

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



Wrangell-Saint Elias National Park and Preserve

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Wrangell-Saint Elias National Park and Preserve

wrst_geology.pdf

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Geologic Resources Inventory Map Document for Wrangell-Saint Elias National Park and Preserve

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Geologic Resources Inventory Map Document



Wrangell-Saint Elias National Park and Preserve, Alaska

Document to Accompany Digital Geologic-GIS Data

[wrst_geology.pdf](#)

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

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 Map and Source Citations** – A listing of the GRI digital geologic-GIS map produced for this project along with the source maps used in its 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.
- 5) **Geologic Cross Sections** – Geologic cross section graphics with source geologic cross section abbreviations.
- 6) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may include a stratigraphic column, index map, map legend and/or map notes.

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

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. 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 GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

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: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: <https://go.nps.gov/gripubs>. GRI digital geologic-GIS data is also available online at the NPS Data Store: <https://irma.nps.gov/DataStore/Search/Quick>. 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: <https://www.nps.gov/subjects/geology/gri.htm>. At the bottom of that webpage is a "Contact Us" link if you need additional information. You may also directly contact the program coordinator:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division. Learn more about I&M and the 12 baseline inventories at the I&M webpage: <https://www.nps.gov/im/inventories.htm>.

GRI Digital Map and Source Map Citations

The GRI digital geologic-GIS map for Wrangell-Saint Elias National Park and Preserve, Alaska (WRST):

Digital Geologic-GIS Map of Wrangell-Saint Elias National Park and Preserve and Vicinity, Alaska (*GRI MapCode WRST*)

The following source map is the primary source for unit descriptions and symbolization of the GRI digital geologic-GIS map.

Richter, D.H., Preller, C.C., Labay, K.A., and Shew, N.B., 2006, Geologic Map of the Wrangell-Saint Elias National Park and Preserve, Alaska: U.S. Geological Survey, Scientific Investigations, SIM-2877, scale 1:350,000 ([Geologic Map of Wrangell-Saint Elias](#)). (*GRI Source Map ID 74822*).

The following source map was the primary source of the GIS data used to produce the GRI digital geologic-GIS map.

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*).

Of note, only a portion (Bering, Cordova, Gulkana, Icy Bay, McCarthy, Nabesna, Valdez, and Yakutat 1' x 3' quadrangles) of the full extent of the source map was used, however, all geologic features within this extent were captured. The USGS geologic-GIS data for the Alaska region includes geologic source map information as an attribute attached to each geologic feature. These attributes are preserved in the GRI data (using the USGS SOURCE code) and unit descriptions from these sources are included in this document. A list of these references and the corresponding USGS SOURCE codes are located in the [Geologic Map of Alaska References](#) section.

The following source was used for age data localities.

Sloan, J., Henry, C.D., Hopkins, M., Ludington, S., Zartman, R.E., Bush, C.A., and Abston, C., 2003, National geochronological database: U.S. Geological Survey, Open-File Report, OF-03-236, scale 1:250,000 ([National Geochronological Database](#)). (*GRI Source Map ID 56069*).

All age-date localities within the extent of the GRI digital geologic-GIS map were captured (see text associated with the Geologic Map of Alaska; Wilson et al., 2105 above, as well as the [Index Map](#) for this extent).

The following source was used for Paleontologic data localities.

Blodgett, R.B., and Zhang, N., 2011, Alaska Paleontologic Database: U.S. Geological Survey, unpublished data, scale 1:250,000 ([Alaska Paleontologic Database](#)). (*GRI Source Map ID 75597*).

All paleontologic localities within the extent of the GRI digital geologic-GIS map were captured (see text associated with the Geologic Map of Alaska; Wilson et al., 2105 above, as well as the [Index Map](#) for this extent).

Digital data from eight Alaska Resource Data File (ARDF) reports, listed below, are included in the GRI digital geologic-GIS data.

Hudson, T.L., 2002, Alaska Resource Data File, Bering Glacier Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-02-115, scale 1:250,000 ([ARDF, 1' x 3' Bering Glacier Quadrangle](#)). (*GRI Source Map ID 55228*).

Nelson, S.W., 2001, Alaska Resource Data File, Cordova Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-01-110, scale 1:250,000 ([ARDF, 1' x 3' Cordova Quadrangle](#)). (*GRI Source Map ID 3005*).

Ellis, W.T., 2001, Alaska Resource Data File, Gulkana Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-01-191, scale 1:250,000 ([ARDF, 1' x 3' Gulkana Quadrangle](#)). (*GRI Source Map ID 3003*).

Hudson, T.L., 2002, Alaska Resource Data File, Icy Bay Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-02-116, scale 1:250,000 ([ARDF, 1' x 3' Icy Bay Quadrangle](#)). (*GRI Source Map ID 55229*).

Richter, D.H., 1998, Alaska Resource Data File, McCarthy Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-98-227, scale 1:250,000 ([ARDF, 1' x 3' McCarthy Quadrangle](#)). (*GRI Source Map ID 3008*).

Richter, D.H., 1997, Alaska Resource Data File, Nabesna Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-97-749, scale 1:250,000 ([ARDF, 1' x 3' Nabesna Quadrangle](#)). (*GRI Source Map ID 3009*).

Hudson, T.L., 2003, Alaska Resource Data File, Valdez Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-03-30, scale 1:250,000 ([ARDF, 1' x 3' Valdez Quadrangle](#)). (*GRI Source Map ID 55223*).

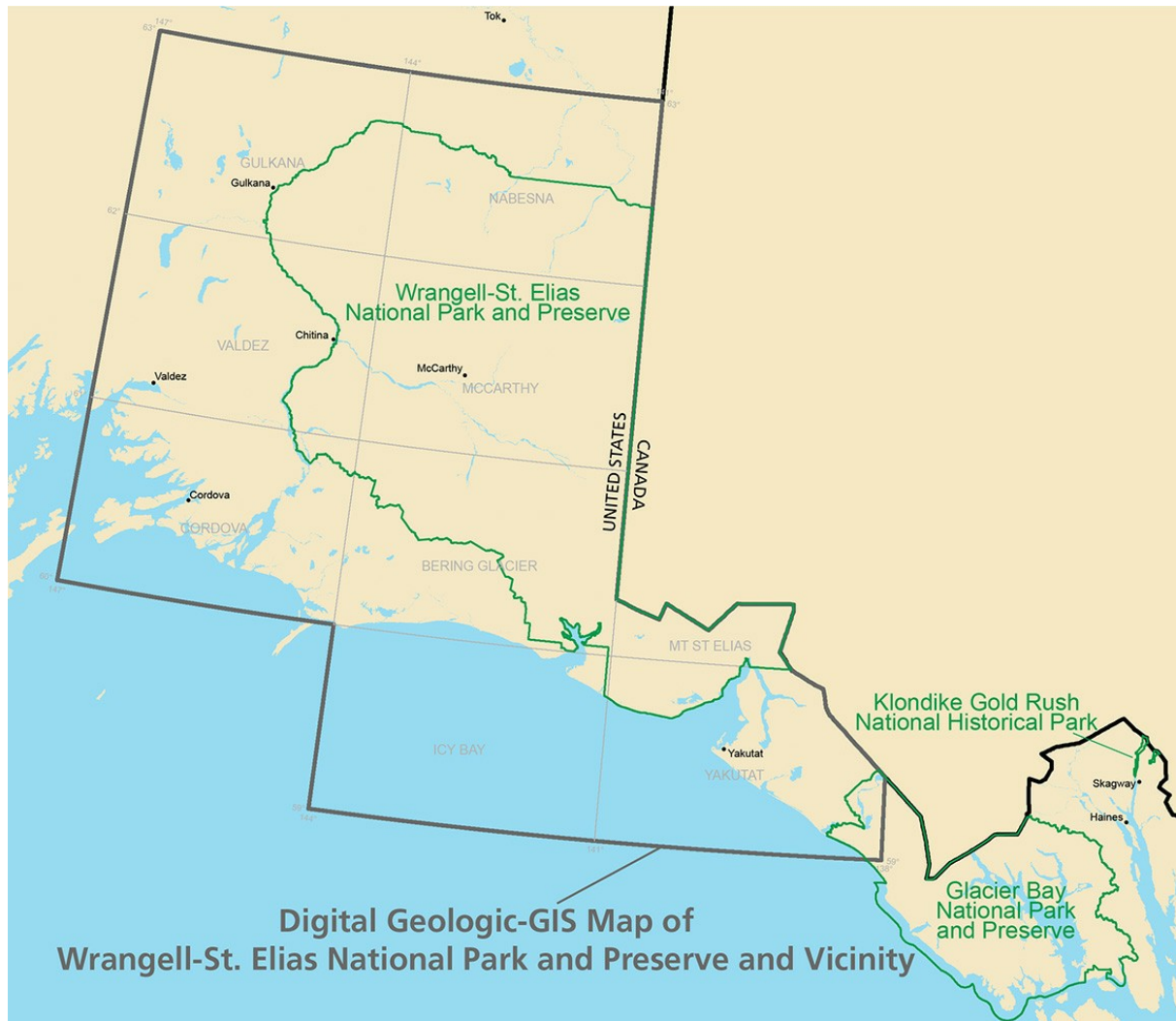
Hawley, C.C., 1999, Alaska Resource Data File, Yakutat Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-99-333, scale 1:250,000 ([ARDF, 1' x 3' Yakutat Quadrangle](#)). (*GRI Source Map ID 2607*).

All ARDF localities within the GRI digital geologic-GIS map extent were captured (see text associated with the Geologic Map of Alaska; Wilson et al., 2105 above, as well as the [Index Map](#) for this extent).

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

Index Map

The following index map displays the extent of the GRI digital geologic-GIS map produced for Wrangell-Saint Elias National Park and Preserve (WRST). The boundary for Wrangell-Saint Elias National Park and Preserve (as of April 2022) is outlined in green. The thick gray boundary delineates the extent of the GRI digital geologic-GIS map.



Index map by Ron Karpilo (Colorado State University).

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Wrangell-Saint Elias National Park and Preserve, Alaska (WRST) 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 (WRSTUNIT) table included with the GRI digital geologic-GIS data.

Cenozoic Era

Quaternary Period

[q](#) - Glaciers and permanent icefields
[Qa](#) - Alluvium
[Qcb](#) - Slope deposits, bluff colluvium
[Qrg](#) - Rock glacier deposits
[Qag](#) - Drift of Alaskan glaciation
[Qsm](#) - Supraglacial deposits
[Qfl](#) - Fine-grained deposits
[Qms](#) - Mineral spring deposits
[Qe](#) - Eolian deposits
[Qb](#) - Beach and delta deposits
[Ql](#) - Slope deposits, landslide deposits
[Qwws](#) - Mount Wrangell volcano, shield lavas
[Qwww](#) - Mount Wrangell volcano, valley-fill lavas
[Qu](#) - Slope deposits, undifferentiated
[Qs](#) - Swamp deposits
[Qic](#) - Ice-contact deposits
[Qao](#) - Older alluvium
[Qg](#) - Drift of older glaciations
[Qcr](#) - Copper River deposits
[Qo](#) - Outwash deposits
[Qwd](#) - Mount Drum volcano, lava flows
[Qwdr](#) - Mount Drum volcano, domes
[Qvd](#) - Volcaniclastic deposits, volcanic debris flows
[Qpf](#) - Volcaniclastic deposits, pyroclastic flows
[Qbc](#) - Cinder cones, flows, and tuffs
[Qws](#) - Mount Sanford volcano, lava flows
[Qwsr](#) - Mount Sanford volcano, rhyolite dome and flow
[Qwc](#) - Capital Mountain volcano, shield and intracaldera lavas
[Qwcr](#) - Capital Mountain volcano, central andesite plug and dike swarm
[Qwj](#) - Mount Jarvis volcanoes, shield and intracaldera lavas
[Qwjdr](#) - Mount Jarvis volcanoes, domes

Quaternary and Tertiary Periods

[QTy](#) - Yakataga Formation
[QTw](#) - Lava flows and sedimentary rocks
[QTwr](#) - Domes and intrusive rocks
[QTwt](#) - Tanada Peak volcano, shield and intracaldera lavas
[QTwi](#) - Lava flows and sedimentary rocks, flows of the Ice Fields Plateau
[QTwd](#) - Dikes

Tertiary Period

[Th](#) - Shallow plutons, small stocks, dikes, and sills
[Tg](#) - Granodiorite
[Tp](#) - Younger plutons
[Tc](#) - Metamorphic complex of Cottonwood Creek of Richter (1976)
[Tw](#) - Lava flows and lahars
[Twr](#) - Rhyolite flow
[Twd](#) - Domes
[Td](#) - Rhyolite porphyry and granite
[Ts](#) - Sedimentary rocks
[Tm](#) - Volcanic and hypabyssal rocks
[Tps](#) - Poul Creek Formation
[Tgp](#) - Granitic plutons
[Tt](#) - Tokun Formation
[Tgt](#) - Granite and tonalite
[Tk](#) - Kulthieth Formation
[Tos](#) - Orca Group, turbidites
[Tov](#) - Orca Group, basalt
[Tmu](#) - Mafic and ultramafic plutonic rock
[Tvu](#) - Tertiary volcanic rocks, undivided
[Tsq](#) - Snag pluton

Cenozoic and Mesozoic Eras**Tertiary and Cretaceous Periods**

[TKm](#) - Orca Group, mélange

Mesozoic Era**Cretaceous Period**

[Kvu](#) - Valdez Group, ultramafic rocks
[Kvv](#) - Valdez Group, greenschist-facies flysch, metamorphosed basalt and tuff
[Kv](#) - Valdez Group, greenschist-facies flysch
[Kvm](#) - Valdez Group, amphibolite-facies flysch
[Kvg](#) - Valdez Group, gneiss and schist
[Ku](#) - Marine sedimentary rocks
[Kun](#) - Nonmarine sedimentary rocks
[Kug](#) - Undifferentiated plutonic rocks
[Kyb](#) - Metamorphic rocks of the Brabazon Range
[Kg](#) - Mid-Cretaceous plutons
[Kyn](#) - Schist of Nunatak Fjord
[Kc](#) - Chisana Formation
[Kl](#) - Shallow marine sedimentary rocks
[Kyf](#) - Yakutat Group, flysch
[Kym](#) - Yakutat Group, mélange

Cretaceous and Jurassic Periods

[KJs](#) - Nutzotin Mountains sequence of Berg and others (1972)
[KJm](#) - Mélange units

Mesozoic Era

[MZc](#) - Conglomerate and sandstone

Mesozoic and Paleozoic Eras

[MZPZu](#) - Alpine-type ultramafic rocks and gabbro

Jurassic Period

[Jc](#) - Chitina Valley batholith

[Js](#) - Sedimentary rocks

[Jk](#) - Kotsina Conglomerate

[Jnt](#) - Mafic and ultramafic rocks

[Jlc](#) - Schist of Liberty Creek of Winkler and others (1981)

[Jhg](#) - Plutonic rocks of Hidden terrane

Jurassic and Triassic Periods

[JTRm](#) - McCarthy Formation

[JTRt](#) - Talkeetna Formation

Triassic Period

[TRI](#) - Triassic limestone

[TRcn](#) - Chitstone and Nizina Limestones

[TRg](#) - Gabbro and diabase and gabbro-norite dikes

[TRcg](#) - Stocks and plugs

[TRn](#) - Nikolai Greenstone

Paleozoic Era**Permian Period**

[Pm](#) - Mankomen Group, undivided

[Pe](#) - Mankomen Group, Eagle Creek Formation

[Pel](#) - Mankomen Group, Eagle Creek Formation, limestone

[Ph](#) - Skolai Group, Hasen Creek Formation

[Pl](#) - Skolai Group, Hasen Creek Formation, limestone

Permian and Pennsylvanian Periods

[PPNsm](#) - Strelina Metamorphics of Plafker and others (1989)

[PPNm](#) - Strelina Metamorphics of Plafker and others (1989), marble

[PPNs](#) - Skolai Group, undivided

[PPNdp](#) - Diorite complex, plutonic part

[PPNdm](#) - Diorite complex, metamorphic part

[PPNss](#) - Mankomen Group, Slana Spur Formation

[PPNt](#) - Tetelna Volcanics

[PPNsc](#) - Skolai Group, Station Creek Formation

Paleozoic Era

[PZv](#) - Metamorphic rocks of the Carden Hills, metavolcanic rocks

[PZvc](#) - Metamorphic rocks of the Carden Hills, metavolcaniclastic rocks

[PZk](#) - Kaskawulsh Group of Kindle (1953)

Pennsylvanian Period

[PNa](#) - Ahtell pluton

[PNm](#) - Monzonite-granite complex

[PNgo](#) - Gabbro and orthogneiss

Devonian Period

[Ddg](#) - Diorite-gabbro

[Dg](#) - Greenstone

[Dl](#) - Limestone

[Dp](#) - Metasedimentary rocks

Map Unit Descriptions

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

g - Glaciers and permanent icefields (Holocene)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Qa - Alluvium (Holocene)

In active streambeds and lowest terraces along larger streams and active alluvial fans. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qa - Alluvium (Quaternary, Holocene) Chiefly well-sorted gravel and sand, minor silt, and boulders in higher terraces along larger streams and active alluvial fans. Description from source map: BG004 and IB003

Qa - Alluvium (Holocene) In active streambeds and lowest terraces along larger streams and active alluvial fans. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: CV004, GU003, NB007, and YA003

Qa - Alluvial deposits (Holocene) Alluvial deposits. Description from source map: GU002 and GU009

Qag - Coarse-grained fluvial deposits (Quaternary) Interbedded and interlensing beds of sand, pebbles, cobbles, and boulders deposited by large to small nonglacial streams and modern glacial streams. Silt content generally low but may be high locally. Large particles rounded to subangular. Description from source map: GU005

Qas - Fine-grained fluvial deposits (Quaternary) Bedded and locally laminated silt and fine to medium sand; may be overlain by or interbedded with organic material and gravel. Gravel or gravelly sand underlies deposits in some areas. Description from source map: GU005

Qal - Alluvium along streams and in fans (Holocene) Mainly in active flood plains and lowermost terraces of major and some minor streams and in larger active fans. Stratified silt, sand, gravel, and boulders. Description from source map: MC003

Qa - Active alluvium (Quaternary) Active alluvium in larger streams and fans. Description from source map: MC004

Qa - Alluvial deposits (Holocene) Alluvium of active flood plains and lowest terraces of major streams, and larger alluvial fans. Boulders, gravel, and sand. Description from source map: NB002

Qal - Alluvium along streams (Quaternary, Holocene) Mainly in active flood plains of major and some minor streams. Locally, includes outwash related to older phases of the Alaska glaciations. Chiefly stratified boulders, cobbles, gravel, and sand; silt locally common. Description from source map: NB008

Qa - Alluvium in streams (Holocene and Pleistocene) Includes alluvium in active flood plains and in principal terraces of major and some minor streams. Chiefly stratified silt, sand, gravel, and boulders. Description from source map: VA006, VA007, VA008, and VA011

Qcb - Slope deposits, bluff colluvium (Holocene)

Occurs along high steep bluffs of the Copper River and its principal tributaries. Locally includes small areas of the Copper River deposits (Qcr) and the drift of older glaciations (Qg). Unsorted silt, sand, gravel, and boulders. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qcb - Bluff colluvium (Quaternary, Holocene) Colluvium along the high steep bluffs of the Copper River and its principal tributaries. Includes numerous local exposures of Copper River deposits (unit Qcr) and drift of older glaciations (unit Qg). Unsorted silt, sand, gravel, and boulders. Description from source map: GU003 and NB007

Qcb - Bluff colluvium (Quaternary) Basin bluff colluvium. Description from source map: MC004

Qcb - Bluff Colluvium (Holocene and Pleistocene) Occurs along high steep bluffs of the Copper River and its principal tributaries. Locally includes small areas of the Copper River deposits (Qcr) and the drift of older glaciations (Qg). Unsorted silt, sand, gravel, and boulders. Description from source map: VA006

Qc - Colluvium, undifferentiated (Holocene and Pleistocene) Chiefly talus but includes deposits of small landslides, rock glaciers, and other mass-wasting processes. Generally includes a large proportion of alluvium in small fans and cones and reworked glacial deposits. Chiefly poorly sorted silt, sand, gravel, and boulders. Description from source map: VA008

Qrg - Rock glacier deposits (Holocene)

Well defined lobate forms that may include glacier ice cores. Chiefly blocks of rubble. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qrg - Rock glaciers (Holocene) Unweathered, poorly sorted, pebble- to boulder sized rock debris and ice. Description from source map: BG002

Qrg - Rock glacier deposits (Quaternary, Holocene) Chiefly blocks of rubble lying on buried glaciers exhibiting well-defined lobate forms. May or may not include glacier cores at depth. Description from source map: BG004

Qrg - Rock glacier deposits (Holocene) Deposits of active rock glaciers exhibiting well-defined lobate form. Chiefly angular blocks and diamicton. Description from source map: MC003

Qrg - Rock glacier deposit (Quaternary) Rock glacier deposit. Description from source map: MC004

Qr - Rock glacier deposits (Holocene) Tallis and deposits from recently active, and recently active, rock glaciers. Rubble and diamicton. Description from source map: NB002

Qrg - Rock glacier deposits (Holocene) Well-defined lobate forms that may include glacier ice cores. Chiefly blocks of rubble. Description from source map: VA006

Qr - Rock glacier deposits (Holocene) Chiefly angular blocks and diamicton. Description from source map: VA007

Qag - Drift of Alaskan glaciation (Holocene)

Neoglacial deposits of end, lateral, and ground moraines, kames and outwash proximal to present glaciers; includes small rock glaciers. Diamicton, local gravel, and sand. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qm - Younger glacial moraine (Holocene) Undifferentiated terminal, lateral, and ground moraine. Locally includes and kame and esker deposits of Guyot Glacier around Icy Bay. Description from source map: BG002 and IB002

Qag - Drift of Alaskan (Neoglacial) glaciation (Quaternary, Holocene) Diamicton, local gravel, and sand in end, lateral, and ground moraines, kames, and outwash proximal to present glaciers; includes small rock glaciers. Description from source map: BG004

Qm - Terminal, lateral, and ground moraine (Quaternary, Holocene) Terminal, lateral and ground moraine-- Unsorted boulders, cobbles, gravel and sand deposited during retreat of glaciers. Description from source map: CV003

Qag - Drift of Alaskan glaciation (Quaternary, Holocene) Neoglacial deposits of end, lateral, and ground moraines, kames and outwash proximal to present glaciers; includes small rock glaciers. Diamicton, local gravel, and sand. Description from source map: CV004

Qmo - Older glacial moraine (Holocene) Undifferentiated terminal, lateral, and ground moraine of Guyot Glacier around Icy Bay. Description from source map: IB002

Qag - Alaskan glaciation deposits (Quaternary) Drift of Alaska glaciation. Description from source map: MC004

Qm - Younger end, ground, and lateral moraine deposits (Holocene) Mainly till, but locally includes lacustrine and glaciofluvial deposits. Arrow indicates direction of ice movement as inferred from trend of elongate trenches and ridges. Advance of Hubbard Glacier culminated in Yakutat Bay between 1700 and 1791 A.D. Description from source map: MS002 and YA002

Qag - Glacial deposits (Holocene) Drift of Alaskan Glaciation. End and lateral moraine deposits of receding glaciers. Rubble and diamicton. Description from source map: NB002

Qag - Drift of Alaskan (neoglacial) glaciation (Quaternary, Holocene (neoglacial)) End, lateral, and ground moraine and kames and outwash proximal to present glaciers. Includes rock glaciers too small to map. Diamicton, local gravel and sand. Description from source map: NB007

Qag - Drift of Alaskan glaciation (Quaternary, Holocene) End, lateral, and ground moraine of the Alaskan glaciations which were deposited during the recession of existing glaciers. In the extensive areas of glacial drift west of Copper Glacier three stages of Alaskan glaciation are recognized (H. Schmoll, written comm., 1994). The youngest stage includes ground, lateral, and end moraines that have been deposited near the margins of present-day glaciers. The two older stages, related to an older phase of Alaskan glaciation and marked by prominent and well-defined lateral moraines, occur further beyond the present-day glacier margins. Dashed line with hachures indicates extent of youngest stage of Alaskan glaciation and locally includes areas within which glaciers have been advancing and retreating during the late 20th century. Plain dashed line separates the two older stages of Alaskan glaciation. Drift is locally modified by colluvial processes, especially along steep eastside of the large nunatak west of Copper Glacier. Diamicton and rubble; local gravel and sand. Description from source map: NB008

Qag - Drift of Alaskan glaciation (Holocene) Neoglacial deposits of end, lateral, and ground moraines, kames and outwash proximal to present glaciers; includes small rock glaciers. Diamicton, local gravel, and sand. Description from source map: VA006

Qag - Drift of Alaskan glaciation (Holocene) Includes end and lateral moraines of the younger and older phases of Alaska glaciation, deposited after recession of existing glaciers. Diamicton, local gravel, and sand. Description from source map: VA007

Qsm - Supraglacial deposits (Holocene)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Qsm - Supraglacial moraine (Holocene) Unweathered, poorly sorted, pebble- to boulder sized rock debris on surfaces of alpine and valley glaciers. Description from source map: BG002 and IB002

Qsm - Supraglacial moraine (Quaternary, Holocene) Supraglacial moraine-- Unweathered, poorly sorted, debris on surfaces of glaciers. Description from source map: CV003

Stipple - Superglacial drift (Quaternary) Rock debris on existing glaciers. Description from source map: GU003

Qsg - Superglacial drift (Quaternary) Superglacial drift. Description from source map: MC004 and NB007

Qsm - Supraglacial deposits (Holocene) Unsorted angular debris ranging in size from silt to blocks on surfaces of the present glaciers. Description from source map: MS002 and YA002

overprint - Superglacial Drift (Quaternary) Superglacial Drift. Description from source map: VA006

Qfl - Fine-grained deposits (Holocene)

In ponds, swamps, lagoons, and along low-gradient streams. Chiefly silt, clay, fine sand, peat, and other organic material. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qfl - Fine-grained deposits (Quaternary, Holocene) Chiefly silt, clay, fine sand, peat, and other organic material in ponds, swamps, lagoons, and along low-gradient streams. Description from source map: BG004

Qfl - Fine-grained deposits (Quaternary, Holocene) In ponds, swamps, lagoons, and along low-gradient streams. Chiefly silt, clay, fine sand, peat, and other organic material. Description from source map: CV004

Qfl - Fine-grained deposits (Quaternary, Holocene) In ponds, swamps, lagoons, and along low-gradient streams. Chiefly silt, clay, fine sand, peat and other organic material. Description from source map: GU003 and NB007

Qfl - Fluvio-lacustrine and swamp deposits (Quaternary) Mud, clay and peat. Description from source map: MC004

Qfl - Fluvio-lacustrine deposits (Holocene and Pleistocene) Deposits of lakes, ponds, and low-gradient streams. Sand, silt, and clay. Description from source map: NB002

Qfl - Fluviolacustrine deposits (Holocene and Pleistocene) In ponds, swamps, lagoons, and along low-gradient streams. Chiefly silt, clay, fine sand, peat, and other organic material. Description from source map: VA006

Ql - Lagoonal deposits (Quaternary, Holocene) Lagoonal deposits--Fine-grained silt rich in organic material, mud, and peat. Description from source map: CV003

Ql - Lagoonal deposits (Holocene) Intertidal mud and sand deposited in swamp areas between beach ridges and in tidal embayments. Description from source map: YA002

Qgl - Glaciolacustrine deposits (Pleistocene) Deposits of glacial lakes. Clay, silt, sand, and minor gravel. Description from source map: NB002

Qms - Mineral spring deposits (Holocene)

Deposited by warm, Na-HCO₃-rich, CO₂-charged, saline spring waters forming the Klawasi Group (Shrub, Upper Klawasi, and Lower Klawasi) mud volcanoes (Motyka and others, 1989) located west of Mount Drum. Also includes one or more inactive deposits west of Capital Mountain; a methane-charged mineral spring found on Copper River's east bank near Copper Center. Mud and clayey-silt. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qms - Mineral spring deposits (Quaternary, Holocene) Chiefly mud (clayey silt) deposited by warm, Na-HCO₃-rich saline water charged with CO₂ from 3 active springs (Klawasi mud volcanoes) west of Mt. Drum and at least one inactive spring west of Capital Mountain. Unit also includes the Copper Center spring, a methane-charged spring, on the east bank of the Copper River near Copper Center. Description from source map: GU003

Qmv - Mud-volcano and mineral spring deposits (Quaternary) Massive to well-bedded clayey silt with some angular rock fragments of diverse lithology comprise the bulk of the mud-volcano and mineral-spring cones, some of which are mantled by glaciolacustrine or ground-moraine deposits. Fossils: Marine fossils, probably derived from underlying rocks are scattered in silt of some cones. Description from source map: GU005

Qms - Mineral spring and mud volcano deposits (Holocene and Pleistocene) Deposited by warm, Na-HCO₃-rich, CO₂-charged, saline spring waters forming the Klawasi Group (Shrub, Upper Klawasi, and Lower Klawasi) mud volcanoes (Motyka and others, 1989) located west of Mount Drum. Also includes one or more inactive deposits west of Capital Mountain; a methane-charged mineral spring found on Copper River's east bank near Copper Center. Mud and clayey-silt. Description from source map: VA006

Qe - Eolian deposits (Holocene)

Dunes on tops of river bluffs, windblown flats, and river bars. Includes informally named Bremner sand dunes, a large barchan field, located at confluence of Bremner and Copper Rivers. Fine-grained sand. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qd - Dunes (Holocene) Well-sorted fine-to medium-grain sand with abundant driftwood and sparse pebbles along the coast south of Bering Glacier. Dunes are nourished by prevailing southeasterly storm winds that blow across outwash deposits of the Bering Glacier. Description from source map: BG002 and IB002

Qd - Dunes (Quaternary, Holocene) Dunes-- Well sorted, fine grained sand and silt aligned in longitudinal ridges. Description from source map: CV003

Qe - Eolian deposits (Quaternary, Holocene) Dunes on tops of river bluffs, windblown flats, and river bars. Includes informally named Bremner sand dunes, a large barchan field, located at confluence of Bremner and Copper Rivers. Fine-grained sand. Description from source map: CV004

Qds - Active cliff-head dune deposits (Holocene) Active cliff-head dune deposits. Description from source map: GU002

Qe - Eolian/Dune (Quaternary) Sand dunes. Description from source map: MC004

Qe - Eolian deposits (Holocene) Dune, and remnant sand dune, deposits. Sand and silt. Description from source map: NB002

Qe - Eolian deposits (Holocene) Dunes on tops of river bluffs, windblown flats, and river bars. Includes informally named Bremner sand dunes, a large barchan field, located at confluence of Bremner and Copper Rivers. Fine-grained sand. Description from source map: VA006 and VA008

Qd - Dunes (Holocene) Larger sand dunes associated with present beaches and streams. Description from source map: YA002

Qb - Beach and delta deposits (Holocene)

Wave-deposited, coarse-grained material and driftwood along seacoast; fine-grained sediment in mud flats of Copper River Delta; and marine uplift terraces. Successive spit-building episodes of progressive gradation are preserved in beach sequences along coastal lowland between Cape Yakataga and Bering Glacier. Boulders, gravel, sand, and silt. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qb - Beaches and spits (Holocene) Constructional shoreline deposits of well-sorted gravel and sand formed as spits extending westward or northwestward from headlands and beaches consisting of successive sequences of marshes and ridges extending landward from the present shoreline. Description from source map: BG002 and IB002

Qb - Beaches, spits, and offshore bars (Quaternary, Holocene) Constructional shoreline deposits of well-sorted gravel and sand. Description from source map: CV003

Qb - Beach and delta deposits (Quaternary, Holocene) Wave-deposited, coarse-grained material and driftwood along seacoast; fine-grained sediment in mud flats of Copper River Delta; and marine uplift terraces. Successive spit-building episodes of progressive gradation are preserved in beach sequences along coastal lowland between Cape Yakataga and Bering Glacier. Boulders, gravel, sand, and silt. Description from source map: CV004 and CV004

Qb - Marine shoreline deposits (Holocene) Mainly sand and gravel of present and former beaches, beach ridges, beach bars and spits. Includes smaller sand dunes. Description from source map: YA002

Ql - Slope deposits, landslide deposits (Holocene and Pleistocene)

Slumps, earth-debris flows, block glides, and debris avalanches. Diamicton and rubble. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qls - Landslide deposits (Holocene) Larger deposits of unsorted, angular rock debris derived by massive failure of steep bedrock slopes. Description from source map: BG002

Qls - Landslides (Quaternary, Holocene) Landslides-- Unsorted, angular rock debris derived by failure of bedrock slopes. Description from source map: CV003

QI - Landslide deposits (Quaternary, Holocene and Pleistocene) Slumps, earth-debris flows, block glides, and debris avalanches. Diamicton and rubble. Description from source map: CV004

QI - Landslide deposits (Quaternary, Holocene and Pleistocene) Includes slumps, earth-debris flows, block glides, and debris avalanches. Diamicton and rubble. Description from source map: GU003 and NB007

QI - Landslide deposits (Holocene and Pleistocene) Includes large slump and debris avalanche deposits. Particularly common along steep north flank of mountain escarpment south of Beaver Creek. Slump deposits consist chiefly of masses of volcanic rock as much as hundreds of meters wide; deposits are chiefly diamicton and rubble. Description from source map: MC003

QI - Landslide deposits (Quaternary) Landslide deposits. Description from source map: MC004

Qls - Landslide deposits (Holocene) Larger landslides; arrows show downslope movement direction. Description from source map: MS002 and YA002

QI - Colluvial deposits (Holocene) Landslide deposits. Description from source map: NB002

QI - Landslide deposits (Holocene) Slumps, earth-debris flows, block glides, and debris avalanches. Diamicton and rubble. Description from source map: VA006

QI - Lagoonal deposits (Holocene) Intertidal mud and sand deposited in swamp areas between beach ridges and in tidal embayments, single polygon at toe of Malaspina Glacier. Description from source map: IB002

Qwws - Mount Wrangell volcano, shield lavas (Holocene and Pleistocene)

Chiefly andesitic flows. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qwws - Wrangell volcano - Shield lavas (Quaternary, Holocene and Pleistocene) Chiefly andesite. Description from source map: GU003

Qwws - Shield lavas -- Mount Wrangell volcano (Holocene and Pleistocene, 0.65 Ma and younger) Chiefly andesitic flows. Description from source map: MC006

Qwa - Wrangell Volcano -- Two-pyroxene high-silica andesite flows (Quaternary, Pleistocene) Medium- to dark-gray, thin to thick (5-30 m) lava flows that generally exhibit oxidized and slightly scoriaceous tops and bottoms. Rock is conspicuously porphyritic containing phenocrysts (2-7 mm) of plagioclase (15-20%), orthopyroxene (1-10%), clinopyroxene (trace -5%), opaque minerals (trace %), resorbed olivine (0-trace %), amphibole (0-trace %), and locally abundant glomerocrystic clots of plagioclase + orthopyroxene ± clinopyroxene ± opaque minerals in a pilotaxitic to intersertal ground mass of plagioclase and pyroxene microlites in a glass or cryptocrystalline matrix. Orthopyroxene is invariably the dominant pyroxene. Some phenocrysts may be largely the result of the disaggregation of glomerocrystic clots. Plagioclase shows evidence of as many as 3 different populations; orthopyroxene is locally rimmed by clinopyroxene and olivine by orthopyroxene, all suggestive of a mixed magma origin. Rock contains 61.8-63.4% SiO₂ (samples 91ARh-11, 91AMI-5, Table 2); in the contiguous Gulkana. A-1 quadrangle, SiO₂ content of correlative lavas ranges from 59-62 % (Richter and others, 1994). Nye (1983) reports a whole-rock K/Ar age of 0.5±0.4 Ma for a flow in sec. 18, T. 4 N., R.9 E.; in the contiguous Gulkana A-1 quadrangle, K/Ar ages for correlative lavas range between 0.5 and 0.6 Ma (Richter and others, 1994). Description from source map: NB008

Qw - Mt. Wrangell shield lava (Quaternary) Mt. Wrangell shield lava. Medium to dark gray, moderately to highly porphyritic two-pyroxene high-silica andesite flows. Radiometric age data: Whole rock K/Ar ages range from 282 ka to 516 ka. Description from source map: VA007

Qwu - Mt. Wrangell shield and valley fill lavas, undifferentiated (Quaternary) Mt. Wrangell shield and valley fill lavas, undifferentiated. Restricted to exposures in nunataks that were not visited on the upper slopes of Mt. Wrangell. Description from source map: VA007

Qwe - Early Mt. Wrangell lavas (Quaternary) Early Mt. Wrangell lavas. The flows north of the Chetaslina Glacier are porphyritic, olivine-bearing, two-pyroxene andesites exhibiting magma mixing features. The isolated flows are also olivine-bearing two-pyroxene porphyritic to seriate andesites. Radiometric age data: K/Ar age of 690 ka. Description from source map: VA007

Qwc - Mt. Wrangell west summit crater (Holocene) Altered flows, breccias, and tuffs. Description from source map: VA007

Qtp - Andesite plug (Pleistocene) Medium gray, plagioclase-rich andesite porphyry containing phenocrysts of fresh, euhedral plagioclase, clinopyroxene, and orthopyroxene in a cryptocrystalline groundmass. Radiometric age data: Whole rock K/Ar age of 529 ka. Description from source map: VA007

Qwwv - Mount Wrangell volcano, valley-fill lavas (Holocene and Pleistocene)

Lavas filled deeply incised glacial valleys cutting into the thick shield lavas (Qwws). A few far-reaching flows interbedded with the Copper River deposits (Qcr); chiefly andesite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

