 Ma. On generalized map, included as part of unit TKpr.

This unit is: TKd, TKv, TKvr, TKvd and TKmv in the GRI digital geologic-GIS data.

TKg - Felsic granitic rocks (Tertiary, Paleocene, or Late Cretaceous, Maastrichtian)

Fine- to coarse-grained or porphyritic, light- to dark-gray, rarely pink, granitic rocks. Unit ranges in composition from granite to quartz diorite, and includes syenite, granodiorite, and quartz monzonite. Biotite and hornblende are locally common; muscovite is uncommon. K/Ar and 40Ar/39Ar ages range from about 76 Ma to about 57 Ma; the vast majority of samples yielded ages in the range 70 to 59 Ma. Available U/Pb zircon ages fall within the same ranges. Unit includes many of the plutons shown on various source maps for this map that are commonly labeled TKg. These plutons tend to be small and are exposed in a broad belt from southwest Alaska through interior Alaska and into the Yukon. They tend to be potassium-rich, even at lower SiO2 contents, having as much as 6 percent K2O at 60 percent SiO2 in the Dillingham quadrangle (F.H. Wilson, unpub.data). Plutons of this unit are common in the western Dillingham quadrangle (Wilson, 1977) and are unusual in that they tend to have biotite and pyroxene, often orthopyroxene, as their mafic minerals, regardless of the overall pluton composition. Unit consists of hundreds of individual plutons. Many of the hot springs of interior Alaska are spatially associated with these plutons (Motyka and others, 1983). Associated mineralization includes gold, tin, and mercury (see http://ardf.wr.usgs.gov for more information about mineral resources in Alaska). On generalized map, included as part of unit TKgi.

This unit is: TKgs, TKg, TKgr and TKgm in the GRI digital geologic-GIS data.

TKgb - Gabbroic rocks (Tertiary to Late Cretaceous or older)

Fresh to altered gabbroic and diabasic intrusive bodies including small plutons, dikes and sills. Widespread throughout western Alaska; distribution of unit mimics distribution of the more granitic rocks of units TKg and TKgd. Age control is limited relative to the granitic rocks and, in many cases, the age assigned by local geologic mappers is Devonian to Tertiary, hence, the rocks included here may, in part, be significantly older that the granitic rocks of units Tpgr, TKg, and TKgd. In the Ophir quadrangle, medium- to coarse-grained gabbro that has minor associated diorite and basalt intrudes rocks of inferred Mississippian to Triassic age and, locally, Cretaceous age. Contact relations are uncertain due to poor exposure, but Chapman and others (1985) indicate at least one gabbro body has a hornfels aureole. A similar unit of gabbroic sills, dikes, and small plugs in the adjoining Medfra quadrangle was given a provisional Devonian to Tertiary age (Patton and others, 1980). Unit also includes poorly exposed small bodies of mafic rocks in Talkeetna Mountains and Tyonek quadrangles. In the Talkeetna Mountains, Csejtey and others (1978) described a medium- to light-gray, coarse- to medium-grained plagioclase and pale-green hornblende-bearing leucogabbro. J.M. Schmidt (written commun., 2007) also described diorite associated with the gabbroic rocks. Reed and Elliot (1970) described diorite and olivine and (or) hornblende gabbro that occur as intrusive bodies and inclusions in other Tertiary intrusive rocks in Tyonek quadrangle. Age is poorly constrained, but

samples of hornblendite and gabbro from Tyonek quadrangle yielded 40Ar/39Ar plateau ages of between about 84 and 69 Ma (P.J. Haeussler, unpub. data). Altered gabbro and diorite bodies crop out as small scattered bodies in the Russian Mission and southern Holy Cross quadrangles; the age of these bodies is uncertain, but not older than Jurassic. Unit TKgb includes dark-colored dikes and sills of diabase, basalt, and dioritic, gabbroic, and biotite lamprophyre that yield a K/Ar age of 64.6±2 Ma on biotite from the western Nushagak Bay quadrangle (Hoare and Coonrad, 1978). Unit also includes a medium- to coarse-grained pyroxene gabbro dike(?) on Saint Matthew Island (Patton and others, 1975). On generalized map, included as part of unit TKm.

This unit is unit TKgb in the GRI digital geologic-GIS data.

TKgg - Gneissose granitic rocks (Tertiary or Late Cretaceous)

Chiefly gneissose granodiorite, quartz diorite, and minor granite referred to as the East Susitna batholith in the Mount Hayes quadrangle (Nokleberg and others, 1992a). In the Talkeetna Mountains quadrangle, Csejtey and others (1978) mapped an early Tertiary andalusite and (or) sillimanite-bearing pelitic schist, lit-par-lit migmatite, and granite unit that we have included here. In the Healy quadrangle, Csejtey and others (1992) mapped similar rocks as part of their unit Kgr, which is, in part, correlative with the East Susitna batholith of Nokleberg and others (1992a). The granitic bodies show moderately to well developed flow foliation and all internal contacts between phases are gradational, as is the contact with unit Mzmu. Unit has pervasive schistosity that generally strikes northeast to southwest and dips moderately to steeply west, is locally blastomylonitic, and contains relict porphyritic textures. Metamorphic grade is middle to upper amphibolite facies (Nokleberg and others, 1992a, 2013). Radiometric ages, including U/Pb zircon and sphene and K/Ar mica and hornblende ages have a wide range, between about 70 and 29 Ma (Nokleberg and others, 1992b; Csejtey and others, 1978, 1992). Youngest ages are close to and may be related to unroofing along the Denali Fault System. In the Healy quadrangle, rocks of this unit are described by Csejtey and others (1992) as their unit Kgr. South of the Susitna Glacier, these rocks are described as migmatitic and thought to reflect lit-par-lit intrusion of Tertiary magma into Cretaceous plutons (Csejtey and others, 1978). These rocks are a major component of the MacLaren metamorphic belt of Smith and Lanphere (1971) and have been correlated with the Ruby Range batholith in the Yukon and part of the Coast plutonic complex of Brew and Morrell (1979b) of southeast Alaska. In the Lime Hills and Tyonek quadrangles, a small area of undated gneiss is included in this unit. It consists of fine- to coarse-grained orthogneiss whose texture is locally cataclastic (Gamble and others, 2013). Primary composition is granodiorite, and as much as 5 percent garnet was noted locally, in contrast to the gneiss of the Mount Hayes and Healy quadrangles (B.M. Gamble, written commun., 1996). Structural grain strikes northeast to southwest and tends to be vertical or steeply dipping (80°) to the northwest; in a general sense, these rocks are on strike with the trend of the gneiss of the Mount Hayes and Healy quadrangles. On generalized map, included as part of unit TMzmb.

This unit is unit TKgg in the GRI digital geologic-GIS data.

Tgba - Diabase and gabbro, Aleutian Islands (Tertiary, Miocene to Paleocene?)

Diabase and gabbro dikes, sills, and small plutons are widespread and form two-thirds of the intrusive rocks on Attu Island and are very common on Agattu Island (Gates and others, 1971). These dikes and sills intrude all Attu Island units as old as the Chuniksak and Chirikof formations, but do not cut the Massacre Bay (included in unit QTv, here) and Faneto Formations (included in unit QTs, here). Hence, they are considered Miocene in age, although some of these rocks may be older (Gates and others, 1971, p. 746). Placed in the Attu Basement Series by Yogodzinski and others (1993). Similar gabbroic bodies in two large intrusions also occur on Kiska Island (Coats and others, 1961) and in a large mass of gabbro that locally includes hornblende gabbro, as well as augite-quartz syenite that

intrudes the Finger Bay Volcanics on Adak Island (Coats, 1956a). On Attu Island, diabase and gabbro that intrude map unit Tba have yielded K/Ar whole-rock ages of 27.2±1.4 and 32.7±1.4 Ma (DeLong and McDowell, 1975). On Amlia Island, gabbro has yielded a K/Ar age of 39.8±1.2 Ma (McLean and others, 1983). Drewes and others (1961) mapped a gabbro body they inferred was a border facies of the granitic Shaler batholith on Unalaska and Sedanka Island; however, the gabbro is spatially distinct from the Shaler batholith and radiometric dates indicate that the gabbro is significantly older—about 30 Ma—whereas the other parts of the Shaler batholith are about 12 Ma. Unit also includes the Sled Pass gabbro of the eastern Lime Hills quadrangle (Gamble and others, 2013) for which Jones and others (2014) have reported a U/Pb zircon age of 28.5 Ma, which is unique for gabbro in that part of Alaska. On generalized map, included as part of unit Tgb.

This unit is unit TKgb in the GRI digital geologic-GIS data.

TKhi - Dikes and subvolcanic rocks (Tertiary and (or) Cretaceous)

Widely distributed in western Alaska, unit consists of a wide variety of shallow intrusive rocks including rhyolite, dacite, trachyte, and andesite plugs, domes, sills, and dikes, and larger, more coarsely crystalline bodies of granite, granodiorite, tonalite, and monzonite porphyry (Patton and others, 2009; Patton and others, in press). Typical rock is composed of a fine-grained felsic groundmass with phenocrysts of plagioclase, quartz, biotite, and hornblende. Unit forms numerous large sills, dikes, and domes intruding Cretaceous and older sedimentary rocks primarily in the Iditarod, Sleetmute, Russian Mission, northwestern Holy Cross, and northeastern Kwiguk quadrangles. Limited age control from K/Ar, $^{40}Ar/^{39}Ar$, and U/Pb techniques in southwest Alaska suggests an age range between about 72 and 60 Ma. Unit is compositionally similar to, and, where age control exists, is also similar in age to units TKg and TKgd. Unit is texturally transitional between TKg, TKgd, and unit TKv. Unit is also found less commonly in the Selawik, Bettles, Hughes, Lime Hills, Dillingham, and Lake Clark quadrangles. In the Selawik, Bettles, and Hughes quadrangles, age control is lacking, but association with mid-Cretaceous plutons suggests that these small intrusions may be older than those in southwest Alaska. On generalized map, included as part of unit TPzi.

This unit is unit TKgp in the GRI digital geologic-GIS data.

TKgd - Granodiorite to quartz monzodiorite (Tertiary, Paleocene, or Late Cretaceous, Maastrichtian)

Typically described as granodiorite, quartz diorite, tonalite, monzonite, and quartz monzodiorite, these plutons compositionally overlap with unit TKg, described above, but are the more mafic plutons in this age range. Also widespread, they tend lie at the periphery of the TKg belt of plutons. They are locally weakly foliated and hypidiomorphic-granular or seriate in texture. K/Ar ages on biotite and hornblende range between 73.5 and 60.0 Ma—very slightly older than unit TKg. An outlier to the belt, a fine-grained hornblende granodiorite, is found on Saint Matthew Island and yielded a K/Ar age on hornblende of 62.3±2.0 Ma (Patton and others, 1975). On generalized map, included as part of unit TKgi.

This unit is TKqd and Tkgd in the GRI digital geologic-GIS data.

Toegr - Granitic rocks (Tertiary, early Oligocene and Eocene)

Granitic rocks that range in composition from granite to diorite in two belts in southern Alaska. The generally older belt occurs east and southeast of Cordova and typically has U/Pb, K/Ar, and 40Ar/39Ar ages that range from about 53 to 42 Ma. This belt, composed of rocks that range in

composition from biotite- and hornblende-bearing granite to tonalite, is distinguished by the almost ubiquitous presence of tonalite phases associated with the plutons. These older plutons intrude Orca Group and Valdez Group rocks and in southeast Alaska are restricted to within a few tens of kilometers of the Gulf of Alaska coast. There is a weak tendency for these plutons to get younger to the southeast. In the Mount Fairweather and Skagway quadrangles, some of the plutons have migmatitic zones. The second, slightly younger belt, exposed in the western Alaska Range and on Adak Island in the Aleutian Islands, ranges in age from about 50 to 32 Ma. Compositionally, plutons in this younger belt range from biotite-bearing granite to biotite- and hornblende-bearing granodiorite; tonalite phases, conspicuously, are not reported. On Adak, the plutons have K/Ar and 40Ar/39Ar ages between 35 and 32 Ma; in the mainland part of the belt, ages range from 55 to 32 Ma and are older to the northeast. An outlier from these belts is found intruding the Ghost Rocks Formation on Kodiak Island; it consists of altered granitic rocks and a fission-track zircon age was 50 Ma (Clendenen, 1991); other plutons intruding the Ghost Rocks Formation, however, have yielded a number of K/Ar ages from 63 to 62.1 Ma (Moore and others, 1983). The plutons yielding these older ages are usually assigned to the Kodiak batholith (unit Tpgi), but that may be inappropriate because these plutons intrude the younger early Tertiary and latest Cretaceous Ghost Rocks Formation (unit TKm, here), whereas the Kodiak batholith is generally restricted to plutons that intrude the Cretaceous Kodiak Formation (included in unit Kaf, here). Another outlier, which intrudes undated peridotite on Saint George Island in the Pribilof Islands, yielded K/Ar ages of 57 to 49.5 Ma (Barth, 1956; Hopkins and Silberman, 1978). On generalized map, included as part of unit Toeg.

This unit is Toem, Tegr and TKoegr in the GRI digital geologic-GIS data.