QTW - Wrangell Lava (Quaternary and Tertiary?) At least 2,000 m of flows, tephra, and minor sedimentary rocks in northeastern Valdez quadrangle. Consists of mainly pyroxene andesite but ranges from basalt to dacite. Radiometric age data: Dates as old as 10 Ma in adjacent Nabesna quadrangle, thought to be largely Quaternary in Valdez quadrangle. Description from source map: VA002

Qwv - Mt. Wrangell valley-fill and basin lavas (Quaternary) Moderately to highly porphyritic, two-pyroxene high-silica andesite flows mineralogically and chemically identical to Mt. Wrangell shield lavas. Radiometric age data: Whole rock K/Ar ages range from 25 ka to 270 ka. Description from source map: VA007

Qu - Slope deposits, undifferentiated (Holocene and Pleistocene)

Colluvium consisting of talus and small landslides, also includes small glacial, rock glacier, and alluvial deposits. Sand, gravel, boulders, diamicton, and rubble. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qs - Alluvial and outwash deposits (Holocene) Mainly fluvial and fluvio-glacial gravel, sand, and mud. Includes smaller areas of talus, glacial, and lacustrine sediments. Description from source map: MS002 and YA002

Q - Undifferentiated surficial deposits (Quaternary) The deposits include alluvium, colluvium, talus, landslides, rock glaciers, eolian and paludal deposits, and a variety of lacustrine, morainal, and ice contact. Description from source map: VA002

Qsw - Slope-wash deposits (Quaternary (Holocene)) Slope wash deposits in northeast part of map. Thought to include: Boulder- to pebble-size, angular rock debris derived from mass wasting of bedrock and overlying moraine deposits along walls of the larger valleys. Includes undifferentiated small landslides, and alluvial and glacial deposits. Description from source map: BG002

Qt - Talus deposits (Holocene) Talus deposits. Description from source map: BG002

Qu - Slope deposits, undifferentiated (Quaternary, Holocene and Pleistocene) Sand, gravel, boulders, diamicton, and rubble colluvium (talus and small landslides), but may also include small glacial, rock glacier, and alluvial deposits. Description from source map: BG004

Qt - Talus (Quaternary, Holocene) Talus-- Boulder- to pebble-sized, angular rock debris. Description from source map: CV003

Qu - Slope deposits, undifferentiated (Quaternary, Holocene and Pleistocene) Colluvium consisting of talus and small landslides, also includes small glacial, rock glacier, and alluvial deposits. Sand, gravel, boulders, diamicton, and rubble. Description from source map: CV004

Qco - Colluvial deposits (Holocene) Colluvial deposits, river bluff type. Description from source map: GU002

Qu - Slope deposits, undifferentiated (Quaternary, Holocene and Pleistocene) Chiefly colluvium (talus and small landslides) but may include local glacial, rock glacier, and alluvial deposits. Sand, gravel, boulders, diamicton, and rubble. Description from source map: GU003 and NB007

Qc - Colluvial deposits (Quaternary) Particle sizes range from clay to boulders and may be composed of varying amounts of each, formed by mass wastage; including solifluction and landslides. Angular boulders dominant in mountains; clasts generally smaller and rounded to subangular toward center of basin. Description from source map: GU005

Qc - Colluvial deposits - Undivided (Quaternary, Holocene) Undivided mass-wastage deposits on moderately steep slopes underlain by bedrock or surficial deposits. Chiefly diamicton, silty gravel, silty rubble, and sand. Most deposits originate by downslope movements such as creep, solifluction, and various types of rapid failure of slopes. Also includes talus, small landslides, small rock glaciers, and small alluvial fans. Description from source map: GU009

Qca - Colluvium, undifferentiated (Holocene and Pleistocene) Talus, but also includes deposits of small landslides, rock glaciers, and other products of mass-wasting processes, and alluvium in small fans and cones. Poorly sorted silt, sand, gravel, and boulders. Description from source map: MC003

Qu - Undifferentiated surficial deposits (Quaternary) Undifferentiated slope deposits, including glacial and alluvial deposits. Description from source map: MC004

Qc - Colluvial deposits (Holocene and Pleistocene) Colluvium, undivided. Description from source map: NB002

Qc - Colluvium, undifferentiated (Quaternary, Holocene and Pleistocene) Chiefly talus but also includes deposits of small landslides, rock glaciers, and other mass-wasting processes; in places includes large proportion of alluvium in small fans and cones and locally includes remnants of morainal deposits. Chiefly unsorted boulders, cobbles, gravel, and sand. Description from source map: NB008

Qc - Colluvium, undifferentiated (Holocene and Pleistocene) Chiefly talus but includes deposits of small landslides, rock glaciers, and other mass-wasting processes. Generally includes a large proportion of alluvium in small fans and cones and reworked glacial deposits. Sand, gravel, boulders, diamicton, and rubble. Description from source map: VA006

Qc - Colluvium, undifferentiated (Holocene and Pleistocene) Chiefly talus but includes deposits of small landslides, rock glaciers, and other mass-wasting processes. Generally includes a large proportion of alluvium in small fans and cones and reworked glacial deposits. Chiefly poorly sorted silt, sand, gravel, and boulders. Description from source map: VA007

Qt - Talus deposits (Holocene) Larger areas of poorly sorted, angular deposits forming cones and aprons at the base of steep slopes. Description from source map: YA002

Qag - Drift of Alaskan (Neoglacial) glaciation (Quaternary, Holocene) End, lateral, and ground moraine and kames and outwash proximal to present glaciers. Includes rock glaciers too small to map. Diamicton, local gravel and sand. Description from source map: GU003

Qag - Drift of Alaskan glaciation (Holocene) Neoglacial deposits of end, lateral, and ground moraines, kames and outwash proximal to present glaciers; includes small rock glaciers. Diamicton, local gravel, and sand. Description from source map: VA011

Qs - Swamp deposits (Quaternary)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Qs - Swamp deposits (Quaternary) Water-saturated, interbedded organic material, silt, and fine sand; locally clayey. Description from source map: GU005

Qic - Ice-contact deposits (Quaternary)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Qic - Ice-contact deposits (Quaternary) Well- to poorly sorted irregularly bedded sandy gravel, gravelly sand and sand. Rounded cobbles and boulders present locally. Deposited by meltwater streams on, under, or beside stagnant glacial ice. Mantled by as much as 5 feet of QIs (glaciolacustrine deposits) below 2,450 feet. Description from source map: GU005

Qao - Older alluvium (Holocene and Pleistocene)

In higher terraces along larger streams and in inactive alluvial fans. Predominantly of Pleistocene age, but may include localized Holocene deposits. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qaf - Alluvium in fans (Holocene and Pleistocene) Mainly large, broad, generally active fans and cones on mountain slopes chiefly along major streams. Chiefly sand, gravel, and boulders. Description from source map: VA007

Qao - Older alluvium (Quaternary, Holocene and Pleistocene) Chiefly well-sorted gravel and sand, also minor silt, and boulders in higher terraces along larger streams and inactive alluvial fans. Predominantly of Pleistocene age, may include localized Holocene deposits. Description from source map: BG004 and IB003

Qao - Older alluvium (Quaternary, Holocene and Pleistocene) In higher terraces along larger streams and in inactive alluvial fans. Predominantly of Pleistocene age, but may include localized Holocene deposits. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: CV004

Qao - Older alluvium (Quaternary, Holocene and Pleistocene) Alluvium in higher terraces along larger streams and in inactive alluvial fans. Chiefly well-sorted gravel and sand, minor silt and boulders. Predominantly of Pleistocene age, localized deposits include the Holocene. Description from source map: GU003, NB007, and YA003

Qao - Older alluvium (Quaternary) Older alluvium in larger streams and fans. Description from source map: MC004

Qau - Alluvial deposits (Holocene and Pleistocene) Alluvium, undivided. Description from source map: NB002

Qao - Older alluvium (Pleistocene) In higher terraces along larger streams and in inactive alluvial fans. Predominantly of Pleistocene age, but may include localized Holocene deposits. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: VA006

Qoa - Older alluvium (Pleistocene) Chiefly sand, gravel, and boulders; may include some diamicton. Maximum thickness about 150m. Description from source map: VA007

Qao - Older alluvium (Holocene and Pleistocene) In higher terraces along larger streams and in inactive alluvial fans. Predominantly of Pleistocene age, but may include localized Holocene deposits. Chiefly well sorted gravel and sand; minor silt and boulders. Description from source map: VA008

Qg - Drift of older glaciations (Pleistocene)

Wisconsin glaciation and older end, lateral, and ground moraines, local kames, kame-like deposits, and outwash. Also includes the glaciolacustrine deposits (Qcr) near complex interface with glacial Lake Atna in lower Chitina River valley. Chiefly diamicton, local gravel and sand. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qml - End- and lateral-moraine deposits (Quaternary) Consists of till with sandy matrix and numerous pebbles, cobbles, and some boulders; unsorted. Bedding absent except in pockets or lenses of sand and gravel. Clasts angular to subrounded. Description from source map: GU005

Qmo - Older end, ground, and lateral moraine deposits (Holocene) Glaciomarine till and till associated with a neoglacial advance of the Hubbard Glacier system which culminated in Yakutat Bay between 970 and 1290 A.D. Description from source map: YA002

Qg - Drift of older glaciations (Quaternary, Pleistocene) Chiefly diamicton, local gravel, and sand in end, lateral, and ground moraines of Wisconsin and older glaciations. Locally includes kames, kame-like deposits and outwash. Also includes glaciolacustrine deposits (Qcr) near the complex interface with Glacial Lake Atna in the lower Chitina River valley. Description from source map: BG004

Qg - Drift of older glaciations (Quaternary, Pleistocene) End, lateral, and ground moraine of Wisconsin and older glaciations. Locally includes kame and kame-like deposits and outwash. The Chitina River valley includes glaciolacustrine deposits near the complex interface with glacial Lake Atna. Chiefly diamicton, local gravel and sand. Description from source map: GU003 and NB007

Qmg - Ground moraine deposits (Quaternary) Largely till consisting of poorly sorted and nonsorted and non-bedded gravelly silty sand; locally gravelly sandy silt. Pebbles, cobbles, and boulders subrounded to subangular. Hillocks, mounds, pockets, or lenses of stratified sand and gravel present locally. Description from source map: GU005

Qog - Older glaciation deposits (Quaternary) Drift of older glaciations. Includes lake deposits in the Chitina River valley. Description from source map: MC004

Qwg - Glacial deposits (Pleistocene) Drift of Wisconsin glaciation. End, lateral, and ground moraine and fluvialglacial deposits. Description from source map: NB002

Qwg - Drift of Wisconsin glaciation (Quaternary, Pleistocene) Drift of Wisconsin glaciation. Chiefly lateral and ground moraine of both younger and older stages of Wisconsin glaciation. Diamicton and rubble; local gravel and sand. Description from source map: NB008

Qg - Drift of older glaciations (Pleistocene) Wisconsin glaciation and older end, lateral, and ground moraines local kames, kame-like deposits, and outwash. Also includes the glaciolacustrine deposits (Qcr) near complex interface with glacial Lake Atna in lower Chitina River valley. Chiefly diamicton, local gravel and sand. Description from source map: VA006

Qyg - Drift of younger (Wisconsin) glaciation (Pleistocene) Well defined lateral moraines high on the valley walls of the Dadina, Chetaslina, and East Fork of the Chetaslina Rivers. Diamicton. Description from source map: VA006 and VA008

Qg - Drift of older glaciations (Quaternary, Pleistocene) Chiefly diamicton, local gravel, and sand in end, lateral, and ground moraine of Wisconsin and older glaciations. Locally includes kames, kame-like deposits, and outwash. Description from source map: YA003

Qwl - Younger Wisconsin glaciation deposits (Pleistocene) Terminal and lateral moraines of late(?) phase of Wisconsin glaciation. Chiefly diamicton and rubble. Description from source map: MC003

Qwg - Older Wisconsin glaciation deposits (Pleistocene) Ground moraine of main(?) phase of Wisconsin glaciation. Diamicton, local gravel and sand. Description from source map: MC003

Qog - Drift of older (Wisconsin and older?) glaciation (Pleistocene) Chiefly ground moraine extensively modified by alluvial and colluvial processes. Diamicton; locally alluvial sand, gravel, and boulders. Description from source map: VA007

Qog - Glacial deposits (Pleistocene) Glacial drift deposits older than Wisconsin glaciation; probably of Illinoian age. Description from source map: NB002

Tg - Glacial, fluvioglacial, and boulder deposits (Tertiary) Weakly consolidated, poorly sorted, fluvioglacial deposits, glacial volcanic boulder deposits, and localized tillite. Fossils: Lignitized wood. Description from source map: NB002

Qcr - Copper River deposits (Pleistocene)

Interbedded glaciolacustrine, glacial, and alluvial deposits. Includes deposits of glacial Lake Atna (Nichols, 1989; Williams and Galloway, 1986); historically complex basin built from numerous lake stages in response to multiple glacial advances and retreats. Locally overlain by small fine-grained alluvium and pond deposits (Qfl). Interbedded with the Mount Wrangell valley-fill lavas (Qwwv) along western margin of Mount Wrangell, especially in Chetaslina River valley area. Clay-pebble silt and

diamicton, containing local to regionally distributed beds of gravel and sand. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qaf - Alluvial fan deposits (Quaternary) Apparent alluvial fan deposits, appear to overlying Lake Atna deposits. Description from source map: VA011

Ql - Lacustrine deposits (Late Pleistocene) Lacustrine deposits. Description from source map: GU002

Qls - Glaciolacustrine deposits (Quaternary) Varies vertically and laterally and includes rhythmically bedded clayey silt, laminated to massive silt, fine or medium sand, clayey silt with scattered pebbles and cobbles, and locally beds of gravelly sand and sandy gravel. Pebbles subangular to sub rounded. Description from source map: GU005

Qcr - Copper River deposits, undifferentiated (Quaternary, Pleistocene) Interbedded glaciolacustrine, glacial, and alluvial deposits including those of glacial Lake Atna at the surface. Chiefly clayey to pebbly silt and diamicton, with many local to regional beds of gravel and sand. Locally overlain by fine-grained alluvium and pond deposits (map unit Qfl) in areas too small to show separately. Description from source map: NB007

Qcr - Copper River deposits (Quaternary) Interbedded glaciolacustrine, glacial, and alluvial deposits. Includes deposits of glacial Lake Atna (Nichols, 1989; Williams and Galloway, 1986); historically complex basin built from numerous lake stages in response to multiple glacial advances and retreats. Locally overlain by small fine-grained alluvium and pond deposits (Qfl). Interbedded by the Mount Wrangell valley-fill lavas (Qwwv) along western margin of Mount Wrangell, especially in Chetaslina River valley area. Clay-pebble silt and diamicton, containing local to regionally distributed beds of gravel and sand. Description from source map: VA006

Qlg - Deposits of the Copper River Basin, undifferentiated (Pleistocene) Chiefly diamicton interbedded with stratified lacustrine sediments. The diamicton interbedded in the lake sediments ranges from non-sorted till to deposits of poorly sorted material that exhibits graded bedding. The lake sediments, consisting of sand, silt, and clay, locally contain ice-rafted dropstones. Diamicton, gravel, sand, silt, and clay. Description from source map: VA007

Qgl - Glaciolacustrine deposit (Quaternary) Interbedded lake and glacial deposits of the Copper River basin. Description from source map: VA008 and VA011

Qo - Outwash deposits (Pleistocene)

Interbedded and well-sorted sand and well-rounded pebble and cobble gravel with thin beds and lenses of silt. Derived from meltwater streams draining glacial ice during the Pleistocene. Modern glacial streams mapped as fluvial deposits. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qo - Outwash deposits (Quaternary) Interbedded and well-sorted sand and well-rounded pebble and cobble gravel with thin beds and lenses of silt. Derived from meltwater streams draining glacial ice during the Pleistocene. Modern glacial streams mapped as fluvial deposits. Description from source map: GU005

Qwd - Mount Drum volcano, lava flows (Pleistocene)

Andesite and dacite flows; dikes. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qdf - Volcanic rocks-Drum Volcano (Pleistocene) Cone building flows. Description from source map: GU002

Qdv - Andesite flows (Pleistocene) Mt. Drum volcano. Medium to dark gray, porphyritic olivine-bearing andesite lava flows containing phenocrysts of plagioclase, olivine, and orthopyroxene in a cryptocrystalline groundmass. Description from source map: VA007

Qwdr - Mount Drum volcano, domes (Pleistocene)

Dacite and rhyolite domes; associated flows and dikes. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qdd - Volcanic rocks-Drum Volcano (Pleistocene) Dacite domes. Description from source map: GU002

Qdr - Volcanic rocks-Drum Volcano (Pleistocene) Rhyolite domes. Description from source map: GU002

Qdc - Volcanic rocks-Drum Volcano (Pleistocene) Collapsed dome. Description from source map: GU002

Qvd - Volcaniclastic deposits, volcanic debris flows (Pleistocene)

Chetaslina volcanic mass-flow deposit, probably sourced from Mount Drum, exposed along Chetaslina and Copper Rivers; Sanford volcanic debris flow exposed along Sanford and Copper Rivers. Large blocks of lava and varied debris. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qvd - Volcaniclastic deposits - Volcanic debris flows (Quaternary, Pleistocene) Includes the Chetaslina volcanic mass-flow deposit exposed along the Chetaslina and Copper Rivers and the Sanford volcanic debris flow exposed along the Sanford and Copper Rivers. Description from source map: GU003

Qvd - Volcanic debris flow (Quaternary, Pleistocene) Includes the Chetaslina volcanic mass-flow deposit exposed along the Chetaslina and Copper Rivers and the Sanford volcanic debris flow exposed along the Sanford and Copper Rivers. Description from source map: GU003

Qvd - Volcanic debris flows (Pleistocene) Chetaslina volcanic mass-flow deposit, probably sourced from Mount Drum, exposed along Chetaslina and Copper Rivers; Sanford volcanic debris flow exposed along Sanford and Copper Rivers. Large blocks of lava and varied debris. Description from source map: MC006

Qvd - Volcanic debris flow (Pleistocene) Chetaslina volcanic mass-flow deposit, probably sourced from Mount Drum, exposed along Chetaslina and Copper Rivers; Sanford volcanic debris flow exposed along Sanford and Copper Rivers. Large blocks of lava and varied debris. Description from source map: VA006

Qcf - Chetaslina volcanic debris flow (Pleistocene) Multi-colored, voluminous debris avalanche deposit containing megablocks of both porphyritic and aphanitic andesite lava, hydrothermally altered lava, volcanic breccia, pyroclastic flow deposits, lacustrine sediments, and glacial deposits. Description from source map: VA007 and VA008

Qpf - Volcaniclastic deposits, pyroclastic flows (Pleistocene)

The extensive informally named Nadina hot avalanche deposit from Mount Drum's cataclysmic eruption and a smaller pyroclastic flow (0.3 Ma), possibly derived during an explosive episode from Mount Drum, deposited at Chetaslina River's two forks. Abundant bombs, scoria, pumice, and ash; lesser andesite and dacite blocks. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qpf - Pyroclastic flow (Pleistocene) Pale yellowish brown to moderate yellowish brown pyroclastic flow containing abundant bombs, scoria, and pumice. Radiometric age data: Whole rock K/Ar age of 342 ka from a scoria bomb. Description from source map: VA007

Qda - Volcanic rocks-Drum Volcano (Pleistocene) Volcanic avalanche deposits. Description from source map: GU002

Qpf - Volcaniclastic deposits - Pyroclastic flows (Quaternary, Pleistocene) Includes the extensive Nadina hot avalanche deposit from Mt. Drum and a pyroclastic flow (0.3 Ma), probably from Mt. Drum, at the junction of the two forks of the Chetaslina River. Description from source map: GU003

Qpf - Pyroclastic flows (Pleistocene) The extensive informally named Nadina hot avalanche deposit resulting from Mount Drum's cataclysmic eruption and a smaller pyroclastic flow (0.3 Ma) possibly derived during an explosive episode from Mount Drum deposited at Chetaslina River's two forks. Abundant bombs, scoria, pumice, and ash; lesser andesite and dacite blocks. Radiometric age data: Whole rock K/Ar age of 342 ka from a scoria bomb. Description from source map: VA006

Qda - Nadina volcanic avalanche, landslide, and glacial deposits, undifferentiated (Pleistocene) Mt. Drum volcano. Chiefly variegated, crudely stratified and poorly sorted juvenile bombs, pumice, and ash and blocks of andesite and dacite. Deposits are locally covered by, and mixed with, glacial drift. Description from source map: VA007

Qbc - Cinder cones, flows, and tuffs (Pleistocene)

Olivine basalt and basaltic andesite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qbc - Cinder cones and associated flows (Pleistocene) Cinder cones and associated flows. Description from source map: GU002

Qbc - Cinder cones, flows, and tuffs (Quaternary, Pleistocene) Olivine basalt and basaltic andesite. Description from source map: GU003

Qbc - Cinder cones, flows, and tuffs (Quaternary, Pleistocene) Chiefly olivine basalt and basaltic andesite. Description from source map: GU003 and NB007

Qbc - Cinder cones (Quaternary, Pleistocene) Chiefly dark reddish-gray cones, severely modified by erosion, comprised of cinder, bombs, spatter, and finer-grained debris and occasional short, rootless flows. A sample from the cone contains 53.3 % SiO₂ (sample 91ADf 11, Table 2). This basalt and the basal Jarvis basalt (sample 91AMI-14B, unit Qjb) are the most primitive rocks identified in the quadrangle. Description from source map: NB008

Qws - Mount Sanford volcano, lava flows (Pleistocene)

Chiefly andesite and dacite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qsf - Volcanic rocks-Sanford Volcano (Pleistocene) Basalt, andesite, and dacite lava, undifferentiated. Description from source map: GU002

Qws - Sanford volcano - Lava flows (Quaternary, Pleistocene) Chiefly andesite. Description from source map: NB007

Qsp - Mount Sanford volcano -- Dacite pyroclastic flow (Quaternary, Pleistocene) Flow consists chiefly of very light gray to olive gray pumice, in moderately welded ash. Pumice is locally banded, and occurs in blocks up to 1 m in diameter. Light colored pumice is sparsely porphyritic containing phenocrysts (1-2 mm) of clear plagioclase (1-3%), orthopyroxene (trace to 1%), clinopyroxene (trace), and opaque minerals (trace) in a groundmass of plagioclase microlites and clear glass. Darker pumice is mineralogically similar, but contains a darker glass and finer grained plagioclase laths than in the lighter colored pumice. The light pumice contains 69.6% SiO₂ (sample 91AM1-3a, Table 2). Plagioclase yielded a K-Ar age of 0.62 ± 0.03 Ma (sample 91ASh-1). Description from source map: NB008

Qsh - Volcanic rocks-Sanford Volcano (Pleistocene) Hyaloclastite. Description from source map: GU002

Qwsr - Mount Sanford volcano, rhyolite dome and flow (Pleistocene)

Thick far-ranging flow (0.6 Ma) probably sourced from northeast flank dome. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qsi - Volcanic rocks-Sanford Volcano (Pleistocene) Shallow plutons. Description from source map: GU002

Qsr - Volcanic rocks-Sanford Volcano (Pleistocene) Rhyodacite dome and flow. Description from source map: GU002

Qwsr - Sanford volcano - Dome (Quaternary, Pleistocene) Rhyolite dome and flow. Description from source map: GU003 and NB007

Qwr - Wrangell Lava (rhyolite cinder cone) (Quaternary) Rhyolite cinder cone and associated nuee ardente deposits. Description from source map: NB002

Qwc - Capital Mountain volcano, shield and intracaldera lavas (Pleistocene)

Chiefly andesite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qcc - Volcanic rocks-Capital Volcano (Pleistocene) Caldera lavas. Description from source map: GU002

Qcs - Volcanic rocks-Capital Volcano (Pleistocene) Shield lavas. Description from source map: GU002

Qwc - Capitol volcano - Shield and intracaldera lavas (Quaternary, Pleistocene) Chiefly andesite. Description from source map: NB007

Qwcr - Capital Mountain volcano, central andesite plug and dike swarm (Pleistocene)

Plug represents final activity; dike originated from laccolith on shield's southeast flank. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qcr - Volcanic rocks-Capital Volcano (Pleistocene) Rhyolite dikes and laccoliths. Description from source map: GU002

Qcd - Volcanic rocks-Capital Volcano (Pleistocene) Radial dike swarm and plugs. Description from source map: GU002

Qwj - Mount Jarvis volcanoes, shield and intracaldera lavas (Pleistocene)

Extensive flat-lying andesitic flows. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qaa - Andesite agglutinate (Quaternary, Pleistocene) Medium dark gray to dark gray high-silica andesite containing sparse small phenocrysts (1 mm) of plagioclase (1-4%), clinopyroxene (trace - 2%) orthopyroxene (trace - 1%), and opaque minerals (trace) and abundant clasts, as much as 1 m in diameter of both vitric and lithic cogenetic (?) andesitic or dacitic debris in a cryptocrystalline to glass groundmass. Agglutinate is apparently a single flow as much as 60 m thick; it exhibits well-formed columnar joints above a vitrophyre base. An analyzed sample contains 59.8% SiO₂ (Richter and Smith, 1976). Source local; probably derived from the collapse of a large cinder/spatter cone in the area now covered by a younger dacitic center in the adjacent Nabesna A-5 quadrangle. Description from source map: NB008

Qvd - Shield and intracaldera lavas -- Mount Jarvis volcanoes (Pleistocene, 1.7-1.0 Ma) Extensive flat-lying andesitic flows. Description from source map: MC006

Qwj - Jarvis volcanoes - Shield and intracaldera lavas (Quaternary, Pleistocene) Chiefly andesite. Description from source map: NB007

Qwjd - Mount Jarvis volcanoes, domes (Pleistocene)

Final stage deposition at chain's north end; dacite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qhad - Ho-Hum dome complex -- High silica andesite and dacite flows (Quaternary, Pleistocene) Undifferentiated porphyritic flows containing phenocrysts (1 mm -1 cm) of oscillatory-zoned plagioclase (5-25%), orthopyroxene (1-6%), hornblende (0-2%), and occasional traces of clinopyroxene, opaque minerals, and quartz in a cryptocrystalline to glassy groundmass that may contain sparse microlites of plagioclase and orthopyroxene. Glomerocystic clots of orthopyroxene + plagioclase + opaque minerals are locally abundant. Analyzed rocks contain 62.6 - 64.7 % SiO₂ (samples 91AM1-10C, 91ARh-21, Table 2). Description from source map: NB008

Qwjd - Jarvis volcanoes - Dome (Quaternary, Pleistocene) Chiefly dacite. Description from source map: NB007

QTy - Yakataga Formation (Holocene(?), Pleistocene, Pliocene, and Miocene)

Interbedded gray to dark-gray and greenish-gray siltstone, mudstone, and sandstone predominate in lower third of formation. Till-like diamictite is interbedded with siltstone and sandstone in all but lowest part of formation and is the dominant rock type in upper part of formation, particularly on Middleton Island. Conglomerate is a minor lithology throughout the formation, and scattered clasts-presumably dropstones-are present in all lithologies. Consists of diverse marine and glaciomarine clastic rocks along the Gulf of Alaska margin more than (?) m thick onshore and is widely distributed on the adjacent continental shelf where it is as much as (?) m thick in exploratory wells (Plafker and Addicott, 1976; Plafker and others, 1975). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

QTy - Yakataga Formation (Pleistocene to Miocene) Interbedded gray to dark-gray and greenish-gray siltstone, mudstone, and sandstone predominate in lower third of formation. Till-like diamictite is interbedded with siltstone and sandstone in all but lowest part of formation and is the dominant rock type in upper part of formation, particularly on Middleton Island. Conglomerate is a minor lithology throughout the formation, and scattered clasts-presumably dropstones-are present in all lithologies. Consists of diverse marine and glaciomarine clastic rocks along the Gulf of Alaska margin more than (?) m thick onshore and is widely distributed on the adjacent continental shelf where it is as much as (?) m thick in exploratory wells (Plafker and Addicott, 1976; Plafker and others, 1975). Fossils: Contains an abundant marine megafauna and microfauna. Description from source map: BG002 and IB002

QTy - Yakataga Formation (Pleistocene(?), Pliocene and Miocene) More than 4,000 m of gray to dark-gray siltstone and mudstone, interbedded with massive subquartzose sandstone, diamictite (conglomeratic sandy mudstone or tillite), and conglomerate. Sandstone less than 25 to 30 percent of surface sections. Fossils: Contains a moderately abundant molluscan megafauna and foraminiferal microfauna. Also rare fossil leaves and vertebrates. Description from source map: MS002

QTw - Lava flows and sedimentary rocks (Pleistocene, Pliocene, or Miocene)

Flat-lying andesite and dacite lava flows; a Tertiary tillite and the fossil-rich conglomeratic sandstone Frederika Formation. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

QTw - Wrangell Lava (older part) (Quaternary and Tertiary) Undivided andesite and basaltic andesite flows, dacite flows and dacite domes, tuffs and breccias, and dacitic andesite agglutinate flows. Radiometric age data: K-Ar dates suggest a minimum of 10 m.y. Description from source map: NB002

Tau - Older andesites and basaltic andesites, undivided (Tertiary, Pliocene) Chiefly flat-lying to gently dipping flows, 3-8 m thick, exhibiting scoriaceous tops and bottoms, and lesser intercalated lahars and flow breccias. Flows range from medium gray to olive gray to dark gray, are locally amygdaloidal, and generally porphyritic. Most prevalent are porphyritic two-pyroxene andesites containing fine- to medium-grained phenocrysts (up to 4 mm) of oscillatory-zoned plagioclase (2-25%), clinopyroxene (trace to 3%), orthopyroxene (trace to 5%), olivine (0-1%), opaque minerals (trace to 1%), and occasional traces of quartz and altered amphibole in a pilotaxitic groundmass of plagioclase laths, minute pyroxene grains, opaque minerals, and cryptocrystalline material. Glomerotryptic clots of plagioclase ± opaque minerals ± SiO₂ (sample 91Ash-7, Table 2) and an olivine-free flow contains 57.1 % SiO₂ (sample 91AM1-11A, Table 2). Correlative flows in the adjacent Nabesna B-6 quadrangle give K-Ar ages of 1.99 and 2.21 Ma (Richter and others, 1993). A light-colored small intrusive body (labeled i) exposed on the steep valley wall above Copper Glacier was not examined on the ground. Description from source map: NB008

Qwf - Volcanic rocks-Wrangell Volcano (Holocene (?) and Pleistocene) Andesite flows and fragmental rocks. Description from source map: GU002

Qnf - Volcanic rocks-Nathlie Mountain eruptive center (Pleistocene) Flows, breccias, and sedimentary rocks. Description from source map: GU002

Qw - Wrangell Lava (younger part) (Quaternary) Andesite and dacite flows, dacite domes, and interbedded breccias and pyroclastic rocks (near Mount Shields stratovolcanoes). basalt, andesite, and dacite flows and basaltic lapilli tuff (near Icefields Plateau area), dacite flow (near Drop Glacier and Copper River). Basalt and andesite flows (near West Glacier). Description from source map: NB002

Qcl - Lava flows, pyroclastic deposits, and breccias, undifferentiated (Pleistocene) Lava flows, pyroclastic deposits, and breccias, undifferentiated. Chiefly a variety of dark brownish gray andesite lava flows. Radiometric age data: Whole rock K/Ar ages of 1580 ka and 980 ka from andesitic lava flows. Description from source map: VA007

Qdb - Dacite block and ash deposit (Pleistocene) Contains blocks chiefly of light gray, porphyritic dacite as much as 2 m in diameter in a matrix of light gray to very light gray ash. Description from source map: VA007

Qcg - Conglomerate (Pleistocene) Weakly indurated pebble to boulder conglomerate and interbedded lenses of sandstone. Conglomerate is continuation of more extensive sedimentary rock unit mapped in the contiguous Gulkana A-1 quadrangle (Richter and others, 1994). Description from source map: VA007

Qah - Andesite flows (Pleistocene) Medium gray, slightly to moderately porphyritic andesite flows containing phenocrysts of plagioclase, orthopyroxene, hornblende, and traces of clinopyroxene and olivine in a cryptocrystalline to plagioclase rich groundmass. Description from source map: VA007

Qba - Basaltic andesite flows (Pleistocene) Dark gray, slightly porphyritic basaltic andesite flows containing phenocrysts of olivine, and a trace of clinopyroxene in a groundmass consisting of plagioclase laths. Description from source map: VA007

Qci - Andesite dikes (Pleistocene) Two dikes, of the five observed were accessible and sampled. Both are dark gray slightly porphyritic andesite. Description from source map: VA007

QTu - Volcanic rocks (Pleistocene and Pliocene (??)) Volcanic rocks, undifferentiated. Description from source map: GU002

QTw - Wrangell Lava (Quaternary and Tertiary) Calc-alkaline volcanic province including flows, tephra, and sedimentary units. Derived from shield or composite stratovolcano flows, or their satellite centers. Flows mainly andesite, also range from basalt to rhyolite, and less abundant dacite. Local sedimentary units include tuff and tillite. Wrangell Lava includes Tertiary tillite and the Frederika Formation which is mainly composed diverse conglomerate and sandstone, with lesser siltstone, shale, impure limestone, and lignite. Coextensive with counterparts in Nabesna Quad. Correlatives in Talkeetna Mountains, Alaska Peninsula, and the Aleutian Islands. Fossils: Fossil leaves from Frederika Formation indicate a Miocene age. Radiometric age data: K-Ar dates of tillite of 2.7 and 10 m.y. Description from source map: MC002

QTw - Lava flows and sedimentary rocks -- Older volcanic and sedimentary rocks (Pleistocene, Pliocene, or Miocene) Flat-lying andesite and dacite lava flows; a Tertiary tillite and the fossil-rich conglomeratic sandstone Frederika Formation. Description from source map: MC006

QTw - Older volcanic and sedimentary rocks - Lava flows (Quaternary and Tertiary, Pleistocene, Pliocene, and Miocene) Chiefly andesite and dacite. Includes the sedimentary non-marine Frederika Formation that occurs locally at the base of the Wrangell volcanic field in the southern Wrangell Mountains. Description from source map: NB007

QTwr - Domes and intrusive rocks (Pleistocene, Pliocene, or Miocene)

Chiefly dacite and rhyolite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Qwd - Volcanic rocks-Wrangell Volcano (Holocene (?) and Pleistocene) Dacite flows. Description from source map: GU002

Qni - Volcanic rocks-Nathlie Mountain eruptive center (Pleistocene) Dacite pluton. Description from source map: GU002

Qod - Dacite intrusion (Pleistocene) Light olive-gray to greenish-gray porphyritic, containing phenocrysts of plagioclase, hornblende, and biotite in a cryptocrystalline groundmass locally flooded by calcite. Description from principal exposure to the north in the Gulkana A-1 quadrangle where unit intrudes older andesite flows of the Chetaslina lavas (Richter and others, 1994). Radiometric age data: K-Ar age of 1.35 Ma. Description from source map: VA007

Qdc - Dacite debris apron (Pleistocene) Blocks and smaller fragments of hornblende dacite in crudely layered deposits. Description from source map: VA007

Qd - Dacite flow dome (Pleistocene) Light gray porphyritic hornblende dacite containing phenocrysts of plagioclase and hornblende that is locally rimmed with black oxides in a cryptocrystalline groundmass. Description from source map: VA007

Qdi - Dacite plugs (Pleistocene) Light gray, moderately porphyritic hornblende dacite containing phenocrysts of plagioclase, hornblende, and traces of orthopyroxene in a cryptocrystalline to microcrystalline groundmass. Description from source map: VA007

Qcd - Andesite-dacite domes (?) and breccias (Pleistocene) Andesite-dacite domes (?) and breccias. Light gray domes ranging from andesite containing plagioclase, orthopyroxene, clinopyroxene, and olivine to porphyritic dacite containing phenocrysts of plagioclase, clinopyroxene, orthopyroxene, and hornblende in a cryptocrystalline groundmass. Radiometric age data: Whole rock K/Ar age of 874 ka. Description from source map: VA007

QTw - Older volcanic and sedimentary rocks - Domes and intrusive rocks (Quaternary (Pleistocene) and Tertiary (Pliocene and Miocene)) Chiefly dacite and rhyolite. Description from source map: GU003 and NB007

QTwr - Domes and intrusive rocks -- Older volcanic and sedimentary rocks (Pleistocene, Pliocene, or Miocene) Chiefly dacite and rhyolite. Description from source map: MC006

QTw - Wrangell Lava (rhyodacite and rhyolite) (Quaternary and Tertiary) Rhyodacite and rhyolite domes, associated, nuee ardente and air-fall deposits (both localized), local mudflow and tillite (?) deposits, and pumice lapilli tuff. Description from source map: NB002

QTwt - Tanada Peak volcano, shield and intracaldera lavas (Pleistocene and Pliocene)

Shield and intracaldera lavas, chiefly andesite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

QTwt - Tanada volcano (Quaternary and Tertiary, Pleistocene and Pliocene) Shield and intracaldera lavas, chiefly andesite. Description from source map: NB007

QTwi - Lava flows and sedimentary rocks, flows of the Ice Fields Plateau (Pleistocene, Pliocene, or Miocene)

Massive dacite and high-silica andesite lavas capping Ice Fields Plateau east of Nabesna Glacier. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

QTwi - Older volcanic and sedimentary rocks - Icefield flows (Quaternary and Tertiary, Pleistocene, Pliocene, and Miocene) Massive flows of high silica andesite capping the Icefields Plateau. Description from source map: NB007

QTwd - Dikes (Pleistocene, Pliocene, Miocene, or Oligocene)

Chiefly andesite and dacite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Th - Shallow plutons, small stocks, dikes, and sills (Tertiary)