KJg - Quartz monzodiorite (Cretaceous to Jurassic)

An elongate, medium-gray, medium-grained, hypidiomorphic granular hornblende-biotite quartz monzodiorite that contains variable amounts of clinopyroxene located in extreme northwest part of Kenai quadrangle, northeast part of Lake Clark quadrangle, and southwest part of Tyonek quadrangle (Nelson and others, 1983; Wilson and others, 2006a, 2009, 2012, in press [a]). Magmatic flow structures locally present; hornblende and plagioclase are aligned north-northeast. Body is sandwiched between Jurassic plutons on the east and early Tertiary or Late Cretaceous and Eocene plutons on the west, all considered part of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). Two samples yielded strongly discordant K/Ar biotite and hornblende ages between 97.5 and 58.8 Ma (Reed and Lanphere, 1973; Nelson and others, 1983). On generalized map, included as part of unit KJgu.

This unit is unit TKJg in the GRI digital geologic-GIS data.

TRcb - Cottonwood Bay and Chilikradrotna Greenstones (Late Triassic, Norian?)

Cottonwood Bay Greenstone is largely dark-gray to dark-green, porphyritic to amygdaloidal basaltic flows altered to greenstone (Detterman and Reed, 1980). Unit occurs either as roof pendants of, or east of, Alaska-Aleutian Range batholith in Iliamna and Mount Katmai quadrangles and, as a result, is commonly contact metamorphosed. Unit is associated with the Kamishak Formation (unit TRcnk here); the basal beds of Bruin Limestone Member of Kamishak Formation contain volcanic rocks similar to Cottonwood Bay Greenstone; using this evidence, Detterman and Reed (1980) assigned a Late Triassic age to unit. Because the Kamishak Formation is Norian age, Detterman and Reed (1980) stated that the Cottonwood Bay Greenstone is probably older than Norian. Together, the Cottonwood Bay Greenstone and Kamishak Formation constitute a package very similar to that defined for the Wrangellia terrane. Because of metamorphism, it can be difficult to distinguish the Cottonwood Bay Greenstone from the Talkeetna Formation (Detterman and Reed, 1980). Chilikradrotna Greenstone (Bundtzen and others,1979), largely metabasalt, locally includes andesite,

chert, limestone, and tuffaceous sedimentary rock, all weakly metamorphosed and exposed to the west of Alaska-Aleutian Range batholith in the Lake Clark quadrangle. Also associated with this unit is highly fractured dark-gray limestone and chert (Eakins and others, 1978), here assigned to the Kamishak Formation. Eakins and others (1978) also mapped gray shale and gray volcaniclastic sandstone in close proximity to outcrops of the Chilikadrotna Greenstone. These units were originally thought to be of Silurian age on the basis of an erroneous fossil determination in the associated limestone; it has since been revised (R.B. Blodgett, 2004, written commun.). On generalized map, included as part of unit TRmb.

This unit is MZPZcb and TRScg in the GRI digital geologic-GIS data.

JPk - Kakhonak Complex and Tlikakila complex of Carlson and Wallace (1983) (Jurassic, Triassic, and older?)

Kakhonak Complex is a lithologically diverse and complex assemblage of metamorphosed mafic plutonic, volcanic, and sedimentary rocks found on west side of Cook Inlet, defined by Detterman and Reed (1980), associated with the Alaska-Aleutian Range batholith and similar rocks in the Talkeetna Mountains. Detterman and Hartsock (1966) mapped metalimestone, argillite, quartzite, metatuff, greenstone, and phyllite as undivided metamorphic rocks in the Kenai and Iliamna quadrangles. Detterman and Reed (1980) named these rocks the Kakhonak Complex and described unit that largely consists of roof pendants within the Alaska-Aleutian Range batholith and along the eastern margin of the Jurassic part of the batholith. They thought that the Kakhonak Complex represented, in part, the metamorphic equivalent of Upper Triassic Kamishak and Lower Jurassic Talkeetna Formations, which are in the vicinity. However, quartzite and quartz-mica schist within the Kakhonak Complex have no direct equivalent within the sedimentary rocks of the area, which indicates that other protoliths may have contributed to the complex. Because Permian rocks were known from Puale Bay, south of the map area, a possible Paleozoic age was not ruled out by Detterman and Reed (1980); subsequent analysis of Alaska Peninsula drill cores has conclusively demonstrated the presence of Paleozoic rocks on the peninsula (R.B. Blodgett, written commun., 2011). Internal contacts are typically faults, resulting in a tectonic mix of lithologies. Although most of the rocks of this complex are greenschist facies, the rocks range in metamorphic grade from not metamorphosed to granulite facies. Intrusive rocks provide a minimum age for the Kakhonak Complex. On the west side of the batholith, the lithologically similar Tlikakila complex of Carlson and Wallace (1983; see also Wallace and others, 1989; Amato and others, 2007) straddles Lake Clark and the Lake Clark Fault without apparent offset. Nelson and others (1983) mapped a unit somewhat more extensive than the Tlikakila complex as shown by Wallace and others (1989) or Amato and others (2007); Nelson and others (1983) described “a diverse complex of metamorphosed and highly deformed rocks, whose protoliths include calcareous to siliceous clastic rocks, limestone, thin-bedded chert, massive basalt, massive to layered gabbro and pyroxenite, and ultramafic rocks. Most of complex metamorphosed to greenschist facies but ranges from nonmetamorphosed to amphibolite facies” (Nelson and others, 1983). 40Ar/39Ar ages on mica from metasedimentary rocks range between 192 and 176 Ma (Amato and others, 2007) and provide a minimum age for metamorphism, which is somewhat older than K/Ar and U/Pb ages determined on nearby parts of the Jurassic phase of the Alaska-Aleutian Range batholith (unit Jgr, 172 to 160 Ma). Detrital zircon data from a single sample of chert-pebble conglomerate (Amato and others, 2007) potentially indicates a Paleozoic source terrane for the conglomerate. The age distribution of the zircons is similar to that for the Terra Cotta Mountains Sandstone (D.C. Bradley, oral commun., 2012; unit Stc here). Unit also includes migmatitic border rocks of the Jurassic plutons and undifferentiated metamorphic and plutonic rocks in the Talkeetna Mountains quadrangle (units Jpmu and Jgdm of Csejtey and others, 1978).

This unit is unit MZPZk and MZPZb in the GRI digital geologic-GIS data.

Kcs - Chignik Formation and similar units in southern Alaska (Upper Cretaceous)

Consists of the Chignik Formation of the Alaska Peninsula, the Summit Island Formation of southwest Alaska (Hoare and others, 1983), and the Saddle Mountain section of Magoon and others (1980) in the Cook Inlet region. Named by Atwood (1911, p. 41–48), the Chignik Formation is a cyclic, nearshore marine, tidal flat, and nonmarine floodplain and fluvial deposit (Fairchild, 1977; Detterman, 1978) as much as 600 m thick between Port Moller and Chignik Bay. Unit is dominantly light-olive-gray to olive-gray sandstone that has interbedded olive-gray to olive-black siltstone and conglomerate. Conglomerate is composed of multicolored chert, white quartz, felsic plutonic, and minor volcanic clasts. Nonmarine part locally contains coal beds as much as 2 m thick. Marine fossils, mainly pelecypods, indicate late Campanian and early Maastrichtian age (J.W. Miller, written commun., 1983–85). Chignik Formation unconformably overlies all older units on the Alaska Peninsula and conformably interfingers with and underlies its deep-water-facies equivalent Hoodoo Formation (unit Khk) (Mancini and others, 1978; Molenaar, 1980; Detterman and others, 1996). As shown here, unit also includes rocks mapped as undivided Chignik and Hoodoo Formations in Ugashik 1:250,000-scale quadrangle by Detterman and others (1987a). Summit Island Formation of southwest Alaska consists of lenses and inter-tonguing beds of nonmarine conglomerate, sandstone, carbonaceous siltstone, mudstone, and shale that contain abundant plant detritus and a few coal seams (Hoare and others, 1983). In the type section, the unit “consists of about 200 m of massive and thick-bedded pebble [to] cobble conglomerate overlain by about 650 m of interbedded sandstone, siltstone, and mudstone and a few conglomerate beds” (Hoare and others, 1983). At the reference section of the unit, its character changes to consist of “about 75 percent carbonaceous mudstone, siltstone, and shale and 25 percent interbedded sandstone and pebble grit” (Hoare and others, 1983). Conglomerate clasts are well-rounded, generally not larger than 10 cm, and primarily derived from flows, tuffs, and sedimentary rocks of Jurassic and Early Cretaceous age (Hoare and others, 1983), as well as white quartz and sparse schist and plutonic clasts; they suggest the schist clasts are derived from tectonically metamorphosed rocks that occur locally along major faults in the region. Noting two contrasting sandstone compositions, Box (1985) divided the unit into two subbasins along the trace of the Togiak-Tikchik Fault; both subbasins contain more than 1 km of section. Sandstone of Summit subbasin (southeast of Togiak-Tikchik Fault) is composed mostly of slaty sedimentary lithic fragments, similar to underlying Jurassic sedimentary rocks. Rocks in this subbasin consist of a lower conglomeratic member (200 m) that probably originates from alluvial fans and braided streams, and an upper carbonaceous shale member that probably originates from meandering streams and floodplains and has channelized sandstone bodies that become finer grained and thinner upward. Sandstone of Hagemeister subbasin (northwest of Togiak-Tikchik Fault) is composed of nonfoliated volcanic detritus similar to underlying Jurassic rocks and consists of a lower channelized sandstone member (600 m) that probably originates from meandering streams, and an upper sandy member (400 m) that has cycles that coarsen and thicken upwards in section, beginning with laminated siltstone-coal intervals that are possibly lacustrine delta deposits. Plant fossils from the base of the reference section indicate a latest Cretaceous or early Tertiary age (J.A. Wolfe, oral commun., 1974, cited in Hoare and others, 1983). A dike that cuts the formation yielded a K/Ar age of 64.6±2 Ma, which suggested to Hoare and others (1983) that a Late Cretaceous age for the Summit Island Formation was more probable. Subsequent dating of a dike cutting the formation yielded an older age of 76.6±4.5 Ma (Box, 1985), further supporting a Cretaceous age assignment for the unit. The Saddle Mountain section of Cook Inlet consists of dominantly nonmarine fine- to medium-grained sandstone that becomes finer grained upward and lesser conglomerate, minor siltstone, and coal in a section 83 m thick (Magoon and others, 1980) found northeast of Chinitna Bay in the Seldovia quadrangle. Unit is soft and friable except where cemented by calcite. Conglomerate contains volcanic and plutonic rock boulders as large as 30 cm in diameter in a sandy matrix. Coal beds, which tend to occur in the upper part of the section, are as much as 2.7 m thick and locally have underclay (Magoon and others, 1980). Sporomorphs Cranwellia striata (Couper) Srivastava, Balmeisporites spp., Wodehouseia spinata Stanley, Proteacidites spp., Aquilapollenites bertillonites Funkhouser, A. reticulatus Mtchedlishvili, and A. delicatus Stanley (Magoon and others, 1980) indicate Maastrichtian age. The Saddle Mountain section was assigned to Kaguyak Formation by Bradley and others (1999), but is distinctly different than Kaguyak Formation (unit Khk). Unit overlies the Upper Jurassic Naknek

Formation with angular unconformity and is overlain by West Foreland Formation with angular unconformity. On generalized map, included as part of unit Knmt.

This unit is unit Kks in the GRI digital geologic-GIS data.

Kgu - Plutonic rocks and dikes, granite to diorite (Cretaceous)

Consists of a variety of granitic rocks, typically granodiorite, tonalite, and quartz diorite bodies found primarily in two areas of the State. A significant area of these rocks were mapped by Nelson and others (1983) in the eastern Lake Clark quadrangle and extend into the Kenai and Tyonek quadrangles and are considered part of Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). They are medium- to coarse-grained, light-to medium-gray, and contain hornblende, biotite, and, rarely, muscovite; they locally have cataclastic textures. Although mapped as separate plutons by Nelson and others (1983), a number of these bodies may be fault-offset extensions of each other. Largely undated, the sparsely available K/Ar and 40Ar/39Ar dates from the west side of Cook Inlet range from 80.7 to 63.1±1.8 Ma (Reed and Lanphere, 1972; P.J. Haeussler, written commun., 2008); a number of these ages are either discordant or have disturbed spectra. These rocks are typically exposed between the Jurassic part of the batholith on the east and the early Tertiary to latest Cretaceous plutons of the batholith on the west. The second large exposure area of these plutons is in the Tanacross and Eagle quadrangles, where a significant part of these quadrangles consist of undated granitic rocks (Foster, 1970, 1976, 1992). In this area, these rocks may range in age from early Tertiary to Jurassic or possibly Triassic; the most likely ages are mid-Cretaceous or early Tertiary to latest Cretaceous. Other undated, but likely Cretaceous, plutons are in the Healy, Kateel River, Hughes, and Bendeleben quadrangles. The Hughes body is a medium- to coarse-grained albite granite, and the Kateel River plutons consist of albite granite and syenite (Patton, 1966; Patton and Miller, 1966). On generalized map, included as part of unit KJgu.

This unit is Kgd and Kqd in the GRI digital geologic-GIS data.