Andesite to dacite porphyry, diorite, and quartz diorite. K-Ar dates indicate ages that range from 7.0 to 3.0 Ma, younger than the plutons (Tp) located on north side of Wrangell Mountains. Probably related to Wrangell volcanism, porphyry rocks may be hypabyssal equivalents of the older Wrangell lavas (QTw) and the Chisana Formation (Kc). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Th - Hypabyssal rocks (Tertiary) Dacite, andesite, and rhyodacite porphyry. Typically strongly porphyritic. Correlates with younger porphyry of Nabesna quadrangle and with hypabyssal rocks associated with the Wrangell Lava in Alaska and Canada. Subdivision of unit Th of MacKevett (1978) south of range divide and Chitna River valley. Radiometric age data: K-Ar on biotite of 3.8 ± 0.8 m.y. and sanidine of 6.5 ± 0.2 m.y. Description from source map: MC006

Tg - Granodiorite (Tertiary)

Plutonic phase of the Wrangell Lava exposed mainly at Hawkins Glacier head, marginal to Mount Blackburn volcano caldera. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tg - Granodiorite (Tertiary) Nonfoliate, fine- to medium-grained hypidiomorphic granular rocks of granodiorite, and subordinate granite, and local dioritic or gabbroic border zones. Radiometric age data: K-Ar on biotite and hornblende of 8.4 ± 0.25 m.y. Description from source map: MC002

Tg - Granodiorite -- Hypabyssal and plutonic rocks (Pleistocene, Pliocene, Miocene, or Oligocene) Plutonic phase of the Wrangell Lava exposed mainly at Hawkins Glacier head, marginal to Mount Blackburn volcano caldera. Description from source map: MC006

Tp - Younger plutons (Tertiary)

Plutonic phase of the Wrangell Lava exposed mainly at Hawkins Glacier head, marginal to Mount Blackburn volcano caldera. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tif - Felsic to intermediate hypabyssal intrusive rocks (Tertiary) Dikes, sills, and small stocks, compositionally diverse, dacite predominates but rocks range from rhyodacite to quartz latite and andesite. Radiometric age data: K-Ar age of 47 and 52 Ma reported as well as numerous 40 to 50 Ma ages and some as young as Pliocene. Description from source map: VA002

Th - Hypabyssal rocks (Tertiary) Dacite, andesite, and rhyodacite porphyry. Typically strongly porphyritic. Correlates with younger porphyry of Nabesna quadrangle and with hypabyssal rocks associated with the Wrangell Lava in Alaska and Canada. Radiometric age data: K-Ar on biotite of 3.8 ± 0.8 m.y. and sanidine of 6.5 ± 0.2 m.y. Description from source map: MC002

Tdqd - Quartz diorite (Tertiary) Medium-grained, subhedral granular quartz diorite containing plagioclase, quartz orthoclase, clinopyroxene, and minor hornblende and biotite. Locally highly altered. Probably mostly subvolcanic and a variant of the diorite intrusive unit (Tdd). Description from source map: MC003

Tdd - Diorite (Tertiary) Medium-grained, subhedral granular diorite consisting of subhedral plagioclase, clinopyroxene generally altered to actinolite, and locally minor hornblende and biotite. Description from source map: MC003

Tp - Younger porphyry (Tertiary) Porphyries ranging from andesite to rhyodacite. Dikes and sills with alteration. Porphyries may represent hypabyssal equivalent of the older part of the Wrangell Lava. Radiometric age data: K-Ar data yields ages between 17 and 39 m.y. Description from source map: NB002

Tp - Younger plutons - Wrangellia Terrane (Tertiary) Chiefly hornblende-feldspar and feldspar porphyry. Some of the younger plutons may be related to Wrangell volcanism. Radiometric age data: K-Ar dates indicate ages of 17-39 Ma. Description from source map: NB007

Tc - Metamorphic complex of Cottonwood Creek of Richter (1976) (Tertiary)

Banded granite and quartz diorite gneiss and biotite- and augite-bearing amphibolite gradational into biotite metagranodiorite and metagranite. Weakly metamorphosed (greenschist facies). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tc - Cottonwood Creek Complex (Tertiary) Banded granite and quartz diorite gneiss and biotite- and augite-bearing amphibolite gradational into biotite metagranodiorite and metagranite. Weakly metamorphosed (greenschist facies). Radiometric age data: K-Ar of metamorphic biotite and amphibole of 17 to 20 m.y. Description from source map: NB002

Tw - Lava flows and lahars (Miocene or Oligocene)

Basaltic andesite, andesite, and dacite lava flows; andesitic lahar deposits. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tsl - Andesite flows (Tertiary) Aphanitic to porphyritic andesite and possibly dacite lava flows and minor interbedded mudflows and glassy agglomerates. Flows are mostly flat-lying and are generally less than 10 m thick; aggregate thickness about 350 m. Wrangell lava; Sonya Creek

shield volcano; shield rocks. Description from source map: MC003

Twl - Lavas of Wiki Peak (Tertiary) Extensive, thin to locally thick (as much as 35 m), lava flows and subordinate interlayered lahars and lapilli tuffs that show an aggregate thickness of more than 1000 m. Basalt to dacite, but predominantly basaltic andesite and andesite. Wrangell lava; Sonya Creek Shield volcano; intracaldera(?) rocks. Radiometric age data: 20.0 +/- 0.6 my, K/Ar, whole rock from a flow high in intracaldera section. Description from source map: MC003

Tcc - Andesite cinder cones (Tertiary) Reddish, oxidized cinder and scoria. West of Sonya Creek, unit may include thin andesite flows. Wrangell lava; Sonya Creek Shield volcano; ring fracture(?) related rocks. Description from source map: MC003

Tm - Mudflows(?) (Tertiary) Structureless to locally stratified mudflows(?) containing clasts of angular volcanic rock as much as 10 m in diameter and minor rounded clasts of exotic plutonic rock. Unit appears to form basal unit in Sonya Creek caldera(?). Wrangell lava; Sonya Creek Shield volcano; intracaldera(?) rocks. Description from source map: MC003

Tsp - Andesite and basalt plugs(?) (Tertiary) Dark, generally aphanitic, dense andesite and basalt rock masses contained within breccias of unit Tsb. Wrangell lava; Sonya Creek Shield volcano; ring fracture(?) related rocks. Description from source map: MC003

Tsb - Andesite and basalt fragmental rocks (Tertiary) Dark volcanic breccias and agglomerates, all generally welded and minor mudflows that are locally palagonitized. Breccias contain clasts as much as 5 m in diameter; agglomerates contain round and spindle bombs as much as 1 m long. Aphanitic to locally sparsely porphyritic. Unit appears to form the base of the sequence of lava flows and tephra in unit Tsf. Description from source map: MC003

Tsf - Andesite flows and tephra (Tertiary) Dark, aphanitic lava flows and interlayered lapilli tuffs that overlie fragmental rocks of unit Tsb. May include some basalt flows. Wrangell lava; Sonya Creek Shield volcano; ring fracture(?) related rocks. Description from source map: MC003

Trl - Rocker Creek volcanic and volcanoclastic rocks, undifferentiated (Tertiary) Dark basalt to andesite lava flows and minor interlayered mudflows and maroon to dark-green volcanic siltstone, sandstone, and pebble conglomerate. Structurally deformed; bedding dips 20–8° to the southwest. Radiometric age data: whole-rock K-Ar age of 26 Ma from basalt lava flow. Description from source map: MC003

Tw - Lava flows and lahars -- Older volcanic rocks (Miocene or Oligocene) Basaltic andesite, andesite, and dacite lava flows; andesitic lahar deposits. Description from source map: MC006

Tsa - Dacite agglutinate (Tertiary) Extensive but relatively thin (25–35 m) dacite agglutinate consisting of densely welded flattened pumice, stretched glass fragments, and equidimensional lithic fragments exhibiting a well developed eutaxitic texture. Agglutinate appears to be a single flow interlayered in Tsl. Wrangell lava; Sonya Creek shield volcano; shield rocks. Description from source map: MC003

Trp - Rhyolite volcanoclastic rocks (Tertiary) Light-colored pyroclastic flows and tephra. Pyroclastic flows contain glassy and fine-grained breadcrust bombs in ash-rich matrix. Source is probably the rhyolite dome of unit Trr. Rocker Creek volcanic rocks. Description from source map: MC003

Twr - Rhyolite flow (Miocene or Oligocene)

Obsidian-bearing lava within Sonya Creek caldera. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Twr - Rhyolite flow(s) (Tertiary) Thick (200 m), light-colored and intricately flow-banded rhyolite lava containing abundant, pristine black obsidian. Locally includes as much as 2 m of overlying rhyolitic lapilli tuff and 10 m of rhyolitic volcanic sandstone. Wrangell lava; Sonya Creek Shield volcano; intracaldera(?) rocks. Description from source map: MC003

Twd - Domes (Miocene or Oligocene)

Dacite and rhyolite underlying the lava flows and lahar deposits (Tw) of Sonya Creek volcano. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tdr - Rhyolite domes (Tertiary) Light-colored, fine-grained rhyolite containing sparse microphenocrysts of plagioclase, hornblende, biotite, and locally, rosettes of black tourmaline. Description from source map: MC003

Tdh - Dacite porphyry domes (Tertiary) Broad belt of at least eight coalesced endogenous and exogenous dacite domes that extends more than 19 km around and under the Sonya Creek shield volcano. Radiometric age data: 23 Ma, by K/Ar on hornblende from dome overlain by Sonya Creek intracaldera(?) rocks. Description from source map: MC003

Tsd - Dacite dome (Tertiary) Glassy, dense dacite dome exhibiting well-developed columnar joints. Wrangell lava; Sonya Creek Shield volcano; ring fracture(?) related rocks. Description from source map: MC003

Tr - Rhyolite dome and plugs (Tertiary) Light-colored, crystal-poor, flow-banded rhyolite. Rock contains a few percent of small plagioclase and biotite phenocrysts in a devitrified chalky matrix. The dome, exposed north of Ptarmigan Lake, apparently was endogenous, and it structurally deformed older sedimentary rocks (Tks) into which it was emplaced. Wrangell lava; Sonya Creek Shield volcano; ring fracture(?) related rocks. Description from source map: MC003

Trr - Rhyolite dome (Tertiary) Small light-colored dome or shallow intrusion that is locally highly brecciated. Rock is fine grained and chalky and contains occasional quartz eyes. Rocker Creek volcanic rocks. Description from source map: MC003

Td - Rhyolite porphyry and granite (Pliocene(?) or Miocene(?))

Discordant hypabyssal plutons and dikes exposed between Mount Augusta and Mount Cook. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Td - Rhyolite porphyry and granite (Pliocene(?) or Miocene(?)) Discordant hypabyssal plutons and related dikes at Mt. Owen and on east flank of Mt. Cook. Vary from porphyritic to fine-grained, hypidiomorphic and equigranular. Description from source map: MS002

Ts - Sedimentary rocks (Cenozoic)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Ts - Sedimentary rocks (Cenozoic) Sedimentary rocks. Description from source map: GU002

Tm - Volcanic and hypabyssal rocks (Miocene and Oligocene)

Mafic dikes, sills, and plugs. Strongly altered intrusions of diabase, alkalic basalt, olivine basalt, and lamprophyre. Probably related genetically to extrusive volcanic rocks (Tpv) in Poul Creek Fm.

Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tm - Basaltic to andesitic plugs and dikes (Tertiary, Miocene and Oligocene) Small basalt plugs and dikes. Generally amygdaloidal and vesicular; may exhibit flow structures. Generally too small to show on map. Some of the basaltic rocks may be of Oligocene age based on correlation with compositionally similar submarine flow and pyroclastic rocks interbedded with sedimentary rocks elsewhere along the Gulf of Alaska margin. Description from source map: BG002

Tm - Mafic dikes, sills, and plugs (Tertiary, Oligocene) Mafic dikes, sills, and plugs. Strongly altered intrusions of diabase, alkalic basalt, olivine basalt, and lamprophyre. Probably related genetically to extrusive volcanic rocks (Tpv) in Poul Creek Fm. Description from source map: CV003

Tps - Poul Creek Formation (early Miocene(?), Oligocene, and late Eocene(?))

Concretionary, pyritic, glauconitic, reddish-weathering, dark-gray to greenish-gray siltstone, claystone, and sandstone; shale that is rich in organic material; gray calcareous sandstone; local thin interbeds of basaltic tuff. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tpv - Poul Creek Formation: Volcanic rocks, undivided (Tertiary, Miocene to Eocene)

Basaltic pyroclastic and flow rocks; locally interbedded with marine sedimentary rocks. Probably related genetically to mafic dikes, sills and plugs unit (Tm). Description from source map: CV003

Tr - Redwood Formation (Tertiary, Pliocene to Oligocene?) Lower sandstone member: about two-thirds thick-bedded sandstone and one-third silty sandstone and siltstone. Upper member: about one-half siltstone, mudstone and claystone, the rest is conglomerate and sandstone.

Description from source map: CV003

Tp - Poul Creek Formation (Miocene to Eocene) Shale and minor sandstone that is, in part, glauconitic, rich in organic material, and intercalated with intrabasinal, water-laid alkalic basaltic tuff, breccia, and pillow lava. Description from source map: BG002

Tps - Sedimentary rocks, undivided (Tertiary, Oligocene and early Eocene) Concretionary, pyritic, glauconitic, reddish weathering, dark-gray to greenish-gray siltstone, claystone, and sandstone; subordinate dark-brown, laminated shale that is rich in organic material, silty shale, and gray calcareous sandstone; locally includes thin interbeds of basaltic tuff. Fossils: Contains an abundant marine megafauna and microfauna. Description from source map: BG002 and IB002

Tps - Poul Creek Formation: Sedimentary rocks, undivided (Tertiary, Miocene, Oligocene, and Eocene) Concretionary, pyritic, glauconitic, reddish-weathering, dark-gray to greenish-gray siltstone, claystone, and sandstone; shale that is rich in organic material; gray calcareous sandstone; local thin interbeds of basaltic tuff. Description from source map: CV003

Tpv - Volcanic rocks, undivided (Tertiary, Oligocene and early Eocene) 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 unit (Tm). [Note similarity to Meshik Volcanics]. Description from source map: IB002

Tp - Poul Creek Formation (Oligocene) Single outcrop consisting of 10 m of intensely sheared, reddish-brown weathering, dark-greenish-black glauconitic and pebbly sandstone containing abundant mafic volcanic detritus. Thought to be correlative with Poul Creek Formation. Description from source map: MS002

Tgp - Granitic plutons (Eocene)

Granite, granodiorite, and diorite intruding Chugach and Prince William terranes; intermediate composition Eocene age dikes not shown on map. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tgt - Granite and tonalite (Granite) (Eocene) Consists of Alsek River pluton of strongly foliate, medium-grained, equigranular, hypidiomorphic muscovite-biotite granite and the Novatak Glacier pluton of foliate, fine- to medium-grained, equigranular to seriate, hypidiomorphic hornblende-biotite tonalite. (Separated for NSA). Radiometric age data: Alsek River pluton has yielded a middle Tertiary, about 23-24 Ma K-Ar date, hornblende from the Novatak glacier pluton gave a 62.5 Ma K-Ar age. Description from source map: YA002

Ti2 - Tonalite (Tertiary) Mostly hornblende-biotite tonalite but also includes biotite tonalite. Strongly foliated and lineated plutons with fabrics subparallel to D2 in adjacent metamorphic rocks. Description from source map: CV006

Ti - Intrusive rocks (Tertiary) Elongate plutons, emplaced in Valdez Group, of medium-grained, hypidiomorphic-granular granodiorite and tonalite, late-stage dikes and sills of dacite. Assumed to be partial melt of flysch of Valdez Group. Similar rocks in Bering Quad. A dacite phase of inferred correlative in Anchorage Quad provided K-Ar. Radiometric age data: K-Ar (from Anchorage quad) of 33.9±2 m.y. Description from source map: MC002

Ti - Granodiorite (Miocene and Oligocene) Dominantly fine- to medium-grained, equigranular to seriate hypidiomorphic muscovite-biotite and biotite granodiorite and related rocks in 10 small, widely distributed bodies cut diverse older plutonic and metamorphic rocks. Radiometric age data: K-Ar ages on mica yielded 20.9, 24.1, and 30.6 Ma; dates on possibly related dikes were 25.3 and 23.5 Ma. Description from source map: MS002 and YA002

Ti? - Granodiorite (Miocene and Oligocene) Dominantly fine- to medium-grained, equigranular to seriate hypidiomorphic muscovite-biotite and biotite granodiorite and related rocks in 10 small, widely distributed bodies cut diverse older plutonic and metamorphic rocks. Radiometric age data: K-Ar ages on mica yielded 20.9, 24.1, and 30.6 Ma; dates on possibly related dikes were 25.3 and 23.5 Ma. Description from source map: MS002

Tg - Granite, granodiorite, and diorite -- Chugach terrane (Tertiary, Eocene) Chiefly light gray, fine- to medium-grained, hypabyssal, biotite and biotite-muscovite granite, granodiorite, and diorite that occur in small- to medium-size stocks that chiefly intrude the Valdez Group of the Chugach terrane. Description from source map: BG002

Tg - Granitoid rocks (Tertiary, Eocene) Granitoid rocks-- Biotite and biotite-hornblende granodiorite, granite, and minor tonalite; generally medium grained, hypidiomorphic, and equigranular; foliated in many places, especially near contacts with country rocks. Radiometric age data: K-Ar ages from 50.5 to 53.5 Ma. Description from source map: CV003

Tg - Granodiorite and granite (Tertiary, Eocene) Chiefly light gray, fine- to coarse-grained, hypabyssal, muscovite-biotite granodiorite and granite that occur in four moderate-size stocks that chiefly intrude the Yakutat group. Radiometric age data: K-Ar dates of 46.8 to 51.1 Ma. Description from source map: MS002 and YA002

Tqd - Quartz diorite (Eocene) Foliate, fine- to medium-grained, seriate, hypidiomorphic, biotite-hornblende quartz diorite on south face of Mount Saint Elias. Description from source map: MS002

Tt - Altered biotite and hornblende tonalite (Eocene) Small, sericitized hornblende-biotite tonalite plugs. Rocks are fine- to medium-grained sericitized tonalite with minor quartz diorite and granodiorite. In most sample, muscovite replaces biotite or has formed from alteration of plagioclase. Radiometric age data: K-Ar hornblende 46.6 +/- 1.4 and muscovite of 52.4 +/- 2.6 Ma. Description from source map: VA002

TKg - Felsic granitic rocks (Tertiary and Cretaceous) Felsic granitic rocks. Description from source map: MS002

Tt - Tokun Formation (Eocene)

Consists predominantly of concretionary siltstone and lesser, variable amount of interbedded sandstone, chiefly in lower part of formation. Siltstone generally is medium to dark gray and nearly massive; locally, thin beds and lenses of lighter gray, brown-weathering calcareous siltstone and silty limestone are found within darker siltstone. Spheroidal calcareous concretions as much as 1 m in maximum dimension are distributed randomly or along bedding surfaces in the siltstone. Thin beds of glauconitic sandstone occur near top of formation. Interbedded sandstone generally is lighter gray than the siltstone, is micaceous, feldspathic, and brown weathering. Occurs only east of Steller Glacier. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tt - Tokun Formation (Tertiary, Eocene) Consists predominantly of concretionary siltstone and lesser, variable amount of interbedded sandstone, chiefly in lower part of formation. Siltstone generally is medium to dark gray and nearly massive; locally, thin beds and lenses of lighter gray, brown-weathering calcareous siltstone and silty limestone are found within darker siltstone. Spheroidal calcareous concretions as much as 1 m in maximum dimension are distributed randomly or along bedding surfaces in the siltstone. Thin beds of glauconitic sandstone occur near top of formation. Interbedded sandstone generally is lighter gray than the siltstone, is micaceous, feldspathic, and brown weathering. Occurs only east of Steller Glacier. Fossils: Contains a very sparse marine megafauna. Description from source map: BG002

Tt - Tokun Formation (Tertiary, Eocene) Consists predominantly of concretionary siltstone and lesser, variable amount of interbedded sandstone. Siltstone is medium to dark gray and nearly massive. Spheroidal calcareous concretions as much as 1 m in maximum dimension are distributed randomly or along bedding surfaces in the siltstone. Description from source map: CV003

Tgt - Granite and tonalite (Eocene)

Consists of Alsek River pluton of strongly foliate, medium-grained, equigranular, hypidiomorphic muscovite-biotite granite and the Novatak Glacier pluton of foliate, fine- to medium-grained, equigranular to seriate, hypidiomorphic hornblende-biotite tonalite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tgt - Granite and tonalite (Tonalite) (Eocene) Consists of Alsek River pluton of strongly foliate, medium-grained, equigranular, hypidiomorphic muscovite-biotite granite and the Novatak Glacier pluton of foliate, fine- to medium-grained, equigranular to seriate, hypidiomorphic hornblende-biotite tonalite. (Separated for NSA). Radiometric age data: Alsek River pluton has yielded a middle Tertiary, 23 Ma K-Ar date, hornblende from the Novatak glacier pluton gave a 62.5 Ma K-Ar age. Description from source map: YA002

Tk - Kulthieth Formation (Eocene and early Paleocene(?))

Includes at least 1,500 m of interbedded, massive to thin-bedded, coal-bearing arkosic sandstone, dark-gray to black carbonaceous siltstone and shale, and minor coal. Commonly intensely deformed into imbricated stacks of fault-bounded chevron folds. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tk - Kulthieth Formation (Tertiary, Eocene) includes at least 1,500 m of interbedded, massive to thin-bedded, coal-bearing arkosic sandstone, dark-gray to black carbonaceous siltstone and shale, and minor coal. Sandstone:shale ratios in measured sections (Martin, 1908) average about 1:1. Sandstone varies from massive intervals as much as 150 m thick to thin-bedded and shaly intervals. Sub-bituminous to semi-anthracite coal in beds as much as 3 m thick is a conspicuous, but minor part of sequence. Commonly intensely deformed into imbricated stacks of fault-bounded chevron folds displaying shearing and structural thinning and thickening of coal beds. Fossils: Contains a sparse marine megafauna and locally abundant plant fossils. Description from source map: BG002

Tk - Kulthieth Formation (Tertiary, Eocene) Includes at least 1,500 m of interbedded, massive to thin-bedded, coal-bearing arkosic sandstone, dark-gray to black carbonaceous siltstone and shale, and minor coal. Commonly intensely deformed into imbricated stacks of fault-bounded chevron folds. Description from source map: CV003

Tk - Kulthieth Formation (Tertiary, Eocene and late Paleocene) At least 3,000 m of orange weathering light-gray feldspathic to lithofeldspathic sandstone and calcareous sandstone interbedded with dark-gray siltstone, pebble conglomerate, and many thin beds of coal. Commonly well-indurated with bituminous rank coal. Complexly deformed into tight fault-bounded chevron folds overturned to south with bedding plane thrusts tending to be localized in coal beds. Fossils: Contains a sparse warm water molluscan megafauna and locally abundant sub-tropical plant fossils. Description from source map: MS002 and YA002

Ts - Stillwater Formation (Tertiary, Eocene) Primarily consists of dense hard dark-gray siltstone. Where siltstone is carbonaceous, it has a coal-like appearance; where it is calcareous, it may be variegated from reddish brown to pale green and usually contains foraminifers. Occurs in limited outcrop area east of Steller Glacier. Fossils: foraminifers. Description from source map: BG002

Ts - Stillwater Formation (Tertiary, Eocene) Dense hard dark-gray siltstone. Where siltstone is carbonaceous, it has a coal-like appearance; where its calcareous, it may be variegated from reddish brown to pale green. Fossils: foraminifers. Description from source map: CV003

Tos - Orca Group, turbidites (early Eocene and late Paleocene)

Mudstone to sandstone, locally fossiliferous submarine gravity flows. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Ts - Siltstone of Oily Lake (Eocene) Dark-gray, siliceous, organic-rich siltstone. Exposed only near Oily Lake in the Samovar Hills. Description from source map: MS002

Tos - Orca Group -- Sedimentary rocks, undivided (Tertiary, Eocene and Paleocene) Very thick, complexly deformed, monotonous sequence of thin- to thick-bedded turbidites consisting of sandstone, siltstone, and mudstone; metamorphosed to zeolite or prehnite-pumpellyite facies. Sandstone is feldspathic to litho-feldspathic. Abundant primary sedimentary features indicate deposition from sediment gravity flows, chiefly turbidity currents, in a submarine-fan complex. Fossils: In Prince William Sound area to the west, contains sparse planktonic foraminifers, fossil crabs, pelecypods, and gastropods. Description from source map: BG002

Tos - Orca Group -- Sedimentary rocks, undivided (Tertiary, Eocene and Paleocene) Very thick, complexly deformed monotonous sequence of thin- to thick-bedded turbidites consisting of sandstone, siltstone, and mudstone; metamorphosed to zeolite or prehnite-pumpellyite facies. Abundant sedimentary features indicate deposition from sediment gravity flows on submarine-fan complex. Lenticular matrix-supported conglomerate, and pebbly mudstone and sandstone are widespread. Fossils: planktonic foraminifers, fossil crabs, pelecypods and gastropods. Description from source map: CV003

Tos - Orca Group -- sedimentary rocks, undivided (Paleocene and Eocene?) Marine argillite, siltstone, sandstone, and conglomerate. Argillite and siltstone are more abundant than the coarser-grained rocks. Well-bedded, repetitive finer-grained and coarser-grained strata; primary sedimentary features are diagnostic of deposition by sediment-gravity flow. Finer-grained facies dominate west of Valdez Arm. Conglomerate clasts are of diverse extrabasinal lithologies. Description from source map: VA002 and VA005

Tovs - Orca Group -- Interbedded sedimentary and volcanic rocks (Tertiary, Eocene and Paleocene) Variable proportions of interbedded, tholeiitic basalt (Tov) and turbidites (Tos). Description from source map: BG002

Tovs - Orca Group -- Interbedded sedimentary and volcanic rocks (Tertiary, Eocene and Paleocene) Variable proportions of interbedded, tholeiitic basalt and turbidites. Basalt--pillowed and massive flows, pillow breccia, and tuff. Turbidites--mudstone, siltstone, and fossiliferous volcanogenic sandstone. Metamorphosed to zeolite or prehnite-pumpellyite facies. Description from source map: CV003

Toc - Orca Group: Conglomerate (Tertiary, Eocene and Paleocene) Massive, clast-supported, well-rounded pebble, cobble, and boulder conglomerate. Variable clast composition. Description from source map: CV003

Toc - Orca Group -- Conglomeratic sedimentary rocks (Paleocene and Eocene?) Very poorly bedded conglomeratic sandstone and argillite mantle the tops of volcanic sequences. Conglomeratic rocks are very poorly sorted; clasts vary in size from granules to boulders and are supported by matrix. Basal parts of conglomeratic frequently contain angular to partly rounded clasts of basalt identical to substrate. Gradationally upward, the conglomeratic strata contain fewer volcanic clasts, but all other clasts are of lithologies that may be intrabasinal, in contrast to other conglomeratic beds in the Orca Group. Description from source map: VA002

Tos - Orca Group, turbidites (Tertiary, early Eocene and late Paleocene) Mudstone to sandstone, locally fossiliferous submarine gravity flows. Description from source map: BG004

Tov - Orca Group, basalt (early Eocene and late Paleocene)

Mostly tabular or lenticular bodies of mafic volcanic rocks altered to greenstone and not examined in detail. As mapped, may include pillowed or massive flows, broken pillow breccia, tuff, and dikes. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tv - Basalt of Hubbs Creek (Eocene and Paleocene(?)) Mafic basalt, layered tuff, tuff breccia and breccia. Description from source map: MS002

Tov - Orca Group -- Volcanic rocks, undivided (Tertiary, Eocene and Paleocene) Thick and thin tabular bodies of altered tholeiitic basalt consist chiefly of variably pillowed, massive, or crudely columnar flows, but also include pillow breccia, aquagene tuff, and diabase or gabbro sills. Minor mudstone and siltstone that are interbedded with basalt are included locally. Commonly contains

green, gray, or red chert in interstices between pillows, rarely includes interpillow clots of pink limestone or black mudstone. Description from source map: BG002

Tov - Orca Group: Volcanic rocks, undivided (Tertiary, Eocene and Paleocene) Thick and thin tabular bodies of altered tholeiitic basalt. Pillowed, massive or crudely columnar flows; pillow breccia, aquagene tuff, and diabase or gabbro sills. Local interbedding of mudstone and siltstone. Metamorphosed to zeolite or prehnite-pumpellyite facies. Description from source map: CV003

Tov - Orca Group -- volcanic rocks, undivided (Paleocene and Eocene?) Tholeiitic pillow basalt, pillow breccia, and minor aquagene tuff. Thin sequences of dark-gray argillite and siltstone are interbedded with the volcanic rocks and locally compressed between pillows. Volcanic rocks are exclusively of oceanic tholeiite and are conformable with enclosing flyschoid sedimentary rocks. Description from source map: VA002

Tmu - Mafic and ultramafic plutonic rock (Eocene and Paleocene(?))

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Tmu - Mafic and ultramafic plutonic rocks (Tertiary, Eocene and Paleocene?) Mafic and ultramafic plutonic rocks-- Compositionally and texturally variable unit consists mainly of medium grained gabbro, local diabase, hornblende gabbro, peridotite, and orthopyroxenite. Gabbro is slightly to moderately foliated except near contacts with country rock. Description from source map: CV003

Tvu - Tertiary volcanic rocks, undivided (Tertiary(?))

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

CZab - Olivine basalt and andesite (Cenozoic) Olivine basalt and andesite. Description from source map: GU002

Ta - Andesite flows; Metamorphic Complex of Gulkana River (Tertiary (?)) Andesite flows. Description from source map: GU002

Tsq - Snag pluton (Tertiary)

Medium- to coarse-grained leucocratic biotite quartz monzonite. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Tsq - Snag Creek Pluton (Tertiary) Medium- to coarse-grained leucocratic biotite quartz monzonite. Radiometric age data: K-Ar date give minimum age of about 51.9 Ma. Description from source map: NB002

TKm - Orca Group, mélangé (Tertiary or Cretaceous)

Consists of extensive serpentized ultramafic rocks including dike-like bodies of rodingite, as well as blocks of layered gabbro, crossite schist, pillow basalt, marble, chert of probable Late Triassic or Early Jurassic age, and diverse metamorphosed and virtually unmetamorphosed sedimentary rocks, including conglomerate that resembles lithologies within the Chickaloon Formation of Paleocene age. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TKm - Orca Group -- melange (Tertiary or Cretaceous) Consists of extensive serpentinized ultramafic rocks including dike-like bodies of rodingite, as well as blocks of layered gabbro, crossite schist, pillow basalt, marble, chert of probable Late Triassic or Early Jurassic age, and diverse metamorphosed and virtually unmetamorphosed sedimentary rocks, including conglomerate that resembles lithologies within the Chickaloon Formation of Paleocene age. Description from source map: VA002

Kvu - Valdez Group, ultramafic rocks (Late Cretaceous)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Kvu - Valdez Group: Ultramafic rocks (Late Cretaceous) Serpentinized peridotite and dunite occur at three localities underlain by the Valdez Group: two of these are on the Resurrection Peninsula and the third is near the head of Port Fidalgo. This description reflects the two localities on the Resurrection Peninsula. On the Resurrection Peninsula small sparse inclusions of altered dunite are found in the gabbro unit. Blocks of serpentinite and serpentinized peridotite crop out within the interbedded volcanic and sedimentary rocks unit. Their strongly shared margins suggest that these rocks have been tectonically emplaced. Description from source map: CV002

Kvv - Valdez Group, greenschist-facies flysch, metamorphosed basalt and tuff (Late Cretaceous)

Tholeiitic metabasalt and basaltic meta-tuff, local pillow lava and pillow breccia, gabbroic dikes and sills. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kvv - Valdez Group: Metavolcanic rocks, undivided (Late Cretaceous) Tholeiitic metabasalt and basaltic metatuff, including local pillow lava, pillow breccia, and gabbroic dikes and sills. Metabasalt forms rugged, nearly massive outcrops, whereas semischistose metatuff forms more subdued outcrops. Variable metamorphic grades. Description from source map: CV003

Kvv - Valdez Group -- Metavolcanic rocks, undivided (Late Cretaceous) Mafic metatuff and minor massive or weakly foliated greenstone having rarely preserved vague pillow shapes. Lower greenschist facies metamorphism. Most of these metavolcanic rocks are schistose and the metavolcanic rocks are often the loci of intense deformation in the Valdez Group. Radiometric age data: K-Ar whole-rock age on metatuff of 53.5 +/- 1.6 Ma is thought to date metamorphism. Description from source map: VA002

Kv - Valdez Group, greenschist-facies flysch (Late Cretaceous)

Flysch metamorphosed to lower greenschist-facies. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kv - Valdez Group -- Metaflysch (Late Cretaceous) Mainly phyllitic metapelite (70-80 percent) and subordinate metagraywacke in thin to very thick beds with minor metavolcanic rocks metamorphosed mainly to lower greenschist facies. Locally hornfelsed and massive near Tertiary plutons. The metapelite is dark gray to black and consists mainly of carbonaceous phyllite and lesser amounts of slate and very fine grained mica schist. Description from source map: BG002

Kvm - Valdez Group, amphibolite-facies flysch (Late Cretaceous) Dominantly schist. Flysch metamorphosed to lower greenschist facies. Description from source map: BG004

Kvs - Valdez Group: Metasedimentary rocks, undivided (Late Cretaceous) Thick sequence of rhythmically alternating, multiply-deformed, metamorphosed turbidites that consist of metasandstone, metasilstone, argillite, slate and phyllite and rare beds of pebbly argillite. Beds generally a few centimeters to a few meters thick. Primary internal sedimentary structures are common. Variably metamorphosed regionally from zeolite to lower greenschist facies. Description from source map: CV003

KJv - Valdez Group (Cretaceous and Jurassic (?)) Thin- to medium-bedded metamorphosed flysch, interlayered metagraywacke and argillite, minor schist, slate, and phyllite; metamorphosed to chlorite- or biotite-grade greenschist-facies mineral assemblages. Fossils: 'Metafossils' recorded by Jones and Clark (1973) yield Maestrichtian age. Description from source map: MC002

Kv - Greenschist-facies flysch -- Valdez Group (Late Cretaceous) Flysch metamorphosed to lower greenschist-facies. Mainly mudstone and graywacke turbidite beds, carbonaceous phyllite, minor mafic tuff and breccia in a thick regionally extensive belt of accreted flyschoid deep marine rocks. Metamorphic grade increases southward from lower greenschist-facies to amphibolite-facies. Description from source map: MC006

Kvs - Valdez Group -- Metasedimentary rocks, undivided (Late Cretaceous) Weakly to strongly foliated marine argillite, siltstone, sandstone, and conglomeratic sandstone. Lower greenschist facies metamorphism. Probable volcanic source terrane. Fossils: Maestrichtian pelecypods collected outside of Valdez quadrangle. Description from source map: VA002

Kvmm - Valdez Group -- Interbedded metavolcanic and metasedimentary rocks- (Late Cretaceous) Approximately equal amounts of interbedded metavolcanic and metasedimentary rocks. Metavolcanic rocks are chiefly semischistose metatuff and breccia, including local probable pillow lava. Metasedimentary rocks chiefly slate and phyllite, although metasilstone and metasandstone are interbedded in many places. Dominantly greenschist facies metamorphism. Description from source map: BG002

Kvvs - Valdez Group: Interbedded metavolcanic and metasedimentary rocks (Late Cretaceous) Equal proportions of interbedded metavolcanic and metasedimentary rocks. Metavolcanic--semischistose metatuff and breccia and minor pillow basalt. Metasedimentary--slate, phyllite, with metasilstone and metasandstone interbedding. Variable metamorphic grades. Description from source map: CV003

Khc - Haley Creek terrane (mid-Cretaceous?) Metamorphosed complexly deformed and tectonically mixed plutonic and sedimentary rocks. Metaplutonic rocks are most abundant in southern part of the terrane and are compositionally diverse and weakly to strongly foliated. Although diorite and granodiorite are most abundant lithologies, compositions range from trondhjemite to hornblende gabbro and hornblendite. Amphibolite is widespread within the metaplutonic rocks. Metasedimentary rocks are dominant in northern part of terrane where marble, metapelite, metapsammite are structurally mixed with subordinate metaplutonic rocks. Unit deleted and merged with Jag (NSA = 3490). Description from source map: VA005

Kvm - Valdez Group, amphibolite-facies flysch (Late Cretaceous)

Flysch metamorphosed to amphibolite-facies schist. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kvm? - Schist of Mount Augusta -- Amphibolite schist (Cretaceous(?)) Dark-greenish black, fine-grained, partially segregated amphibolite schist. Description from source map: MS002

Kvm - Valdez Group -- Amphibolite schist (Late(?) Cretaceous) Mostly massive, black to greenish-black fine- to medium-grained amphibolite schist Probably derived from massive basalt and gabbro. Description from source map: MS002

Kvm - Valdez Group -- Schistose metaflysch (Late Cretaceous) Medium to medium-light gray, very fine- to medium-grained schistose metapelite, metagraywacke, and minor metatuff. Commonly weathers to blocky or tabular fragments and form banded gray outcrops streaked with iron-oxide stains. Description from source map: BG002

Kvm - Valdez Group: Schist (Late Cretaceous) Homogenous pelitic schist and minor amphibolite; includes spotted biotite-plagioclase-quartz schist. Common banding probably represents original layering. Transitional into gneissose rocks to the east and into greenschist-facies rocks of metasedimentary rocks to the west. Description from source map: CV003

Kvm - Valdez Group -- Amphibolite-facies flysch (Late Cretaceous) Flysch metamorphosed to amphibolite-facies schist. Description from source map: VA006

Kpm - Pelitic and quartzofeldspathic schist and gneiss (Cretaceous) Pelitic and quartzofeldspathic schist and gneiss with abundant sills, dikes, and small intrusive bodies of felsic granitic rocks (2715 on WRST map). Description from source map: YA002

Kvg - Valdez Group, gneiss and schist (Late Cretaceous)

Gneiss, banded and migmatite. Includes the amphibolite-facies schist of Mount Augusta of Plafker (written communication, 2000). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

av - Schist of Mount Augusta -- Amphibolite schist (Cretaceous(?) and Jurassic(?)) Dark-greenish black, fine-grained, partially segregated, amphibolite schist having assemblages of hornblende and plagioclase (An > 15) with minor quartz, magnetite, and sphene. Probably mainly derived from mafic basaltic flow rocks. Occurs in a large fault-bounded block of metavolcanic and metasedimentary rocks metamorphosed to dominantly epidote-amphibolite facies assemblages that are in part doubly foliated. Inferred to be correlative with the Valdez Group metamorphic rocks on basis of lithology, metamorphic grade, and structural style (Plafker and others, 1994). Radiometric age data: K-Ar dating of a biotite and hornblende pair in the adjacent Saint Elias quadrangle yields recrystallization ages of 17-23 m.y. Description from source map: BG002

Kvsm - Valdez Group -- Undifferentiated metavolcanic and metasedimentary rocks (Late Cretaceous) Largely interbedded mafic to intermediate metavolcanic rocks that were mainly volcanoclastic and metaclastic. Metasedimentary sequence locally includes metachert and thin lenses of marble. Description from source map: MS002

Kvm - Valdez Group -- Amphibolite schist (Late(?) Cretaceous) Mostly massive, black to greenish-black fine- to medium-grained amphibolite schist Probably derived from massive basalt and gabbro. Coded as 2710 on WRST map. Description from source map: YA002

Kvsm - Valdez Group -- Undifferentiated metavolcanic and metasedimentary rocks (Late Cretaceous) Largely interbedded mafic to intermediate metavolcanic rocks that were mainly volcanoclastic and metaclastic. Metasedimentary sequence locally includes metachert and thin lenses of marble. (2715 on WRST map). Description from source map: YA002

Kvg - Valdez Group -- Schistose to gneissic metaflysch and migmatite (Late Cretaceous) Amphibolite-facies schist, banded gneiss, and migmatitic gneiss. Fine- to coarse-grained but mostly medium- to coarse-grained. Gray to light gray, and characteristically weathers rusty brown.