Klgr - Intermediate granitic rocks (Late Cretaceous)

Granitic rocks including alaskite, granite, quartz monzonite, and dominantly granodiorite of Late Cretaceous age, generally between 85 and 70 Ma. Sparsely distributed in western and south-central Alaska, the largest exposures are the isolated pluton in the Hooper Bay quadrangle and a number of monzogranite to quartz monzodiorite plutons on the Seward Peninsula. Important additional exposures include the so-called tin granites of the Seward Peninsula (Till and others, 2010; 2011). Other areas of significant exposure are in the Talkeetna Mountains north of Anchorage and across the Susitna basin in the Tyonek quadrangle. In the Yukon-Koyukuk Basin (Shungnak, Hughes, and Melozitna quadrangles), large and small plutons of granodiorite and quartz monzonite are spatially associated with the syenitic rocks of unit Ksy, but these rocks are significantly younger than unit Ksy. A small pluton in the Circle quadrangle yields a K/Ar cooling age of 72.8 Ma and is included in this unit; however, given its setting (Wilson and others, 1984), the age may be reset and the pluton may be an older Cretaceous pluton more typical of the Yukon-Tanana Upland. Similarly, other plutons of this unit in the Circle and Big Delta quadrangle yield discordant ages and may also be thermally reset plutons of older Cretaceous age (see, for example, Smith and others, 1994). A number of small, dioritic plutons of Late Cretaceous age also occur in the eastern Taylor Mountains and Lake Clark and Iliamna quadrangles.

This unit is TKgdt and Kgl in the GRI digital geologic-GIS data.

Klqm - Quartz monzonite and monzonite (Late Cretaceous)

Massive, coarse-grained, light-gray porphyritic quartz monzonite (Detterman and Reed, 1980; Nelson and others, 1983) is associated spatially with the Alaska-Aleutian Range batholith in the Iliamna and Lake Clark quadrangles. K/Ar ages range from 85.5 to 75.6 Ma (Reed and Lanphere, 1972). In northern Tyonek quadrangle, fine- to medium-grained pink monzonite or syenite intrudes sedimentary rocks of unit Kfy and contains primary pyroxene and has yielded a concordant U/Pb zircon age of 80.3 ±0.1 Ma (P.J. Haeussler, unpub. data). Pluton is distinctive in being more potassium-feldspar-rich and quartz-poor than other granitic rocks in the region. Unit also includes undated plutons in the Talkeetna Mountains quadrangle. In the west-central Dillingham quadrangle, an unusual highly potassic coarse-grained biotite-pyroxene granite or syenite yielded an 40Ar/39Ar age of 84.49 Ma; this pluton is similar to other potassium-rich rocks in the Dillingham area (see unit TKg) except for age. On generalized map, included as part of unit Klgr.

This unit is Kgk in the GRI digital geologic-GIS data.

Kmqm - Quartz monzonite, monzonite, and syenite (Cretaceous, Coniacian to Albian)

Large quartz monzonite plutons occur in three general areas of the state. The largest exposures are found in the Ruby terrane north of the Kaltag Fault in west-central Alaska. Plutons, such as the large Melozitna pluton, are largely quartz monzonite, but also have granite and monzonite phases. Locally, the Melozitna pluton intrudes granitic augen gneiss that has yielded a protolith emplacement age of 117.5 Ma (Roeske and others, 1995). On the southeastern Seward Peninsula, an elongate pluton 80 km long and 3 to 8 km wide extends along the crest of the Darby Mountains in the southeast part of the peninsula (Till and others, 2011). Other plutons of this unit are exposed in the Yukon–Koyukuk Basin in the Candle, Selawik, and Shungnak quadrangles, spatially associated with similar age syenite and nepheline syenite of unit Ksy. Additional exposures occur on the islands offshore of the Seward Peninsula—Little Diomede, King, and Sledge Islands. Plutons in these two areas range in age between about 112 and 85 Ma. In the transition zone between the Tintina and Kaltag Fault Systems in north-central Alaska, a number of 92- to 88-Ma quartz monzonite plutons lie in a belt parallel to the structural trend. In eastern Alaska, a number of large quartz monzonite plutons are found in the Tanacross and Nabesna quadrangles and extend into the Yukon of Canada. Age determinations on these plutons, of which there have been very few, are more restricted in age, between about 98 and 91 Ma. Included here is a small syenite body located just a few miles north of Fairbanks in central Alaska, which has been described by Newberry and others (1998a) and yielded a nearly concordant TIMS U/Pb date of 110.6±0.6 Ma. Also included is the quartz monzonite phase of the Mount Kashagnak pluton of the Skagway quadrangle, which is undated. On generalized map, included as part of unit Kmgr.

This unit is unit Kmqm in the GRI digital geologic-GIS data.

Kmgr - Granitic rocks of central and southeast Alaska (Cretaceous, Coniacian to Albian)

Primarily granodiorite and lesser quartz diorite, granite, and quartz monzonite that is widely exposed in central and southeastern Alaska. Exposed primarily in four areas: (1) southern southeast Alaska west of the Coast plutonic complex; (2) in the Yukon-Tanana Upland of east-central Alaska and northern Alaska Range; (3) on Saint Lawrence Island in western Alaska; and (4) in southwest Alaska in the Bethel and Russian Mission quadrangles. In southeast Alaska, the plutons tend to be more mafic than other areas and consist of granodiorite and quartz diorite and lesser tonalite; most rocks are medium-grained and moderately foliated and lineated parallel to the fabric in country rocks. Some bodies are tabular and oriented parallel to the foliation; epidote is a common accessory mineral, and

garnet is less common. Radiometric ages (K/Ar) are commonly discordant and range from 112 Ma to as young as 22.8 Ma, but most age determinations yielded Coniacian (~86 Ma) or older ages. Mid-Cretaceous plutons in the Yukon-Tanana Upland tend to be biotite granite and biotite-hornblende granodiorite with minor diorite phases and are relatively well dated. Some bodies are batholithic in size, like the Goodpaster and Mount Harper batholiths. Analyses, such as those by Wilson and others (1985), have demonstrated that emplacement of these plutons postdate regional metamorphism and reflect relatively slow cooling. Gold mineralization is commonly associated with these plutons, such as at the Fort Knox and Pogo deposits. In the Eagle and Tanacross quadrangles, radiometric dating is sparse and many of the plutons shown as part of this unit are undated. Limited dating in the adjacent northeastern Big Delta quadrangle suggests that at least some of these plutons may be of latest Cretaceous or earliest Tertiary age. A significant part of Saint Lawrence Island is made of these plutons, which consist of fine- to coarse-grained granite and subordinate granodiorite, monzonite, syenite, and alaskite (Patton and others, 2011). In southwest Alaska, this unit includes the Nyac and nearby plutons. Age control on these plutons is somewhat imprecise; K/Ar and 40Ar/39Ar ages vary between 120 and 101 Ma, and the only available U/Pb age was reported as an upper intercept on concordia described as between 129 and 104 Ma (Box and others, 1993). Atypical occurrences of the rocks of this unit are a granodiorite body associated with the Pebble copper deposit in southwest Alaska, dated to 90 Ma, and a coarse-grained biotite granite in the northern Tyonek quadrangle that was dated to 96.9 Ma (Wilson and others, 2009, 2012).

This unit is Kmg and Kmgd in the GRI digital geologic-GIS data.

Kvu - Volcanic rocks, undivided (Cretaceous)

Volcanic rocks that range in composition from rhyolite to olivine basalt flows, from dacitic to andesitic tuff and tuffaceous sandstone, and rhyolitic domes (Hoare and Coonrad, 1978; Patton and others, 1968, 1975; Box 1985; Box and others, 1993). Includes Tulip volcanic field rhyolite domes and flows; Swift Creek volcanic field lithic air-fall tuff; Kipchuk volcanic field andesite and basalt flows, tuff, tuffaceous sandstone; and rhyolite domes and flows in the Bethel quadrangle (Box and others, 1993). In Shungnak and Kateel River quadrangles, unit varies locally but generally consists of latite, quartz latite, and trachyte flows, crystal-lithic tuff, rhyolitic and rhyodacitic welded tuff and flows(?), and hypabyssal intrusive rocks (Patton and others, 1968). In the Tyonek quadrangle, unit is andesite, dacite, and rhyolite flows and tuff. Includes massive and crystal-rich tuff that contains either hornblende or plagioclase as phenocryst phases, as well as flow-banded rhyolite (Solie and others, 1991; Wilson and others, 2009, 2012). In the Healy quadrangle, small exposures of andesitic and basaltic subvolcanic rocks (Csejtey and others, 1992) have yielded late Cretaceous radiometric ages of 97.3±2.9 Ma and 79.1±6.0 Ma, respectively. In the Tyonek and Nabesna quadrangles, unit consists of dominantly andesitic composition metamorphosed and altered volcanic tuff, breccia, or agglomerate. More mafic compositions are suggested by one outcrop of pillow lavas (small pillows, up to 30 cm in diameter) and lesser metasedimentary volcaniclastic turbidites and rare nonvolcaniclastic turbidites. Rocks are generally light green, indicative of alteration or low-grade metamorphism, but others are light-gray and fresh. Age best constrained at a locality near Hayes River Pass in the Tyonek quadrangle where the youngest detrital zircons in volcaniclastic sedimentary rocks were dated between 151 and 136 Ma, Late Jurassic to Early Cretaceous, indicating the sedimentary rocks are Hauterivian or younger (D.C. Bradley, written commun., 2008). Magoon and others (1976) included these rocks in their undivided metasedimentary rocks unit of Jurassic and (or) Cretaceous age. Other authors have included these rocks in the informally named Kahiltna assemblage (see, for example, Jones and others, 1981). In many other parts of western Alaska, unit consists of felsic dikes, sills, and hypabyssal rocks. In southeast Alaska, andesitic shallow intrusive rocks are found in the Juneau and Petersburg quadrangles thought to be Cretaceous in age (Brew and others, 1984; Brew and Ford, 1985). Locally subdivided into unit Kmvi.

This unit is Kvi and Kivs in the GRI digital geologic-GIS data.

Kfy - Flysch (Upper and Lower? Cretaceous)

Monotonous sequence in central Alaska of intensely deformed and locally highly metamorphosed turbidites; includes dark-gray to black argillite; fine- to coarse-grained, generally dark-gray graywacke, siltstone, and shale turbidites; thinly bedded and dense cherty argillite; dark-gray polymictic pebble conglomerate; subordinate black chert pebble conglomerate; a few thin layers of dark-gray to black radiolarian chert; and thin, and dark-gray impure limestone interbeds described by Csejtey and others (1992) and Reed and Nelson (1980), among others. Commonly referred to as the Kahiltna terrane or assemblage (Nokleberg and others, 1994) or “black crap.” Includes rocks mapped by Reed and Elliot (1970) as units Km, Mzu, and Mzs. In Tyonek quadrangle, coquina beds yielded Buchia sublaevis Keyserling of Valanginian age (Solie and others, 1991b). Inoceramus hobetsensis Nagao and Matsumoto, of middle Turonian age, was also found within unit (W.P. Elder, written commun. to D. Bradley, 1989). Csejtey and others (1992) reported additional fossils from unit ranging from Valanginian to Cenomanian as well as several collections of radiolarians that could only be described as Jurassic or Cretaceous. Fossils indicate unit contains both Lower and Upper Cretaceous rocks; 40Ar/39Ar age determinations on hornblende from igneous clasts in the conglomerate yield Cenomanian ages (Layer and Solie, 2008), which suggests a maximum age of latest Early Cretaceous age. Detrital zircon studies by Dwight Bradley and Peter Haeussler (see Wilson and others, 2009, 2012; and Hults and others, 2013) have yielded a variety of minimum age results from Barremian to Aptian and Turonian to Santonian. Studies by Ridgway and others (2002), Kalbas and others (2007), and Hampton and others (2007) provided information indicating multiple provinces for unit and reported detrital zircon analyses that suggest the Kahiltna assemblage is, at least in part, Aptian or Albian or younger in age. Hults and others (2013) suggest unit represents multiple discrete basins separated by a major suture zone. In Talkeetna quadrangle, similar rocks were assigned a Jurassic and Cretaceous age (unit KJs of Reed and Nelson, 1980), however, the Jurassic fossils were derived from spatially and lithologically distinct rocks not part of this Kfy map unit. The Kahiltna assemblage, as generally mapped, is widespread in southern Alaska, and often the repository for miscellaneous dark-colored sedimentary rock units, and as such, does not represent a coherent package of rocks.

This unit is Ksf, Kesv and KJs in the GRI digital geologic-GIS data.