Layering is irregular and inhomogeneous with discontinuous quartz-rich layers and lenses alternating with finer-grained, streaky, biotite -rich layers. Description from source map: BG002

Kvg/Tg - Valdez Group -- Schistose to gneissic metaflysch and migmatite and stockwork of dikes? (Late Cretaceous) Amphibolite-facies schist, banded gneiss, and migmatitic gneiss. Fine- to coarse-grained but mostly medium- to coarse-grained. Gray to light gray, and characteristically weathers rusty brown. Layering is irregular and inhomogeneous with discontinuous quartz-rich layers and lenses alternating with finer-grained, streaky, biotite -rich layers. Intruded by stockwork of dikes. Description from source map: BG002

ap - Schist of Mount Augusta -- Pelitic schist (Cretaceous(?)) Reddish-weathering, quartzofeldspathic pelitic schist; characteristic assemblages consist of plagioclase (An 15), biotite, and quartz with accessory magnetite and sulfides. Locally contains porphyroblasts of euhedral garnet and poikilitic staurolite. Occurs in a large fault-bounded block of metavolcanic and metasedimentary rocks metamorphosed to dominantly epidote-amphibolite facies assemblages that are in part doubly foliated. Inferred to be correlative with the Valdez Group metamorphic rocks on basis of lithology, metamorphic grade, and structural style (Plafker and others, 1994). Radiometric age data: K-Ar dating of a biotite and hornblende pair in the adjacent Saint Elias quadrangle yields recrystallization ages of 17-23 m.y. Description from source map: BG002

avp - Schist of Mount Augusta -- Intercalated quartzofeldspathic schist and amphibolite (Cretaceous(?) and Jurassic(?)) Intercalated quartzofeldspathic schist and amphibolite. Large fault-bounded block of metavolcanic and metasedimentary rocks metamorphosed to dominantly epidote-amphibolite facies assemblages that are in part doubly foliated. Inferred to be correlative with the Valdez Group metamorphic rocks on basis of lithology, metamorphic grade, and structural style (Plafker and others, 1994). Radiometric age data: K-Ar dating of a biotite and hornblende pair in the adjacent Saint Elias quadrangle yields recrystallization ages of 17-23 m.y. Description from source map: BG002

Kvg - Valdez Group: Gneiss (Late Cretaceous) Muscovite-biotite-quartz-plagioclase (+/- sillimanite and garnet) schist, banded gneiss, and migmatitic gneiss; many local intrusive stringers, dikes, and sills of granodiorite and granite. Transitional into schistose rocks to the north, south, and west. Description from source map: CV003

pink - Transitional gneiss (Age not given) Upper amphibolite facies schist and gneiss interlayered at scale of meters to centimeters. Top of unit marked by appearance of quartzofeldspathic segregations in metapelite and base of unit marked by loss of stratal continuity through development of gneissic segregations. Description from source map: CV005 and CV006

Kvsm? - Schist of Mount Augusta -- Interbedded quartzofeldspathic schist and amphibolite (Cretaceous(?)) Reddish weathering doubly foliated quartzofeldspathic schist interbedded with amphibolite schist. Description from source map: MS002

Ksm - Valdez Group -- Pelitic and quartzofeldspathic schist and gneiss (Late Cretaceous) Reddish weathering, variably banded, strongly schistose to granoblastic pelitic and quartzofeldspathic schist and gneiss. Typically a garnetiferous graphitic schist. Sedimentary clastic protolith. Description from source map: MS002 and YA002

Ku - Marine sedimentary rocks (Early and Late Cretaceous)

Sandstone and siltstone deposited at shallow to moderate depths; locally abundant marine fossils. Includes the MacColl Ridge, Chititu, Schulze, and Moonshine Creek Formations. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Ku - Predominantly Upper Cretaceous sedimentary rocks (Cretaceous) Parts of the Matanuska-Wrangell terrane; locally subdivided into Moonshine Creek Formation: siltstone and sandstone, with minor conglomerate; Schulze Formation: porcellanite, with minor sandstone and conglomerate; Chititu Formation: mudstone and shale, subordinate porcellanite, sandstone, and impure limestone; MacColl Ridge Formation: Coarse sandstone and minor granule and pebble conglomerate. Correlates to part of the Matanuska Formation in the Talkeetna Mtns, Matanuska Valley, and probably with rocks of the Matanuska geosyncline. Fossils: 'Abundant fossils' indicate an age span from late Albian to Maestrichtian. Description from source map: MC002

Ku - Marine sedimentary rocks -- Wrangellia terrane (Early and Late Cretaceous) Sandstone and siltstone deposited at shallow to moderate depths; locally abundant marine fossils. Includes the MacColl Ridge, Chititu, Schulze, and Moonshine Creek Formations. Description from source map: MC006

Kun - Nonmarine sedimentary rocks (Late Cretaceous)

Conglomerate, sandstone, siltstone, and mudstone. Locally contains abundant fossils. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kun - Nonmarine sedimentary rocks - Wrangellia Terrane (Late Cretaceous) Conglomerate, sandstone, siltstone, and mudstone. Fossils: Locally contains abundant fossils. Description from source map: GU003

Tks - Continental sedimentary rocks (Tertiary and Cretaceous) Predominantly conglomerate, grit, and coarse sandstone. Conglomerate ranges from clast-supported massive beds to bedded conglomerate sandstone. Clasts (up to 20 cm) rounded to subrounded crystalline rock, gneiss, gray chert, greenstone, and quartz (Cret. or older). Intruded by hornblende dacite sills in lower Rocker Creek. Fossils: fragments of lignitized wood (up to 30 cm long) locally abundant. Description from source map: MC003

Ks - Continental sedimentary rocks (Late Cretaceous) Conglomerate, coarse- to fine-grained sandstone, siltstone, mudstone, and subordinate shale. Fossils: Petrified wood; well preserved leaves and plants. Description from source map: NB002

Kug - Undifferentiated plutonic rocks (Cretaceous(?))

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Kug - Undifferentiated Plutonic rocks (Cretaceous (?)) Porphyritic medium-grained biotite-hornblende granodiorite, coarse-grained ophitic gabbro, and medium-grained, weakly foliated biotite-rich granodiorite-diorite. Description from source map: NB002

Kyb - Metamorphic rocks of the Brabazon Range (Cretaceous(?))

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Kyb - Metamorphic rocks of the Brabazon Range (Cretaceous(?)) Mainly amphibolite facies rocks more than 1,000 -m-thick. Grades over narrow interval into zeolite- and prehnite-pumpellyite-grade rocks of the Yakutat Group. Protolith mainly graywacke-carbonaceous pelite sequence recrystallized to quartzofeldspathic schist. Description from source map: YA002

Kg - Mid-Cretaceous plutons (Cretaceous)

Medium grained biotite-hornblende granodiorite with hypidiomorphic-granular texture; locally weakly to strongly foliated. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TKp - Older Porphyry (Tertiary or Cretaceous) Baultoff Creek region is highly altered chlorite, carbonate mineral, and zoisite matrix with plagioclase phenocrysts. Chisana region is an andesite porphyry with plagioclase phenocrysts. May be a hypabyssal equivalent to the Chisana Formation. Description from source map: NB002

Kgq - Gardiner Creek Pluton (Cretaceous) Part of the Middle Cretaceous plutonic event. Rocks are mainly foliated quartz monzonite. Also coarse-grained leucocratic biotite quartz monzonite. Part of pluton, which is described as granodiorite, reassigned because of significantly younger age. Radiometric age data: K-Ar dates indicate emplacement of 89 to 94 m.y. This individual pluton dated at 73.3 Ma. Description from source map: NB017

Kgq - Gardiner Creek Pluton (Cretaceous) Part of the Middle Cretaceous plutonic event. Rocks are mainly foliated quartz monzonite. Also coarse-grained leucocratic biotite quartz monzonite. Radiometric age data: K-Ar dates indicate emplacement of 89 to 94 m.y. Description from source map: NB002

Kcg - Cheslina Pluton (Cretaceous) Part of the Middle Cretaceous plutonic event. Rocks are mainly foliated quartz monzonite. Also medium-grained biotite-hornblende granodiorite with hornblende monzonite. Radiometric age data: K-Ar dates indicate emplacement of 89 to 94 m.y. Description from source map: NB002

Ktg - Tok-Tetlin Pluton (Tetlin phase) (Cretaceous) Porphyritic biotite-hornblende quartz monzonite locally gradational to biotite-hornblende granodiorite. Radiometric age data: K-Ar dates indicate emplacement of 92 to 94 m.y. Description from source map: NB002

Ktg - Tok-Tetlin Pluton (Tok phase) (Cretaceous) Fine- to medium-grained biotite-hornblende granodiorite. Radiometric age data: K-Ar dates indicate emplacement of 92 to 94 m.y. Description from source map: NB002

Kmg - Tok-Tetlin Pluton (Mineral Cairn phase) (Cretaceous) Porphyritic biotite-hornblende granodiorite and quartz monzonite with minor biotite diorite. Radiometric age data: K-Ar dates indicate emplacement of 92 to 94 m.y. Description from source map: NB002

Kg - Altered tonalite (Cretaceous) Fine- to medium-grained, equigranular to seriate, hypidiomorphic and foliate hornblende-biotite tonalite. Mafic grains are oriented; most samples are pervasively sheared and altered along fractures. Intrudes Yakutat Group melange facies. (NSA = 2493 on WRST map). Radiometric age data: K-Ar age reported on something related to pluton at 100 Ma (report unclear). Description from source map: YA002

Kgq - Gardiner Creek Pluton (Cretaceous) Part of the Middle Cretaceous plutonic event. Rocks are mainly foliated quartz monzonite. Also coarse-grained leucocratic biotite quartz monzonite. Based reported, this individual pluton is biotite gabbro. Radiometric age data: K-Ar dates indicate emplacement of 89 to 94 m.y. Dated sample was 100.4 Ma. Description from source map: NB017

Kgd - Granodiorite -- Wrangellia Terrane (Cretaceous (?)) Granodiorite pluton. Description from source map: GU002

Kg - Granodiorite pluton (Cretaceous (?)) Granodiorite pluton, Wrangellia terrane. Description from source map: GU002

Kkg - Klein Creek Pluton (Cretaceous) Medium grained, hypidiomorphic granular, unfoliated hornblende-biotite granodiorite and quartz monzonite. Coextensive with, or satellites of, the Klein Creek intrusive of Nabesna Quad. Radiometric age data: Nabesna Quad date of 111+3 m.y. Description from source map: MC002

Kkg - Klein Creek pluton (Cretaceous) Hornblende-biotite granodiorite and quartz monzonite. Radiometric age data: K-Ar ages indicate emplacement age of 105-117 Ma. Description from source map: MC003

TKg - Graphic granodiorite (Tertiary or Cretaceous) Hornblende granodiorite with graphic quartz and potassium feldspar. Description from source map: NB002

Ksg - Slana Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende granodiorite. Locally weakly foliated. Description from source map: NB002

Kng - Nabesna Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende-biotite granodiorite with quartz diorite, diorite, and trondhjemite. Propylitic and argillic alteration common. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Kas - Antler Creek Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende syenodiorite. Weakly foliated. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Kah - Border of Antler Creek Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Coarse-grained hornblendite. Description from source map: NB002

Kkg - Klein Creek Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende-biotite granodiorite and quartz monzonite with minor hornblende syenodiorite, biotite gabbro, and hornblende diorite. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Knp - Quartz-feldspar porphyry (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular, quartz-feldspar, porphyry with altered plagioclase. Description from source map: NB002

TKd - Diorite (undifferentiated) (Tertiary and Cretaceous) Porphyritic to equigranular granitic intrusives that are predominantly augite-hornblende diorite, equigranular hornblende diorite, augite-olivine syenodiorite, and augite bearing norite. Description from source map: NB002

Kbd - Buck Creek Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende quartz diorite and syenodiorite, and subordinate leucocratic hornblende granodiorite. Locally strongly foliated. Description from source map: NB002

Ksd - Suslota Pass Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende diorite. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Kdd - Devils Mountain Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende diorite, quartz diorite, and hornblende granodiorite. Strongly porphyritically altered. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Kcs - Chisana Pluton (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular clinopyroxene diorite, clinopyroxene syenodiorite, and clinopyroxene-hornblende monzonite. Radiometric age data: K-Ar data yields ages between 105 and 117 m.y. Description from source map: NB002

Kkd - Hornblende-rich diorite (Cretaceous) Part of a Middle Cretaceous plutonic event. Equigranular hornblende-rich diorite. Description from source map: NB002

KTj - Trondhemite (Tertiary or middle Cretaceous) White (C.I. 0-5), fine-to medium grained, small trondhemite stocks and associated dikes consisting of plagioclase and -quartz with sparse biotite and white mica in the southeastern part of the D-2 quadrangle. Description from source map: BG002

Knt - Trondhemite (Cretaceous) Part of a Middle Cretaceous plutonic event. Medium- to coarse-grained leucocratic trondhemite with sodic plagioclase, quartz, and biotite. Description from source map: NB002

hbqd - Hornblende-biotite quartz diorite; Peninsular Terrane (Jurassic or Cretaceous) Hornblende-biotite quartz diorite. Description from source map: GU002

hbqm - Hornblende-biotite quartz monzonite; Peninsular Terrane (Jurassic or Cretaceous) Hornblende-biotite quartz monzonite. Description from source map: GU002

Kyn - Schist of Nunatak Fjord (Cretaceous)

High-grade amphibolite-diorite complex characterized by segregation and injection gneisses. Probable metamorphosed equivalent of Yakutat Group flysch facies. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kym - Schist of Nunatak Fiord -- schist (Cretaceous(?)) Typically fine- to medium-grained, semigranoblastic quartzofeldspathic schist. Description from source map: MS002 and YA002

Kyn - Schist of Nunatak Fiord -- Amphibolite-diorite complex at the Nunatak (Cretaceous(?)) High-grade amphibolite-diorite complex characterized by segregation and injection gneisses. Probable metamorphosed equivalent of Yakutat Group flysch facies. Radiometric age data: Discordant K-Ar biotite-hornblende pair yielded 30 and 47 Ma, respectively. Description from source map: YA002

Kyvm - Schist of Nunatak Fiord -- Metavolcanic rocks of Novatak Glacier area (Cretaceous(?)) Predominantly massive porphyritic mafic flow rocks interbedded with thinly laminated green to light-gray metatuff. Metamorphosed to fine-grained, schistose, partly segregated epidote-amphibolite and amphibolite-facies assemblages. (NSA = 2981 on WRST map). Description from source map: YA002

Kyxm - Schist of Nunatak Fiord -- Schist of Novatak Glacier area (Cretaceous(?)) Lithologically diverse sequence of metasedimentary and metavolcanic rocks. Mainly thin-bedded metapelite, tuffaceous metapelite, pelitic schist, and quartzofeldspathic schist with subordinate stretched pebble conglomerate, metachert, gray-weathering marble, and thinly laminated tuffaceous greenschist. Radiometric age data: K-Ar recrystallization age of 65 Ma. Description from source map: YA002

Kc - Chisana Formation (Early Cretaceous)

Thin- to medium-bedded andesite flows and diverse volcanoclastic rocks. Probably represents Klein Creek and related mid-Cretaceous plutons of Nabesna Quad. Widespread in Nabesna Quad.

Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kc - Chisana Formation (Early Cretaceous) Thin- to medium-bedded andesite flows and diverse volcanoclastic rocks. Probably represents Klein Creek and related mid-Cretaceous plutons of Nabesna Quad. Widespread in Nabesna Quad. Description from source map: MC002

Kc - Chisana Formation (Early Cretaceous) Subaqueous and subaerial volcanic and volcanoclastic rocks; Upper Part: primarily andesite, basaltic andesite flows, fragmental volcanic rocks, subordinate porphyritic andesite, thin-bedded conglomerate, grit, sandstone, and tuff. Lower Part: fragmental volcanic rocks, dacite to andesite porphyritic flows, volcanic sandstone and siltstone, argillite, graywacke, conglomerate, and a tuffaceous mudstone. Fossils: Lignitized wood; Inoceramus; Shasticioceras. Description from source map: NB002

KI - Shallow marine sedimentary rocks (Early Cretaceous)

Conglomerate, sandstone, siltstone, and clastic sandy limestone deposited under nearshore, high-energy, transgressive marine conditions; locally includes concretions and abundant fossils. Includes the Kennicott, Kuskulana Pass, and Berg Creek Formations. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Km - Matanuska Formation (Cretaceous) Matanuska Formation. Description from source map: GU002

Kmu - Matanuska Formation -- upper part (Late Cretaceous -- mid-Coniacian to Maestrichtian) A very thick sequence of marine siltstone, claystone, and sandstone in interbedded with lenticular and channelized deposits of sandstone and conglomerate. Contact with lower part of unit presumed to an unconformity. Deposition thought to occur on the fringes of a deep-sea fan. Thinly interbedded siltstone, claystone, and sandstone, which predominate, represent deposition in interchannel areas; whereas thick beds and lenses of sandstone and conglomerate represent distributary channels. Description from source map: VA002

Kml - Matanuska Formation -- lower part (Cretaceous -- late-early-Albian, Cenomanian, Turonian, and early Coniacian) Marine siltstone, shale, sandstone, and pebbly sandstone are interbedded with subordinate siliceous, foraminiferal shale and fine-grained zeolitized sandstone. Contact with upper part of unit (unit Kmu) presumed to be an unconformity and is angular unconformity with the lower Talkeetna Formation (unit Jtk). Description from source map: VA002

KI - Clastic sedimentary rocks (Early Cretaceous) Dark greenish-gray to very dark gray shale, locally concretionary, with subordinate siltstone, arkosic sandstone, and arkosic granule- to pebble conglomerate. Chocolate-brown to reddish-brown weathering colors and hackly to slaty cleavage are conspicuous in the shale, completely obscuring bedding in most places. Locally contain thin coquina and carbonaceous detritus, particularly in sandstone and pebble conglomerate beds near base of unit. Thickness unknown, but exceeds 200 meters. Presumed to correlate with unnamed Neocomian rocks that occur in scattered exposures in the adjacent McCarthy quadrangle (MacKevett, 1978) and extend westward as far as the mouth of the Chitina River (Grantz and others, 1966) and eastward into adjacent parts of Canada (Campbell and Dodds, 19) and the St. Elias Mountains (Sharp and Rigsby, 1956). Fossils: Contains sparse but diverse megafauna of probable Neocomian age. Description from source map: BG002

KI - Lower Cretaceous sedimentary rocks (Early Cretaceous) Parts of the Matanuska-Wrangell terrane; locally subdivided into unnamed Neocomian rocks: sandstone, shale, and impure bioclastic limestone with *Inoceramus*; (Albian) Kennecott Formation: sandstone, siltstone, minor basal and intraformational conglomerate, and shale. Correlates to much in Matanuska geosyncline and Matanuska Formation in Talkeetna Mtns. Fossils: Neocomian rocks: *Inoceramus* and other fossils that indicate Hauterivian and barremian; Kennecott Formation: *Moffittes robustus*, and *Breweriaceras hulenense*. Description from source map: MC002

Kb - Berg Creek Formation (Early Cretaceous) Marine clastic rocks consisting of calcareous conglomerate, conglomeratic sandstone and siltstone, and calcarenite. Basal strata generally are pebble, cobble, and boulder conglomerate consisting of clasts derived from nearby bedrock. Fossils: *Inoceramus*. Description from source map: VA002

Ks - Marine sedimentary rocks (Early Cretaceous) Wrangellia terrane. Consists of Berg Creek Formation and unnamed marine sedimentary rock. Description from source map: VA007

Kyf - Yakutat Group, flysch (Cretaceous and Jurassic(?))

High-grade amphibolite-diorite complex characterized by segregation and injection gneisses. Probable metamorphosed equivalent of Yakutat Group flysch facies. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kys - Yakutat Group -- flysch facies (Cretaceous and Jurassic(?)) Yakutat Group is a heterogeneous assemblage including clastic sedimentary rocks, altered volcanic rocks, chert, carbonate, and granitic rocks. Two major subdivisions that are commonly structurally juxtaposed, a flysch facies and a melange facies. Flysch facies is dominantly dense, hard, poorly sorted gray to brown feldspathic to lithofeldspathic sandstone (graywacke), pebble-cobble conglomerate, and shale-chip conglomerate in thick channel deposits or rhythmically interbedded and graded with gray to black siltstone, argillite, or slate. Description from source map: BG002, MS002, and YA002

Kys? - Yakutat Group -- flysch facies(?) (Cretaceous and Jurassic(?)) Yakutat Group is a heterogeneous assemblage including clastic sedimentary rocks, altered volcanic rocks, chert, carbonate, and granitic rocks. Two major subdivisions that are commonly structurally juxtaposed, a flysch facies and a melange facies. This unit is predominantly dark-gray weathering clastic sedimentary rocks (siltstone) at Haydon Peak. Consists of 30 to 70 percent dark-gray, partly slaty carbonaceous and concretionary siltstone interbedded with thin beds and laminae of fine-grained, banded, sandstone and lesser olive-gray to dark-gray partly carbonaceous sandstone, pebble conglomerate having a dark silty matrix, green basaltic tuff, and light-gray tuffaceous sandstone. Intertongues and is gradational with lower part of Kulthieth Formation. Questionably part of Yakutat Group flysch facies, consisting of dominantly dense, hard, poorly sorted gray to brown feldspathic to lithofeldspathic sandstone (graywacke), pebble-cobble conglomerate, and shale-chip conglomerate in thick channel deposits or rhythmically interbedded and graded with gray to black siltstone, argillite, or slate. Fossils: Contains very sparse warm water molluscan fauna and abundant carbonized sub-tropical plant remains. Description from source map: MS002

Kym - Yakutat Group, mélangé (Cretaceous and Jurassic(?))

Discrete blocks of greenstone, limestone, marble, graywacke, chert, conglomerate, and plutonic rocks, up to several kilometers in greatest dimension, in a sheared matrix of mudstone. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kyx - Yakutat Group -- melange facies (Cretaceous and Jurassic(?)) Yakutat Group is a heterogeneous assemblage including clastic sedimentary rocks, altered volcanic rocks, chert,

carbonate, and granitic rocks. Two major subdivisions that are commonly structurally juxtaposed, a flysch facies and a melange facies. Melange facies is characteristically composed of blocks of competent rocks of heterogeneous lithology as much as several kilometers in size enclosed in a pervasively sheared matrix of dark-gray to black pelite, cherty pelite or tuffaceous pelite. Melange blocks are predominantly greenstone, oolitic limestone, marble, granitic plutonic rocks, chert, and graywacke. Description from source map: MS002 and YA002

s - Sandstone (Age not given) Larger lenticular bodies to 300m thick of massive laumontite-rich lithofeldspathic to feldspatholithic sandstone mainly within the flysch facies. Probably represent deep sea channel fills with andesitic volcanic detritus dominant in the lithic component. Description from source map: YA002

c - Conglomerate (Age not given) Larger lenses and beds of well rounded and sorted pebble and cobble conglomerate to 200m thick that are locally developed within both the flysch and melange facies. Includes abundant angular blocks of gray oolitic limestone containing chert nodules in Kys unit at Russell Fiord near Hidden Glacier and olistostrome deposits exhibiting soft-sediment deformation in Kyx unit. Description from source map: YA002

g - Greenstone (Age not given) Larger greenstone masses within the melange facies of the Yakutat Group, generally massive and structureless but locally with faint pillow forms and agglomeratic texture. Commonly with epidote-rich pods and stringers and cut by diorite dikes. Associated with limestone and marble and pods of radiolarian ribbon chert. Marble may be Late Triassic age based on poorly preserved fossils near Russell Fiord. Interpreted as allochthonous blocks in the melange. Description from source map: YA002

d - Tonalite (Jurassic) Large bodies of foliate, fine- to medium-grained hornblende biotite tonalite associated with meta-greenstones. Interpreted as allochthonous blocks in the melange. Radiometric age data: K-Ar ages ranging from 146-178 m.y. Description from source map: YA002

KJs - Nutzotin Mountains sequence of Berg and others (1972) (Early Cretaceous and Late Jurassic)

Marine assemblage of dark argillite, gray siltstone, and graded beds of argillite-siltstone-graywacke. Contact metamorphism with the quartz diorite (Kg) has resulted in a banded calc-silicate hornfels. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

KJs - Marine sedimentary rocks (Cretaceous and Jurassic) Thin- to medium-bedded argillite and graywacke, metamorphosed to hornfels near Klein Creek pluton. Part of informally designated Nutzotin Mountains sequence. Fossils: *Buchia* pelecypod, indicating Late Jurassic age. Description from source map: MC002

KJs - Marine sedimentary rocks (Cretaceous and Jurassic) Thin- to medium-bedded argillite and graywacke. Graywacke is typically graded and rhythmically bedded. Metamorphosed to hornfels near Klein Creek pluton. Part of the informal Nutzotin Mountains sequence. Description from source map: MC003

KJs - Marine sedimentary rocks (Early Cretaceous and Late Jurassic) Upper Part: Argillite, graywacke, and mudstones, capped by sandstone, siltstone, and shale. Middle (major) Part: Argillite, siltstone, and graywacke, that alternate with a pebble to cobble conglomerate, pebbly graywacke, and an argillite. Lower Part: Argillite, minor siltstone, mudstone, graywacke, and impure limestone, and a localized pebble conglomerate. Locally known as the Nutzotin Mountains Sequence. Fossils: *Buchia* indicate Late Jurassic and Early Cretaceous age. Description from source map: NB002

KJm - Mélange units (mid-Cretaceous, Jurassic, and Late Triassic(?))

Tholeiitic pillowed basalt, chert, tuff, greywacke, argillite, and phyllite-greenstone deposited along a convergent plate margin as early as Late Triassic continuously into middle Cretaceous. Includes the McHugh Complex, a structurally complex and chaotic assemblage of oceanic rocks containing abundant slightly deformed radiolarian chert; and a mélange-like unit between the McHugh Complex and the Valdez Group (Kv). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

MZm - McHugh Complex (Early(?) Cretaceous to Late Jurassic) A structurally chaotic melange-like unit of accreted oceanic rocks that crops out in a narrow belt to about 1.5 km wide. The complex consists of pervasively disrupted broken formation that originally was mainly tholeiitic pillowed basalt and related fragmental volcanic rocks containing subordinate amounts of argillite, tuff or tuffaceous argillite, radiolarian chert, graywacke, mudstone, siltstone, and carbonate rocks. The unit was originally defined in the Anchorage area by Clark (1973) and subsequently geographically extended to comparable rocks that crop out discontinuously along the north margin of the Chugach and Kenai Mountains (Plafker and others, 1994). Description from source map: BG002

KJm - Melange units -- Valdez Group (mid-Cretaceous, Jurassic?, and Late Triassic)

Tholeiitic pillowed basalt, chert, tuff, greywacke, argillite, and phyllite-greenstone deposited along a convergent plate margin as early as Late Triassic continuously into middle Cretaceous. Includes the McHugh Complex, a structurally complex and chaotic assemblage of oceanic rocks containing abundant slightly deformed radiolarian chert; and a melange-like unit between the McHugh Complex and the Valdez Group (Kv). Description from source map: MC006

KJm - McHugh Complex (Early Cretaceous and Jurassic?) Pervasively deformed assemblage of diverse lithologies (melange). Lithologies include gabbro, greenstone, marble, wacke, and diverse plutonic and metamorphic rocks including blueschist. Rocks occur in three discrete belts, the northernmost which yields Triassic radiolarians, a medial belt yielding Jurassic and Cretaceous age, and a southernly belt yielding radiolaria as young mid-Cretaceous age. Rocks typically shown prehnite-pumpellyite facies metamorphism. Fossils: Radiolaria from chert ranges from Triassic to mid-Cretaceous (Albian or Cenomanian). Description from source map: VA002

MZpg - Phyllite/greenstone melange (Early(?) Cretaceous to Late Jurassic) Structurally chaotic melange-like unit of dominantly massive medium- to dark-green metabasalt interbedded with gray to black metapelitic rocks and intercalated minor gray to white metachert; occurs structurally between the McHugh Complex and Valdez Group. Structural thickness is up to 2.5 km, and thickness of the dominantly greenstone units is as much as 600 m. Metamorphic grade is lower greenschist facies. Description from source map: BG002

GG - Gabbroic phacoids in McHugh Complex (Jurassic and Late Triassic(?)) Strongly altered gabbroic phacoids that are tectonic inclusions in the McHugh Complex. Description from source map: VA004

MZc - Conglomerate and sandstone (Early Cretaceous(?) and Late Jurassic(?) or older)

Pebble to boulder conglomerate and coarse-grained sandstone. May reflect the Nutzotin Mountains sequence (KJs) of Berg and others (1972) northern shore facies; hornfels alteration along southern contact of the Snag pluton (Tsq). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TKc - Conglomerate and sandstone (Tertiary and Cretaceous) Green-gray to brown-gray pebble-to-boulder conglomerate, conglomeritic sandstone, and coarse-grained sandstone.

Description from source map: NB002

MZPZu - Alpine-type ultramafic rocks and gabbro (Cretaceous(?), Jurassic(?), Triassic, Permian, and Pennsylvanian(?))

Serpentinized peridotite and dunite, locally containing chromitite, leucocratic gabbro, and hornblende gabbro. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Kum - Ultramafic rocks (Cretaceous (?)) Serpentinite, serpentinized peridotite, and dunite, with subordinate clinopyroxenite. Description from source map: NB002

scgb - Schistose clinopyroxene gabbro; Metamorphic Complex of Gulkana River (Late Jurassic or older) Schistose clinopyroxene gabbro. Description from source map: GU002

IPu - Ultramafic rocks (Pennsylvanian) Small serpentinized alpine-type ultramafic masses north of, but near the Border Ranges Fault fault; tectonically emplaced in metamorphosed Skolai Group; includes some partly serpentinized gabbro intensely sheared. Consists largely of ferruginous serpentine minerals; lesser amounts of phlogopite, tremolite, magnetite, chromite, calcite, pyrrhotite, and a few relicts of olivine and pyroxene; probably originally peridotite and dunite. Small small anomalous concentrations of nickel and chromium. Interpreted as fragments of tectonically emplaced upper Paleozoic (Pennsylvanian) oceanic crust. Correlates with some ultramafic rocks west of the quadrangle that have similar geologic settings; these include peridotite masses at the Spirit Mountain prospect [refs inc.] and the Bernard (red) Mountain [refs inc.] ultramafic assemblage; also correlates with sparsely distributed ultramafic rocks that were emplaced in upper Paleozoic terranes in the Nabesna quadrangles and in the Yukon Territory. Description from source map: MC002

PZg - Gabbro and Anorthosite (Late Paleozoic (?)) Predominantly medium-grained leucocratic gabbro and hornblende gabbro intimately mixed with altered anorthositic rocks. Gabbros have a hypidiomorphic texture and consist of calcic plagioclase, clinopyroxene, and hornblende; anorthositic rocks lack clinopyroxene, but locally contain abundant segregations, lenses, and wavy bands of fibrous tremolite-actinolite and minor clinozoisite. Description from source map: NB002

PZum - Ultramafic rocks (Late Paleozoic (?)) Alpine-type ultramafic consisting chiefly of serpentinized peridotite (Iherzolite) and dunite. Description from source map: NB002

Jc - Chitina Valley batholith (Late Jurassic)

Compositionally diverse quartz monzodiorite, ranging from granite to diorite, generally foliated and locally gneissic particularly within plutons enclosed by the Strelina Metamorphics of Plafker and others (1989) (PPNsm). K-Ar dates indicate plutonic ages of 157–138 Ma, foliated phase ages are as young as 122 Ma; synchronous with Late Jurassic major regional orogeny perhaps related to subduction along Border Ranges Fault. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Jt - Tonalite, diorite, and leucodiorite of Chitina Valley batholith (Late Jurassic) Tonalite, diorite, and leucodiorite of Chitina Valley batholith. Mainly diorite, leucodiorite, and tonalite, but locally includes gabbro, especially near contacts. Generally medium-grained but varies from fine to coarse and pegmatitic. Ranges from weakly to non-foliated in interior of plutons to strongly foliated and locally mylonitic towards contacts. Description from source map: BG002

Jgd - Granodiorite to quartz diorite (Jurassic?) Weakly foliated to foliated granodiorite to quartz diorite. Possibly equivalent to rocks of the Chitina Valley batholith Granite Range plutonic suite in the northern Chugach Mountains. Description from source map: BG002

Jc - Chitina Valley batholith (Late Jurassic) Chiefly quartz monzodiorite, but compositionally diverse, ranging from granite to diorite. Generally foliated and locally gneissic, especially in plutons enclosed in the Strelina Metamorphics. Radiometric age data: K-Ar ages range from 157 to 138 Ma with foliated phases yielding dates as young as 122 Ma. Description from source map: BG004

Jc - Chitina valley batholith - Wrangellia Terrane (Late Jurassic) Chiefly quartz monzodiorite, but compositionally diverse ranging from granite to diorite. Generally foliated and locally gneissic, especially in plutons enclosed in the Strelina Metamorphics (PPasm). Radiometric age data: K-Ar dates indicate plutonic ages of 138-157 Ma; ages and foliated phases are as young as 122 Ma. Description from source map: GU003

Jc - Chitina Valley Batholith (Late Jurassic) Strongly foliated Tonalite, granodiorite, and rocks ranging from granite to quartz diorite. No known volcanic equivalents, however, coextensive with batholithic rocks of Bering Glacier Quad. Also correlates with granitic rocks of the E Valdez Quad. Radiometric age data: Hornblende radiometric age range of 138 to 146+4 m.y. Description from source map: MC002

Jc - Chitina Valley batholith (Late Jurassic) Compositionally diverse quartz monzodiorite, ranging from granite to diorite, generally foliated and locally gneissic particularly within plutons enclosed by the Strelina Metamorphics of Plafker and others (1989) (PPasm). K-Ar dates indicate plutonic ages of 157-138 Ma, foliated phase ages are as young as 122 Ma; synchronous with Late Jurassic major regional orogeny perhaps related to subduction along Border Ranges Fault. Radiometric age data: K-Ar dates indicate plutonic ages of 157-138 Ma, foliated phase ages are as young as 122 Ma. Description from source map: MC006, VA006, and VA006

Jc - Chitina Valley batholith (Late Jurassic) Weakly to strongly foliated compositionally diverse plutonic rocks. Dominant lithology is fine-to medium-grained hypidiomorphic granular quartz monzodiorite, but quartz diorite, tonalite, and granodiorite are nearly as abundant. Radiometric age data: K-Ar hornblende ages range from 147 +/- 7 to 157 +/- 8 Ma, biotite ages are 134 and 144 +/- 7 Ma; one mineral pair is slightly discordant. Description from source map: VA002

Jc - Chitina Valley batholith (Late Jurassic) Wrangellia terrane, Chitina Valley batholith. Description from source map: VA007

JTrq - Hornblende quartz-diorite (Jurassic and Triassic) Part of "diorite complex." Medium- to coarse-grained hornblende quartz-diorite, hornblende-biotite quartz diorite, and subordinate leucocratic quartz diorite. Radiometric age data: K-Ar dates of Middle Jurassic for plutonic rocks and Late Triassic for metamorphic rocks. Description from source map: NB002

Js - Sedimentary rocks (Late, Middle, or Early Jurassic)

Chiefly spiculite, graywacke, mudstone, and conglomerate deposited in a shallow-marine and nearshore littoral setting. Includes the fossil-rich Lubbe Creek, Nizina Mountain, and Root Glacier Formations. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Js - Undivided Jurassic marine sedimentary rocks (Jurassic) Lower parts of the Matanuska-Wrangell terrane; subdivided into Lubbe Creek Formation: spiculite and minor coquina; Nizina Mountain Formation: graywacke; Root Glacier Formation: mudstone, siltstone, and subordinate sandstone, shale, and conglomerate. Broadly correlate with Jurassic rocks in Valdez Quad and Talkeetna Mtns. Fossils: 'Abundant fossils' indicate an age span from Pliensbachian to Kimmeridgian. Description from source map: MC002

Jk - Kotsina Conglomerate (Middle or Late Jurassic?)

Conglomerate and minor sandstone deposited under rapid local marine circumstances during orogenesis. Fossils absent. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Jk - Kotsina Conglomerate (Late and Middle Jurassic) Thin- to thick-bedded conglomerate with locally derived pebbles and cobbles and subordinate sandstone and shale. Extends into Valdez Quad. Correlates to rocks in Talkeetna Mtns. Radiometric age data: Isotopic age indicates an age span from late Jurassic to Middle to Late Jurassic. Description from source map: MC002

Jk - Kotsina Conglomerate (Middle or Late Jurassic?) Well-indurated massive to very thick-bedded cobble- and pebble-conglomerate, with some bouldery strata. Olive-gray lithic and feldspathic sandstone, siltstone, and carbonaceous shale are interbedded in many places and increase in proportion west of Long Glacier. Fossils: Plant scraps. Radiometric age data: K-Ar age on biotite from a clast of 161 Ma and on hornblende from cross-cutting dike of 145 Ma. Description from source map: VA002

Jnt - Mafic and ultramafic rocks (Middle or Early Jurassic)

Gabbro, pyroxenite, peridotite and dunite. Includes the Nelchina River Gabbro, the Tonsina ultramafic, and a mafic sequence of Winkler and others (1980). K-Ar dates indicate ages of 188–171 Ma. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Jum - Ultramafic rocks (Early Jurassic or older) Dunite, harzburgitic dunite, wehrlite, websterite, and clinopyroxenite comprise the Tonsina ultramafic complex. The rocks are folded but not intensely sheared or serpentized. Description from source map: VA002

Jmp - Mafic plutonic complex (Early or Middle Jurassic) Consists dominantly of layered hornblende-pyroxene gabbro and leucogabbro, with minor ultramafic, dioritic, and tonalitic rocks. The southern margin of complex is a major fault zone; cataclastic modification of mineral layering in the complex near the fault zone is severe; in many places the complex is thoroughly sheared and includes boudins of country rock. Mylonitic layering is also conspicuous along a major east-west fault within the complex. Radiometric age data: K-Ar ages on low-potassium hornblende and chloritized biotite range from 153 to 171 Ma. Description from source map: VA002

Jgl - Hornblende gabbro and leucogabbro (Early Jurassic or older) Layered gabbro and leucogabbro; layered gabbro is dominantly hornblende gabbro; hornblende-augite gabbro is common, however, with the hornblende replacing or molded upon the augite; and layers and lenses of hornblende occur at several places. Mafic part of the Tonsina Complex (now shown on Winkler's map as Jtg). Radiometric age data: K-Ar ages on hornblende of 419 $\pm$ 21, 188 $\pm$ 8, and 171 $\pm$ 5 Ma; the older age is considered suspect. Description from source map: VA002

Jnt - Ultramafic rocks (Middle or Early Jurassic) Gabbro, pyroxenite, peridotite and dunite. Includes the Nelchina River Gabbro, the Tonsina ultramafic, and a mafic sequence of Winkler and others (1980). K-Ar dates indicate ages of 188–171 Ma. Radiometric age data: K-Ar dates indicate ages of 188–171 Ma. Description from source map: VA006

Jnt - Mafic and ultramafic rocks (Early or Middle Jurassic) Gabbro, pyroxenite, peridotite and dunite. Includes the Nelchina River Gabbro, the Tonsina ultramafic, and a mafic sequence of Winkler and others (1980). Radiometric age data: K-Ar dates indicate ages of 188–171 Ma. Description from source map: VA006

shgb - Schistose hornblende gabbro; Metamorphic Complex of Gulkana River (Late Jurassic or older) Schistose hornblende gabbro. Description from source map: GU002

Jlc - Schist of Liberty Creek of Winkler and others (1981) (Jurassic(?))

Basalt flows, breccia, and tuff; regionally metamorphosed greenschist- and blueschist-facies Middle Jurassic or older oceanic assemblage protolith. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Klc - Schist of Liberty Creek (mid-Cretaceous? or Jurassic?) Well-foliated, multiply-deformed greenschist and transitional blueschist facies mafic metavolcanic and metasedimentary rocks. Schistosity is well-developed although primary sedimentary or volcanoclastic features are retained locally. There are no marker strata and units do not persist laterally. Description from source map: VA002

Jgb - Greenschist and transitional blueschist (Jurassic) Chiefly intercalated greenschist and blueschist, but includes lawsonite, muscovite, or actinolite schist, carbonaceous schist, highly siliceous rocks containing stilpnomelane, and foliated calcareous rocks. Similar to Raspberry, Seldovia, and Knik River schist units. Radiometric age data: K-Ar ages on crossite and muscovite range from 152 to 175 Ma, thought to be metamorphic ages. Description from source map: VA002

Klc - Schist of Liberty Creek of Winkler and others (1981) (Jurassic??) Basalt flows, breccia, and tuff; regionally metamorphosed greenschist- and blueschist-facies Middle Jurassic or older oceanic assemblage protolith. Description from source map: VA006

Jhg - Plutonic rocks of Hidden terrane (Early Jurassic)

No description on source map: [Geologic Map of Wrangell-Saint Elias](#)

Jgr - Biotite-epidote granite (Middle Jurassic) Irregularly shaped small stocks of pink-weathering medium-grained granite. Green biotite and granular to coarse-grained epidote are constant accessories. Description from source map: VA002

Jgd - Biotite-hornblende granodiorite (Middle Jurassic) Irregularly shaped small stocks of pink-weathering medium-grained granite. Green biotite is a constant accessory; hornblende and epidote are less abundant and are not present in all samples. Description from source map: VA002

JTRm - McCarthy Formation (Early Jurassic and Late Triassic)

Spiculite, impure chert and limestone, and shale deposited in a starved marine basin environment. Fossils locally abundant. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

JTrm - McCarthy Formation (Early Jurassic and Late Triassic) Named by MacKevett (1963) for exposures in the Wrangell Mountains. Exposed in Bering Glacier D-2 quadrangle only along the south side of the Chitina River where it consists of a few hundred meters of mostly of dark-gray to black, calcareous carbonaceous shale and subordinate thin-bedded limestone containing numerous calcite veinlets. Formation contains minor asymmetric, north-verging tightly-appressed folds and is cut by numerous south-dipping faults roughly parallel to the Chitina Valley fault. Paleontologic evidence (cited in MacKevett, 1970a, b; 1971, p. 15, 29) documents Early Jurassic ages that range from Hettangian to Pliensbachian Stages; possibly the unfossiliferous lowermost parts of the unit are as old as latest Triassic. Fossils: Paleontologic evidence (cited in MacKevett, 1970a, b; 1971, p. 15, 29) documents Early Jurassic ages that range from Hettangian to Pliensbachian Stages. Description from source map: BG002

JTrm - McCarthy Formation (Early Jurassic and Late Triassic) Formerly named McCarthy Shales. Upper: thin bedded, fine-grained spiculite, impure chert, impure limestone, and shale; Lower: thin-bedded impure limestone (wackestone), calcareous carbonaceous shale, and impure, locally spiculitic, chert. Temporal, but not lithologic, equivalents in Talkeetna Formation in Talkeetna Mtns. Monotis-bearing Upper Triassic rocks in Nabesna Quad probably correlative. Fossils: Upper: 'paleontological evidence' indicates an age span from Hettangian to Pliensbachian. Lower: Monotis pelecypods and other 'fossils' indicate Norian age. Description from source map: MC002

JTrm - McCarthy Formation (Early Jurassic and Late Triassic) Spiculite, impure chert and limestone, and shale deposited in a starved marine basin environment. Fossils: Fossils locally abundant. Description from source map: MC006

JTrm - McCarthy Formation -- lower member (Early Jurassic? and Late Triassic (Norian)) Marine limestone, shale, and chert. Lower member consists of interbedded finely-laminated, dark-gray, impure limestone, subordinate fissile shale, and minor chert. Fossils: Monotis and both calcareous and siliceous microfossils. Radiometric age data: Minimum age from intruding granodiorite of 144 Ma. Description from source map: VA002

JTRt - Talkeetna Formation (Early Jurassic and Late Triassic(?))

Dominantly andesitic volcanoclastic rocks, products of Late Triassic and Early Jurassic oceanic volcanic arcs. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

JTrd - Rhyodacite flows; Talkeetna Formation (Early Jurassic) Rhyodacite flows with minor sandstones and lesser dacite flows. Description from source map: GU002

Jta - Hornblende andesite flows; Talkeetna Formation (Early Jurassic) Hornblende andesite flows. Description from source map: GU002

Jts - Talkeetna Formation, sandstone (Early Jurassic) Sandstone with sparse volcanoclastic rocks. Description from source map: GU002

Jtk - Talkeetna Formation (Early Jurassic) Marine and non-marine andesitic and basaltic tuff, tuff breccia, and volcanogenic sedimentary rocks. Small, isolated bodies of light- to dark-gray unfossiliferous saccharoidal limestone may be parts of the units in the Valdez quadrangle. Fossils: Mollusks and brachiopods. Description from source map: VA002

JTRt - Talkeetna Formation (Early Jurassic and Late Triassic(?)) Dominantly andesitic volcanoclastic rocks, products of Late Triassic and Early Jurassic oceanic volcanic arc. Fossils: Mollusks and brachiopods. Description from source map: VA006

TRI - Triassic limestone (Late Triassic)

Locally fossil rich, thin-bedded limestone and interbedded argillite in partially starved marine basin; overlies shallow marine to intertidal fossil-poor cherty massive limestone. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TRI - Triassic limestone (Late Triassic) Locally fossil-rich, thin-bedded limestone and interbedded argillite in partially starved marine basin; overlies shallow marine to intertidal fossil-poor cherty massive limestone. Fossils: Fossils locally abundant. Description from source map: MC006

TRI - Limestone (Late Triassic) Upper Part: thin-bedded, fine-grained limestone, interbedded with thin beds of argillite and carbonaceous shale. Minor beds of calcareous sandstone and grit. Lower Part: fine-grained, massive limestone with chert lenses. Fossils: *Monotis subcircularis*; hydrozoa (*Lovcenipora?*); *Spondylspira*. Description from source map: NB002

TRcn - Chitistone and Nizina Limestones (Late Triassic)

Chiefly limestone and dolomite; minor chert and marble; locally fossil rich. The upper Chitistone and cherty Nizina, deposited in a shallow to moderately deep marine neritic environment, transition into an intertidal-supratidal setting with local sabkha facies full of algal-mat chips, stromatolites, and evaporate relics typical of the dolostone-rich lower Chitistone rocks. Description from source map:

[Geologic Map of Wrangell-Saint Elias](#)

TRn - Chitistone and Nizina Limestones (Late and Middle Triassic) The limestone is medium- to thick-bedded, white to medium gray, and commonly emits fetid odors when freshly broken. Undifferentiated Chitistone and Nizina limestones occur locally along the south side of the Chitina River in the D-2 quadrangle and between the Chitina and Logan glaciers in the D-1 quadrangle. Maximum aggregate thickness of the two formations in these areas is about 250 meters and both formations are characterized by marked lateral changes in thickness. Local minor to major, north-verging isoclinal folds occur in the Chitistone or Nizina Limestones near the Chitina Valley fault system. Disconformably overlies the Nikolai Greenstone in Marble Canyon and probably grades upward into the McCarthy Formation. Fossils: Unfossiliferous; in the McCarthy quadrangle to the north, diagnostic fossils indicate a Late Triassic age (MacKevett, 1978). Description from source map: BG002

TRcn - Chitistone and Nizina Limestones (Late Triassic) Chiefly limestone and dolomite; minor chert and marble. Both units locally fossiliferous. Fossils: Abundant algal-mat chips and stromatolites,. Description from source map: BG004

TRI (1) - Limestone (Late Triassic) Chiefly dark- to light-gray micrite, dismicrite, or microsparite. Conformably overlies Nikolai Greenstone (unit TRn). Fine- to medium-grained, medium- to massive-bedded containing lenses and nodules of gray and black chert and irregular patchworks of disseminated fine-grained quartz. Generally metamorphosed to lower greenschist facies. Fossils: Locally contains moderately abundant Late Triassic mega- and microfossils. Description from source map: GU009

TRcn - Chitistone and Nizina Limestones (Late Triassic) Both have marked lateral changes in thickness. Lowest Chitistone: dolomite algal-mat chips, stromatolites and evaporites. Upper Chitistone: diverse limestone including lime mudstones, wackestone, packstone, and grainstone. Nizina: diverse limestone with subordinate chert nodules, lenses, and coalescing masses. Probable correlatives of Triassic carbonate rocks in Nabesna Quad and south-central Alaska. Fossils: Chitistone: *Tropites* indicate a Karnian age. Nizina: ammonites and pelecypods indicate an age span from Late Karnian to Middle Norian. Description from source map: MC002

TRm - Marble (Late Triassic) Fine- to medium-grained calcite-rich marble, locally dolomitic, sometimes schistose or banded. Contact-metamorphosed Chitistone and Nizina Limestones, near granitic plutons of the Chitina Valley batholith. Description from source map: MC002

TRcn - Chitistone and Nizina Limestones (Late Triassic) Chiefly limestone and dolomite; minor chert and marble; locally fossil rich. The upper Chitistone and cherty Nizina deposited in a shallow to moderately deep marine neritic environment; transition into an intertidal-supratidal setting with local sabkha facies full of algal-mat chips, stromatolites, and evaporate relics typical of the dolostone-rich lower Chitistone rocks. Description from source map: MC006

TRI - Chitistone and Nizina Limestones (Late Triassic (Karnian and Norian)) Light- to medium-gray limestone of diverse textural varieties and include minor dolomite lower in the sequence and nodules and lenses of dark-gray chert high in the sequence. Lower thicker-bedded sequence is Chitistone Limestone, upper, thinner-bedded sequence is Nizina Limestone. Description from source map: VA002 and VA005

TRg - Gabbro and diabase and gabbronorite dikes (Late Triassic(?))

Clinopyroxene-hornblende gabbro and diabase and gabbronorite dikes. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TRg - Gabbro and diabase and gabbronorite dikes -- Wrangellia Terrane (Late Triassic (?))

Clinopyroxene-hornblende gabbro and diabase and gabbronorite dikes. Description from source map: GU002

TRcg - Stocks and plugs (Late Triassic(?))

Clinopyroxene-hornblende stocks and plugs. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TRcg - Stocks and plugs -- Wrangellia Terrane (Late Triassic (?)) Clinopyroxene-hornblende stocks and plugs. Description from source map: GU002

TRn - Nikolai Greenstone (Late and(or) Middle Triassic)

Widespread sequence of tholeiitic flood basalt flows, mainly subaerial and characteristically amygdaloidal, include subordinate volcanoclastic interbeds and volcanic conglomerate basal sections. Metamorphosed to prehnite-pumpellyite facies although alteration rarely masks primary mineralogy and texture. Contains anomalously high amounts of copper. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

TRng - Nikolai Greenstone (Late and (or) Middle Triassic) Dominantly thick flow units of slightly porphyritic tholeiitic basalt with medium-grained plagioclase (labradorite) and less abundant clinopyroxene phenocrysts in fine-grained intergranular groundmasses rich in plagioclase and clinopyroxene. Characteristically greenish black with light green to white amygdules; typically altered and locally metamorphosed to prehnite-pumpellyite facies assemblages. Named by Rohn (1900, p. 425) for extensive, mainly altered tholeiitic basalt sequence that occurs widely in the Wrangell Mountains and Chitina Valley area; at least 3,000 m in aggregate thickness. In the map area the unit is at 60 meters thick; the lower contact is faulted; overlain disconformably(?) by undifferentiated Chitistone and Nizina limestones (Upper Triassic) or unconformably by younger rocks. Description from source map: BG002

TRn - Nikolai Greenstone (Late Triassic) Nikolai Greenstone. Description from source map: GU002

TRn - Nikolai Greenstone (Late and Middle Triassic) Altered tholeiitic basalt. Largely subaerial, locally submarine in northeastern part of quadrangle. where basal sections contain pillow basalt and intercalated argillite. elsewhere, base generally characterized by volcanic conglomerate as much as 70-m-thick. Consists dominantly of pahoehoe and aa flows between 15-cm- and 15-m-thick; some flow tops are brecciated. Characteristically amygdaloidal except interiors of thicker flows. Typically altered and metamorphosed to prehnite-pumpellyite facies. Description from

source map: MC002

TRn - Nikolai Greenstone (Triassic) Amygdaloidal tholeiitic basalt lava flows and minor associated volcanoclastic rocks. Pillow structures common along lower Ptarmigan Creek, but lavas are typically subaerial. Description from source map: MC003

TRn - Nikolai Greenstone (Late and/or Middle Triassic) Widespread sequence of tholeiitic flood basalt flows, mainly subaerial and characteristically amygdaloidal, include subordinate volcanoclastic interbeds and volcanic conglomerate basal sections. Metamorphosed to prehnite-pumpellyite facies although alteration rarely masks primary mineralogy and texture. Contains anomalously high amounts of copper. Description from source map: MC006

TRn - Nikolai Greenstone (Triassic) Subaerial porphyritic basalt flows interbedded with volcanoclastic rocks; basal sections include volcanic conglomerate-breccia with dominant intermixed pahoehoe and aa. Description from source map: NB002

TRn - Nikolai Greenstone (Middle and (or) Late Triassic) Weakly metamorphosed, lightly altered tholeiitic basalt that is characteristically amygdaloidal and poorly bedded. Metamorphosed to prehnite-pumpellyite facies. Radiometric age data: K-Ar whole-rock isochron of 112 +/- 11 Ma thought to indicate collision of Wrangellia with North America. Description from source map: VA002 and VA005

PPNsm - Strelina Metamorphics of Plafker and others (1989) (Jurassic(?), Triassic(?), Permian, Early Pennsylvanian, and Late Mississippian(?))

Dominantly calcareous metasedimentary rocks, schist, phyllite, amphibolite, and marble; lesser quartzite, meta-andesite, and metabasalt in thin to thick thrust sheets containing local pods of the tectonically emplaced ultramafic rock and marble (PPNm); overlying the gabbro and orthogneiss (PNgo). Includes the Jurassic Uranatina Metaplutonic Complex and the Dadina Schist of Carboniferous and possibly older(?) age exposed near Mount Drum. Metamorphic grade increases closer to the Chitina Valley batholith (Jc) and might represent metamorphosed roots of the Skolai-Tetelna magmatic arc (PPNt, PPNs, and PPNsc). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Jlg - Layered quartz gabbro (Jurassic) Conspicuously layered, hypidiomorphic-granular textured quartz gabbro. Layers enriched in clinopyroxene or in plagioclase and quartz give unit its prominent banded appearance. Prehnite-pumpellyite metamorphosed, little deformed and dips quite uniformly northward. Radiometric age data: K-Ar age on pyroxene of 185 +/- 19 Ma is highly suspect, however matches ages on Afognak Pluton, the pluton of the Barren Islands and reputed ages on small dioritic plutons near Seldovia. Description from source map: VA002

Jag - Uranatina River metaplutonic unit (Jurassic and Middle Pennsylvanian) Portion of tectonic inclusion 10 by 15 km in McHugh Complex consisting of layered quartz gabbro, amphibolite, and orthogneiss. This unit consists of compositionally banded very mafic amphibolite to hornblende-biotite dioritic and quartz dioritic gneiss. Contains lenses of pyroxenite as much as 2 m across. Foliation of the rocks is swirled or tightly folded in many places and large hornblende or hornblende-plagioclase pods have grown in the hinges of many folds. Most of unit is likely of Jurassic age but is known to contain at least locally Middle Pennsylvanian metagranodiorite. Radiometric age data: Low-potassium hornblende yielded K-Ar age of 267 +/- 8 Ma (mid-Permian), thought to approximate time of metamorphism. Description from source map: VA002

mha - Metamorphosed hornblende andesite; Metamorphic Complex of Gulkana River (Late Paleozoic (?) or older) Metamorphosed hornblende andesite. Description from source map: GU002

qmfs - Quartz-muscovite-feldspar schist; Metamorphic Complex of Gulkana River (Late Paleozoic (?) or older) Quartz-muscovite-feldspar schist. Description from source map: GU002
mmp - Metamorphosed pelitic and calc-schist; Metamorphic Complex of Gulkana River (Late Paleozoic (?) or older) Metamorphosed pelitic and calc-schist. Description from source map: GU002

PZmv - Metamorphic complex of Gulkana River metavolcanic rocks, undivided (Paleozoic?) Inferred metabasalt or metaandesite along quadrangle boundary with Talkeetna Mountains quadrangle. Description from source map: GU009

sqm - Schistose quartz monzonite; Metamorphic Complex of Gulkana River (Late Jurassic or older) Schistose quartz monzonite. Description from source map: GU002

sgd - Schistose quartz diorite; Metamorphic Complex of Gulkana River (Late Jurassic or older) Schistose quartz diorite. Description from source map: GU002

sgd - Schistose granodiorite; Metamorphic Complex of Gulkana River (Late Jurassic or older) Schistose granodiorite. Description from source map: GU002

ds - Dadina Schist (Late Paleozoic (?) or older) Coarse quartz-biotite schist, altered and cataclastic meta-andesite, overlain(?) by amphibolite schist, mica-schist, and minor meta-limestone. Intruded by unmetamorphosed coarse-grained quartz diorite dikes. Also includes sheared meta-gabbro. Dadina Schist (Mendenhall, 1905). Correlated with Klutina of Schrader (1900) or with Strelina Formation of Moffit and Mertie (1923). Description from source map: GU002 and GU009

PIPs - Metamorphosed Skolai Group (Early Permian and Pennsylvanian) Greenschist- to amphibolite-facies metamorphic rocks, mainly schist, phyllite, amphibolite, and marble. Corresponds to the Mississippian Strelina Formation. Fossils: 'Fossil collections' indicate an Early Permian age. Description from source map: MC002

PIPs - Skolai Group, undivided (Early Permian and Pennsylvanian) Lower late Paleozoic magmatic arc and associated upper sedimentary rocks. Equivalent to the Mankomen Group (Pe, Pel, and PPass) and the Tetelna Volcanics (PPat) in northern Wrangell Mountains and eastern Alaska Range. Description from source map: VA006

JIPhc - Haley Creek metamorphic assemblage (Late Jurassic and Pennsylvanian or older?) Wrangellia terrane, Haley Creek metamorphic assemblage, Consists of Uranatina River metaplutonic unit (Jurassic and Pennsylvanian) and Strelina Metamorphics (Early Pennsylvanian and older?). Description from source map: VA007

mcb - Metamorphosed clinopyroxene basalt; Metamorphic Complex of Gulkana River (Late Paleozoic (?) or older) Metamorphosed clinopyroxene basalt. Description from source map: GU002

ag - Amphibolite gneiss; Metamorphic Complex of Gulkana River (Late Jurassic or older) Amphibolite gneiss. Description from source map: GU002

am - Amphibolite; Metamorphic Complex of Gulkana River (Late Paleozoic (?) or older) Amphibolite. Description from source map: GU002

IPs - Strelina Metamorphics, Metasedimentary and metavolcanic rocks (Pennsylvanian, and older(?)) Metasedimentary and metavolcanic rocks. Dominantly interlayered quartz-feldspar mica schist and mica-quartz schist and subordinate marble beds or lenses. Description from source map: BG002

PIPs - Strelina Metamorphics of Plafker and others (1989) (Jurassic(?), Triassic(?),

Permian, Early Pennsylvanian, and Late Mississippian(?) Dominantly calcareous metasedimentary rocks, schist, phyllite, amphibolite, and marble; lesser quartzite, meta-andesite, and metabasalt in thin to thick thrust sheets containing local pods of the tectonically emplaced ultramafic rock and marble (PPam); overlying the gabbro and orthogneiss (Pago). Includes the Jurassic Uranatina Metaplutonic Complex and the Dadina Schist of Carboniferous and possibly older(?) age exposed near Mount Drum. Metamorphic grade increases closer to the Chitina Valley batholith (Jc) and might represent metamorphosed roots of the Skolai-Tetelna magmatic arc (PPat, PPaS, and PPasc). Description from source map: MC006

Psm - Strelina Metamorphic Complex (Mesozoic or Paleozoic) A diverse and intimately mixed group of low- to medium-grade greenschist and amphibolite which also includes abundant pelitic and psammitic schist, metachert, and gneiss having pronounced mortar structure. Contains no marble but does contain extensive massive to gneissose mafic to intermediate (meta?) plutonic rocks. Rocks are tightly folded on all scales and pervasively faulted; they are strongly foliated and partially mylonitic and are cut by post-metamorphic Late Jurassic and Early Cretaceous plutons. Has been thought to be metamorphosed equivalent of the Strelina Formation or the Skolai Group, however it lacks any meta-limestone as would be expected for the Skolai Group. Unit is also similar to Triassic and Jurassic diorite complex of the Nabesna quadrangle. Radiometric age data: K-Ar age on hornblende from metagabbro of 152 +/- 6 Ma; thought to be reset. Description from source map: VA002 and VA005

Pm - Mankomen Group, undivided (early Permian)

Thermally altered, weakly foliated, Mankomen Group. Wollaston-, diopside-, and garnet-bearing marble, calcareous metasiltstone and metasandstone, and pyroxene and hornblende hornfels. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Pm - Mankomen Group (undivided) (Early Permian) Thermally altered, weakly foliated, Mankomen Group. Wollastonite-, diopside-, and garnet-bearing marble, calcareous metasiltstone and metasandstone, and pyroxene and hornblende hornfels. Description from source map: NB002

Pe - Mankomen Group, Eagle Creek Formation (early Permian)

Nonvolcanogenic argillite and siltstone deposited in a moderately deep quiet basin. Abundant fossils, cone-in-cone structures, and concretions. Intruded by locally abundant Triassic gabbroic inclusions (TRn) and porphyry dikes and sills (Tp). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Pe - Eagle Creek Formation (Early Permian) Part of Mankomen Group. Thin-bedded argillite and siliceous siltstone, with interbedded of calcareous siltstone and sandstone, biomicritic limestone, and a pebble to cobble conglomerate. Gabbroic dikes and sills. Equivalent to parts of the Cache Creek Group and the Skolai Group. Fossils: Daonella; Abundant brachiopods, cephalopods, corals, foraminifera, and bryozoan. Description from source map: NB002

Pel - Mankomen Group, Eagle Creek Formation, limestone (early Permian)

Fossiliferous thin- to thick-bedded limestone. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Pel - Limestone (Early Permian) Part of Mankomen Group. Thin- to thick-bedded fossiliferous limestone occurring at the base of the Eagle Creek Formation. Base is a coarse-grained clastic

limestone. Gabbroic dikes and sills. Equivalent to parts of the Cache Creek Group and the Skolai Group. Description from source map: NB002

Ph - Skolai Group, Hasen Creek Formation (early Permian)

Fossil-rich marine argillite, shale, and sandstone; nonvolcanic origin. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Ph - Hasen Creek Formation (Early Permian) Argillite, shale, sandstone, chert, limestone, and minor conglomerate. Locally thermally metamorphosed near Jurassic plutons. Description from source map: MC002

Ph - Hasen Creek Formation (Permian) Marine argillite and minor sandstone and chert, locally fossiliferous. May include some volcanoclastic rocks. Abundant Triassic gabbro sills. Correlative with the Mankomen Group in Nabesna quadrangle. Description from source map: MC003

PI - Skolai Group, Hasen Creek Formation, limestone (early Permian)

Fossil-rich, lenticular, marine limestone; partially equivalent to the Strelina metamorphic marble of Plafker and others (1989) (PPNm). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PI - Limestone of the Hasen Creek Formation (Early Permian) Thin- to thick-bedded, fossiliferous, limestone. Includes Golden Horn Limestone Lenticle. Correlates with the Eagle Creek Formation of the Mankomen Group in eastern Alaska Range in Nabesna Quad. Also correlates with Cache Creek Group of Yukon Territory. Fossils: Corals, crinoids, brachiopods, bryozoans, fusulinid indicate Early Permian (Wolfcampian). Description from source map: MC002

PI - Limestone (Permian) Thin unit (10-30 m) of sand- and silt-rich limestone that appears to separate sedimentary rocks of the Hasen Creek Fm (Ph) from the underlying volcanoclastic rocks of the Station Creek Fm (PIPsc). Found in small block of Paleozoic and Mesozoic rocks north of Ptarmigan Lake. Fossils: abundant crinoid and coral fragments. Description from source map: MC003

PPNm - Strelina Metamorphics of Plafker and others (1989), marble (Permian and Early Pennsylvanian)

Dominantly calcareous metasedimentary rocks, schist, phyllite, amphibolite, and marble; lesser quartzite, meta-andesite, and metabasalt in thin to thick thrust sheets containing local pods of the tectonically emplaced ultramafic rock and marble (PPNm); overlying the gabbro and orthogneiss (PNgo). Includes the Jurassic Uranatina Metaplutonic Complex and the Dadina Schist of Carboniferous and possibly older(?) age exposed near Mount Drum. Metamorphic grade increases closer to the Chitina Valley batholith (Jc) and might represent metamorphosed roots of the Skolai-Tetelna magmatic arc (PPNt, PPNs, and PPNsc). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

IPsm - Strelina Metamorphics, Marble (Early Pennsylvanian) White to gray marble (m) forms conspicuous deformed and folded bands and pods throughout the unit. Individual marble beds vary markedly in thickness along strike; maximum measured thickness of the unit is about 1,200 meters. The unit is commonly composed of 90 percent more strongly regionally metamorphosed calcite and lesser calc-silicate minerals. The marble is typically found in association with greenschist and quartz-rich schist, but also forms pods to a few hundred meters thick within predominantly phyllitic schist or as inclusions within associated metaplutonic rocks. Description

from source map: BG002

Pm - Marble of the metamorphosed Skolai Group (Early Permian and Pennsylvanian) Fine- to medium-grained banded impure marble, locally deformed. Interpreted as temporal equivalent of limestones of the Hasen Creek Formation. Fossils: Poorly preserved Early Permian fossils. Description from source map: MC002

PIPm - Marble (Permian, Early Pennsylvanian?) Regionally metamorphosed with poorly preserved and locally placed Permian and Early Pennsylvanian fossils. Partially equivalent to the Permian limestone of the Hasen Creek Formation (PI). Description from source map: MC006

M - Haley Creek terrane -- schistose marble (mid-Cretaceous?) Schistose marble. Individual marble layers can be traced for several km, however the layers vary greatly in thickness, terminate abruptly in places, and are generally thoroughly folded. Small isolated bodies of marble mark unmapped fault within the Haley Creek terrane. Radiometric age data: K-Ar ages on hornblende range from 122 to 148 Ma. A muscovite age is 133 +/- 4 Ma. Description from source map: VA002

PZm - Skolai Group -- marble unit (Late Paleozoic, Middle Pennsylvanian to Early Permian) Subordinate light- or medium-gray and buff calcareous rocks, mostly recrystallized to marble but containing scanty fragments of fossils, interbedded with dark-gray calcareous siltstone and shale. Change unit designator to ma, per Winkler (1998). Fossils: Scanty fragments of bryozoans, crinoids, corals, and brachiopods. Description from source map: VA002

PPNs - Skolai Group, undivided (early Permian and Pennsylvanian)

Lower late Paleozoic magmatic arc and associated upper sedimentary rocks. Equivalent to the Mankomen Group (Pe, Pel, and PPNss) and the Tetelna Volcanics (PPNt) in northern Wrangell Mountains and eastern Alaska Range. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PIPs - Skolai Group, undivided (Early Permian and Pennsylvanian) Lower late Paleozoic magmatic arc and associated upper sedimentary rocks. Equivalent to the Mankomen Group (Pe, Pel, and PPass) and the Tetelna Volcanics (PPat) in northern Wrangell Mountains and eastern Alaska Range. Description from source map: MC006

Pzs - Skolai Group -- greenstone unit (Late Paleozoic, Middle Pennsylvanian to Early Permian) Diverse Upper Paleozoic volcanic, volcanoclastic, and marine sedimentary rocks. Unit consists largely of two lithologies, map unit Pzs is dark, greenish-gray poorly bedded greenstone, characterized by prehnite-pumpellyite mineral assemblages, locally retaining relict pillows and map unit PZm is subordinate light- or medium-gray and buff calcareous rocks, mostly recrystallized to marble but containing scanty fragments of fossils, interbedded with minor dark-gray calcareous siltstone and shale. Description from source map: VA002

PPNdp - Diorite complex, plutonic part (Permian(?) and Pennsylvanian)

Hornblende diorite grading into gneissic diorite. Together with associated metamorphics (PPNdm), almost certainly represents the Skolai-Tetelna magmatic arc's (PPNt, PPNs, and PPNsc) roots. Possibly correlative with the gabbro and orthogneiss (PNgo) in southern Wrangell Mountains. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PIPa - Diorite Complex (Permian and Pennsylvanian) Altered diabase and gabbro. Description from source map: GU002

PIPd - Diorite Complex (Permian and Pennsylvanian) Diorite, granodiorite, and gabbro. Description from source map: GU002

Jtrd - Hornblende-rich diorite (Jurassic and Triassic) Part of "diorite complex." Hornblende diorite with subordinate hornblende granodiorite, hornblende-biotite quartz monzonite, biotite quartz monzonite, hornblende diorite gneiss, clinopyroxene-hornblende gneiss, hypersthene-hornblende gneiss, and amphibolite with subordinate syenite-monzonite gneiss. Amphibolite-facies metamorphism. Radiometric age data: K-Ar dates of Middle Jurassic for plutonic rocks and Late Triassic for metamorphic rocks. Description from source map: NB002

MZa - Anorthosite (Mesozoic) Part of "diorite complex." Medium- to coarse-grained bytownite anorthosite with hypidiomorphic to allotriomorphic texture. Diopside pyroxene and gabbro pegmatite. Radiometric age data: K-Ar dates of Middle Jurassic for plutonic rocks and Late Triassic for metamorphic rocks. Description from source map: NB002

PPNdm - Diorite complex, metamorphic part (Permian(?) and Pennsylvanian)

Amphibolite-grade metamorphic rocks of mainly quartz-feldspar schist, biotite-hornblende gneiss, and syenite-monzonite gneiss. Jurassic K-Ar ages in probability reflect a metamorphic age. Together with associated late Paleozoic plutons (PPNdp) construct part of the Skolai-Tetelna magmatic arc (PPNt, PPNs, and PPNsc) and Pennsylvanian oceanic crust. Possibly correlative with the gabbro and orthogneiss (PPNgo) in southern Wrangell Mountains. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

JTRs - Quartz-feldspar schist and cataclastite (Jurassic and Triassic) Part of "diorite complex." Quartz-feldspar schist and cataclastite. Radiometric age data: K-Ar dates of Middle Jurassic for plutonic rocks and Late Triassic for metamorphic rocks. Description from source map: NB002

JTRg - Pink biotite-hornblende syenite-monzonite gneiss (Jurassic and Triassic) Part of "diorite complex." Pink biotite-hornblende syenite-monzonite gneiss with thin layers of gray hornblende diorite gneiss, and minor dark biotite schist. Small syenite pegmatite dikes. Radiometric age data: K-Ar dates of Middle Jurassic for plutonic rocks and Late Triassic for metamorphic rocks. Description from source map: NB002

PPNss - Mankomen Group, Slana Spur Formation (early Permian and Pennsylvanian)

Fossil-rich volcanic sandstone, siltstone, conglomerate, and impure bioclastic limestone; shed off the Tetelna volcanic arc (PPNt). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

grcl - Granite porphyry of Caribou Lake (Early Cretaceous and (or) Late Jurassic?) Chiefly biotite granite porphyry. Fine-grained; locally medium-grained. Local hyalotomorph granular texture. Local extensive hydrothermal alteration. Extended into Gulkana quadrangle to match Mount Hayes. Description from source map: GU009

PIPs - Slana Spur Formation (Middle and Late Pennsylvanian and Early Permian) Slana Spur Formation. Description from source map: GU002

Ps - Slana Spur Formation (Early Permian) Part of Mankomen Group. Volcanic siltstone, sandstone, and conglomerate with subordinate lapilli tuff, volcanic breccia and impure biomicritic limestone. Equivalent to parts of the Cache Creek Group and the Skolai Group. Description from source map: NB002

PPNt - Tetelna Volcanics (early Permian and Pennsylvanian)

Subaerial and submarine basaltic to dacite lava, lahar flows, tuff deposits, and fine-grained volcaniclastic rocks. Extensive late Paleozoic magmatic arc vestiges form Wrangellia terrane's basement in northern Wrangell Mountains and eastern Alaska Range. Correlates to the Skolai Group's (PPNs) Station Creek Formation (PPNsc) in southern Wrangell Mountains. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

IPt - Tetelna Volcanics (Pennsylvanian) Tetelna Volcanics, hornblende andesite and other volcanic rocks, metamorphosed to greenschist facies. Description from source map: GU002

PIPt - Tetelna Volcanics (Permian and Pennsylvanian) Volcanic flows of porphyritic andesite, volcanic mud and debris avalanches, lapilli-pumice tuffs, and fine- to coarse-grained volcaniclastic rocks ranging from mudstone to conglomerate, and volcanic-rich limestone. Areas of contact metamorphism creating foliated hornblende diorite and quartz monzonite, and amphibolite. Fossils: Brachiopods and cephalopods. Description from source map: NB002

PPNsc - Skolai Group, Station Creek Formation (early Permian and Pennsylvanian)

Magmatic arc consists of a younger volcaniclastic member and an older andesitic and basaltic lava flow member, both of submarine origin; locally metamorphosed to greenschist-facies south of Chitina Fault. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PIPsc - Station Creek Formation (Early Permian and Pennsylvanian) A volcanoclastics member, which grades from coarse volcanic breccia through volcanic graywacke to volcanilutite; Also a volcanic flow member, locally pillowed and brecciated, and includes altered lavas of andesites and basalts, and minor intercalated volcanoclastic rocks. Volcanoclastic member correlates with Early Permian Slana Spur Formation of Mankomen Group. Volcanic flow member correlates with parts of the Tetelna Volcanics in the Nabesna Quad. See also 5810 Permian(?) volcanic rocks. Description from source map: MC002

PIPsc - Station Creek Formation (Pennsylvanian and Permian) Chlorite-rich amygdaloidal andesitic lava flows and volcaniclastic rocks. Correlative with the Tetelna Volcanics in the Nabesna quadrangle. Description from source map: MC003

PIPsc - Station Creek Formation (Early Permian and Pennsylvanian) Magmatic arc consists of a younger volcaniclastic member and an older andesitic and basaltic lava flow member, both of submarine origin; locally metamorphosed to greenschist-facies south of Chitina Fault. Description from source map: MC006

PZv - Metamorphic rocks of the Carden Hills, metavolcanic rocks (Permian(?), Pennsylvanian, Mississippian, and Devonian(?))