Kk - Kuskokwim Group, undivided (Upper Cretaceous to upper Lower Cretaceous)

Interbedded graywacke and shale that has local interbeds of argillite and conglomerate. Graywacke fine- to medium-grained, gray, commonly micaceous and locally silty; in places it is crossbedded or contains siltstone partings. Contains rare argillite pebbles. Originally described by Cady and others (1955), the Kuskokwim Group is widespread in southwestern Alaska and, although largely a flysch deposit, represents a range of local depositional environments. A number of workers (Patton and others, 1980; Bundtzen and others, 1992; Box and others, 1993; Miller and Bundtzen, 1994) have subdivided the Kuskokwim Group into two facies: a predominantly deep-water, turbidite-dominated facies; and a shallow-marine and fluvial facies (unit Kkn, here). Box and others (1993) subdivided the upper part of the unit in the Bethel quadrangle on the basis of provenance and depositional environment, but data are insufficient to carry those distinctions throughout the exposure area. Box and others (1993) described three depositional environments: outer-fan turbidite, inner-fan turbidite, and deltaic; and they described three packages of rock that provide material to the depositional environments—provenances that they called chert-clast, volcanic, and mixed. We have chosen to subdivide the Kuskokwim Group into two subunits that reflect the depositional environments represented (nearshore or outer fan), but we retain Box and others’ (1993) distinctions of clast provenance. Box and others’ (1993) deltaic environment, which is consists only of chert clasts, has been placed in the nearshore facies subdivision (unit Kkn) of this map. The other chert-clast provenance rocks are described as outer-fan facies and consist of thin-bedded, fine-grained, quartzose sandstone and shale with lesser thin- and thick-bedded medium-grained sandstone (Box and others, 1993). Volcanic provenance rocks consist of interbedded shale, siltstone, sandstone, and

conglomerate composed of rounded clasts of volcanic, volcaniclastic, and plutonic rocks deposited in slope and inner-fan environments (Box and others, 1993). The rocks having clasts of mixed provenance represent two depositional environments: an outer-fan turbidite facies that consists of a shale-rich sequence and lesser thin- to thick-bedded, medium-grained sandstone sections; and an inner-fan-channel facies that consists of mixed shale-rich and sandstone-rich sections, and coarse sandstone and pebbly sandstone in thick-bedded, amalgamated sequences containing minor interbedded shale (Box and others, 1993). Age of the Kuskokwim Group is not well constrained because of the multiple provenances and potentially multiple depositional systems that are represented by the map unit. Cady and others (1955) assigned an early Late Cretaceous age on the basis of 38 fossil collections, but acknowledged fossil collections outside their map area that might indicate an age older than Late Cretaceous or as young as Tertiary. Elder and Box (1992) and Box and others (1993) assigned a late Cenomanian to early Turonian age based on inoceramid fossil collections in the Bethel quadrangle, whereas Hoare and Coonrad (1959a) reported Albian and Cenomanian to Coniacian fossils from the same area, and Murphy (1989) reported an Albian collection. Other age assignments have ranged as young as Santonian (Decker and others, 1994) and Campanian(?) (Miller and Bundtzen, 1994).

This unit is KJk in the GRI digital geologic-GIS data.

KJgn - Gravina-Nuzotin unit (Lower Cretaceous and Upper Jurassic)

Marine graywacke and mudstone, subordinate conglomerate and andesitic to basaltic volcanic rocks, minor limestone, and regionally metamorphosed and deformed equivalents of these strata. Unit is exposed in southeast Alaska and in eastern Alaska near the Denali Fault System. Metamorphic grade varies regionally; in southeast Alaska, it generally increases from nonmetamorphosed or subgreenschist facies in the southwest to greenschist and locally amphibolite facies in the northeast (Berg and others, 1972; Gehrels and Berg, 1992). Higher grade parts of unit are primarily phyllite, schist, and gneiss. Unit consists of the Gravina Island and Seymour Canal Formations and unnamed strata in southeast Alaska (Berg and others, 1978, 1988; Eberlein and others, 1983; Lathram and others, 1965; Muffler, 1967). In south-central Alaska, includes the Nutzotin Mountain sequence of Lowe and others (1982) and other unnamed graywacke and mudstone rock units south of the Denali Fault System. In southwest Alaska, the Koksetna River sequence of Wallace and others (1989) is also included here. In southeast Alaska, the Gravina-Nutzotin unit is locally mapped as an undivided unit that includes several volcanic-rich parts. Where possible these volcanic-rich rocks are included here in unit KJgv. Gehrels and Berg (1992) suggested that geologic and geochemical considerations indicate that some volcanic rocks in this unit are genetically related to Early Cretaceous ultramafic bodies of unit Kum here (Irvine, 1973, 1974) and possibly to Early Cretaceous and (or) Jurassic diorite and gabbro of unit KJdg here (Berg and others, 1978, 1988). Fossils in the widespread Gravina-Nutzotin unit range in age from Cenomanian to Late and possibly Middle Jurassic (Berg and others, 1972; Brew and others, 1984; Buddington and Chapin, 1929). Wallace and others (1989) reported four fossil localities in the Koksetna River sequence, which contain Buchia mosquensis of Late Jurassic (late Kimmeridgian) age and Buchia sublaevis of Early Cretaceous (Valanginian) age. Unit represents a thick deep-ocean trench, fossil-poor marine flysch sequence. Unit locally subdivided into unit KJgv.

This unit is KJkr in the GRI digital geologic-GIS data.

KTRvs - Volcanic and sedimentary rocks of southwest Alaska (Cretaceous to Triassic?)

Thick unit that consists of low-grade metamorphic or contact-metamorphosed marine volcanic and sedimentary rocks; restricted to mainland part of southwest Alaska. According to Hoare and Coonrad (1978), “* * * the volcanic rocks range in composition and type from mafic pillow basalts to more

abundant andesitic and trachytic flows, tuffs, and breccias. Interbedded with the volcanic rocks are thick sections of tuffaceous siltstone, tuffaceous cherts, and massive or thin-bedded argillite. Tuffs and tuffaceous sedimentary rocks associated with the intermediate composition volcanic rocks are commonly laumontized." Radiolarians of Late Jurassic to Early Cretaceous age and fragmentary ammonites of Jurassic age have been collected from this unit in the Goodnews Bay quadrangle (Hoare and Coonrad, 1978). In the Bethel quadrangle, Box and others (1993) subdivided this unit into their units KJc, KJb, Ja, and Jvs, whereas, in the Hagemeister Island and southern Goodnews Bay quadrangles, Box (1985) subdivided this unit into Jlt, Jvt, and JTrcv. Units KJc and KJb of Box and others (1993) are included herein; unit KJc consists of thin-bedded green to brown argillite with occasional 1- to 4-cm-thick tuffaceous chert, siltstone, and fine-grained tuff interbeds. A Late Jurassic and (or) Early Cretaceous age is suggested from poorly preserved radiolarians (Box and others, 1993). Unit KJb, south of Crooked Mountain in the Bethel quadrangle, is a highly altered pillow basalt sequence exposed along a narrow trend about 1 km wide and 10 km long (Box and others, 1993) and interbedded with the argillite and chert. Unit also includes olivine basalt flows and fragmental mafic volcanic rocks in the Dillingham quadrangle. Locally subdivided here into units Jvs and JTrvs.

This unit is KJv and KJvs in the GRI digital geologic-GIS data.

Jnk - Naknek Formation and Kotsina Conglomerate (Upper Jurassic, Tithonian to Oxfordian)

Sandstone, conglomerate, and siltstone whose clasts have a primarily plutonic provenance. Unit is widespread in southern Alaska, in a long belt that ranges from south-central Alaska (Wilson and others, 1998) to the southwest end of the Alaska Peninsula (Wilson and others, 1999, 2015)—about 1,150 km (Detterman and others, 1996). Aggregate thickness of the unit members exceeds 3,000 m, though the average thickness is more typically 1,700 to 2,000 m (Detterman and others, 1996). Megafossils, particularly the pelecypod Buchia and ammonites (Detterman and others, 1996), are age diagnostic and provide excellent control. Detterman and others (1996; see also, Detterman and Hartsock, 1966; Martin and Katz, 1912) subdivided unit into the following formal members, top to bottom: Pomeroy Arkose, Katolinat Conglomerate, Indecision Creek Sandstone, Snug Harbor Siltstone, Northeast Creek Sandstone, and Chisik Conglomerate. The Naknek is conformable with the overlying Staniukovich Formation (unit Kst) and unconformably overlies the Middle Jurassic Shelikof Formation (included here in unit Jsc). The Jurassic portion of the Alaska-Aleutian Range batholith (unit Jgr) was main source of sedimentary debris for Naknek Formation, which, on faunal evidence, ranges in age from about 163.5 to 145 Ma; hence, uplift and erosion of batholith occurred during and shortly after emplacement. The Kotsina Conglomerate is a stratigraphic equivalent of the Naknek and consists mainly of well-indurated massive cobble and pebble conglomerate and minor boulder conglomerate, with some arenitic sandstone and siltstone interbeds. Conglomerate clasts in it are derived from Triassic limestone, Nikolai Greenstone, and the Skolai Group, reflecting local uplift and erosion (MacKevett and others, 1978). On generalized map, included as part of unit KJsnk.

This unit is Jn, Jnp, Jnn, Jns and Jnc in the GRI digital geologic-GIS data.

Jsc - Shelikof and Chinitna Formations (Middle Jurassic, Callovian)

Primarily consists of siltstone that is best exposed along the west side of Cook Inlet and in the Anchorage quadrangle within fault splays that are the eastern end of the Castle Mountain Fault System. The Chinitna Formation, found on the west side of Cook Inlet, is subdivided into two members: the upper Paveloff Siltstone Member, which is approximately equivalent to the Shelikof Formation; and lower Tonnie Siltstone Member (Detterman and Hartsock, 1966). Paveloff Siltstone Member is massive, dark-gray arenaceous siltstone in its upper part and thick graywacke sandstone at its base and ranges in thickness from about 275 m to more than 400 m (Detterman and Hartsock, 1966). Large ellipsoidal concretions and lenticular beds of limestone occur throughout, and thin

interbeds of sandstone occur in the siltstone. Limestone concretions and interbeds common; fresh surfaces are very dark-gray, but weather buff to cream colored. Locally the limestone is bioclastic (Detterman and Hartsock, 1966). Siltstone is well indurated; uppermost part is thinly bedded and fractures into angular fragments. Graywacke of the lower part is "…thin bedded to massive, locally lenticularly bedded, fine to coarse grained, gray to greenish gray" (Detterman and Hartsock, 1966, p. 43). Ammonites within upper part of unit include species of Cadoceras, Stenocadoceras, Pseudocadoceras, Kepplerites, Kheraiceras, and Lilloettia (Detterman and Hartsock, 1966) and indicate Middle Jurassic (Callovian) age. Paveloff Siltstone Member is the age equivalent of Shelikof Formation of the Alaska Peninsula, but the Shelikof contains a higher proportion of coarse volcanic debris and is thought to have been deposited in a deep- to shallow-water environment (Detterman and others, 1996). Megafauna are locally abundant in the Shelikof, although, in general, formation is not fossiliferous. Many lithic intervals in upper part of section have a fining-upward sequence from conglomerate to sandstone or from sandstone to siltstone (Allaway and others, 1984). Tonnie Siltstone Member of the Chinitna Formation is massive, marine, gray arenaceous shale and siltstone that contains numerous large limestone concretions, typically about 250 m thick but thickens to as much as 400 m in southern exposures. Contains mixture of plutonic and volcanic detritus, which is thought to be derived from erosion of the Talkeetna Formation (unit Jtk) and related plutonic rocks of the Early to Middle Jurassic magmatic arc. Lower part of type section is mainly thick-bedded to massive, dusky-yellowish-green graywacke and conglomerate, and minor siltstone, whereas upper part is mainly volcanic sandstone interbedded with massive and laminated brownish-gray siltstone containing calcareous sandstone clasts. Contact with underlying Kialagvik Formation is considered conformable (see Detterman and others, 1996). Upper contact is an unconformity. In the northeastern Anchorage quadrangle, the Chinitna Formation is not subdivided and may be as thick as 600 m. On generalized map, included as part of unit Jsct.

This unit is Js and Jc in the GRI digital geologic-GIS data.

Jtr - Trondhjemite (Jurassic)

Composed of medium- to coarse-grained, seriate, leucocratic trondhjemite exposed as long, linear bodies, all trending northeast-southwest; unit is known from two occurrences. In south-central Alaska, the trondhjemite is considered a component of the Alaska-Aleutian Range batholith, where it is exposed on the west side of the Jurassic part of the batholith in the Kenai, Lake Clark, and Iliamna quadrangles and in much more areally extensive exposures in the batholith's northern extension in the Anchorage and Talkeetna Mountains quadrangles. The exposures near Anchorage and in the Talkeetna Mountains consist of locally altered, sheared, and faintly foliated trondhjemite in large, structurally discordant, northeast-trending plutons that intrude Jurassic quartz diorite and amphibolite (Winkler, 1992). Generally accepted K/Ar age determinations come from many sources and range from 151.6 to 129 Ma throughout the exposure area and can be considered cooling ages; U/Pb zircon ages range between 156.9 to 152.7 Ma in Talkeetna Mountains quadrangle (Rioux and others, 2007). A zircon analysis in the Iliamna quadrangle did not yield a concordant age (Rioux and others, 2010) but was estimated to be about 160 Ma. In the second area of exposure, in the Holy Cross and Unalakleet quadrangles (Patton and others, 2006, 2009, in press), unit is composed chiefly of trondhjemite and tonalite plutonic bodies that, locally, have been metasomatized by potassium-rich fluids to pink granite and granodiorite. Unit also includes subordinate amounts of quartz diorite, diorite, and gabbro. Some of the plutonic bodies have been cataclastically deformed. Unit confined to the north-central part of the Holy Cross quadrangle and the central Unalakleet quadrangle, where it intrudes a fault-bounded belt of undivided Koyukuk and Angayucham-Tozitna terranes (unit KMmu). Unit is assigned a Jurassic age on the basis of five K/Ar ages that range from 173 to 130 Ma (Patton and Moll-Stalcup, 1996), suggesting this trondhjemite is possibly slightly older than the exposures in south-central Alaska. On generalized map, included as part of unit Jlmgr,

This unit is Jtr in the GRI digital geologic-GIS data.