Slightly porphyritic meta-andesite and metabasalt; greenschist-facies metamorphism. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PZv - Volcanic rocks (Late (?) Paleozoic) Dark-greenish-gray fine-grained to weakly porphyritic andesite and basalt flows with abundant reddish jasperoid breccia, and minor interbeds of red and green cherty mudstone. Weakly metamorphosed (greenschist facies). May be equivalent to Tetelna Volcanics (PPt) or Devonian terrane (Dp). Description from source map: NB002

PZvc - Metamorphic rocks of the Carden Hills, metavolcaniclastic rocks (Permian(?), Pennsylvanian, Mississippian, and Devonian(?))

Chiefly meta-sandstone, metatuff, and quartzite; greenschist-facies metamorphism. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PZvc - Volcanic rocks (Late Paleozoic) Dark-gray thin-bedded fine- to medium-grained volcanic sandstone, cherty argillite, quartzite, and tuff. Weakly metamorphosed (greenschist facies). May be equivalent to Tetlina Volcanics (PPt) or Devonian terrane (Dp). Description from source map: NB002

PNa - Ahtell pluton (Pennsylvanian)

Quartz monzonite and granodiorite discordant zoned pluton. Together with the monzonite-granite complex (PNm) in Saint Elias Mountains make part of the Skolai-Tetelna magmatic arc's (PPNt, PPNs, and Phsc) core. K-Ar data indicates an age of 285 Ma. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PIPf - Ahtell Pluton (Permian and Pennsylvanian) Fine-grained biotite granite. Description from source map: GU002

PIPp - Ahtell Pluton (Permian and Pennsylvanian) Porphyritic hornblende granodiorite. Description from source map: GU002

PIPg - Ahtell Pluton (Permian and Pennsylvanian) Biotite-hornblende granite and granodiorite. Description from source map: GU002

PNm - Monzonite-granite complex (Pennsylvanian)

Large composite granite and quartz monzonite pluton containing lesser monzonite, syenite, and gabbro emplaced between Wrangellia and Alexander(?) terranes. K-Ar dates indicate ages of 297–295 Ma. Correlates with the Ahtell pluton (PNa) in northern Wrangell Mountains to construct the Tetelna-Skolai magmatic arc's (PPNt, PPNs, and PPNsc) core. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

IPm - Monzonite, syenite, gabbro (Middle Pennsylvanian) Massive to schistose, medium- to coarse-grained monzonite, syenite, gabbro, contains local inclusions of meta-andesite. Chiefly pink to gray-green monzonite and syenite, consisting of hornblende, K-spar, biotite, and plagioclase with local K-spar rich areas up to 8 cm diameter. Description from source map: BG002

Pm - Monzonitic-Granitic Complex (Early Permian and Pennsylvanian) Medium-grained, equigranular granitic rocks with fine- to coarse-grained variants. Abundant granite and quartz monzonite and some quartz syenite, syenite, and monzonite, with border zones of quartz monzodiorite, monzodiorite, and gabbro. In both the Bering Glacier and McCarthy Quads. Correlates with Ahtell pluto of E Alaska Range (pluton has a K-Ar of 285 m.y.). Radiometric age data: Hornblende of monzonite and quartz monzonite gives age of 295+8 and 297+9 m.y. Description from source map: MC002

IPg - Diorite and quartz diorite (middle Paleozoic(?) and older(?) (Pennsylvanian?)) Granite and syenite, medium- to coarse-grained, and schistose. Syenite chiefly schistose, gray-green hornblende-K-spar-biotite-plagioclase syenite. Local K-spar rich areas up to 8 cm diameter. Contains local inclusions of meta-andesite. Description from source map: MS002 and YA002

PNgo - Gabbro and orthogneiss (Pennsylvanian)

Interlayered hornblende pyroxene gabbro and monzonitic gneiss; overlain by the Skolai Group (PPNs, Ph, Pl, and PPNsc) and their metamorphosed equivalent, the Strelina Metamorphics of Plafker and others (1989) (Phsm). Represents, in part, Pennsylvanian oceanic crust correlative with the diorite complex (PPNdm and PPNdp) in northern Wrangell Mountains and eastern Alaskan Range.

Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

IPgo - Gabbro and Orthogneiss (Pennsylvanian) Interlayered quartz monzonite gneiss, monzonite gneiss, and associated altered and foliated gabbro, with minor dioritic phases. Gabbro and orthogneiss extend into Valdez Quad. Radiometric age data: Biotite of the gneiss yields a radiometric date of 271±11 m.y. Description from source map: MC002

PZg - Gabbro and leucogabbro (Late Paleozoic, Permian to Pennsylvanian) Gabbroic rocks consisting of sills, dikes, and discordant plutons. Medium- to coarse-grained, massive to foliated, altered gabbro, leucogabbro, and minor diorite. Coextensive with layered gabbro in the McCarthy quadrangle. Radiometric age data: K-Ar age on actinolitic amphibole of 246 ± 12 Ma, thought to be minimum age, may be partially reset by intrusion of nearby Late Jurassic hornblende granodiorite pluton. Description from source map: VA002

PZk - Kaskawulsh Group of Kindle (1953) (Pennsylvanian, Mississippian, Devonian(?), and older)

A metamorphosed marine sequence of marble, schist, and phyllite; minor meta-tuff, flows, breccia, and meta-conglomerate; probably oceanic crustal progression with carbonate reefs. Poorly preserved Ordovician, Devonian, and possible Mississippian and Pennsylvanian fossils present.

Metamorphosed to upper greenschist-facies and locally intensely folded. Coextensive with widely occurring rocks within neighboring Yukon Territory, Canada; potentially representing westernmost known extent of Alexander(?) terrane. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

PZk - Kaskawulsh Group, Metavolcanic rocks (Mississippian to Ordovician) Chiefly schistose, fine-grained metaandesite tuff and flows, and coarse-grained breccia and conglomerate, along with minor dark-gray argillite. Metavolcanic and volcanoclastic rocks massive to crudely layered. Metavolcanic breccia and conglomerate contain fragments of fine-grained metavolcanic rocks as much as 1 cm diameter. Includes local metamorphosed hypabyssal intrusive rocks, chiefly meta-hornblende diorite. Description from source map: BG002

IPvs - Metamorphic rocks between Border Ranges and Hubbard Faults, Metasedimentary and metavolcanic rocks (Pennsylvanian, and older(?)) Metasedimentary and metavolcanic rocks. Dominantly interlayered quartz-feldspar mica schist and mica-quartz schist and subordinate marble beds or lenses. Description from source map: MS002

IPv - Metamorphic rocks between Border Ranges and Hubbard Faults, Metavolcanic rocks (Pennsylvanian, and older(?)) Mainly dark green metatuff with minor carbonate and chert. Description from source map: MS002

IPvs - Metamorphic rocks between Border Ranges and Hubbard Faults, Metasedimentary and metavolcanic rocks (Pennsylvanian, and older(?)) Metasedimentary and metavolcanic rocks. Dominantly interlayered quartz-feldspar mica schist and mica-quartz schist and subordinate marble beds or lenses. (NSA = 7240 on WRST map). Description from source map: YA002

IPv - Metamorphic rocks between Border Ranges and Hubbard Faults, Metavolcanic rocks (Pennsylvanian, and older(?)) Mainly dark green metatuff with minor carbonate and chert (NSA =

7240 on WRST map). Description from source map: YA002

PZv - Kaskawulsh Group -- metavolcanic rocks (Devonian and older(?)) Massive to thinly banded, green to greenish black recrystallized mafic volcanic rocks (7240 on WRST map). Description from source map: YA002

PZvp - Kaskawulsh Group -- interbedded metavolcanic and metasedimentary rocks (Devonian and older(?)) Foliated and doubly folded massive to thinly banded mafic metavolcanic rocks; typically greenschist, semischist to mica schist, and thin pods and beds of marble. (7240 on WRST map). Description from source map: YA002

Dkm - Kaskawulsh Group, Calcschist (early Late or Middle Devonian) Massive to thick-bedded, gray to white fine- to coarse-grained marble, dolomite, and muscovite-quartz-calcite schist; commonly complexly and tightly folded into isoclinal folds. Fossils: Contains sparse tabulate corals and *Amphipora* of Middle or early Late Devonian age. Description from source map: BG002

PZk - Kaskawulsh Group of Kindle (Devonian (?) and Older (?) Paleozoic) Mainly thick-bedded, fine- to coarse-grained, locally schistose, banded, or granulated marble, also schist, phyllite, and minor amphibolite, all strongly schistose. Fossils: Tabulate horn corals suggest a Devonian age. Description from source map: MC002

PZp - Kaskawulsh Group -- metasilite (Devonian and older(?)) Dark-reddish brown weathering, black massive meta-siltstone interbedded with marble. Description from source map: MS002

PZm - Kaskawulsh Group -- marble (Devonian and older(?)) Massive to thin-bedded white, gray, and black marble in complexly folded beds and lenses totaling more than 1,000-m-thick. Description from source map: MS002

PZs - Quartz mica schist (Early(?) Paleozoic) Tan, light-gray, and light-gray-green quartz-muscovite schist, quartz-muscovite-chlorite schist, dark-gray graphitic schist, and minor calcareous mica schist. Regionally metamorphosed (greenschist facies). Description from source map: NB002

Ddg - Diorite-gabbro (Devonian)

Dark-greenish-gray, fine- to coarse-grained augite- and hornblende-bearing mafic diorite and gabbro. Regionally metamorphosed (greenschist facies). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

MZPZi - Diorite-gabbro (Devonian) Dark-greenish-gray, fine- to coarse-grained augite- and hornblende-bearing mafic diorite and gabbro. Regionally metamorphosed (greenschist facies). Description from source map: NB002

Dg - Greenstone (Devonian)

Dark-greenish-gray massive greenstone. Locally contains thin septa of phyllite. Regionally metamorphosed (greenschist facies). Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Dg - Greenstone (Devonian) Dark-greenish-gray massive greenstone. Locally contains thin septa of phyllite. Regionally metamorphosed (greenschist facies). Description from source map: NB002

DI - Limestone (Devonian)

Gray to dark-gray recrystallized limestone. Regionally metamorphosed (greenschist facies).

Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

DI - Limestone (Devonian) Gray to dark-gray recrystallized limestone, weather light-gray, and forms conspicuous castles and pinnacles protruding above generally colluvium covered phyllite surface. Regionally metamorphosed (greenschist facies). Fossils: Rugose and tabulate corals from widely scattered localities indicate a Middle Devonian age. Description from source map: NB002

Dp - Metasedimentary rocks (Devonian)

Mainly phyllite, also includes calcareous mica-schist, quartzite, metaconglomerate, and thin marble lenses. Greenschist-facies metamorphism. Contains poorly preserved Devonian fossils. Description from source map: [Geologic Map of Wrangell-Saint Elias](#)

Dp - Phyllite (Devonian) Dark- to light-gray phyllite and brownish-gray metaconglomerate, containing clasts of quartz mica schist, quartzite, calcareous mica schist, quartz-chlorite schist and thin marble lenses. Regionally thermally metamorphosed (greenschist facies). Description from source map: NB002

Dms - Phyllite (Devonian) Dark-gray phyllite, dark-gray to buff quartzite, calcareous quartzite, porcellanite, buff to light-gray calcareous quartz mica schist, and light-gray marble. Regionally metamorphosed (greenschist facies). Description from source map: NB002

Geologic Map of Alaska Unit Descriptions

Unit descriptions from the Geologic Map of Alaska (SIM-3340) are provided for units present in the WRST GRI digital geologic-GIS data. As previously mentioned, the Geologic Map of Wrangell-Saint Elias (SIM-2877) is the primary source of most units in the GRI digital geologic-GIS map, so many units on the more generalized SIM-3340 are subdivided based on SIM-2877. For example, unit Qs (on SIM-3340, see listing and description below) is divided into units Qa, Qcb, and many other units, whereas unit QTgm (on SIM-3340, see listing and description below) is represented by just one unit, QTy. Following each unit description is a list of the GRI subdivided units. In the GRI digital geologic-GIS data the SIM-3340 unit symbols are found in the field named STATE_LABEL2.

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: [Qa](#), [Qcb](#), [Qrg](#), [Qag](#), [Qsm](#), [Qfl](#), [Qms](#), [Qe](#), [Qb](#), [Ql](#), [Qu](#), [Qs](#), [Qic](#), [Qao](#), [Qg](#), [Qcr](#), and [Qo](#) 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 Edgumbe 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: [Qwws](#), [Qwwv](#), [Qwd](#), [Qvd](#), [Qpf](#), [Qbc](#), [Qws](#), [Qwc](#), [Qwcr](#), [Qwj](#), [Qwid](#), [QTw](#), [QTwr](#), and [QTwt](#) 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 divided into units: [Qwdr](#), [Qwsr](#), [Qwcr](#), [Qwid](#), and [QTwr](#) in the GRI digital geologic-GIS data.

QTgm - Yakataga and Tugidak Formations (Quaternary and uppermost Tertiary)

Mudstone, siltstone, sandstone, and diamictite in a diverse marine and glaciomarine clastic continental shelf deposit. Winkler and Plafker (1993) and Plafker and Addicott (1976) report that the Yakataga Formation is more than 1,670 m thick on Kayak and Wingham Islands and at least an additional 1,200 m thick on Middleton Island, suggesting a total thickness of about 3,000 m. George Plafker (written commun., 2002) reports that the Yakataga Formation is at least 4,000 m thick in the Mount Saint Elias and Mount Fairweather quadrangles. Interbedded gray to dark-gray and greenish-gray siltstone, mudstone, and sandstone predominate in lower third of formation. Till-like diamictite is interbedded with siltstone and sandstone in all but the lowest part of the formation and is the dominant rock type in the upper part of the formation, particularly on Middleton Island. Conglomerate is a minor lithology throughout the formation, and scattered larger clasts, presumably dropstones, are present in all lithologies. In most exposures, the Yakataga Formation is conformable and gradational on the underlying Poul Creek Formation; locally there is an angular unconformity of up to 15 degrees (Plafker and Addicott, 1976). Age control derived from abundant mollusks and foraminifers, although most are identical to living species (Winkler and Plafker, 1981; Plafker and Addicott, 1976). Tugidak Formation on Trinity Island is similar and consists of 1,500 m of interbedded sandstone and siltstone characterized by randomly distributed pebbles and cobbles of glacial-marine origin (Allison, 1978). Richly fossiliferous, it contains marine fossils of Pliocene age. Allison (1978, p. 177) reported the occurrence of a diverse fauna consisting of more than 80 species that are “* * * largely composed of living, cold-water, North Pacific and Arctic taxa” and indicate water conditions colder than the present Gulf of Alaska. Allison (1978) suggested that deposition occurred in the upper part of the outer neritic zone in water depths between 91 and 145 m. The Albatross sedimentary sequence of Trinity Island (Clendenen and others, 1992) includes diamictite, sandstone, and siltstone. Conglomerate horizons contain clasts of granite, chert, mélange, and slate. Also contains distinctive calcareous shale clasts unlike any nearby exposed units. Calcareous shale clasts contain a late early Miocene fauna of foraminifers and flora of diatoms.

This unit is [QTy](#) 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 divided into units: [QTw](#), [QTwr](#), and [QTwj](#) in the GRI digital geologic-GIS data.

Twv - Wrangell Lava (Tertiary, Pliocene to Oligocene)

Consists of basaltic andesite, andesite, and dacite lava flows; andesitic lahar deposits and andesite to dacite porphyry, diorite, and quartz diorite. This is the older part of the Wrangell Lava in the McCarthy and Nabesna quadrangle, exposed on either side of the Totshunda Fault and in the adjacent Yukon. Includes the Sonya Creek and other Tertiary volcanic centers. Includes rhyolitic rocks, domes, hypabyssal, and plutonic rocks (Richter and others, 2006). K/Ar ages of volcanic rocks range between 26.3 ± 0.8 and 8.8 ± 0.9 Ma, whereas intruding plutons have K/Ar ages that range from 9.4 ± 0.7 to 3.41 ± 0.46 Ma. On generalized map, included as part of unit Tv.

This unit is divided into units: [QTw](#), [Tp](#), [Th](#), [Tw](#), [Twr](#), and [Twd](#) in the GRI digital geologic-GIS data.

Tmi - Younger granitic rocks (Tertiary, Pliocene to Miocene)

Medium- to coarse-grained, equigranular, granodiorite to quartz diorite plutons and stocks that have hornblende, biotite, and pyroxene as mafic minerals typically surrounded by well-developed hornfels zones and sporadic hydrothermal alteration in country rocks. Includes finer grained plutons and phases. Along the Alaska Peninsula and Aleutian Islands, plutons are typically located along Pacific coast and include, but are not limited to, large plutons on Unalaska Island at Captains Bay, and at Moss Cape on the southern Alaska Peninsula, American Bay, Mitrofanina Island, Devils Bay (Devils batholith, Detterman and others, 1981), Agripina Bay, Cape Igvak, and Cape Douglas (Wilson and others, 1999, 2015). In the McCarthy quadrangle of east-central Alaska, includes fine- to medium-grained hypidiomorphic granular rocks of granodiorite, subordinate granite, and local dioritic or gabbroic border zones (MacKevett, 1978; Richter and others, 2006). In southern southeast Alaska, includes a suite of alkalic granite largely in the Petersburg quadrangle, plutons of varying composition in the Petersburg, Bradfield Canal, Ketchikan, Craig, and Port Alexander quadrangles (Eberlein and others, 1983; Brew and others, 1984; Koch and Berg, 1996; Karl and others, 1999), and small, undated plugs of leucocratic, medium-grained quartz monzonite in the Skagway quadrangle (Redman and others, 1984). Radiometric ages range from about 23.5 Ma to as young as 2.1 Ma (Carr and others, 1970; Marlow and others, 1973; Citron and others, 1980; Wilson and others, 1981; Douglas and others, 1989; Wilson and Shew, 1992).

This unit is [Tg](#) in the GRI digital geologic-GIS data.

Tcc - Gneiss and amphibolite (Tertiary, Miocene)

Banded granite and quartz diorite gneiss of the Cottonwood Creek Complex of Richter (1976) enclosed in schist and phyllite. Greenschist to amphibolite facies metamorphism yields a $40\text{Ar}/39\text{Ar}$ biotite metamorphic age of 18.0 ± 0.7 Ma (Richter, 1976). Complex occurs within Denali Fault System in the eastern Nabesna quadrangle. A similar package of rocks occurs in the western Mount Hayes quadrangle between strands of the Denali Fault System and consists chiefly of fine- to medium-grained, metamorphosed diorite and minor quartz diorite, granite, granodiorite, and gabbro that has relict hypidiomorphic-granular texture. The rocks are moderately deformed and exhibit moderate schistosity that dips steeply to vertically and strikes west-northwest (Nokleberg and others, 1992a). These rocks yield latest Oligocene and early Miocene K/Ar ages (Nokleberg and others, 1992b). Both packages appear to be spatially associated with metasedimentary rocks of Triassic and Devonian age.

This unit is [Tc](#) 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 $^{40}\text{Ar}/^{39}\text{Ar}$ hornblende plateau age of 115 ± 2 Ma, but either the age or the sample setting must be considered suspect because this is significantly older than the unit it intrudes; an intermediate-composition dike yielded an $^{40}\text{Ar}/^{39}\text{Ar}$ 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 $^{40}\text{Ar}/^{39}\text{Ar}$ 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 $^{40}\text{Ar}/^{39}\text{Ar}$ plateau age on amphibole from an andesite dike yielded an age of 58.64 ± 0.52 Ma. Unit also includes unit TJs 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 divided into units: [Tp](#), [Td](#), and [Tm](#) 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 [Ts](#) in the GRI digital geologic-GIS data.

Top - Redwood and Poul Creek Formations (Tertiary, Miocene to Eocene?)

These units, exposed in northeast Prince William Sound, are a generally coarsening-upward sequence of marine deposits. The stratigraphically higher Redwood Formation has two members: the upper Puffy Member that contains as much as 50 percent conglomerate, conglomeratic mudstone, and sandstone in addition to siltstone, mudstone, and claystone, and the lower unnamed member that consists of thick-bedded sandstone and silty sandstone and siltstone (Winkler and Plafker, 1981). The underlying Poul Creek Formation consists of about 1,600 m of concretionary, glauconitic, dark-gray to greenish-gray siltstone, claystone, and sandstone and subordinate dark-brown laminated shale rich in organic material, silty shale, and gray calcareous sandstone; it locally includes thin interbeds of basaltic tuff (Miller, 1975; Winkler and Plafker, 1993). Siltstone, mudstone, and claystone of the Redwood Formation are similar in appearance to parts of the underlying Poul Creek Formation but contain few or no concretions, no glauconitic or volcanic beds, and are sandier and more resistant to erosion (Winkler and Plafker, 1993). Fossil control from mollusks suggests an age range of late Eocene through the Oligocene for both units (Addicott and others, 1978), whereas foraminifera indicate younger ages and that the Redwood Formation may extend into the late Miocene (Rau and others, 1977, cited in Winkler and Plafker, 1981; Rau and others, 1983, cited in Winkler and Plafker, 1993). Deposition was in cold to cool waters, below wave base at neritic or bathyal depths (Plafker and others, 1994). Intercalated basaltic fragmental rocks and less common pillow basalt indicate episodic submarine mafic volcanism in the basin during deposition of the Poul Creek Formation (Plafker, 1974).

This unit is [Tps](#) in the GRI digital geologic-GIS data.

Tcp - Younger phase, Coast plutonic complex of Brew and Morrell (1979b) (Tertiary, Eocene)

Consists of biotite-dominant, hornblende- and sphene-bearing granodiorite and subordinate quartz monzonite, quartz diorite, and leucogranite found in Coast Mountains of southeast Alaska (Berg and others, 1978, 1988; Elliott and Koch, 1981; Brew and others, 1984; Webster, 1984; Brew and Grybeck, 1984; Brew and Ford, 1977, 1985; Souther and others, 1979; Redman and others, 1984; Barker and others, 1986; Gehrels and Berg, 1992; Karl and others, 1999; Brew and Friedman, 2002). These plutons are found in a belt adjacent to the international border along the east side of southeast Alaska. Associated is migmatite that consists of schist, gneiss, tonalite, and granodiorite that is invaded by the plutonic rocks of this unit. The migmatite includes stockwork agmatite and banded hornblende gneiss and biotite-hornblende gneiss, amphibolite, biotite quartz schist, and some calc-silicate rocks (Brew and Grybeck, 1984; Koch and Berg, 1996). Radiometric ages vary; K/Ar ages on biotite and hornblende yield both concordant and discordant Eocene ages, whereas U/Pb analyses (Barker and others, 1986; Aldrick and others, 1987; Berg and others, 1988) yield Eocene ages. Age determinations primarily reflect timing of intrusions; the original country rock many have been significantly older. On generalized map, included as part of unit TKcp.

This unit is [Tgp](#) 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 Segum 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 [Tgp](#) 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 divided into units: [Tgp](#), [Tgt](#), and [Tsq](#) 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 [Tgp](#) in the GRI digital geologic-GIS data.

Tes - Tokun and Stillwater Formations and similar rocks (Tertiary, Eocene)

Units are restricted to eastern Prince William Sound and consist primarily of siltstone and less common interbedded sandstone (Nelson and others, 1985; Winkler and Plafker, 1981, 1993; George Plafker, written commun, 2003). Marine units are separated by the nonmarine Kulthieth Formation (unit Tkf, below). Siltstone of Tokun Formation is concretionary, and sandstone appears to be present mostly in lower part of formation. "Siltstone generally is medium to dark gray and nearly massive; locally, thin beds and lenses of lighter gray, brown-weathering calcareous siltstone and silty limestone are found within darker siltstone. Spherical calcareous concretions as much as 1 m in maximum dimension are distributed randomly or along bedding surfaces in siltstone. Interbedded sandstone in Tokun, which generally is lighter gray than the siltstone, is micaceous, feldspathic, and brown weathering" (Winkler and Plafker, 1993). Tokun Formation has a gradational to sharp contact with the overlying Poul Creek Formation (unit Top) and a gradational contact with underlying Kulthieth Formation (unit Tkf) (Winkler and Plafker, 1981). "Lithology and megafauna indicate general deposition under quiet bottom conditions seaward of the surf zone in tropical to warm temperature water" (Miller, 1975, cited in Winkler and Plafker, 1981). Unit is a transgressive marine sequence approximately 1,070 m thick (Winkler and Plafker, 1981). Fossil crabs are abundant, especially in the upper part of the formation, and occur intact in concretions (Winkler and Plafker, 1981). Siltstone of underlying Stillwater Formation is carbonaceous or calcareous; calcareous siltstone commonly contains foraminifers (Nelson and others, 1985; Winkler and Plafker, 1993; George Plafker, written commun, 2000). Lithology and microfauna of lower part of formation indicates marine deposition in neritic to upper bathyal depths (Tysdal and others, 1976; Winkler and Plafker, 1981). Grades upward into the nonmarine rocks of the overlying Kulthieth Formation (Miller, 1951; MacNeil and others, 1961). "The Stillwater Formation is complexly deformed and is characterized by tight folds and shearing in incompetent strata; hence its thickness can be estimated only crudely to be at least 1,500 m" (Plafker, 1974; cited by Winkler and Plafker, 1981). Age control derived from poorly constrained ages of foraminifers and mollusks, ranging from possibly Paleocene to middle Eocene (from the foraminifers) or to middle or early late Eocene (from the mollusks) (Winkler and Plafker, 1981). Unit also includes siltstone of Oily Lake, as defined by Plafker (1987), which consists of 100 to 200 m of thick-bedded dark-gray to greenish-gray siltstone and very-fine grained sandstone of middle Eocene age. Unit contains a small proportion of basaltic tuff. On generalized map, included as part of unit Tspw.

This unit is divided into units: [Tt](#), [Tk](#), and [Tos](#) in the GRI digital geologic-GIS data.

Tkf - Kulthieth Formation (Tertiary, Eocene)

Exposed in eastern Prince William Sound, unit consists of mostly fluvial and lacustrine deposits and local debris flow deposits and some shallow marine deposits. Unit contains at least 3,000 m of orange-weathering, light gray feldspathic to lithofeldspathic sandstone and calcareous sandstone interbedded with dark-gray siltstone, pebble conglomerate, and many thin beds of coal. Commonly well-indurated with bituminous coal. "Sandstone to shale ratios in measured sections of the Kulthieth Formation (Martin, 1908) average about 1:1. Sandstone varies from massive intervals as much as 150 m thick to thin-bedded and shaly intervals. Bituminous to semi-anthracite coal in beds as much as 3 m thick is conspicuous, but minor part of sequence. Commonly intensely deformed into imbricated stacks of fault-bounded chevron folds displaying shearing and structural thinning and thickening of coal beds" (Winkler and Plafker, 1993). Bedding plane thrusts tend to be localized in coal beds (George Plafker, written commun., 2003). Sparse warm-water marine molluscan megafauna and locally abundant subtropical plant fossils are present; unit has minor tongues of transitional marine strata lithologically similar to the underlying Stillwater Formation and overlying Tokun Formation (Nelson and others, 1985). Age control derived from widespread fossil plant collections and a single mollusk collection near the top of the section (Winkler and Plafker, 1981). Mollusks indicate a late Eocene age, whereas fossil plant collections indicate wider range, from late middle Eocene to early Oligocene (Winkler and Plafker, 1981; Wolfe, 1977), but the widely accepted age for the unit is Eocene. On generalized map, included as part of unit Tspw.

This unit is [Tk](#) in the GRI digital geologic-GIS data.

Tos - Sedimentary rocks of the Orca Group (Tertiary, Eocene to Paleocene)

Thin- to thick-bedded graywacke sandstone, siltstone, mudstone, slate, and, locally, minor conglomerate, which display abundant sedimentary structures, such as graded bedding, crossbedding, and ripple marks, along with flute, groove, and load casts, which together indicate deposition from turbidity currents (Tysdal and Case, 1979; Nelson and others, 1985). Graywacke sandstone is more abundant than finer-grained rocks (Tysdal and Case, 1979). Bioturbated limestone lenses and concretions are found locally and, along with conglomerate, are characteristic of the unit (Moffit, 1954; Tysdal and Case, 1979; Nelson and others, 1985). Matrix-supported conglomerate and pebbly mudstone and sandstone lenses are widespread (Winkler and Plafker, 1993). Conglomerate "ranges from matrix-supported pebbly mudstone and sandstone to massive clast-supported pebble, cobble, and boulder conglomerate" (Nelson and others, 1985). The generally well-rounded clasts consist primarily of extrabasinal felsic volcanic and igneous rocks (felsic porphyry and tuff, granitic rocks, and white quartz) and intrabasinal sedimentary and mafic rocks (greenstone, sandstone, siltstone argillite, and limestone (Nelson and others, 1985; Winkler and Plafker, 1993; Winkler and Tysdal, 1977; Moffit, 1954). Conglomerate usually occurs as lenses 90 to 210 m thick, though the thickest lens measured 900 m thick (Nelson and others, 1985). Matrix-supported conglomerate and pebbly mudstone may have been formed by submarine landslides on unstable slopes, whereas inversely and normally graded clast-supported conglomerate beds are channel-fill deposits (Winkler and Tysdal, 1977). Thin-section petrography shows that most of the sandstone is feldspathic to feldspatholithic (Nelson and others, 1985) and contains abundant monocrystalline quartz, which indicates a plutonic provenance (Dumoulin, 1987, 1988). Unit metamorphosed to zeolite or prehnite-pumpellyite facies in the Cordova and Middleton Island quadrangles (Winkler and Plafker, 1993); Nelson and others (1985) reported that alteration ranges from diagenetic recrystallization of the matrix to low greenschist-facies metamorphism. In the Seward and Blying Sound quadrangles, unit also includes rocks mapped as siltstone by Tysdal and Case (1979). Their siltstone unit is locally tightly folded and metamorphosed to slate; medium-gray and green lenses of micritic limestone as much as 2 m thick are present locally. At several places in the islands south of Knight Island Passage, Tysdal and Case (1979) describe locally folded and contorted sequences of siltstone and isolated greenstone blocks mixed in with sandstone and siltstone within otherwise uniformly layered sections that they thought were olistostromes. Fossils reported by Nelson and others (1985) include: *Alnus* (Alder) pollen; foraminifers: *Globogerina* sp., *G. senni*, *Globogerina* sp. (hispid), and *Globorotalia* sp.; and echinoids: *Holaster* sp.?, *Hypsopygaster* sp., and *Nucleopygus* as well as a crab, *Branchioplax washingtoniana*, and a pelecypod, *Acila decisa*, reported by Addicott and Plafker (1971, cited in Nelson and others, 1985), which together suggest a Paleocene(?) to late Eocene age. On generalized map, included as part of unit Tovs.

This unit is [Tos](#) in the GRI digital geologic-GIS data.

Tovs - Sedimentary and volcanic rocks of the Orca Group, undivided (Tertiary, Eocene to Paleocene)

Consists of locally variable amounts of tholeiitic basalt and tuffaceous and generally minor turbiditic sedimentary rocks (Tysdal and Case, 1979; Nelson and others, 1985; Winkler and Plafker, 1993; Wilson and others, 2012) in Prince William Sound. Volcanic rocks are pillowed, and massive basalt flows, pillow breccia, and tuff are intermixed and interbedded with turbiditic mudstone, siltstone, and fossiliferous volcanogenic sandstone; locally nonvolcanogenic sandstone is interbedded (Winkler and Plafker, 1993). Locally subdivided into units Tos, below, and Togv, described with the volcanic rocks on p. 80.

This unit is [Tos](#) in the GRI digital geologic-GIS data.

Togv - Volcanic rocks of the Orca Group and Ghost Rocks Formation (Tertiary, Eocene to Paleocene)

The volcanic rocks of the Orca Group consist of thick to thin tabular bodies of altered tholeiitic basalt that have pillowed, massive, or crudely columnar flows and also include pillow breccia, aquagene tuff, and diabase or gabbro sills; pillows have palagonitic and amygdaloidal chilled margins (Winkler and Plafker, 1993). Also includes mafic sheeted-dike complexes that consist of dark-green, gray, and brown, aphanitic to porphyritic, chiefly basaltic, but locally gabbroic to dioritic dikes (Tysdal and others, 1977; Tysdal and Case, 1979; Winkler and Plafker, 1993). Minor interbedded mudstone and siltstone included locally. Commonly contains green, gray, or red chert in interstices between pillows; rarely includes interpillow clots of pink limestone or black mudstone. In the Knight Island area, felsic plagioclase-quartz dikes occur locally and plagioclase-clinopyroxene-olivine dikes are present but not common (Tysdal and Case, 1979). The dikes are commonly 1 to 2 m thick, vertical or nearly so, and generally strike north (Tysdal and others, 1977; Tysdal and Case, 1979). The dikes contain greenschist facies mineral assemblages ascribed to ocean-floor metamorphism by Bradley and Miller (2006). The dikes crosscut one another, intrude the adjacent pillow basalt, and, on Knight Island, locally intrude sedimentary rocks of the Orca Group (Tysdal and others, 1977). Pillow basalt screens are common in the up-to-2-km-wide transition zone between the pillow basalt and sheeted dike units (Tysdal and others, 1977; Tysdal and Case, 1979; Miller, 1984; Bradley and Miller, 2006). Xenoliths of gabbro and peridotite are present locally on Knight Island (Richter, 1965; Nelson and others, 1985). Small irregular pods, veins, and dikes of plagiogranite are also present in the dike complex north of Bay of Isles on Knight Island (Nelson and others, 1985). The dikes are intruded by and also intrude the gabbro in the transition zone between the gabbro and sheeted dike units (Tysdal and Case, 1979; Tysdal and others, 1977). The dikes make up the topographically high and rugged core of Knight and Glacier Islands (Tysdal and others, 1977). Whole rock K/Ar ages on greenstone, reported by Miller (1984), are 38.8 ± 1.9 and 35.0 ± 1.3 Ma on Knight Island; Miller (1984) interpreted these ages to represent minimum ages for accretion due to heating during the accretionary event that may have caused argon loss. The Ghost Rocks Formation, exposed along the Pacific Ocean side of the Kodiak Island archipelago, consists of tholeiitic basalt that occurs within both sandstone- and argillite-rich subunits of the Ghost Rocks Formation. Rocks are typically altered by shearing and low-grade metamorphism. The basalt is included in this unit and, according to Moore and others (1983, p. 270), “* * * these lavas cannot have been derived from a single source and in many respects exhibit chemical affinities to magmas found in a variety of tectonic environments.” Mafic and ultramafic intrusive rocks of the Orca Group are included in unit Togum.

This unit is [Tov](#) 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, Ogluiga, 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 divided into units: [Tm](#), [Tps](#), and [Tvu](#) in the GRI digital geologic-GIS data.

Togum - Mafic and ultramafic rocks of the Valdez and Orca Groups (Tertiary, Eocene to Paleocene)

Dark-gray, fine- to medium-grained locally porphyritic gabbro that occurs in distinct mafic-ultramafic complexes in the Prince William Sound region. The largest exposure is on Esther Island (Tysdal and Case, 1979). Several small intrusive bodies of gabbro occur on Knight Island, where they intrude sheeted dikes of unit Togb of Nelson and others (1985, included in unit Togum, here). On the Resurrection Peninsula in the Seward quadrangle, Miller (1984) described local occurrences of west-dipping magmatic mineral layering and cumulate textures within the gabbro. The gabbro grades into the sheeted dike map unit (Togv herein) and is generally elongate and parallel to the sheeted dikes, but it also crosscuts the dikes locally (Tysdal and Case, 1979; Miller, 1984). Tysdal and Case (1979) state that, on the Resurrection Peninsula, "The gabbro intrudes slate and sandstone of the Valdez Group, crosscuts the bedding, and forms aphanitic sills in other places. A blue-gray and whitish thermal aureole, at least 200 m wide, marks the contact zone with the sedimentary rocks." Nelson and others (1985) and Bradley and Miller (2006) instead interpreted the contacts between the gabbro and Valdez metasedimentary rocks on the Resurrection Peninsula as faults. On Knight Island, the gabbro intrudes rocks of the Orca Group. Nelson and others (1989) reported a 57 Ma U/Pb zircon age on a plagiogranite that intrudes the gabbro on the Resurrection Peninsula. The ultramafic rocks are primarily exposed in the Cordova quadrangle and in a small exposure associated with the Resurrection Peninsula ophiolite. The larger exposure is part of a compositionally and texturally variable unit that consists mainly of medium-grained gabbro, local diabase, hornblende gabbro, peridotite, and orthopyroxenite (Winkler and Plafker, 1993). Exposures associated with the ophiolite

consist of dunite, locally with layers of chromite, moderately to mostly altered to serpentine, serpentine-talc, and talc schist (Tysdal and Case, 1979). "In most places enough relict texture and mineralogy remains to recognize original clinopyroxenite, dunite, and harzburgite" (Miller, 1984). Unit occurs as small pods in gabbro and fault-bounded slices within Valdez Group metasedimentary rocks (Miller, 1984; Nelson and others, 1985). On Knight Island, xenoliths of peridotite in sheeted dikes were observed by Richter (1965) but not by subsequent workers (Tysdal and Case, 1979; Nelson and others, 1985). Nelson and others (1985) mapped three peridotite bodies, including two that lie within or near a shear zone in their sheeted dikes unit Tod (unit Togv, here) and the other body occurs as a xenolith in the sheeted dikes unit. These ultramafic rocks weather orange-brown in color and form subdued rubble outcrops.

This unit is divided into units: [Tmu](#) and [Kvu](#) 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 $^{40}\text{Ar}/^{39}\text{Ar}$ 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 SiO_2 contents, having as much as 6 percent K_2O at 60 percent SiO_2 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: [Tgp](#) in the GRI digital geologic-GIS data.

Kaf - Chugach flysch (Upper Cretaceous)

Extensive unit includes Valdez Group and Kodiak and Shumagin Formations, which extend from southeast Alaska to the western end of the Alaska Peninsula around the Gulf of Alaska. Formations generally consist of very fine- to medium-grained, medium-light-gray to medium-dark-gray, highly indurated, lithic graywacke and siltstone that generally increases in metamorphic grade to the northeast (Dusel-Bacon and others, 1993, 1996). At Sanak Island and in the Shumagin Islands in southwest Alaska, Shumagin Formation is largely not metamorphic, except for some contact metamorphism around the Sanak and Shumagin plutons. Kodiak Formation displays very low-grade metamorphism, and the Valdez Group is locally metamorphosed to amphibolite facies in the northeastern part of its exposure range. Shumagin Formation consists of interbedded sandstone, siltstone, mudstone, and shale at least 3,000 m thick (Burk, 1965; Moore, 1974a). Sandstone beds in unit vary in thickness from 2 cm to 20 m, are graded, and contain abundant shale and siltstone chips (Moore, 1974a; Detterman and others, 1996). Thin (<10 cm) grayish-black mudstone is interbedded with sandstone; however, locally, mudstone forms dominant lithology. Thin-bedded siltstone, mudstone, and sandstone sequences are rhythmically bedded and have sharp upper and lower contacts indicative of turbidity-current deposition in deep-sea-fan and abyssal-plain environments. Fossils are uncommon in Shumagin; existing collections indicate early Maastrichtian age (J.W. Miller, written commun., 1983–88, oral commun., 1991), which is age-equivalent to upper parts of Hoodoo,

Kaguyak, and Chignik Formations (units Khk, and Kcs, respectively). Shumagin is a trench- and abyssal-plain-facies equivalent of Hoodoo Formation (Mancini and others, 1978); Plafker and others (1977) correlated Shumagin Formation with Kodiak Formation of the Kodiak Islands and with the Valdez Group of south-central Alaska. Thin-section analysis of samples by John Decker (DGGS, oral commun., 1985), suggests close lithologic correlation with Kodiak Formation on Kodiak Island. According to Decker, protolith for Shumagin was derived from north and transported along paleo-Aleutian trench, though a component of apparently local derivation has same provenance as Hoodoo Formation. Kodiak Formation consists of medium- to thick-bedded graded bed sequences, averaging 1 m thick, of arkosic wacke and shale that has occasional beds of pebbly conglomerate. Flute casts and complete Bouma sequences indicate deposition by turbidity currents below wave base. Moore (1969) designated the type section along the west shore of Uyak Bay. Nilsen and Moore (1979) indicated that the unit is approximately 5,000 m thick, in contrast to the estimate of 30,000 m originally suggested by Moore (1969). Nilsen and Moore (1979) found that the unit is repeated structurally by folding and faulting, which makes internal stratigraphic correlation difficult. Nilsen and Moore (1979) used a turbidite facies and facies association scheme that generally followed the system of Mutti and Ricci Lucchi (1972, 1975, cited in Nilsen and Moore, 1979) and Nelson and Nilsen (1974, cited in Nilsen and Moore, 1979); under this system the Kodiak Formation consists largely of the basin-plain and slope-facies associations. The basin-plain facies is the structurally lowest part of the Kodiak Formation and is characteristic of most of the unit on the southeast side of Kodiak Island (Nilsen and Moore, 1979). Slope facies occur primarily on the northwest side of Kodiak Island and are primarily thick mudstone sequences and “* * * may form imbricate slices juxtaposed during multiple phases of synsedimentary slumping * * * [and may] contain chaotically oriented blocks, slabs, and disordered fragments of hemipelagic mudstone that probably slid from upper slope depositional sites to the lower slope or base of slope under the influence of gravity” (Nilsen and Moore, 1979, p. 6). Conglomerate and sandstone channels occur locally within the slope facies associations; Nilsen and Moore (1979) mention occurrences in Uyak Bay in particular, where they are on the order of 50 m thick. Fossils from the Kodiak Formation include *Inoceramus kusiroensis* of Maastrichtian age. Valdez Group consists of dark-gray, thin- to thick-bedded, moderately to poorly sorted sandstone, siltstone, and mudstone flysch that has been metamorphosed to laumontite to mid-greenschist facies; sandstone is fine- to coarse-grained and mainly composed of plagioclase, quartz, and igneous rock fragments (Tysdal and Case, 1979; Dumoulin, 1987). Unit is a thick sequence of rhythmically alternating, multiply-deformed, metamorphosed sandstone-siltstone turbidites in beds that generally range from a few centimeters to a few meters thick and, locally, massive beds as much as tens of meters thick (Winkler and Plafker, 1981; Nelson and others, 1985; Winkler and Plafker, 1993; Bradley and others, 1999). Point count analysis by Dumoulin (1987) showed Valdez Group sandstone contains 6 to 30 percent quartz, 23 to 45 percent feldspar, and 28 to 68 percent lithic fragments; lithic fragments are dominantly volcanic rocks. Proportion of lithic fragments decreases from west to east, as feldspar and quartz increase (Nelson and others, 1985). Conglomeratic sandstone containing clasts of quartzite, intermediate and felsic volcanic rocks, and rare sandstone, limestone, and granitic rocks is uncommon but widely distributed, occurring at base of some sandstone beds (Bradley and others, 1999; Bradley and Miller, 2006). In some places, primary sedimentary structures such as graded bedding, current-ripple cross-lamination, convolute bedding, and sole markings are preserved (Nelson and others, 1985; Winkler and Plafker, 1993). *Inoceramus kusiroensis*, *I. ulrichi*, and *I. concentrica*, of Maastrichtian age, have been reported (Tysdal and Plafker, 1978; Tysdal and Case, 1979; Nelson and others, 1985; Bradley and others, 1999). Rocks north of Cross Sound in the Glacier Bay region are regionally metamorphosed and range from subgreenschist facies to as high-grade as amphibolite facies, producing graywacke semischist, phyllite, slate, and layered schist, semischist, and gneiss (Brew and others, 1978). These metasedimentary rocks are correlated with strata in the Valdez Group to the northwest by lithologic similarity (Brew and Morrell, 1979a) and by stratigraphic continuity (Plafker and Campbell, 1979; Campbell and Dodds, 1983). More eastern exposures of the Valdez Group contain an increasing proportion of interbedded volcanic rocks; where these igneous rocks dominate, they are described as unit Kafv. A K/Ar date on biotite semischist in the Seward quadrangle of 51.5 ± 1.5 Ma was reported by Nelson and others (1985) and was interpreted as a metamorphic age or a cooling age of Valdez Group schist unit along Placer River Fault. Bradley and others (2009) reported 70-Ma detrital zircons from unit near Anchorage. On generalized map, included as part of unit Kchf.

This unit is divided into units: [Kv](#) and [Kvm](#) in the GRI digital geologic-GIS data.

Kafv - Volcanic rocks of Chugach accretionary complex (Upper Cretaceous)

Tholeiitic metabasalt; massive greenstone; and basaltic metatuff, including local pillow lava, pillow breccia, and gabbroic dikes and sills (Winkler and Plafker, 1993) typically interbedded with flysch of the Valdez Group (unit Kaf) and Sitka Graywacke (unit Ksg). Metabasalt forms rugged, nearly massive outcrops, whereas semischistose metatuff forms more subdued outcrops (Winkler and Plafker, 1993). Dated by association with the sedimentary part of the Valdez Group. Metamorphic grade ranges from prehnite-pumpellyite to lower greenschist facies (Winkler and Plafker, 1993). Basalt and basaltic tuff north of Cross Sound are deformed and regionally metamorphosed as high as amphibolite facies (Gehrels and Berg, 1992; Dusel-Bacon and others, 1996b). Common rock types include schist, gneiss, and amphibolite (Brew and others, 1978). Correlation with volcanic rocks in Valdez Group to northwest suggests a Cretaceous age (Brew and Morrell, 1979a; Plafker and Campbell, 1979). On generalized map, included as part of unit Kchf.

This unit is divided into units: [Kv](#), [Kvm](#), [Kvw](#) and [Kvg](#) in the GRI digital geologic-GIS data.

Ksd - Sandstone, shale, and conglomerate deltaic deposits (Upper and upper Lower Cretaceous)

Nonmarine and delta-plain deposits that grade downward into marine delta-front deposits in east- and west-central and southwestern Alaska. In west-central Alaska, unit includes polymictic conglomerate of the Yukon-Koyukuk Basin (Patton and others, 2009; in press). Fluvial deposits are characterized by fine-grained, locally cross-bedded quartzose sandstone interbedded with micaceous shale and siltstone. Near the base, the fluvial beds are composed of fine- to coarse-grained, lenticular, crossbedded, friable sandstone and conglomerate that contain pebble- to grit-size clasts of quartz and chert and lesser amounts of mafic intrusive and extrusive rocks, and schist clasts. Contains bituminous coal seams as thick as 90 cm. Sandstone and conglomerate clasts suggest a mixed metamorphic and granitic provenance and, in combination with limited paleocurrent data, indicate that the unit prograded westward from a source area in the Ruby terrane bordering the southeastern margin of the Yukon-Koyukuk Basin. Fluvial deposits contain abundant fresh- and brackish-water mollusks and well-preserved plant remains of Late Cretaceous (Cenomanian to Turonian?) age. Shallow marine deposits contain an abundant molluscan fauna of late Early (Albian) and early Late (Cenomanian) Cretaceous age. Unit poorly exposed along the eastern and western margins of the Yukon-Koyukuk Basin. On the western margin of the basin, exposures of this unit are confined to a few small isolated outcrops on the coastal plain in the northern Kwiguk and the southeastern Saint Michael quadrangles. In east-central Alaska, unit includes the sedimentary rocks of the Cantwell Formation (see unit Tpcv for the volcanic rock unit of the Cantwell Formation) as well as continental sedimentary rocks of Turonian to Albian ages in the McCarthy region. Unit consists of a fluvial, intercalated sequence, containing various proportions of conglomerate that is dominantly polymictic, sandstone (including arkose), siltstone, argillite, shale, and a few thin coal beds (Csejtey and others, 1992). Thin volcanic flows and thin tuff layers are present locally. Conglomerate clast lithology varies greatly within the outcrop area, indicating different geologic source areas and deposition by several river systems. Ridgeway and others' (1994) recent palynological analyses suggest an early Campanian to late Maastrichtian age and they report a maximum thickness of 4,000 m for the Cantwell. As mapped here, unit Ksd also includes other nonmarine sedimentary rocks that crop out in east-central and southern Alaska. These chiefly consist of medium- to dark-gray phyllitic shale, sandstone, grit, and conglomerate containing minor carbonaceous shale and tuffaceous sandstone. Locally subdivided into unit TKis; on generalized map, included as part of unit Knmt.

This unit is [Kun](#) in the GRI digital geologic-GIS data.

Keg - Granodiorite and other plutonic rocks (Early Cretaceous, Aptian to Hauterivian)

Fine- to medium-grained hornblende granodiorite, hornblende diorite, and biotite-hornblende monzodiorite and minor quartz diorite and tonalite, generally massive but locally foliated. Unit primarily exposed in southeast and eastern south-central Alaska. In eastern south-central Alaska and the southwest Yukon, granodiorite plutons of this unit are largely exposed along the southwestern side of the Denali Fault System. In the Nabesna quadrangle, a few small plutons of the unit are exposed to the northeast of the Denali Fault System and are much more extensively exposed in the Yukon (Gordey and Makepeace, 2003). In southeast Alaska, these plutons are exposed on either side of the Chatham Strait Fault, most commonly west of the fault in the Mount Fairweather, Sitka, and Juneau quadrangles. Tonalite and trondhjemite of this unit are found on both sides of the Chatham Strait Fault in southeast Alaska as well as in the Anchorage quadrangle. Also includes minor quartz-feldspar porphyry in the Nabesna quadrangle. Radiometric dating of the rocks in this unit is sparse and many of the available K/Ar dates, as young as 91 Ma, are cooling ages and are thought to not be reflective of emplacement; other K/Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ ages are as old as 128 Ma. Trondhjemite and tonalite within the Border Ranges Fault Zone of the Anchorage quadrangle has yielded multiple K/Ar, $^{40}\text{Ar}/^{39}\text{Ar}$, and U/Pb ages between 132 and 110 Ma (Winkler, 1992; Barnett and others, 1994; Amato and Pavlis, 2010); similar trondhjemite in the Bering Glacier quadrangle is undated, but is spatially associated with rocks of the Jurassic-Cretaceous Saint Elias Suite. The isolated Khotol pluton in the Nulato quadrangle of western Alaska is a large (12 km by 20 km), poorly exposed, coarsely porphyritic granite that has large K-feldspar phenocrysts in a moderately coarse groundmass and has yielded an age of 112 Ma K/Ar (Patton and others, 1984).

This unit is divided into units: [Kug](#) and [Kg](#) in the GRI digital geologic-GIS data.

Kgb - Gabbro and diorite of southeast Alaska (Cretaceous)

Primarily gabbro, hornblende gabbro, hornblendite, leucogabbro, and subordinate norite, syenite, and pyroxenite on Prince of Wales Island (Eberlein and others, 1983), Kuiu Island (Brew and others, 1984), and Chichagof Island (also described as the layered gabbro near the head of Tenakee Inlet by Loney and others [1975]), where it is associated with Early Cretaceous granodiorite and diorite (units Keg and KJse) (Loney and others, 1975; Johnson and Karl, 1985). Also includes hornblende diorite and gabbro in the Haines area that grades laterally into granodiorite and quartz diorite. Potassium-argon ages are Late Cretaceous (Redman and others, 1984). Hornblende and biotite diorite of the Jualin Diorite (Knopf, 1911) along east shore of Lynn Canal in the northern Juneau quadrangle has produced a hornfels aureole in adjacent metasedimentary and metavolcanic rocks. Gehrels (2000) reported a U/Pb zircon age of 105 Ma on this pluton. At an unusual occurrence in the Craig quadrangle, epidote replaces the gabbro in irregular masses up to several meters in diameter or as veinlets cutting the rock (Herreid and others, 1978). In thin section, the replacement origin of the epidote is clearly shown by gradational embayed contacts with gabbro. The gabbro, which is a small border phase of Cretaceous granodiorite, contains medium-sized subhedral crystals of sericitized labradorite and subordinate hornblende, pyroxene, ilmenite, sphene, and apatite (Herreid and others, 1978). On generalized map, included as part of unit KPZm.

This unit is [Kg](#) 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 [Kq](#) 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 alkali (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 [Kq](#) 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 Diomedé, 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 [Kg](#) 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 volcanoclastic turbidites and rare nonvolcanoclastic 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 volcanoclastic 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 [Kg](#) in the GRI digital geologic-GIS data.

Khnl - Herendeen Formation and similar units (Lower Cretaceous)

Thin calcarenite, limestone coquina, or similar rock units are widely present in Alaska. Units included are the Herendeen Formation on the Alaska Peninsula, the Nelchina Limestone in south-central Alaska, the Berg Creek Formation of eastern Alaska, and similar unnamed units in southwest and west-central Alaska in the Charley River quadrangle and the Brooks Range ("coquinoid limestone"). The Herendeen Formation was originally described as limestone (Atwood, 1911), but rocks are actually unusually uniform, thin-bedded, medium-grained, calcarenaceous sandstone (Detterman and others, 1996). Inoceramus fragments form major component of formation, although complete specimens have only been found in the Mount Katmai area. Presence of *Buchia crassicolis* indicates a Valanginian age for the Herendeen in its type area, and ammonite fossils and other collections indicate a Hauterivian and Barremian age at its northern extent (J.W. Miller, written commun., 1983–85; Detterman and others, 1996). The Nelchina Limestone (Martin, 1926) of south-central Alaska and the similar Berg Creek Formation (MacKevett and others, 1978) are lithologically similar to the Herendeen, and consists of "massive dark-colored unaltered fine-grained limestone separated by thin laminae of gray shale. Some beds are highly siliceous and probably ought to be called calcareous sandstone (Martin, 1926)." *Buchia crassicolis* has also been reported from the Nelchina Limestone. The coquinoid limestone of the northern Alaska is a "distinctive thin marker unit of gray to dark-gray limestone coquina composed of the pelecypod *Buchia sublaevis*, in beds up to 2 m thick, interbedded with reddish-brown to black clay shale" (Mull and others, 1994); its thickness is less than 10 m. Stratigraphically, unit has been associated with the Okpikruak Formation. Kelley (1990a) states that the unit occurs in both structural and stratigraphic settings; in depositional contact with the Otuk Formation and the undifferentiated Otuk and Shublik Formations; and as tectonic blocks in mélange in his Arctic Foothills assemblage (which is included here in unit JPZs). Tectonic blocks of coquinoid limestone in the Arctic Foothills assemblage, as well as those associated with Okpikruak Formation, may be olistostromal in nature. Other calcareous clastic units of similar age are known from southwestern Alaska (Hoare and Coonrad, 1978), western Alaska (Patton, 1966; Hoare and Condon, 1971; Patton and others, 2009) and in the Charley River area of eastern Alaska (Dover and Miyaoka, 1988). Also includes Kennicott and Kuskulana Pass Formations of eastern Alaska, composed dominantly of thin-bedded, fine-grained feldspathic graywacke and arkosic wacke and siltstone. Also includes shale and some conglomerate whose clasts are predominantly Nikolai Greenstone (unit ^n) at the base (MacKevett and others, 1978). Kennicott Formation is generally dark-greenish-gray, weathers brown, and has crude graded bedding, cross-bedding, sole markings, and spherical limy concretions; the older Kuskulana Pass Formation is generally similar. Both represent fairly rapid shallow marine deposition in a transgressive sea. An Albian age is assigned to the Kennicott on the basis of abundant molluscan fauna, particularly the occurrence of *Inoceramus altifluminis* McLearn (Patton, 1966) and pelecypods of genus *Aucellina*, whereas the age of the Kuskulana Pass Formation is defined as Hauterivian and Barremian based on a meager ammonite and pelecypod fauna (MacKevett and others, 1978). On generalized map, included as part of unit Kcca.

This unit is [Kl](#) in the GRI digital geologic-GIS data.

Km - Matanuska Formation and correlative rocks (Upper Cretaceous to upper Lower Cretaceous)

Matanuska Formation is well-indurated, thinly bedded, dark-gray, fossiliferous marine shale deposited at shallow to moderate depths and contains conspicuous calcareous concretions, volcanic-lithic siltstone, sandstone, graywacke, and subordinate conglomerate (Winkler, 1992). According to Martin (1926), unit is at least 1,250 m thick. Grantz (1964) reported results of a stratigraphic reconnaissance of the Matanuska Formation and found it to include several mappable lithologic units and suggested that when these units are defined as formations, the Matanuska Formation merits elevation to group rank. Winkler (1992) described unit as diverse shallow to deep marine (in part, turbiditic) deposits derived from a northern source, either from an unidentified mid-Cretaceous magmatic arc or from the Jurassic arc represented in part by the Talkeetna Formation. Upper part of unit is coeval with the

flysch of the Valdez Group to the south. Unit overlies and is separated from Early Cretaceous and older strata by a pronounced angular unconformity (Csejtey and others, 1978) and contains locally abundant marine fossils. In Wrangell Mountains, unit consists of Upper Cretaceous sedimentary rocks as defined by MacKevett (1978), which are locally subdivided into (1) Moonshine Creek Formation, siltstone and sandstone, with minor conglomerate; (2) Schulze Formation, porcellanite, with minor sandstone and conglomerate; (3) Chititu Formation, mudstone and shale, subordinate porcellanite, sandstone, and impure limestone; and (4) MacColl Ridge Formation, coarse sandstone and minor granule and pebble conglomerate. These correlate to part of the Matanuska Formation in the Talkeetna Mountains and Matanuska Valley. On generalized map, included as part of unit Ksmc.

This unit is divided into units: [Kl](#) and [Ku](#) in the GRI digital geologic-GIS data.

Kumc - McHugh and Uyak Complexes (Late Cretaceous)

Tectonic mélange that consists of fault-bounded blocks that have protolith ages of Mississippian through mid-Cretaceous; largely of oceanic affinity (Clark, 1973; Connelly, 1978; Tysdal and Case, 1979; Winkler, 1992). Unit is found inboard of the Valdez Group and Kodiak Formation (unit Kaf) around the Gulf of Alaska. According to Clark (1973), the McHugh Complex consists of two lithologically distinct but structurally juxtaposed packages. Dominant or most common is a metaclastic sequence “composed predominantly of gray, gray-green, and dark-green weakly metamorphosed * * * siltstone, graywacke, arkose, and conglomeratic sandstone” (Clark, 1973). A metavolcanic sequence consists of “greenstones of mostly basaltic composition and texture that are commonly associated with radiolarian metachert, cherty argillite, and argillite. Small amounts of ultramafic rocks and marble occur locally as isolated, discontinuous outcrops or lenticular masses” (Clark, 1973). Uyak Complex of Connelly (1978) is similar in character, but the metasedimentary (metaclastic-equivalent) part consists dominantly of deformed gray chert and argillite (Connelly, 1978). Within the McHugh and Uyak Complexes, “broad zones as wide as 1 km of intense shearing lack any stratal continuity and, in many places, are marked by angular, elongate phacoids, either enclosed in pervasively sheared matrix or juxtaposed against other phacoids. Larger phacoids are lithologically diverse, consisting of schist, amphibolite, marble, sandstone, conglomerate, diorite, gabbro, serpentized ultramafic rocks, and mafic volcanic rocks” (Winkler, 1992). Metamorphic minerals include muscovite, epidote, calcite, chlorite, albite, and veinlets of prehnite (Tysdal and Case, 1979). Blocks of mafic and ultramafic rocks are serpentized near their margins (Connelly, 1978). Slickensides are common both as subparallel anastomosing fractures in competent rocks and as closely spaced fractures in less competent rocks (Connelly, 1978). In the McHugh Complex, sedimentary rocks of the matrix have yielded Early Cretaceous (Valanginian) fossils, whereas protolith ages on blocks in the mélange have yielded radiolarians of Cretaceous (Albian-Aptian), Jurassic, and Triassic age (Bradley and others, 1999; Winkler and others, 1981), Permian conodonts and fusulinids of Tethyan affinities (Connelly, 1978; Stevens and others, 1997; Bradley and others, 1999), and Mississippian to Pennsylvanian conodonts (Nelson and others, 1986). Bradley and others (2009) reported 90-Ma detrital zircons from metasandstone collected along Turnagain Arm in the Anchorage quadrangle, within the McHugh Complex. Bradley and others (1999) locally subdivided the McHugh Complex into distinct lithologic packages loosely similar to the two packages originally defined by Clark (1973). On generalized map, included as part of unit Kmuc.

This unit is divided into units: [KJm](#) and [TKm](#) in the GRI digital geologic-GIS data.

KJyg - Yakutat Group, undivided (Lower Cretaceous and Upper Jurassic?)

Heterogeneous assemblage that includes clastic sedimentary rocks, altered volcanic rocks, chert, carbonate, and granitic rocks. Yakutat Group consists of two major subdivisions that are commonly structurally juxtaposed: a flysch facies and a mélange facies (unit Kmy). Shown here, unit is the undivided Yakutat Group and the flysch facies, which locally has been mapped separately (G. Plafker,

written commun., 2000). Flysch facies is dominantly dense, hard, poorly sorted gray to brown feldspathic to lithofeldspathic sandstone (graywacke), pebble-cobble conglomerate, and shale-chip conglomerate in thick channel deposits or rhythmically interbedded and graded with gray to black siltstone, argillite, or slate. Fossils of Campanian age have been reported from the flysch facies (Plafker and others, 1994). Locally, contains very sparse warm water molluscan fauna and abundant carbonized subtropical plant remains (G. Plafker, written commun., 2000). Also included here is the schist of Nunatak Fiord of Plafker (written commun., 2000), which is complexly deformed, interbedded mudstone and sandstone and minor volcanoclastic rocks and conglomerate metamorphosed to greenschist- and epidote-amphibolite facies. At southern extent of outcrop area, unit includes volcanic rocks metamorphosed to as high as amphibolite facies. Crops out between Boundary and Fairweather Fault Systems and intruded extensively by Tertiary granitic plutons (G. Plafker, written commun., 2000).

This unit is divided into units: [Kyb](#), [Kyn](#), and [Kyf](#) in the GRI digital geologic-GIS data.

KJgv - Volcanic rocks of the Gravina-Nutzotin belt (Lower Cretaceous or Upper Jurassic?)

Included here are the Chisana Formation, Douglas Island Volcanics, and Brothers Volcanics, as well as other volcanic rocks in the Gravina-Nutzotin belt that can not be explicitly assigned to the Lower Cretaceous Douglas Island or Brothers Volcanics. Primarily exposed in southeast Alaska but rocks also occur in the Healy quadrangle of central Alaska. Unit consists of andesitic to basaltic flows, flow breccia, agglomerate, and tuff (generally containing conspicuous clinopyroxene phenocrysts), subordinate graywacke and mudstone, and regionally metamorphosed and deformed equivalents of these strata. Chisana Formation is exposed in east-central Alaska; Douglas Island and Brothers Volcanics (part of Stephens Passage Group) are exposed in southeast Alaska on and near Admiralty Island (Latham and others, 1965) and in the Juneau area (Ford and Brew, 1973, 1977; Brew and Ford, 1985). Unit is a thick volcanic arc assemblage of marine and subaerial volcanic and volcanoclastic rocks. Rocks of its older part consist primarily of volcanoclastic rocks, such as would be included in the informal middle member of Gravina Island Formation, which consists chiefly of distinctly foliated, but locally massive, greenish-hued metavolcanic rocks derived from andesitic and subordinate basaltic tuff and agglomerate (Berg, 1973), as well as other volcanic rock units included in the belt for which explicit age control is not available. Age constrained by the Cretaceous and Jurassic sedimentary rocks of the Gravina-Nutzotin unit (KJgn), which generally overlie, but also intertongue with, the volcanic rocks. On generalized map, included as part of unit KJgn.

This unit is [Kc](#) in the GRI digital geologic-GIS data.

KJmy - Melange of the Yakutat Group (Cretaceous and Jurassic?)

Yakutat Group is a heterogeneous rock assemblage including clastic sedimentary rocks, altered volcanic rocks, chert, carbonate, and granitic rocks largely outboard of the Fairweather Fault in the vicinity of Yakutat on the Gulf of Alaska. It consists of two major subdivisions that are commonly structurally juxtaposed: a flysch facies, which is described above as unit KJyg, and a mélangé facies, which is described here. The mélangé facies is characteristically composed of blocks of competent rocks of heterogeneous lithology, as much as several kilometers in size, enclosed in a pervasively sheared matrix of dark-gray to black mudstone, which may be cherty or tuffaceous (G. Plafker, written commun., 2000). Mélangé blocks are predominantly greenstone, oolitic limestone, marble, granitic plutonic rocks, chert, and graywacke. Greenstone masses are generally massive and structureless but locally have pillow forms and agglomeratic texture, commonly have epidote-rich pods and stringers, are cut by diorite dikes, and are associated with limestone and marble, as well as pods of radiolarian-bearing ribbon chert. Poorly preserved fossils near Russell Fiord indicate that the marble may be Late Triassic in age. Bodies of foliated, fine- to medium-grained hornblende biotite tonalite are

associated with the greenstone; a pluton in Russell Fiord, an arm of Yakutat Bay, yielded a K/Ar hornblende age of 163.3 ± 3.5 Ma (Hudson and others, 1977). Lenticular bodies of massive laumontite-rich volcanic lithic and feldspathic sandstone and lenses as thick as 300 m and beds of well-rounded and sorted pebble and cobble conglomerate as thick as 200 m are locally developed and are thought to be olistostrome deposits exhibiting soft-sediment deformation; they probably represent deep sea channel fills (G. Plafker, written commun, 2000). At Russell Fiord near Hidden Glacier, unit also includes angular blocks of gray oolitic limestone that has chert nodules. On generalized map, included as part of unit MZm.

This unit is [Kym](#) 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 divided into units: [KJs](#) and [MZc](#) in the GRI digital geologic-GIS data.

KJse - Saint Elias suite of Gordey and Makepeace (2003) and similar rocks (Early Cretaceous and Late Jurassic)

Chiefly quartz monzodiorite, but compositionally diverse: ranges from granite to diorite. Generally foliated and locally gneissic, especially in plutons enclosed in the Strelina Metamorphics of Plafker and others (1989) (included in unit PIPsm, here). Also includes rocks locally known as the Chitina Valley batholith composed mainly of diorite, leucodiorite, and tonalite, but includes gabbro, especially near contacts (Winkler and others, 1981). Generally medium-grained but varies from fine- to coarse-grained and pegmatitic. Ranges from weakly foliated to nonfoliated in interior of plutons to strongly foliated and locally mylonitic near contacts. K/Ar and $40\text{Ar}/39\text{Ar}$ dates indicate plutonic ages as old as 162 Ma (Brew and others, 2013) and possibly as young as 117 Ma (Dodds and Campbell, 1988); metamorphic ages are as young as 52 Ma (Roeske and others, 2003). Unit includes the metaplutonic rocks of metamorphic complex of Gulkana River of Nokleberg (written commun., 1997) as well as isolated fine- to medium-grained, hypidiomorphic granular textured granitic and minor monzonite and

diorite dikes, stocks, and small plutons that are largely undated. A single K/Ar hornblende date of 129 Ma (Nokleberg and others, 1992b) suggests at least part of the metamorphic complex is Early Cretaceous in age. These central Alaska exposures are locally metamorphosed to lower greenschist facies. A southern extension of this unit of similar quartz diorite and tonalite plutons is in the Mount Fairweather, Sitka, and Juneau quadrangles as the suite extends through the Yukon and British Columbia of Canada (Gordey and Makepeace, 2003; Massey and others, 2005). On Chichagof Island, these plutons are spatially associated with others that have yielded Middle Jurassic ages; the diorite and tonalite plutons of unit KJse may also form sills and dikes within the Whitestripe Marble and along the contacts of the Whitestripe Marble and Goon Dip Greenstone (Johnson and Karl, 1985) along both sides of the Peril Strait Fault. Where mapped in the Mount Fairweather quadrangle, unit also includes Jurassic trondhjemite (Roeske and others, 1992) that has not been distinguished as a separate unit; it is the same age as the trondhjemite of the Talkeetna Mountains and northern Alaska Peninsula (unit Jtr) and may have originated from the same magmatic system. While the older country rocks of these two units bear some similarities, the voluminous Jurassic sedimentary section and Talkeetna magmatic arc products (which are spatially associated with the trondhjemite) are not associated with the Saint Elias Suite or Chitina Valley batholith.

This unit is divided into units: [Jc](#), [Jnt](#), [Kg](#), [MZPZu](#), [PPNsm](#), and [PPNss](#) in the GRI digital geologic-GIS data.

KJmu - Mafic and ultramafic rocks (Cretaceous to Jurassic or older)

Mafic and ultramafic rocks that are widely distributed in the southern part of Alaska and have poor age control. Includes a small dark greenish- or brownish-gray, coarse- to medium-grained, plagioclase-bearing, sill-like ultramafic intrusion in the Healy quadrangle (Csejtey and others, 1992). It appears to intrude Late Triassic calcareous rocks of unit ^cs and to have been metamorphosed during a mid-Cretaceous regional event that affected rocks in the eastern Healy quadrangle. In the southeastern Healy quadrangle, a small discordant pluton of alkali gabbro (monzogabbro) has an inferred age of Late Jurassic (Csejtey and others, 1992) on the basis of K/Ar and U/Pb radiometric dates. This pluton intrudes an argillite and metagraywacke unit that yields Late Jurassic detrital zircon ages. In the northern Anchorage quadrangle, north of the Border Ranges Fault Zone, Winkler (1992) reported small, structurally bounded, pervasively sheared, discordant bodies of serpentinized ultramafic rocks wholly enclosed in pelitic schist (unit Kps). Winkler (1992) reported that the timing of origin was unknown, but early Late Cretaceous K/Ar dates (91–89 Ma) were presumed to provide a minimum age for their emplacement. In the northern Nabesna quadrangle, Richter (1976) mapped several small ultramafic bodies that consist of serpentinite, serpentinized peridotite, dunite, and subordinate clinopyroxenite; he suggested they were of possible Cretaceous age. Includes two units on Baranof Island. At Red Bluff Bay on the southeast coast of the island, red-weathering, fine-grained dunite-wehrlite and clinopyroxenite form a body 3 km by 6 km. In the interior of the island, structurally concordant sills as much as 1.5 km in length and 0.5 km wide of yellowish-brown-weathering, clinopyroxene-antigorite and talc-tremolite-chrysotile serpentinite are commonly associated with strands of the Patterson Bay Fault (Karl and others, 2015). In the Bethel quadrangle, Box and others (1993) also report small, pervasively slickensided bodies of serpentinite, serpentinite-matrix mélange, and silica-carbonate altered serpentinite, which they inferred to be Late Cretaceous in age. On generalized map, included as part of unit KPZu.

This unit is [MZPZu](#) in the GRI digital geologic-GIS data.

Jum - Gabbro and other mafic and ultramafic rocks of Hidden terrane (Early Jurassic)

Complexly intermixed series of ultramafic and mafic to intermediate plutonic rocks. "Plutons consist of gabbro, hornblende gabbro, diorite, and tonalite. * * * Xenoliths of gabbro show ductile

deformation as though they still were warm when intruded by silicic magmas and migmatite textures are common at contacts between lithologies” (Winkler, 1992). Plutons are cut by steeply dipping faults that form the northern part of the Border Ranges Fault System. Fault-bounded cumulate ultramafic and mafic rocks of the Wolverine and Eklutna complexes of Winkler (1992) are also included in unit and have an inferred age of Middle and Early Jurassic based on correlation with Tonsina complex of adjacent Valdez quadrangle and intrusion by Middle and Early Jurassic dikes (Winkler, 1992). These rocks have typically been considered part of the root of the Talkeetna arc (Burns, 1985), which includes rocks of three units: Jtk, the Talkeetna Formation; Jtr, trondhjemite; and Jgr, the Jurassic phase of the Alaska-Aleutian Range batholith. An alternative explanation associates these rocks with the slightly older magmatic arc of the Hidden terrane. Unit also includes rocks of the Uyak Complex, in the Kodiak Island archipelago, which consist of gabbroic and ultramafic rocks including layered gabbro, clinopyroxenite, dunite, and plagioclase peridotite. The mafic and ultramafic rocks of the Uyak Complex occur as kilometer-sized fault-bounded slabs in the westernmost exposures of the Uyak Complex (Connelly, 1978) within the Border Ranges Fault Zone. The margins of these slabs have pronounced serpentinization. On generalized map, included as part of unit KPZum.

This unit is divided into units: [Kv](#), [KJm](#), [Jnt](#), and [PPNsm](#) in the GRI digital geologic-GIS data.

Js - Marine sedimentary rocks of the Wrangell Mountains, undivided (Jurassic, Kimmeridgian to Pliensbachian)

Consists of three units defined by MacKevett (1969) in the McCarthy quadrangle. Uppermost is the Root Glacier Formation, which is mainly mudstone and siltstone, and less abundant graywacke, arenite, shale, and well-indurated pebble and cobble conglomerate. It has an estimated thickness of 400 to 1,200 m and is Late Jurassic (late Oxfordian and Kimmeridgian) in age. The Root Glacier Formation disconformably overlies the Nizina Mountain Formation, which is mainly dark-greenish-gray and weathers to reddish brown, fine- to very fine-grained graywacke that has shaly partings and a few limy lenses and concretions. Thickness is about 410 m at type locality and is Middle and Late Jurassic in age. It disconformably overlies the Lubbe Creek Formation, which consists of medium-gray-weathering to medium-brown, impure spiculite and minor coquina and chert lenses; about 90 m thick; age is late Early Jurassic, Pliensbachian and Toarcian (MacKevett, 1969). On generalized map, included as part of unit KJsnc.

This unit is [Js](#) 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 KJsnnk.

This unit is [Jk](#) in the GRI digital geologic-GIS data.

Jhg - Plutonic rocks of Hidden terrane (Early Jurassic)

Relatively homogeneous, fine- to medium-grained quartz diorite and tonalite that have extensive areas that have been sheared and altered (Winkler, 1992). Unit is found within the Border Ranges Fault Zone in the Anchorage and Valdez quadrangles. U/Pb zircon ages range between 193.9 and 183 Ma (Rioux and others, 2007), which are similar to, but marginally older than, plutons of Alaska-Aleutian Range batholith that have similar composition. The plutons of this unit are often considered part of the Alaska-Aleutian Range batholith and considered part of the Talkeetna magmatic arc, but we interpret these rocks, in companion with mafic rocks of unit Jum, to represent a slightly older but distinct magmatic arc. As analyzed by Rioux and others (2007), unit also includes trondhjemite, which yields significantly older U/Pb ages—between 193.3 and 184.1 Ma—than the trondhjemite of map unit Jtr, which is part of Alaska-Aleutian Range batholith. K/Ar ages generally range from 194 to 161 Ma, but most ages are older than 172 Ma (Winkler, 1992; Hacker and others, 2011). On generalized map, included as part of unit Jegr.