Jgr - Jurassic phase, Alaska-Aleutian Range batholith, undifferentiated (Jurassic)

The Alaska-Aleutian Range batholith (Reed and Lanphere, 1972) ranges from granite and granodiorite to quartz diorite and tonalite and includes some quartz monzonite. As defined, the batholith includes Jurassic (included here and in unit Jtr), Cretaceous (included in unit Kgu), and Tertiary (included in units Tpgr and TKgd) phases. The Jurassic phase, in general, is exposed on the east side of the batholith. A subunit of the Jurassic phase, trondhjemite, is described in unit Jtr. The most extensive area of exposure is in the Aleutian Range on the west side of Cook Inlet, where the plutons lie to the southeast of the Castle Mountain and Lake Clark Fault Systems and are bounded on the east by the Bruin Bay Fault. The Aleutian Range exposures extend to the southwest a distance of 430 km to Becharof Lake and, on the basis of geophysical trends, have been inferred to continue in the subsurface along the Alaska Peninsula (Case and others, 1981, 1988) and possibly into the Bering Sea. The unit is also exposed in the Talkeetna Mountains and Anchorage quadrangles. The rocks there are truncated on the south by the Border Ranges Fault System. Generally thought to be the plutonic equivalent of volcanic rocks of Talkeetna Formation (unit Jtk, here), northern exposures of the plutons are commonly found in close proximity to the Talkeetna Formation. The Alaska-Aleutian Range batholith has been best described and dated by Reed and Lanphere (1969, 1972, 1973). Locally subdivided by lithology, significant phases are granite, granodiorite, quartz monzonite, quartz diorite, tonalite, and gabbro. The quartz diorite and tonalite phases form the majority of the batholith on the Alaska Peninsula and form the southwest part of the Talkeetna Mountains section. These rocks are typically medium-grained, gray equigranular rocks, and are locally foliated. Either clinopyroxene or hornblende is the dominant mafic mineral. Biotite increases in proportion to the presence of quartz and potassium feldspar. Detterman and Reed (1980) reported that rocks of unit in Iliamna region grade to diorite but they did not observe it grading into quartz monzonite or granodiorite (their unit Jqm). Inclusions of fine-grained mafic rocks or of porphyro-aphanitic volcanic rocks are common. K/Ar and 40Ar/39Ar ages generally range from 174.7±8.8 to 146±4.3 Ma (Reed and Lanphere, 1973; Magoon and others, 1976; Csejtey and others, 1978; Hacker and others, 2011); a number of samples yielded younger ages that were considered suspect or thought to be reset by younger plutonism; the majority of concordant ages are between about 165 and 160 Ma. U/Pb ages are bimodal—on the Alaska Peninsula they range between 183 and 164 Ma and no inheritance is indicated, whereas in the Talkeetna Mountains the ages range from as old as 208 Ma to 187 Ma, and most sample analyses indicate inheritance (Rioux and others, 2007). A diorite pluton has been mapped on the eastern side of the batholith in northeast Iliamna quadrangle and it mostly likely continues in the adjacent Lake Clark quadrangle (Detterman and Reed, 1980). Unit also includes a group of lamprophyre and basalt dikes on west side of Cook Inlet that intrude the quartz diorite. Two rocks sampled northeast of Lake Iliamna yielded mid-Cretaceous K/Ar age determinations (Reed and Lanphere, 1972) and may indicate presence of an otherwise unrecognized mid-Cretaceous magmatic event in the batholith or may more likely indicate resetting by nearby middle Tertiary plutons. Granodiorite and quartz monzonite phase is also widely distributed, occurring throughout the range of exposure. On the Alaska Peninsula, it is exposed on the eastern side of the batholith; mapping in the northern section of the batholith does not separate this phase from the quartz diorite and tonalite phase. The granodiorite is typically whitish-gray, medium-grained and biotite-bearing with minor hornblende and accessory primary muscovite, and the quartz monzonite is medium-grained, light-gray with a pinkish cast. K/Ar age determinations from both sections range from 180.4±5.0 to 140.0±4.2 Ma (Csejtey and others, 1978; Shew and Lanphere, 1992; Wilson and Shew, 1992), but the majority of ages and the most reliable ones are older than 157 Ma. U/Pb zircon ages range between 177 and 169 Ma, all from the northern section of the batholith (Rioux and others, 2007). Granite is the least common phase and is typically found at the southern end of the exposure range; it is typically light-gray, porphyritic, contains more biotite than hornblende, and is locally foliated (Riehle and others, 1993). K/Ar ages range between 173.6±2.0 and 159.6±2.0 Ma (Shew and Lanphere, 1992); no U/Pb ages have been determined on this granitic phase. Detterman and Reed (1980) and Riehle and others (1993) also reported small bodies of dark gray, diabase and gabbro, which are included here. Trondhjemite, a subunit of the Jurassic phase, is described in unit Jtr. On generalized map, unit Jgr included as part of unit Jlmgr.

This unit is Jgd, Jqd, Jdg, Jqt, Jla and Jgaa in the GRI digital geologic-GIS data.

Jt - Tuxedni Group (Middle Jurassic)

Fossiliferous, light- to dark-gray and green marine graywacke, conglomerate, siltstone, and shale (Detterman and Hartsock, 1966). Graywacke ranges from feldspathic to lithic to laumontitic conglomerate composed mainly of volcanic clasts in a graywacke matrix. Unconformably overlies Talkeetna Formation and is disconformably overlain by Chinitna Formation. Unit locally subdivided into, in ascending stratigraphic order: the Red Glacier Formation, Gaikema Sandstone, Fitz Creek Siltstone, Cynthia Falls Sandstone, Twist Creek Siltstone, and Bowser Formation. Red Glacier Formation is about 40 percent thin-bedded to massive, red-brown weathering dark-gray to moderate olive-gray siltstone concentrated in the upper part of the unit; underlying this is light-tan to buff arkosic sandstone that consititutes about 25 percent of the unit and a thick, black, silty to arenaceous, very fissile shale that constitutes the rest of the unit. Gaikema Sandstone is resistant, cliff-forming, massive to thin-bedded graywacke sandstone and cobble conglomerate that has graded bedding 150 to 260 m thick. Fitz Creek Siltstone is a thick sequence (up to 400 m thick) of massive, bluish dark-gray, arenaceous coarse- to fine-grained siltstone that commonly weathers rusty orange and contains many small limestone concretions. Cynthia Falls Sandstone is massive to thick-bedded graywacke sandstone and pebble conglomerate about 200 m thick. Twist Creek Siltstone is soft, poorly consolidated, thin-bedded to massive siltstone and silty shale as much 125 m thick. Bowser Formation is a heterogeneous assemblage of sandstone, conglomerate, shale, and siltstone characterized by rapid facies changes. Age of Tuxedni Group was revised to lower Bathonian to Aalenian by Detterman and Westermann (1992). In Talkeetna Mountains quadrangle, this unit is included in an undivided Tuxedni Group–Chinitna Formation unit (Csejtey and others, 1978). In the Anchorage quadrangle (Winkler, 1992), it is mapped as undivided Tuxedni Group. See Detterman and Hartsock (1966) and Detterman and others (1996) for a fuller description of each of the included formations. On generalized map, included as part of unit Jsct.

This unit is Jtb, Jtt, Jtc, Jtf, Jtg and Jtrg in the GRI digital geologic-GIS data.

Jtk - Talkeetna Formation (Early Jurassic)

Volcanic flows, breccia, tuff, and agglomerate that is locally interbedded with minor sandstone and shale, all typically somewhat altered or metamorphosed (Detterman and Hartsock, 1966; Detterman and Reed, 1980), widely distributed in the Talkeetna Mountains and west of Cook Inlet. First described in Talkeetna Mountains of south-central Alaska by Paige and Knopf (1907); the name Talkeetna Formation was introduced by Martin (1926) and now is recognized as a widespread and important marker horizon in southern Alaska. The unit consists of andesitic flows, flow breccia, tuff, and agglomerate, and includes subordinate interbeds of sandstone, siltstone, and limestone in a dominantly shallow marine sequence 1,000 to 2,000 m thick (Csejtey and others, 1978). Detterman and Hartsock (1966) geographically extended unit into Cook Inlet area and formally divided unit into three members: Horn Mountain Tuff, Marsh Creek Breccia, and Portage Creek Agglomerate. Detterman and others (1987a, 1996) further geographically extended unit to include a section composed primarily of gray-green, coarse-grained tuffaceous sandstone with lesser amounts of green to red, massive coarse-grained tuff and minor brownish-gray siltstone and gray to gray-brown limestone. This section is 405 m thick and is exposed on the northeast shore of Puale Bay; it was originally considered part of the Bidarka Formation (Kellum, 1945). At Puale Bay, rocks of the formation record an inner-neritic to sublittorial environment; to the northeast, the formation is primarily volcanic rocks (Detterman and Hartsock, 1966). Stratigraphically and lithologically equivalent rocks have been encountered in drillholes as far southwest as the Cathedral River on the southwest part of Alaska Peninsula. An Early Jurassic age (Hettangian and early Sinemurian) is based on an abundant megafauna; this megafauna is present in great abundance in only a few horizons and may represent mass kills as a result of volcanic eruptions (Detterman and others, 1996). At Puale Bay, contact of

Talkeetna with underlying calcareous Kamishak Formation (unit TRcnk) is conformable and gradational; it is arbitrarily placed where clastic sedimentary rocks replace limestone as major constituents of rock sequence. Contact of Talkeetna with overlying Kialagvik Formation (included in unit Jt, here) is structurally conformable, but it is considered a disconformity because rocks of late Sinemurian, Pliensbachian, and most of Toarcian Stages are missing. In the Talkeetna Mountains, fossils (Weyla) in the upper part of Talkeetna Formation, which is considered correlative to the rocks of Horn Mountain Tuff Member, indicate a late Pliensbachian and Toarcian (Early Jurassic) age (A. Grantz, oral commun., 1963, cited in Detterman and Hartsock, 1966). No lower contact is known from the Talkeetna Mountains.

This unit is Jtk, Jtkh, Jtkp and Jtkm in the GRI digital geologic-GIS data.

JTRmv - Tatina River volcanics of Bundtzen and others (1997a) and similar mafic volcanic rocks (Jurassic and Triassic)

The informally defined Tatina River volcanics of Bundtzen and others (1997a) consists of three members: a lower volcanic member, a phosphatic shale and volcaniclastic sandstone member, and a conglomerate and volcanic sandstone member. The lower volcanic member consists of dark-greenish-gray elongate bodies of pillow basalt that include interbeds and lenses of mudstone, shale, and siltstone. Locally, gabbro bodies, interpreted by Bundtzen and others (1997a) as feeders to the pillow basalt flows, are included in the unit. In the western Talkeetna quadrangle, includes basaltic rocks mapped by Reed and Nelson (1980) as units KJb and Pzbs. Also includes a thick submarine sequence of several hundred—and perhaps several thousand—meters of basalt flows, mostly pillowed, and associated sills and dikes of diabase and gabbro and subordinate dark-gray to dark-grayish-green, fine-grained sandstone, siltstone, and argillite, some having abundant angular tuffaceous material. Mapped by Csejtey in the Healy and Denali quadrangles (Csejtey and others, 1992; Bela Csejtey, Jr. written commun., 1993). Each of these units has similar reported major element oxide contents and also shows similar copper content, between 200 and 500 ppm. Age control is lacking; assignment is based on association with the sedimentary members. Laterally gradational with the volcanic member is a volcaniclastic member (unit Trs of Bundtzen and others, 1997a), which consists of tan to greenish-gray, buff- to orange-weathered, pebble rich, immature conglomerate, coarse volcaniclastic sandstone, distinctly brown silty shale, and light-gray, green, and black chert. Bundtzen and others (1997a) reported the occurrence of Monotis subcircularis, and Halobia cf. H. fallax, which indicates a Late Triassic (Norian) age. The three uppermost members of the unit are medium- to very dark-gray, bluish-white bleached phosphatic shale; green, medium-grained, concretion-rich, volcaniclastic sandstone; and minor tan chert-cobble pebble conglomerate. Bundtzen and others (1997a) report Entolium sp. and Eopecten(?) sp. of Jurassic age. Includes Lower Jurassic brachiopod, pelecypod, and ammonite-bearing, reddish-brown-weathering sandstone and dark-gray shale in the western Talkeetna quadrangle (Reed and Nelson, 1980), as well as Early Jurassic silty shale and siltstone in the western Lime Hills quadrangle (Blodgett and others, 2000a). Unit occurs on both sides of the Denali Fault System.

This unit is TRtv in the GRI digital geologic-GIS data.

TRcnk - Chitistone and Nizina Limestones and Kamishak Formation (Upper Triassic, Norian to Carnian)

The Chitistone and Nizina Limestones, correlative unnamed units in the Mount Hayes and Healy quadrangles, and the Kamishak Formation to the southwest are widespread in southern Alaska. The Chitistone Limestone is stratigraphically lower than the Nizina Limestone and is as thick as 600 m. Its lower part consists of abundant dolostone, algal-mat chips, stromatolites, and relicts of evaporites, whereas the upper part consists of varieties of limestone including lime mudstone, wackestone,

packstone, and grainstone; both parts are exposed in southern east-central Alaska. The overlying Nizina Limestone is as thick as 500 m and consists of varieties of limestone that generally contain subordinate chert as nodules, lenses, and coalescing masses; its lithology is gradational into the overlying McCarthy Formation (unit JTRmc). The upper Chitistone and cherty Nizina were deposited in a shallow to moderately deep marine neritic environment, transitioning from an intertidal to supratidal setting with local sabkha facies full of algal-mat chips, stromatolites, and evaporate relics typical of the dolostone-rich lower Chitistone rocks (Richter and others, 2006). Sparse fossils characterized by the ammonite genus Tropites indicate a late Carnian age for the Chitistone (MacKevett, 1971). Fossils are also sparse in the Nizina; those that are found consist mainly of pelecypods of the genus Halobia. Paleontologic studies by N.J. Silberling (written commun., 1962, to E.M. McKevett) indicate that the Nizina Limestone is Late Triassic and ranges in age from late Karnian or early Norian to early middle Norian. Along with the underlying Nikolai Greenstone, these limestone units are defining parts of the Wrangellia terrane (Jones and others, 1977). Kamishak Formation consists of limestone, chert, porcellanite, and minor tuff and volcanic breccia that are divided into two formal members and an informal middle member; they are, in descending order: the Ursus, middle, and Bruin Limestone Members (Detterman and Reed, 1980). Unit primarily found along west side of Cook Inlet, east of the mountain range crest where a measured reference section is about 800 m thick. Depositional environment of Kamishak Formation was shallow water and high energy; intervals of unit include both reefs and biohermal buildups. Fossils found within the middle and Bruin Limestone Members of the Kamishak Formation yield a Norian age (Detterman and Reed, 1980; C.D. Blome, oral commun., 1981). As mapped here, unit also includes a small area of Triassic limestone and chert associated with the Chilikadrotna Greenstone in the central Lake Clark quadrangle. Kamishak Formation is cut by abundant dikes and sills that are related either to the Cottonwood Bay Greenstone or the Talkeetna Formation (Detterman and Reed, 1980). On generalized map, included as part of unit TRmls.

This unit is JTRku, TRkm, TRkb and Srk in the GRI digital geologic-GIS data.

DCd - White Mountain sequence, basinal facies (Devonian to Cambrian or older)

Finely laminated limestone and dolomitic limestone and subordinate chert and siliceous siltstone indicative of deep-water deposition. Rocks included here were originally considered part of the now-abandoned Holitna Group and later were assigned to the Dillinger terrane, now considered the basinal facies of the White Mountain sequence of the Farewell terrane (Decker and others, 1994). They were originally assigned an Ordovician to Devonian age on the basis of a sparse conodont fauna (Dutro and Patton, 1982). More recent work, however, indicates that the unit also contains conodonts of Cambrian age (Dumoulin and others, 1997). Includes East Fork Hills, Post River, and Lyman Hills Formations, Terra Cotta Mountains Sandstone, and Barren Ridge Limestone, all interpreted as slope or basinal deposits (Patton and others, 2009). Includes lime-rich sedimentary rocks in unit Pzd of Reed and Nelson (1980) in the Talkeetna quadrangle; unit Pzs of Gamble and others (2013) in eastern Lime Hills quadrangle; and unit Pzdu of Bundtzen (written commun., 1998) in western Lime Hills quadrangle. In the northwestern Denali quadrangle, includes chert and slate that yielded Ordovician graptolites, and, in the southern Denali quadrangle, quartz-rich turbiditic sandstones and minor interbedded limestone yielded early Silurian (Llandovery) conodonts (Dumoulin and others, 1998), and quartzite that yielded Silurian to Devonian corals (William Oliver, written commun., 1997). On generalized map, included as part of unit DCwbl. Where subdivided, includes the following units, DSbr, DSpf, Stc, and SCpl.

This unit is PZd in the GRI digital geologic-GIS data.

PDsc - Sheep Creek formation of Bundtzen and others (1997a) and correlative siliciclastic units of the Mystic structural complex (Permian to Devonian)

Clastic-dominated but heterogeneous middle third of the Mystic structural complex. Consists of sandstone, conglomerate, siltstone, and argillite, and lesser chert and limestone. Depositional environments are dominantly fluvial, but carbonate platform and deep marine environments are also represented by subordinate rock types in this grouping of units. Includes the clastic parts of the informal Sheep Creek formation of McGrath and Lime Hills quadrangles, an argillite and chert unit thought equivalent to the Sheep Creek formation of Bundtzen and others (1997a; T.K. Bundtzen, DGGS, unpub. data, 1997, 1998), and the conglomerate of Mount Dall in the Talkeetna quadrangle (Reed and Nelson, 1980), which is a “dark-brown to yellowish-brown-weathering sequence of conglomerate, sandstone, siltstone, and shale mainly of continental origin that forms a broad, open, east-plunging syncline.” Unit is chiefly massive lenticular beds of conglomerate and sandstone with numerous cut and fill channels, which have yielded a Permian plant assemblage of Siberian affinity (Mamay and Reed, 1984). Conglomerate of Mount Dall of Reed and Nelson (1980) contains clasts of Devonian limestone, as well as chert, chert-pebble conglomerate, and graded sandstone, presumably derived from the White Mountain sequence of Decker and others (1994). Age control is provided by conodonts, fusulinids, brachiopods, corals, and plants. Unit tentatively includes an unnamed shale and chert (T.K. Bundtzen, DGGS, written commun., 1998) that occurs in a limited area in the Lime Hills quadrangle and that hosts the Gargaryah bedded-barite deposit (Bundtzen and Gilbert, 1990) as well as includes dark gray-green to distinctly maroon, pyrite-rich volcanogenic phyllite, and white-weathering, gray-green, banded phyllitic ribbon chert (Bundtzen and others, 1997a) exposed between strands of the Denali Fault System in the eastern McGrath quadrangle. The ribbon chert has yielded Permian through Pennsylvanian Radiolaria and Permian through Mississippian conodonts (Bundtzen and others, 1997a). On generalized map, included as part of unit PDms.

This unit is PDsc and DSc in the GRI digital geologic-GIS data.

DSbr - Barren Ridge Limestone and correlative units (Devonian to Silurian?)

As defined by Churkin and Carter (1996), unit consists of two more-or-less pure limestone members separated by a siltstone member of calcareous siltstone and sandy limestone.” Lower limestone is medium-dark-gray, medium-gray-weathering, well-bedded, thick- to thin-bedded, and has orange-weathering silty beds in upper half of member that form less than 50 percent of section, which is about 100 m thick. Siltstone member is about 200 m thick and is composed of very thin-bedded, cross-laminated, yellowish-orange-weathering, silty and sandy limestone and calcareous siltstone, which contain occasional 3-m-thick pure limestone interbeds and rare argillaceous beds. Uppermost member is massive, indistinctly bedded to laminated, medium-dark-gray, finely crystalline limestone more than 100 m thick and contains minor lighter gray dolostone (Churkin and Carter, 1996). Unit is known from the McGrath quadrangle and correlative rocks are found in the Lime Hills quadrangle; the unit undoubtedly extends into the Talkeetna quadrangle, where is it included in unit DCd. Bundtzen and others (1997a) reported late Silurian to Late Devonian conodonts from unit, based on a report in Bundtzen and others (1994) where the reported conodont has an age range of middle Silurian to Early Devonian. Churkin and Carter (1996) interpreted the lower contact of the Barren Ridge Limestone with the underlying Terra Cotta Sandstone as a thrust fault and noted that rocks of latest Silurian age are not present. On generalized map, included as part of unit DCwbl.

This unit is DSca in the GRI digital geologic-GIS data.

Stc - Terra Cotta Mountains Sandstone (Silurian)

Mainly composed of sandstone and mudstone and divided into three prominent limestone members. Best described by Churkin and Carter (1996), the Terra Cotta Mountains Sandstone is distinguished

from other formations in the area by abundant rhythmically interbedded sandstone and mudstone; more than three-quarters of its total thickness consists of calcareous sandstone interbedded with mudstone. In addition, the formation contains three mappable limestone members (although they are not distinguished here). Stratigraphically lowest part of unit is approximately 90 to 120 m of thick-bedded and massive sandstone that has subordinate argillite or mudstone interbeds. Overlying this part of the unit is a medium-dark-gray, thick-bedded, and relatively pure limestone about 45 to 60 m thick; locally has very pale brown mottling. Most of the limestone is massive or blocky, but its basal part is laminated and platy. No megafossils have been found in it. A second sandstone interval, 150 m thick, is interbedded with cross-laminated mudstone and argillic shale and is overlain by the middle limestone member, a dark-gray, generally thin- bedded, platy, laminated limestone usually about 35 m thick, but as much 60 m thick. The laminations in the limestone are accentuated by silt, mica, and argillaceous impurities. In contrast to other limestone of the Terra Cotta Mountains Sandstone, the middle limestone member contains shelly fossils at several localities. These fossils include pelecypods and straight-shelled cephalopods that are so poorly preserved that they have not been identified by genus or age (Churkin and Carter, 1996). Churkin and Carter (1996) indicate that, because of structural complications, the middle limestone member may be a repetition of the lower limestone member. Overlying the middle limestone is another interval of sandstone, siltstone and argillite as thick as 90 m that contains, near its base, a distinctive knobby limestone section 7.5 to 15 m thick (Churkin and Carter, 1996). The third, or upper, limestone member is medium-dark-gray, weathers medium-gray, is generally thick-bedded and massive, and is as thick as 120 m. Locally, where thinner bedded and evenly laminated, the limestone is slabby weathering. This upper limestone member contains dome-shaped structures that may represent stromatolites. Otherwise no fossils were noted (Churkin and Carter, 1996). Stratigraphically highest is a 90- to 150-m-thick calcareous siltstone and sandstone interval that appears to be a finer grained equivalent of the basal, more sandstone-rich lowest interval. Shale beds with phyllitic partings are common, as are slabby weathering argillaceous and silty limestone beds. Sedimentary structures such as graded bedding, flute casts, and cross-lamination indicate that the Terra Cotta Mountains Sandstone was deposited by turbidity currents in a deep marine setting (Churkin and Carter, 1996; Wilson and others, 1998). On generalized map, included as part of unit SCwbc

This unit is Stc in the GRI digital geologic-GIS data.

SCpl - Post River Formation and correlative units (middle Silurian, Wenlock, to Upper Cambrian)

Best described by Churkin and Carter (1996), the Post River Formation consists mainly of fissile shale, mudstone, and silty and argillaceous limestone divided into five members. At the base is (1) a lower siltstone member, as thick as 300 m, characterized by thin beds of cross-laminated calcareous siltstone and argillaceous limestone rhythmically interbedded with shale and argillite. Above this is (2) a relatively noncalcareous mudstone member, at least 75 m thick, overlain by (3) another calcareous siltstone and argillaceous interval only 30 m thick that is thinner than, but otherwise closely lithologically resembles, the lower siltstone member. Overlying these is (4) the formally defined, 220-m-thick Graptolite Canyon Member, a nearly pure, dark-gray shale and siliceous shale that contains abundant graptolites and forms most of the upper two-thirds of the formation. The uppermost part of the Post River Formation is (5) the limestone member, a dark, laminated limestone, probably not much more than 18 m thick, interbedded with thin beds of black graptolitic shale (Churkin and Carter, 1996). Age control from graptolites indicates that most of the Ordovician and early Silurian is represented. The Lyman Hills formation of Bundtzen and others (1997a), equivalent to the lower siltstone of the Post River Formation as defined by Churkin and Carter (1996), consists of silty limestone and shale, is commonly cross-laminated, and locally contains Bouma ‘cde’ intervals. Age of the Lyman Hills formation of Bundtzen and others (1997a) is constrained by uppermost Cambrian conodonts and Ordovician and Silurian graptolites. Exposed primarily in the Lime Hills and McGrath quadrangles, unit likely extends into Talkeetna quadrangle where it is mapped as part of undivided unit DCd. On generalized map, included as part of unit DCwbc.

This unit is SOCpl in the GRI digital geologic-GIS data.

bu - Bedrock of unknown type or age or areas not mapped (unknown)

No additional description present on source map.

This unit is bu in the GRI digital geologic-GIS data.

Ancillary Source Map Information

The following sections present ancillary source map information associated with sources used for this project.

USGS Source Map References

USGS geologic-GIS data for the Alaska region maintains geologic source information as an attribute attached to each geologic feature. Although the GRI considers the USGS to be the mapping source for this project, sources used and referenced by the USGS have been preserved in the GRI digital geologic-GIS data. Geologic features in the GRI digital geologic-GIS data and the unit descriptions listed in this document have references to the sources listed here.

Several attribute fields present in the USGS source GIS data were retained in the GRI digital geologic-GIS data to provide users with the ability to relate back to the USGS source data. To view source publications used in the creation of this dataset refer to the References sections of this document and visit the USGS Alaska Science Center at: http://alaska.usgs.gov/ to obtain USGS source GIS data files.

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Geologic Map of Alaska (SIM-3340)

The formal citation for this source.

Wilson, F.H., Hults, C.P., Mull, C.G, and Karl, S.M., 2015, Geologic Map of Alaska: U.S. Geological Survey, Scientific Investigations Map SIM-3340, scale 1:1,584,000 (*GRI Source Map ID 76064*).

Prominent graphics and text associated with this source.

Pamphlet

The pamphlet for the Geologic Map of Alaska (SIM-3340) is available for download at the following site: SIM-3340 Pamphlet PDF.

Data

The digital data and map of the Geologic Map of Alaska (SIM-3340) is available for download at the following site: SIM-3340 Data.

Alaska Resource Data Files

Ancillary information regarding Alaska Resource Data Files (ARDF) data for seven 1' x 3' quadrangles that define the extent of the GRI digital geologic-GIS data is presented below. This information, as well as additional information, tables and metadata can be found online at: https://ardf.wr.usgs.gov/index.php. Note that as only a portion of each ARDF 1' x 3' quadrangle was used in the GRI digital geologic-GIS data, and therefore not all mineral occurrence localities displayed on each source's mineral occurrence map are present in the GRI digital geologic-GIS data. As previously mentioned in the source ciattions section of this document, although the GRI digital geologic-GIS dataset included a portion of the Seldovia 1' x 3' quadrangle, no Alaska Resource Data File (ARDF) information was present within this extent, and thus the Alaska Resource Data File (ARDF) for the Seldovia 1' x 3' quadrangle was not used by the GRI.

ARDF, 1' x 3' Dillingham Quadrangle

The formal citation for this source.

Hudson, T.L., 2001, Alaska Resource Data File; Dillingham Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2001-192, 1:250000 scale (*GRI Source Map ID 2205*).

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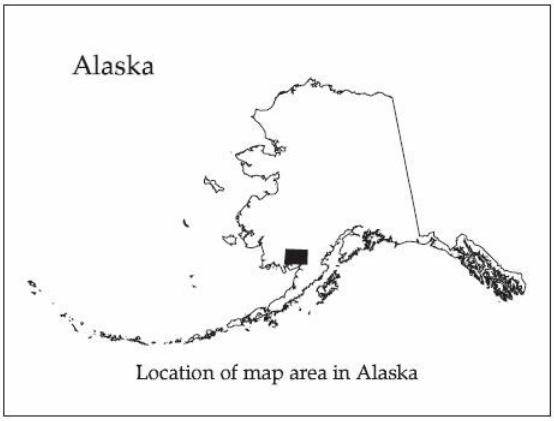
Report

The Alaska Resource Data File (ARDF) report for the Dillingham quadrangle, Alaska (OF-2001-192) is available for download at the following link: Report PDF.

Data

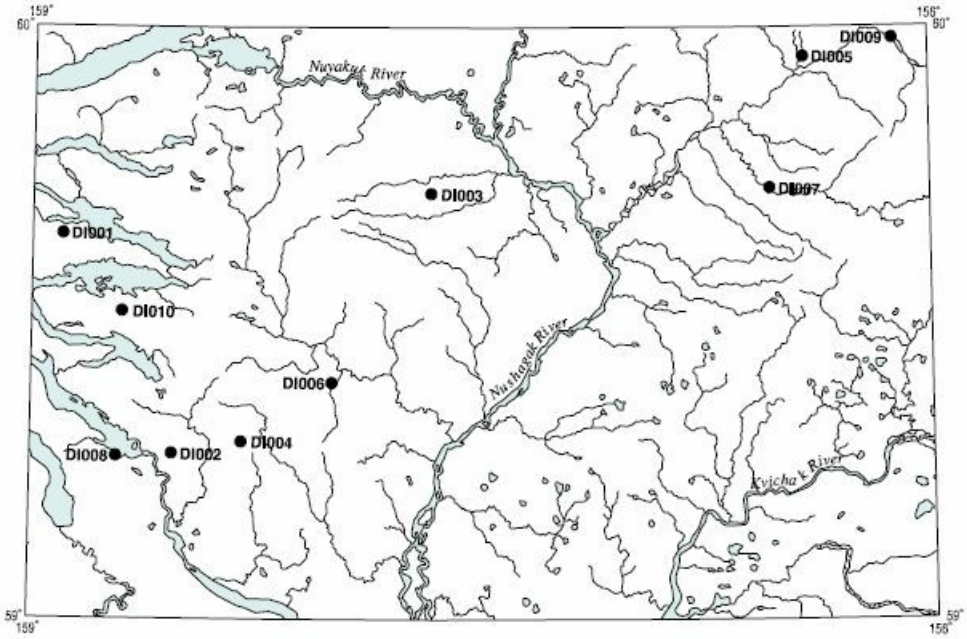
The Alaska Resource Data File (ARDF) data for the Dillingham quadrangle, Alaska (OF-2001-192) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Dillingham Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Dillingham 1:250,000-scale quadrangle, Alaska

Graphic from source map: ARDF, 1' x 3' Dillingham Quadrangle

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ARDF, 1' x 3' Iliamna Quadrangle

The formal citation for this source.

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Prominent graphics and text associated with this source.

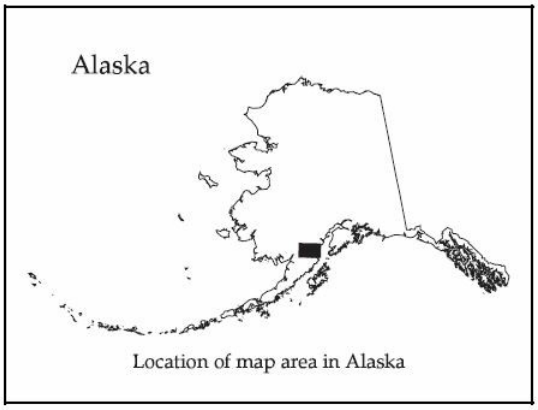
Report

The Alaska Resource Data File (ARDF) report for the Iliamna Quadrangle, Alaska (OF-2004-1057) is available for download at the following link: Report PDF.

Data

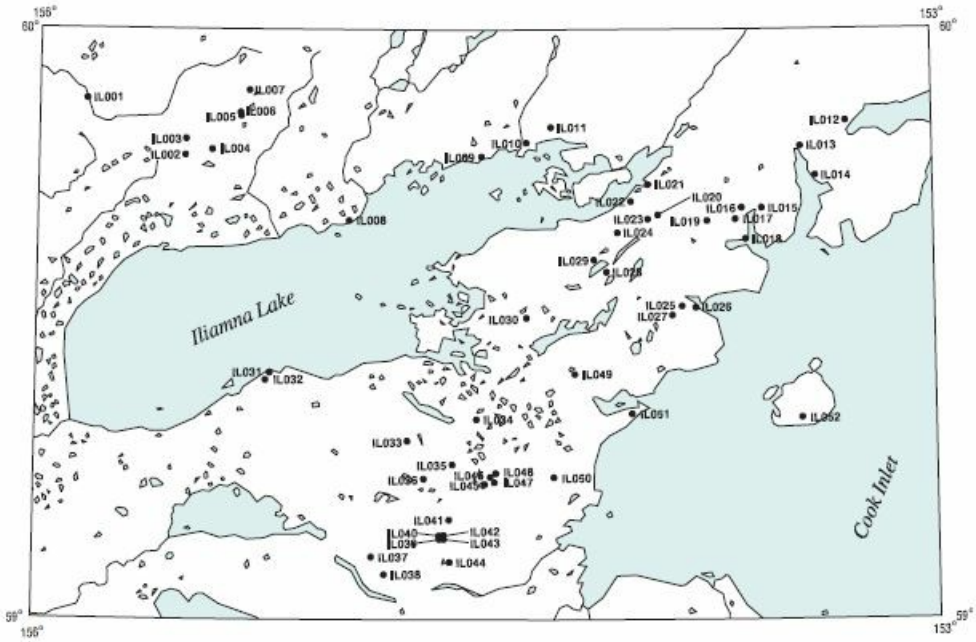
The Alaska Resource Data File (ARDF) data for the Iliamna Quadrangle, Alaska (OF-2004-1057) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Iliamna Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Iliamna 1:250,000-scale quadrangle, Alaska

Graphic from source map: ARDF, 1' x 3' Iliamna Quadrangle

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ARDF, 1' x 3' Kenai Quadrangle

The formal citation for this source.

Huber, J.A., 1999, Alaska Resource Data File; Kenai Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-99-393, 1:250000 scale (*GRI Source Map ID 2724*).

Prominent graphics and text associated with this source.

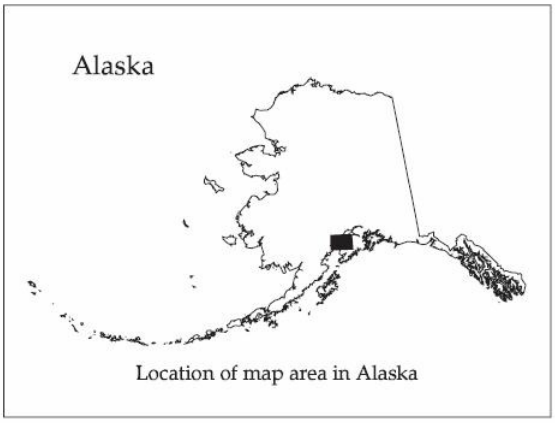
Report

The Alaska Resource Data File (ARDF) report for the Kenai Quadrangle, Alaska (OF-99-393) is available for download at the following link: Report PDF.

Data

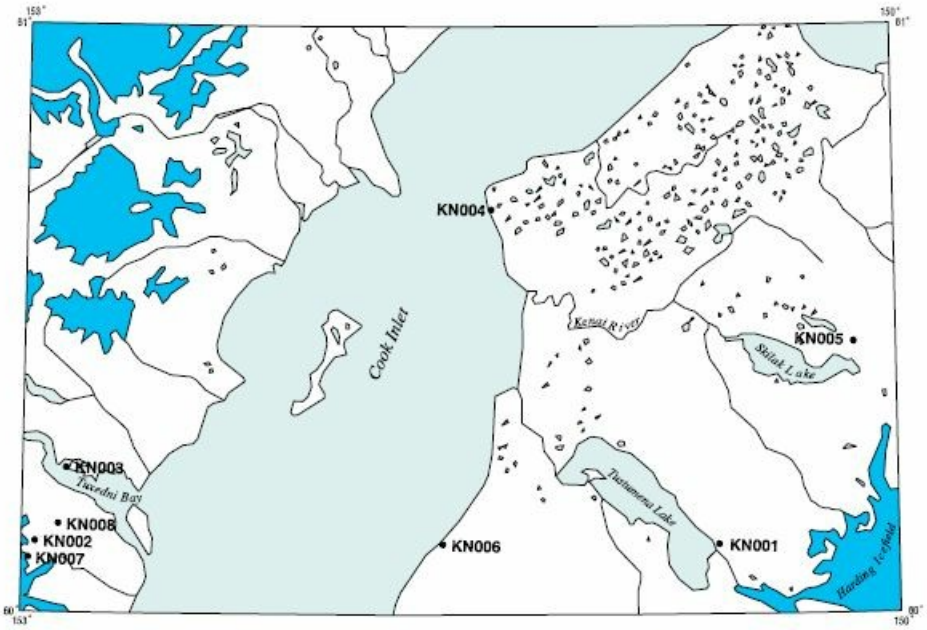
The Alaska Resource Data File (ARDF) data for the Kenai Quadrangle, Alaska (OF-99-393) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Kenai Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Kenai 1:250,000-scale quadrangle, southcentral Alaska

Graphic from source map: ARDF, 1' x 3' Kenai Quadrangle

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ARDF, 1' x 3' Lake Clark Quadrangle

The formal citation for this source.

Bickerstaff, D., 1998, Alaska Resource Data File; Lake Clark Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-98-356, 1:250000 scale (*GRI Source Map ID 5204*).

Prominent graphics and text associated with this source.

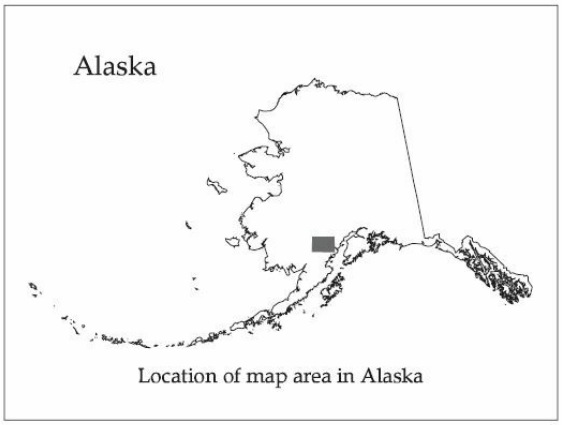
Report

The Alaska Resource Data File (ARDF) report for the Lake Clark Quadrangle, Alaska (OF-98-356) is available for download at the following link: Report PDF.

Data

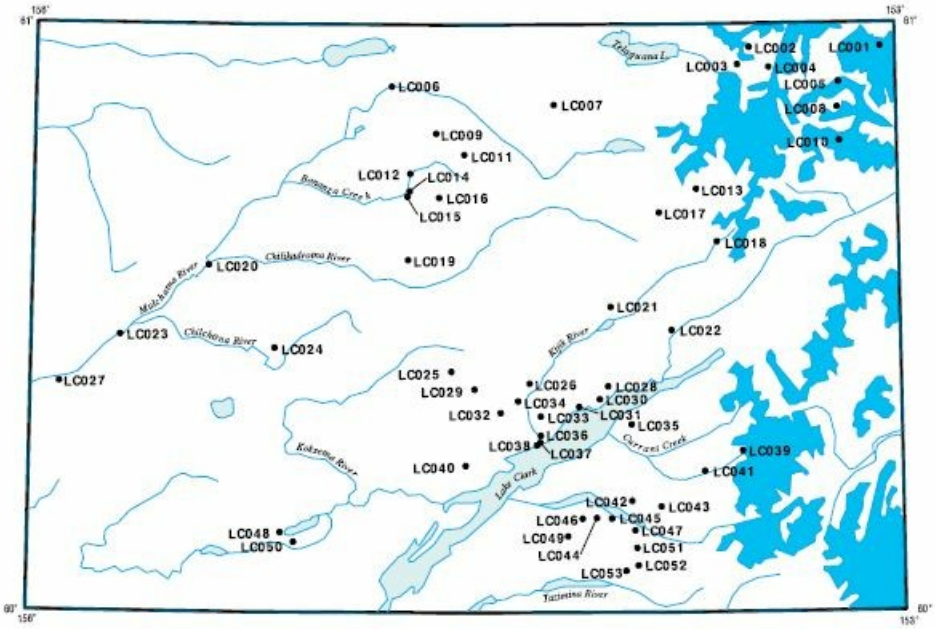
The Alaska Resource Data File (ARDF) data for the Lake Clark Quadrangle, Alaska (OF-98-356) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Lake Clark Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Lake Clark 1:250,000-scale quadrangle, Alaska

Graphic from source map: ARDF, 1' x 3' Lake Clark Quadrangle

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ARDF, 1' x 3' Lime Hills Quadrangle

The formal citation for this source.

Hudson, T.L., and Millholland, M.A., 2002, Alaska Resource Data File; Lime Hills Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2002-76, 1:250000 scale (*GRI Source Map ID 2725*).

Prominent graphics and text associated with this source.

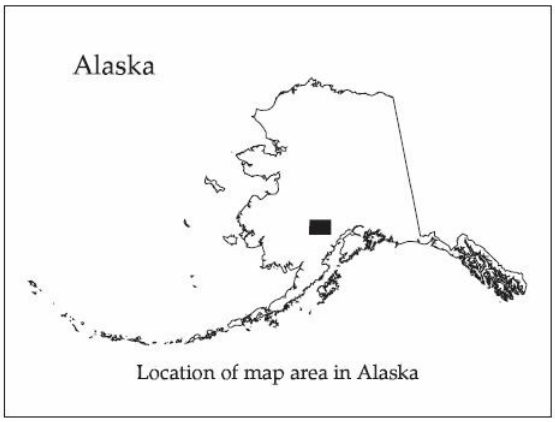
Report

The Alaska Resource Data File (ARDF) report for the Lime Hills Quadrangle, Alaska (OF-2002-76) is available for download at the following link: Report PDF.

Data

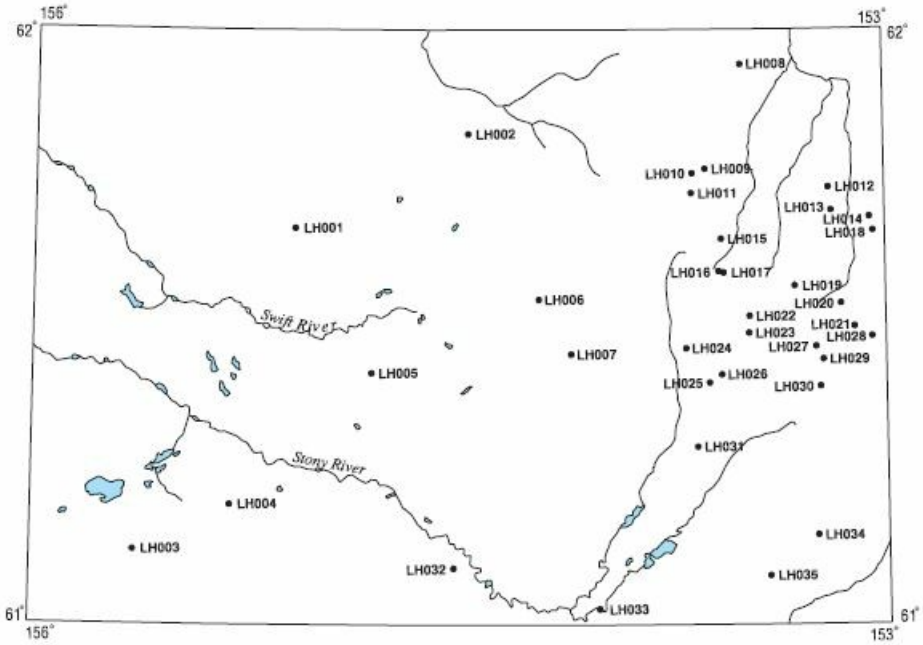
The Alaska Resource Data File (ARDF) data for the Lime Hills Quadrangle, Alaska (OF-2002-76) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Lime Hills Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Lime Hills 1:250,000-scale quadrangle, Alaska

Graphic from source map: ARDF, 1' x 3' Lime Hills Quadrangle

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References from source map: ARDF, 1' x 3' Lime Hills Quadrangle

ARDF, 1' x 3' Taylor Mountains Quadrangle

The formal citation for this source.

Hudson, T.L., 2001, Alaska Resource Data File; Taylor Mountains Quadrangle, Alaska, U.S. Geological Survey Open-File Report OF-2001-200, 1:250000 scale (*GRI Source Map ID 51666*).

Prominent graphics and text associated with this source.

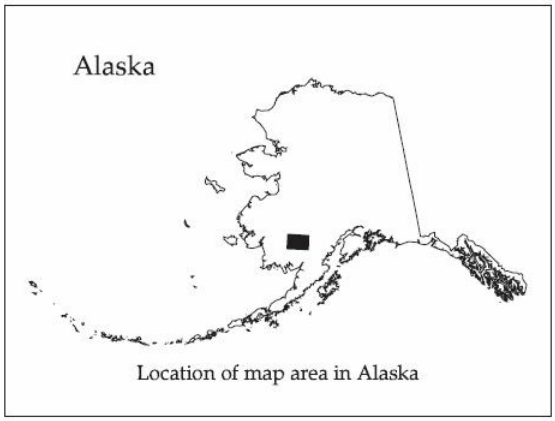
Report

The Alaska Resource Data File (ARDF) report for the Taylor Mountains Quadrangle, Alaska (OF-2001-200) is available for download at the following link: Report PDF.

Data

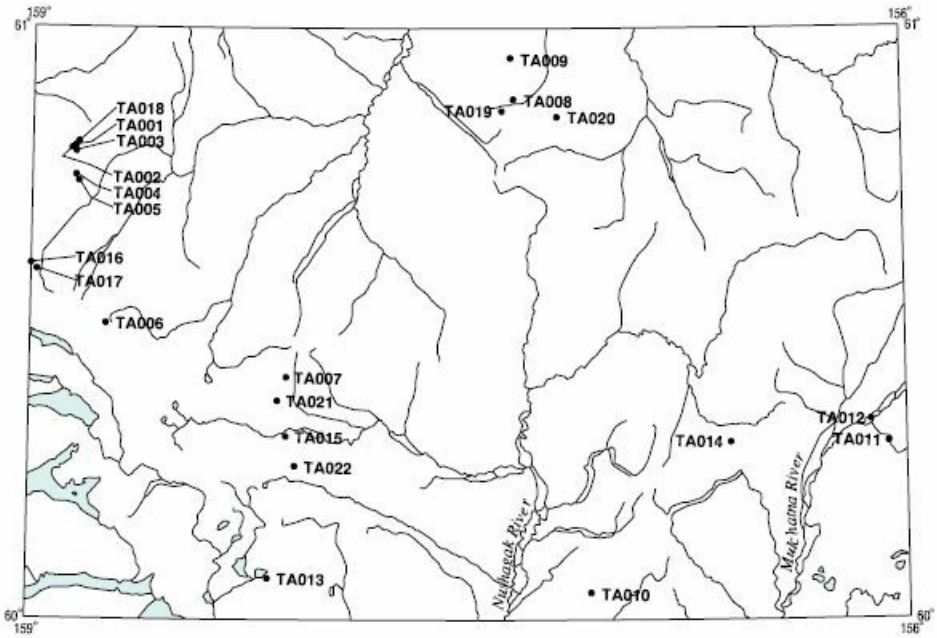
The Alaska Resource Data File (ARDF) data for the Taylor Mountains Quadrangle, Alaska (OF-2001-200) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Taylor Mountains Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Taylor Mountains 1:250,000-scale quadrangle, Alaska

Graphic from source map: ARDF, 1' x 3' Taylor Mountains Quadrangle

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ARDF, 1' x 3' Tyonek Quadrangle

The formal citation for this source.

Millholland, M.A. and Riehle, J.R., 1998, Alaska Resource Data File; Tyonek Quadrangle, Alaska, U. S. Geological Survey Open-File Report OF-98-525, 1:250000 scale (*GRI Source Map ID 2726*).

Prominent graphics and text associated with this source.

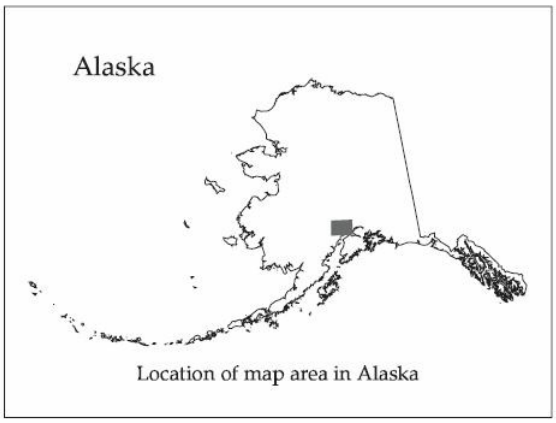
Report

The Alaska Resource Data File (ARDF) report for the Tyonek Quadrangle, Alaska (OF-98-525) is available for download at the following link: Report PDF.

Data

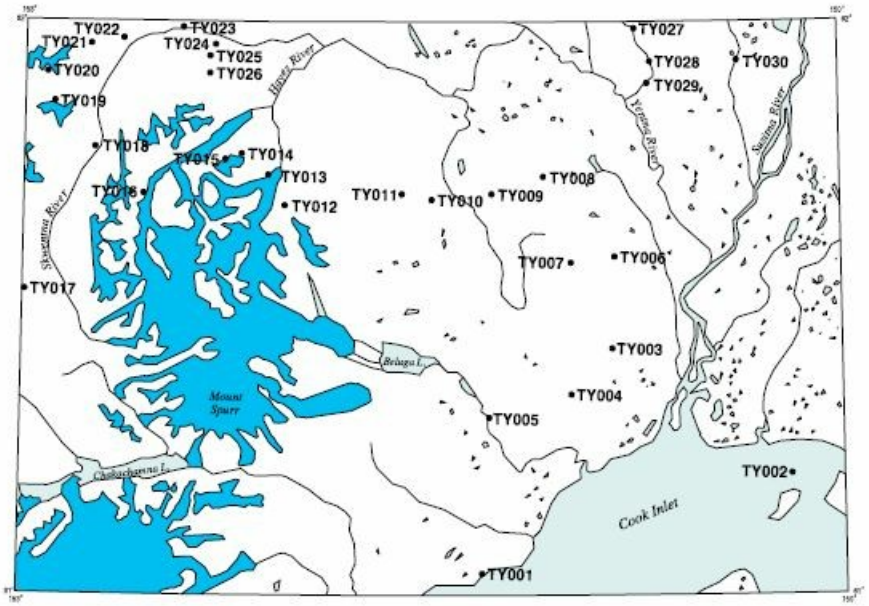
The Alaska Resource Data File (ARDF) data for the Tyonek Quadrangle, Alaska (OF-98-525) are available for download at the following link: Data.

Index Map



Graphic from source map: ARDF, 1' x 3' Tyonek Quadrangle

Mineral Occurrence Map



Distribution of mineral occurrences in the Tyonek 1:250,000-scale quadrangle, southcentral Alaska

Graphic from source map: ARDF, 1' x 3' Tyonek Quadrangle

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ARDF New and Revised Records

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Report

The Alaska Resource Data File (ARDF) report for the New and Revised Records Version 1.6 (OF-2008-1225) is available for download at the following link: Report PDF.

Data

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References

References for this document are available in the Report PDF.

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This document was developed and completed by Ron Karpilo, Stephanie O'Meara, Jake Suri and 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 and Stephanie O'Meara (Colorado State University).

The information in this document was compiled from GRI source maps, and intended to accompany the digital geologic-GIS map(s) and other digital data for Lake Clark National Park and Preserve, Alaska (LACL) developed by Ron Karpilo (see the GRI Digital Map and Source Maps Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map).

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