This unit is [Jhg](#) 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 sublittoral 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 [JTRt](#) in the GRI digital geologic-GIS data.

JTRsch - Blueschist of southern Alaska (Early Jurassic to Triassic)

Diverse, well-foliated, multiply-deformed, variably foliated, metasedimentary and metavolcanic rocks closely associated with the Border Ranges Fault System. Sedimentary protoliths were shale, chert, tuffaceous arenite, and limestone; volcanic protoliths were probably mostly basalt (Winkler, 1992). Consists of thinly layered and complexly folded quartz-mica schist, greenschist, crossite-epidote schist (blueschist), and epidote amphibolite (Connelly and Moore, 1979). Whereas metamorphism varies from greenschist to amphibolite facies (Winkler, 1992), locally glaucophane-bearing and crossite-bearing rocks suggest unit was metamorphosed under conditions transitional to and including blueschist facies (Forbes and Lanphere, 1973; Carden and Decker, 1977; Carden and others, 1977; Connelly and Moore, 1979; Winkler and others, 1981; Bradley and others, 1999). Outcrops along northern flank of Chugach Mountains in Anchorage, Seldovia, and Valdez quadrangles are closely associated with Border Ranges Fault System and the McHugh Complex. Unit is also exposed along the west side of Afognak, Shuyak and Kodiak Islands, associated with the Border Ranges Fault System and the Uyak Complex. Includes the schist of Liberty Creek of Winkler and others (1981; Richter and others, 2006), the Knik River schist of Winkler, 1992 (also called the Knik River terrane of Pavlis, 1983; Pavlis and others, 1988), the Seldovia Schist of Roeske (1986; see also Cowan and Boss, 1978; Bradley and others, 1999), and the Raspberry Schist of Roeske and others (1989). Raspberry Schist of Roeske and others (1989) was subdivided into two units that consist of (1) metabasite and metasedimentary rocks that have some relict textures and phases preserved, including pillow shapes and bedding and (2) a unit that is completely recrystallized and preserves no original textures or phases. Carden and others (1977) reported 10 K/Ar ages on mica, chlorite, and amphibole from unit that range from 196.6 ± 5.8 to $157.8.3 \pm 4.8$ Ma, and Bradley and Karl (2000) reported 40Ar/39Ar plateau ages on mica of 191.7 ± 0.3 and 190.98 ± 0.3 Ma and on hornblende of 191.92 ± 0.6 Ma. Roeske and others (1989) reported Rb/Sr isochron ages ranging from 212 to 189 Ma. Dating of the blueschist facies metamorphism of this metamorphic complex supports a pattern of decreasing age from west to east, as originally suggested by Sisson and Onstott (1986); however, it is unlikely that the reported ages are a true reflection of the timing of metamorphism. Clark (1972, cited in Winkler, 1992) reported a single Permian fossil collection from limestone. Winkler (1992) suggested that the diverse protolith lithologies may indicate tectonic mixing prior to metamorphism.

This unit is [Jlc](#) in the GRI digital geologic-GIS data.

JTRmc - McCarthy Formation (Lower Jurassic and Upper Triassic)

Exposed in eastern Alaska, unit is divided into two informal members: an upper member of dominantly thin-bedded, very fine-grained spiculite, impure chert, impure limestone, and shale; and a lower member that is characteristically thin-bedded impure limestone, calcareous carbonaceous shale, and impure, locally spiculitic chert (MacKevett, 1978). Fossils in upper member indicate an Early Jurassic age, from Hettangian to Pliensbachian, and *Monotis subcircularis*, *M. alaskana*, and *M. jakutica* (Silberling and others, 1997) from the lower part of the lower member indicate a Late Triassic, mainly late Norian, age. Unit as a whole is deep marine and the depositional character indicates a restricted environment, possibly a starved basin. Unit also includes some rocks in west-central Alaska that are similar to the lower part of the McCarthy Formation (unit TRsl). On generalized map, included as part of unit JTRsr.

This unit is [JTRm](#) 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 evaporite relicts 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. MacKevett) 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 divided into units: [TRI](#) and [TRcn](#) in the GRI digital geologic-GIS data.

TRgb - Gabbro and quartz gabbro (Late Triassic?)

Consists of a variety of amphibole- and pyroxene-bearing gabbro and sparse quartz gabbro and quartz diorite, along with other mafic and ultramafic rocks. Unit has rare porphyritic phases. Crops out in small plutons, dikes and sills cutting, predominantly, the Hasen Creek Formation with a few small dikes within the Nikolai Greenstone and is possibly magmatically related to the Nikolai Greenstone and its related units (MacKevett and others, 1978). Occurs in the McCarthy quadrangle (MacKevett and others, 1978), the northern Talkeetna Mountains (Kline and others, 1990) and Gulkana quadrangles (Wilson and others, 1998; W.J. Nokleberg, written commun., 1997), and the Mount Hayes quadrangle (Nokleberg and others, 1992a). Also present in the Healy quadrangle as part of map units TrIPam and Trbd of Csejtey and others (1992), though not mapped separately. On generalized map, included as part of unit KPZum.

This unit is divided into units: [TRg](#) and [TRcg](#) in the GRI digital geologic-GIS data.

TRms - Metavolcanic and metasedimentary rocks (Late Triassic)

Consists, in part, of the informal Amphitheater group of Smith (1981), which ranges in western exposures from thinly stratified greenish volcanoclastic metasedimentary rocks, chert, and greenschist interbedded with basalt and dark carbonaceous argillite to thicker bodies of undifferentiated pelitic and volcanoclastic metasedimentary rocks. The thinly stratified volcanoclastic sedimentary rocks have common graded laminae, cross bedding, and other depositional textures. The thicker undifferentiated pelitic and volcanoclastic metasedimentary rocks typically show lateral change from argillite to thin tuffaceous interbeds (Smith, 1981; Smith and others, 1988). Unit also includes clayey and silty lenses and interbeds of microsparite that are locally carbonaceous, laminated, or fossiliferous; presence of *Halobia* cf. *H. superba* and *Tropites* sp. indicate a Late Triassic age. Marble contains structures suggestive of scleractinian colonial corals such as *Thamnastraea*(?). Smith (1981) also reported thickly bedded greenish flows that show numerous exposures of columnar jointing and pillows, and he suggested that these and their underlying rocks may be as old as late Paleozoic. Eastern exposures, such as in the Mount Hayes and Nabesna quadrangle, are chiefly fine-grained quartz–white-mica schist, chlorite-calcite-quartz schist, marble, greenstone, and sparse metadacite that exhibits a weak schistosity that strikes northeast to east and dips moderately to steeply northward (Nokleberg and others, 1992a). This map unit is contiguous with rocks of the Permian to Pennsylvanian Mankomen and Skolai Groups (unit PIPms and subunits), but available data does not allow distinction at map scale. On generalized map, included as part of unit TRPIm.

This unit is [PPNdm](#) in the GRI digital geologic-GIS data.

TRn - Nikolai and Goon Dip Greenstones and equivalent rocks (Late and Middle Triassic)

Massive, dark-gray-green, dark-gray-brown, and maroon-gray, subaerial and submarine basalt flows and minor interbedded volcanoclastic sedimentary rocks, aquagene and epiclastic tuff, breccia, argillite, and radiolarian chert (Nokleberg and others, 1992a), commonly metamorphosed to lower greenschist facies. Widely distributed and several thousands of meters thick. Includes unnamed Triassic greenstone units in Talkeetna Mountains quadrangle (Csejtey and others, 1978). Commonly associated with Late Triassic carbonate and cherty carbonate rocks. Together with Chitistone and Nizina Limestones, this is one of the diagnostic units of the Wrangellia terrane (Jones and others, 1977). Plafker and others (1976) and Jones and others (1977) correlated the Goon Dip Greenstone of southeast Alaska with the Nikolai Greenstone based on similar lithology and stratigraphic position relative to the overlying Whitestripe Marble, which they correlated with the Upper Triassic Chitistone Limestone. Goon Dip Greenstone is dominantly massive greenstone and minor greenschist and marble. The greenstone also commonly contains sparsely distributed copper-bearing sulfides; the Nikolai was the host rock for the Kennecott group of mines. Similar and possibly correlative units, the Cottonwood Bay and Chilikradotna Greenstones of the Alaska Peninsula, are described below as unit TRcb. On generalized map, included as part of unit TRmb.

This unit is [TRn](#) in the GRI digital geologic-GIS data.

TRum - Mafic and ultramafic rocks in the vicinity of the Denali Fault System (Triassic?)

Gabbro of Mount Moffit of the Mount Hayes quadrangle and a correlative unit of gabbro, diorite, metagabbro, metadiabase, and amphibolite dikes, sills and small plutons (units gbm and mgb of Nokleberg and others, 1992a) are distributed along the Denali Fault System in the Mount Hayes quadrangle and also in the adjacent Tanacross and Nabesna quadrangles. In south-central Alaska, we correlate the country rocks of these intrusive rocks with the Yanert Fork sequence of Csejtey and others (1992 (unit Dmvs here) in the Mount Hayes quadrangle, but such correlation is increasingly

speculative east of the Mount Hayes quadrangle. Unit also includes medium- to coarse-grained hornblende gabbro, hornblendite, plagioclase-hornblende pegmatite, and tectonized peridotite, informally named the Katzehin ophiolite complex; it is associated with the Coast plutonic complex of Brew and Morrell (1979b) in the Atlin quadrangle (Brew and others, 2009) and small peridotite bodies in the Juneau and Taku River quadrangles (Brew and Ford, 1985). In the Atlin quadrangle, these rocks are associated with greenstone and amphibolite. These rocks have an inferred Early Triassic age because they are close to, and may be stratigraphically overlain by, bedded sedimentary rocks of Early and Middle Triassic age (Brew and others, 2009). We suggest these rocks may correlate with other Jurassic or Triassic mafic and intermediate plutons associated with the Coast plutonic complex of Brew and Morrell (1979b), such as the Texas Creek granodiorite of unit TRqd. On generalized map, included as part of unit KPZm.

This unit is [Ddg](#) in the GRI digital geologic-GIS data.

PIPsm - Strelna Metamorphics and related rocks (early Permian to Middle Pennsylvanian)

Variably metamorphosed, but largely lower greenschist-facies metasedimentary and metavolcanic rocks that are generally considered a metamorphic equivalent of the Skolai and Mankomen Groups (Richter and others, 2006). Includes the Uranatina River metaplutonic complex of Winkler and others (1981) and the Dadina Schist of Carboniferous and possibly older age exposed near Mount Drum (Richter and others, 1994). Unit includes quartzofeldspathic and quartz-mica schist, which locally has compositional layering reflecting original bedding; greenstone derived from mafic to intermediate volcanic rocks; locally abundant marble interbeds; tectonically emplaced ultramafic rock; and marble lenses, as well as metachert and orthogneiss. Metamorphic grade generally increases to amphibolite facies near contacts with the Uranatina River metaplutonic complex. Tightly folded and pervasively faulted in most localities. Generally undated, the Strelna Metamorphic Complex is on trend with similar strata containing age-diagnostic conodonts in marble (Plafker and others, 1985). Uranatina metaplutonic complex is part of a 10-by-15-km tectonic inclusion in the McHugh Complex that consists of compositionally banded quartz gabbro, amphibolite, and hornblende-biotite dioritic and quartz dioritic orthogneiss. Foliation of the rocks is swirled or tightly folded in many places and large hornblende or hornblende-plagioclase pods have grown in the hinges of many folds. Unit yields Cretaceous and Jurassic cooling ages, as well as a Permian K/Ar age (267 ± 8 Ma) on pegmatite (Winkler and others, 1981) and is known to contain, at least locally, Middle Pennsylvanian metagranodiorite (Plafker and others, 1989). Metamorphic grade of the Strelna Metamorphic Complex increases toward the Chitina Valley batholith and near plutons of the Saint Elias suite (unit KJse) (Richter and others, 2006). The northern part of this unit, locally mapped as the metamorphic complex of Gulkana River (W.J. Nokleberg, written commun., 1997), trends across the northern part of the Gulkana quadrangle and into the northeast part of the Talkeetna Mountains quadrangle. Also see description of the Skolai and Mankomen Groups, undivided (unit PIPms).

This unit is divided into units: [Pm](#), [PPNm](#), [PPNsm](#), and [PPNs](#) in the GRI digital geologic-GIS data.

PIPms - Mankomen and Skolai Groups, undivided (lower Permian and Pennsylvanian)

Each of these groups is divided into two formal units: the Mankomen into the Eagle Creek and Slana Spur Formations and the Skolai into the Hasen Creek and Station Creek Formations. The lowermost formations of each group, the volcanic Slana Spur and Station Creek Formations (unit PIPt, described together below). The Station Creek Formation is correlated on stratigraphic and lithologic grounds with the Slana Spur Formation (Nokleberg and others, 1992a). Age assignment is relative to overlying Eagle Creek and Hasen Creek Formations (Peh; early Permian; MacKevett, 1978), also correlated on stratigraphic and lithologic grounds. Interpreted to be the products of a late Paleozoic magmatic arc

and associated sedimentary rocks (see, for example, Nokleberg and others, 1994). A metamorphic equivalent of these units is generally considered to be the Strelina Metamorphics (unit PIPsm, here; Nokleberg and others, 1994). Locally mapped as units Peh, Pehls, and PIPT, described below; on generalized map, all are included as part of unit TRPIPms.

This unit is [Pm](#) in the GRI digital geologic-GIS data.

Peh - Eagle Creek and Hasen Creek Formations (lower Permian)

These two argillic formations are part of the Mankomen and Skolai Groups, respectively. Eagle Creek Formation (Richter, 1976) is thin-bedded argillite and siliceous siltstone, with interbedded calcareous siltstone and sandstone, biomicritic limestone, and pebble to cobble conglomerate. Eagle Creek Formation is cut by gabbroic dikes and sills and is abundantly fossiliferous; it includes specimens of brachiopods, cephalopods, corals, foraminifera, and bryozoans. Richter (1976) reported that thin lenses (less than 30 m) of carbonaceous shale, calcareous argillite, and chert that contain the Middle Triassic pelecypod *Daonella* separate the Eagle Creek Formation from the overlying Nikolai Greenstone. These lenses are not separately mapped here from the Eagle Creek Formation, but are not considered part of the Eagle Creek Formation. Hasen Creek Formation (MacKevett and others, 1978) is weakly metamorphosed, diverse, thin-bedded argillite with less abundant lithic graywacke, conglomerate, shale, chert, schist, marble, and limestone (carbonates are mapped separately as unit Pehls, described below). The argillite and shale are shades of gray or yellowish-brown, fine-grained, silica-rich rocks. The graywacke and conglomerate are both variegated and have calcite-rich matrices and multicolored clasts. The Hasen Creek Formation is also cut by Triassic gabbro, the Chitina Valley batholith (unit KJse), and Tertiary hypabyssal rocks.

This unit is divided into units: [Pe](#) and [Ph](#) in the GRI digital geologic-GIS data.

Pehls - Limestone of the Hasen Creek and Eagle Creek Formations (lower Permian)

Thin- to thick-bedded, fossiliferous limestone (MacKevett, 1978) associated with the Hasen Creek Formation. Also includes thin- to thick-bedded fossiliferous limestone at the base of the Eagle Creek Formation (Richter, 1976). Locally, base of limestone is a coarse-grained clastic limestone. Fossils include corals, crinoids, brachiopods, bryozoans, and fusulinids, which together indicate early Permian (Wolfcampian, which corresponds to the earlier part of the Cisuralian stage) age. Unit also includes white to gray marble, which forms conspicuous deformed and folded bands and pods throughout the Strelina Metamorphics (unit PIPsm). Individual marble beds vary markedly in thickness along strike; maximum measured thickness of the marble is about 1,200 m. The marble is typically found in association with greenschist and quartz-rich schist, but also forms pods as much as a few hundred meters thick within predominantly phyllitic schist or as inclusions within associated metaplutonic rocks (Winkler and others, 1981; George Plafker, written commun., 2000). Age equivalent to parts of the Cache Creek Group of the Yukon, although the Cache Creek Group has Tethyan fauna, whereas the Hasen Creek and Eagle Creek Formations have boreal fauna (R.B. Blodgett, written commun., 2014).

This unit is divided into units: [Pel](#) and [Pl](#) in the GRI digital geologic-GIS data.

PIPt - Slana Spur and Station Creek Formations and Tetelna Volcanics (lower Permian to Middle Pennsylvanian)

Lower volcanic section chiefly submarine andesite and basalt flows, locally pillowed and brecciated; upper volcanoclastic section generally grades upward from coarse volcanic breccia to abundant volcanic graywacke and finally to volcanic lutite. No fossils are known in the type area. Age assignment is constrained by overlying Hasen Creek Formation (unit Peh) and stratigraphic and lithologic correlation with the Slana Spur Formation (Nokleberg and others, 1992a). As here mapped, includes units Pzt and IPt (Tetelna Volcanics) of Nokleberg and others (1992a). Unit Pzt of Nokleberg and others (1992a) consists of andesitic flows, mud and debris avalanches, and aquagene tuff interbedded with fine- to coarse-grained volcanoclastic rocks; this unit has yielded fragments of late Paleozoic bryozoans. The Tetelna Volcanics is similar, and consists chiefly of dark-green, dark-gray-green, and purplish-gray-green volcanic flows, locally graded mud and debris avalanches, and lapilli-pumice tuff interbedded with fine- to coarse-grained volcanoclastic rocks. In the Talkeetna Mountains quadrangle, Permian conodonts were collected from unit Pzv (Csejtey and others, 1978). Metamorphosed to lower greenschist facies. As here mapped, unit also includes greenstone of the Skolai Group in the Valdez quadrangle (Winkler and others, 1981) and early Permian(?) and Pennsylvanian andesitic volcanic rocks in the Healy quadrangle (Csejtey and others, 1992). Locally, may also include rocks that could be assigned to the Nikolai Greenstone (TRn) following more detailed mapping (J.M. Schmidt, written commun., 2007).

This unit is divided into units: [PPNt](#), [PPNss](#), and [PPNsc](#) in the GRI digital geologic-GIS data.

PIPgi - Granodiorite, syenite, and other granitic rocks (early Permian and Pennsylvanian)

Granodiorite, syenite, granite, monzonite, and other granitic rocks that form a discontinuous belt from southeast Alaska to south-central Alaska and typically yield Permian radiometric ages. The rocks are fine- to coarse-grained, may be massive or schistose, and are locally porphyritic. Unit includes shoshonitic Ahtell pluton (Richter, 1966; W.J. Nokleberg, written commun., 1997), also called the Ahtell complex by Beard and Barker (1989) in the Gulkana quadrangle, which has been dated by K/Ar to between 291 and 288 Ma. Map unit also includes the granodiorite of Rainbow Mountain in the Mount Hayes quadrangle (unit grrm, Nokleberg and others, 1992a), which yielded a K/Ar age of 325.94 ± 9.78 Ma and a U/Pb zircon age of 309 ± 2 Ma (Nokleberg and others, 1992b). Richter and others (1975) and Richter (1976) defined a diorite complex to the east of the Ahtell pluton and considered it to be of Jurassic and Triassic age on the basis of K/Ar dates that range from 204 to 167 Ma (recalculated using constants of Steiger and Jager, 1977); subsequent U/Pb dating reported by Beard and Barker (1989) indicated that the diorite complex was mostly of Pennsylvanian age, between 311 and 290 Ma, and possibly older than the Ahtell pluton. The diorite complex includes a range of lithologies, from quartz diorite to gabbro, including minor anorthosite and gabbro cumulates and a small area of pink biotite-hornblende syenite-monzonite gneiss, gray hornblende diorite gneiss, minor dark biotite schist, and small syenite pegmatite dikes. In the McCarthy and Bering Glacier quadrangles, MacKevett (1978) and George Plafker (written commun., 2006) mapped a monzonitic to granitic complex that consists of "medium-grained, equigranular granitic rocks with fine- to coarse-grained variants. Abundant granite and quartz monzonite and some quartz syenite, syenite, and monzonite, with border zones of quartz monzodiorite, monzodiorite, and gabbro" (MacKevett, 1978). Radiometric ages for this complex range from 312 to 279 Ma, and most K/Ar ages are only slightly younger than the U/Pb age, unlike the dates on the diorite complex, which are highly discordant. Nokleberg and others (1992a), mapping in the Mount Hayes quadrangle, reported sparse to locally abundant andesite and lesser dacite and rhyolite stocks, sills, and dikes that intrude the Permian to Pennsylvanian Slana Spur Formation and Tetelna Volcanics but not the Permian Eagle Creek Formation. These igneous rocks have been metamorphosed to lower greenschist facies and have granoblastic overprint texture and local weak schistosity; their age is inferred from intrusive relations. The rocks of this unit, in the Bering Glacier, Gulkana, McCarthy, and Mount Haues quadrangles, are inferred to represent the plutonic root of the Skolai magmatic arc (Nokleberg and others, 1994). Small,

undated, exposures of medium- to medium dark-gray, fine- to coarse-grained diorite appear to intrude the Totatlanika Schist (unit MDts) in the Big Delta quadrangle (Weber and others, 1978). Distally associated with the rocks of this map unit are felsic to mafic rocks that intrude the Retreat Group (unit PzPxrg) in the Juneau and Sitka quadrangles, orthogneiss in the Sumdum and Petersburg quadrangles, and syenitic rocks in the Craig quadrangle of southeast Alaska. In the Craig quadrangle, syenite and leucosyenite of the map unit locally grade to sodic diorite (Eberlein and others, 1983) and are compositionally similar to the other parts of this unit; they yield K/Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ ages between 293 and 276 Ma, comparable to the K/Ar ages in south-central Alaska. Though included in this map unit on the basis of common age and lithology, these rocks may not all be genetically related.

This unit is divided into units: [Jc](#), [PPNdp](#), [PPNdm](#), [PNa](#), and [PNm](#) in the GRI digital geologic-GIS data.

PZgb - Gabbro and orthogneiss (late Paleozoic)

Medium- to coarse-grained, massive to foliated, altered gabbro, leucogabbro, and minor diorite in sills, dikes, and discordant plutons (Richter, 1976; MacKevett, 1978; Winkler and others, 1981) in the Nabesna, McCarthy, and Valdez quadrangles. These rocks are similar to the more mafic part of the diorite complex of unit PIPgi, described below, and yield similar radiometric ages; K/Ar on biotite of 271 ± 11 Ma (MacKevett, 1978) and U/Pb on zircon of 307 ± 2 Ma (Plaker and others, 1989). Gabbroic parts of the unit in the McCarthy quadrangle were interpreted by MacKevett (1978) to be part of the oceanic crust that underlies the Skolai arc. In the Valdez quadrangle, however, as the unit is emplaced at a stratigraphic level near the base of rocks equivalent to the lower Permian Hasen Creek Formation (Winkler and others, 1981, unit Peh here), the Devonian zircon age, if interpreted as an emplacement age, is problematic. Unit also includes a mass that is predominantly medium-grained leucocratic gabbro and hornblende gabbro intimately mixed with altered anorthositic rocks in the Nabesna quadrangle north of the Denali Fault System and in the adjacent Yukon. This gabbro has a hypidiomorphic texture and consists of calcic plagioclase, clinopyroxene, and hornblende; anorthositic rocks lack clinopyroxene, but locally contain abundant segregations, lenses, and wavy bands of fibrous tremolite-actinolite and minor clinozoisite (Richter, 1976). On generalized map, included as part of unit KPZum.

This unit is divided into units: [MZPZu](#) and [PNgo](#) in the GRI digital geologic-GIS data.

MOkg - Kaskawulsh group of Kindle (1953) (Mississippian and older)

Metamorphosed marine sequence of marble, schist, and phyllite; minor meta-tuff, flows, breccia, and meta-conglomerate (MacKevett, 1978; G. Plaker, written commun., 2000). Poorly preserved Ordovician, Devonian, and possible Mississippian and Pennsylvanian fossils present. Metamorphosed to upper greenschist facies and locally intensely folded. Found in the McCarthy, Mount Saint Elias, and Yakutat quadrangles in Alaska, unit is coextensive with widely occurring rocks within neighboring Yukon; potentially represents westernmost known extent of Alexander(?) terrane (Richter and others, 2006). In Canada, the Kaskawulsh group unit name is informally used and "includes Upper Cambrian volcanics, Ordovician greywacke, Ordovician and Silurian carbonate, Middle Devonian carbonate, Mississippian(?) to Permian slate, greywacke, volcanics and limestone and Upper Triassic limestone in a highly faulted and deformed complex that at present cannot be adequately subdivided" (from the lexicon of Canadian geologic units, <http://weblex.nrcan.gc.ca/html/007000/GSCC00053007399.html>).

This unit is [PZk](#) in the GRI digital geologic-GIS data.

PZPxyqs - Quartzite and pelitic schist (Devonian and older)

Dominantly quartzite, schistose quartzite, and quartz-mica schist; also contains subordinate gritty quartzite, chlorite schist, calc-silicate schist, marble, magnetite-biotite schist, amphibolite, and greenstone. Ranges from amphibolite to upper greenschist facies and locally retrograded to lower greenschist facies (Nokleberg and others, 1992a; Smith and others, 1994). Corresponds, in part, to the Fairbanks schist of Newberry and others (1996) of the Fairbanks mining district and surrounding areas of the southeastern Livengood and northeastern Fairbanks quadrangles (Robinson and others, 1990; Weber and others, 1992; Newberry and others, 1996) as well as a large portion of the Circle quadrangle (Foster and others, 1983). Smaller areas of exposure occur in the southern Big Delta quadrangle (Weber and others, 1978) and in the Eagle quadrangle (Foster, 1976). In the Circle quadrangle and northern Big Delta quadrangle, small exposures of gray or greenish-gray marble and gray to cream-colored dolomitic marble are included in this unit; diopside is present locally, indicating amphibolite facies metamorphism. No age control exists for these carbonate rocks. On generalized map, included as part of unit DPxsq.

This unit is [PZk](#) in the GRI digital geologic-GIS data.

Dmi - Metamorphosed mafic igneous rocks (Late Devonian)

Consists of a variety of metaigneous rocks of presumed Devonian age in central Alaska. Main part of unit lies north of the Denali Fault System and consists of a mixture of massive greenstone that locally contains thin septa of phyllite (Richter, 1976) and fine-grained, mylonitic, metavolcanic rocks interlayered with lesser metasedimentary rocks (Nokleberg and others, 1992a; Csejtey and others, 1992). Metavolcanic rocks are interpreted to consist chiefly of metamorphosed quartz keratophyre, dacite, andesite, and lesser metarhyodacite and metabasalt derived from fine-grained tuffs and flows (Nokleberg and others, 1992a) or metabasalt (Csejtey and others, 1992). Regionally metamorphosed to greenschist facies. Unit most certainly extends through the Tanacross quadrangle, but mapping is insufficient to allow us to distinguish this unit there. Unit includes the Spruce Creek sequence of Bundtzen (1981) and the Muskox sequence of Newberry and others (1996). Two samples of metarhyolite schist from the Spruce Creek sequence in the Denali quadrangle yielded TIMS U/Pb zircon ages of 370 ± 5 and 369 ± 4 Ma (Dusel-Bacon and others, 2006). South of the Denali Fault System, unit is sheared serpentinite tectonically intermixed with chert and pillow basalt, which form lenticular and podiform tectonic blocks (Csejtey and others, 1992). Radiolaria from the chert are Late Devonian (Famennian). South of the Denali Fault System, in the Healy and Denali quadrangles, this unit is part of the Chulitna sequence; it was originally interpreted by Jones and others (1981) to be part of a dismembered ophiolite sequence, and it was reinterpreted by Clautice and others (2001) as feeders for the volcanic rocks included in unit TRPZvs. On generalized map, included as part of unit MDmg.

This unit is divided into units: [PZv](#), [PZvc](#), and [Dq](#) in the GRI digital geologic-GIS data.

DOMvs - Yanert Fork sequence of Csejtey and others (1992) and correlative rocks (Devonian to Ordovician?)

Consists of a metamorphosed marine sequence of phyllite, metavolcanic rocks, schist, and marble exposed along the north side of the Denali Fault System and found between the Hines Creek strand and main Denali Fault, in the Healy and Mount Hayes quadrangles. Mainly phyllite, but unit also includes argillite, slate, phyllonite, semischist, impure quartzite, schistose stretched-pebble conglomerate, banded metachert, felsic metatuff, metabasalt, and marble. Metamorphic grade is dominantly greenschist facies but ranges to amphibolite facies locally. Conodonts from a marble interbed in the Healy quadrangle indicate a Late Devonian age (Csejtey and others, 1992), whereas, in the Nabesna quadrangle, "rugose and tabulate corals from widely scattered localities indicate a

Middle Devonian age" (Richter, 1976). U/Pb zircon analysis of metavolcanic rocks in this unit yielded an apparent age of 372 ± 8 Ma, which is a composite age based on multiple samples in a concordia plot (Aleinikoff and Nokleberg, 1985). Nokleberg and others (1992a) mapped fine-grained metavolcanic and metasedimentary phyllonite and blastomylonite and fine-grained schistose metasedimentary rocks in the Mount Hayes quadrangle that are on strike with the Yanert Fork sequence of Csejtey and others (1992). In the Tanacross quadrangle Foster (1970) mapped an undivided phyllite and schist unit of which these rocks are a part. In the Nabesna quadrangle, this unit includes the Devonian phyllite and limestone mapped by Richter (1976). Csejtey and others (1992) mapped a unit of flysch along the Healy-Mount Hayes quadrangle boundary that they believed was of Cretaceous or Jurassic age; however, we have included it within this map unit because of its direct association with rocks thought to be Devonian in the Mount Hayes quadrangle. On generalized map, included as part of unit DCsp

This unit is divided into units: [Dl](#) and [Dp](#) 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.

Geologic Map of Wrangell-Saint Elias

The formal citation for this source.

Richter, D.H., Preller, C.C., Labay, K.A., and Shew, N.B., 2006, Geologic Map of the Wrangell-Saint Elias National Park and Preserve, Alaska: U.S. Geological Survey, Scientific Investigations, SIM-2877, scale 1:350,000 (*GRI Source Map ID 74822*).

Prominent graphics and text associated with this source.

Report

Geologic Map of the Wrangell-Saint Elias National Park and Preserve, Alaska

Compiled by Donald H. Richter, Cindi C. Preller, Keith A. Labay, and Nora B. Shew

INTRODUCTION

Wrangell-Saint Elias National Park and Preserve, the largest national park within the U.S. National Park Service system, extends from the northern Pacific Ocean to beyond the eastern Alaska Range into interior Alaska. It features impressively spectacular scenery such as high and craggy mountains, active and ancient volcanoes, expansive ice fields, immense tidewater glaciers, and a myriad of alpine glaciers. The park also includes the famous Kennecott Mine, a world-class copper deposit that was mined from 1911 to 1938 (fig. 1), and remnant ghost town, which is now a National Historic Landmark.

PREVIOUS WORK

Geologic investigations encompassing Wrangell-Saint Elias National Park and Preserve began in 1796, with Dmitriv Tarkhanov, a Russian mining engineer, who unsuccessfully ventured up the Copper River in search of rumored copper (Grinev, 1987, as cited in Hunt, 1996). Lieutenant H.T. Allen (1897) of the U.S. Army made a successful epic summer journey with a limited military crew up the Copper River in 1885, across the Alaska Range, and down the Tanana and Yukon Rivers. Allen's crew was supported by a prospector named John Bremner and local Eyak and Ahtna native guides whose tribes controlled access into the Copper River basin. Allen witnessed the Ahtnas' many uses of the native copper. His stories about the copper prompted prospectors to return to this area in search of the rich copper ore in the years following his journey. The region boasts a rich mining and exploration history prior to becoming a park in 1980 (fig. 2). Several U.S. Geological Survey geologists have conducted reconnaissance surveys in the area since Allen's explorations. This map is the result of their work and is enhanced by more detailed investigations (fig. 3, on map sheet), which began in the late 1950's and are still continuing. For a better understanding of the processes that have shaped the geology of the park and a history of the geologic investigations in the area, we recommend U.S. Geological Survey Professional Paper 1616, "A Geologic Guide to Wrangell-Saint Elias National Park and Preserve, Alaska", an exceptionally well illustrated and informative book by Gary R. Winkler, 2000.

BEDROCK TERRANES

Geologically, the park consists of a collage of seven tectonostratigraphic terranes that formed south in the equatorial Pacific Ocean and rafted northward on oceanic plates, eventually accreting to Alaska and the North American continent (fig. 4, on map sheet). Each terrane features a distinct stratigraphy and is separated from neighboring terranes by major strike-slip or thrust faults. The Windy terrane, exposed in the Alaskan interior north of the Denali Fault System and composed largely

of Paleozoic metavolcanic and metasedimentary rocks, was the first to arrive; it accreted to the continent in Triassic and early Jurassic time (225–180 Ma). Next to arrive was the Wrangellia composite terrane (Peninsular, Wrangellia, and Alexander(?) terranes), presently separated from the Windy terrane by the Denali Fault System, a series of strike-slip faults. During its journey north, the Wrangellia terrane merged with the Alexander(?) terrane before docking to the continent in early Cretaceous time (11,110–85 Ma). The Nutzotin Mountains sequence of Berg and others, 1972, a thick marine flysch of Late Jurassic and Early Cretaceous age, and the short-lived Cretaceous Chisana volcanic arc, formed in and along an oceanic trough next to the north edge of the Wrangellia composite terrane. As the composite terrane progressed north, the Nutzotin Mountain sequence eventually became the glue that attached Wrangellia to the continent. The Alexander(?) terrane, located on the eastern edge of the park and extending into the neighboring Yukon Territory, Canada, stitched to the Wrangellia terrane by a Pennsylvanian monzonite-granite complex, is composed of early Paleozoic marble, schist, phyllite, and amphibolite. Wrangellia, the principal terrane in the Wrangellia composite terrane, consists chiefly of a Pennsylvanian-Permian volcanic arc, probably built on oceanic crust, overlain by a sequence of thick Triassic flood basalts, Triassic limestones, and Jurassic sedimentary rocks. It occupies the bulk of the region with magnificent volcanic edifices and broad glacial valleys. The Peninsular terrane, buried by the deposits of ancient glacial Lake Atna (Nichols, 1989; Williams and Galloway, 1986) and exposed only locally west of the park, consists chiefly of a Jurassic volcanic arc that overlies the Wrangellia terrane. Located south of the Wrangellia composite terrane and separated by the Border Ranges Fault, the Southern Margin composite terrane's spectacular mountains consist of two distinct terranes: the Chugach and Prince William terranes. The Chugach terrane's towering peaks are composed largely of another, younger, marine flysch that formed in a deep oceanic trough, which arrived in the latest Cretaceous (about 67 Ma). Following and separated by the Contact Fault System, the Chugach terrane was joined by the Prince William terrane (about 50 Ma), a Tertiary deep-sea fan and volcanic rock assemblage, home to the ecologically sensitive Copper River Delta. Finally, arriving about 26 Ma and still actively accreting to the continent, is the Yakutat terrane, a series of Jurassic(?) and Cretaceous to late Tertiary sedimentary rocks that include minor amounts of oceanic volcanic rocks. The Yakutat terrane, host to some of the world's largest glaciers (fig. 5, on map sheet), is separated from the northern terranes by the Chugach-Saint Elias Fault System and the Fairweather Fault.

QUATERNARY ACTIVITY

The Wrangell volcanic field forms much of the higher elevations of the Wrangell and Saint Elias Mountains. Initial volcanism began about 26 million years ago near the Alaska-Yukon border and progressed northwestward terminating at the spectacular Quaternary volcanoes of Mount Drum, Mount Wrangell, and Mount Sanford. The volcanic activity is related to the subduction of the Pacific Plate and coincided with the Yakutat terrane's time of arrival. Subduction and associated volcanic activity largely ended about 200,000 years ago when much of the north movement of the Pacific Plate was then accommodated by right-lateral movement along the Denali Fault System, the Totschunda Fault System, and the Fairweather Fault; all strike-slip faults. As subduction mostly ceased, that part of Alaska south of the Denali-Totschunda Fault Systems, which includes most of Wrangell-Saint Elias National Park and Preserve, was largely coupled to the Pacific Plate. The latest activity to occur on the bounding faults was the shallow Magnitude 7.9 earthquake of November 3, 2002, whose epicenter was on the Denali Fault System northwest of the park. The ground rupture produced along the Denali and the Totschunda Fault Systems stretched into the park, as far southeast as the Nabesna River.

ACKNOWLEDGMENTS

Many of our colleagues have contributed to the compilation of this geologic map, for which we are grateful. E.M. MacKevett, Jr., George Plafker, H.R. Schmoll, G.R. Winkler, and L.A. Yehle all reviewed parts of the map; their efforts and comments contributed significantly to the map's integrity. G.R. Winkler (bedrock) and H.R. Schmoll and L.A. Yehle (surficial deposits) reviewed the final product. Scott Starratt conducted the geologic names review. Carolyn Donlin edited the map. Rich Koch provided the digital cartography. Our most sincere appreciation extends to Logan Hovis, Suzanne McCarthy, D.S. Rosenkrans and the rest of the staff at Wrangell-Saint Elias National Park and Preserve, as well as many local residents of the Copper River basin, who helped in preparation of this map.

Text from source map: [Geologic Map of Wrangell-Saint Elias](#)

Figure 1

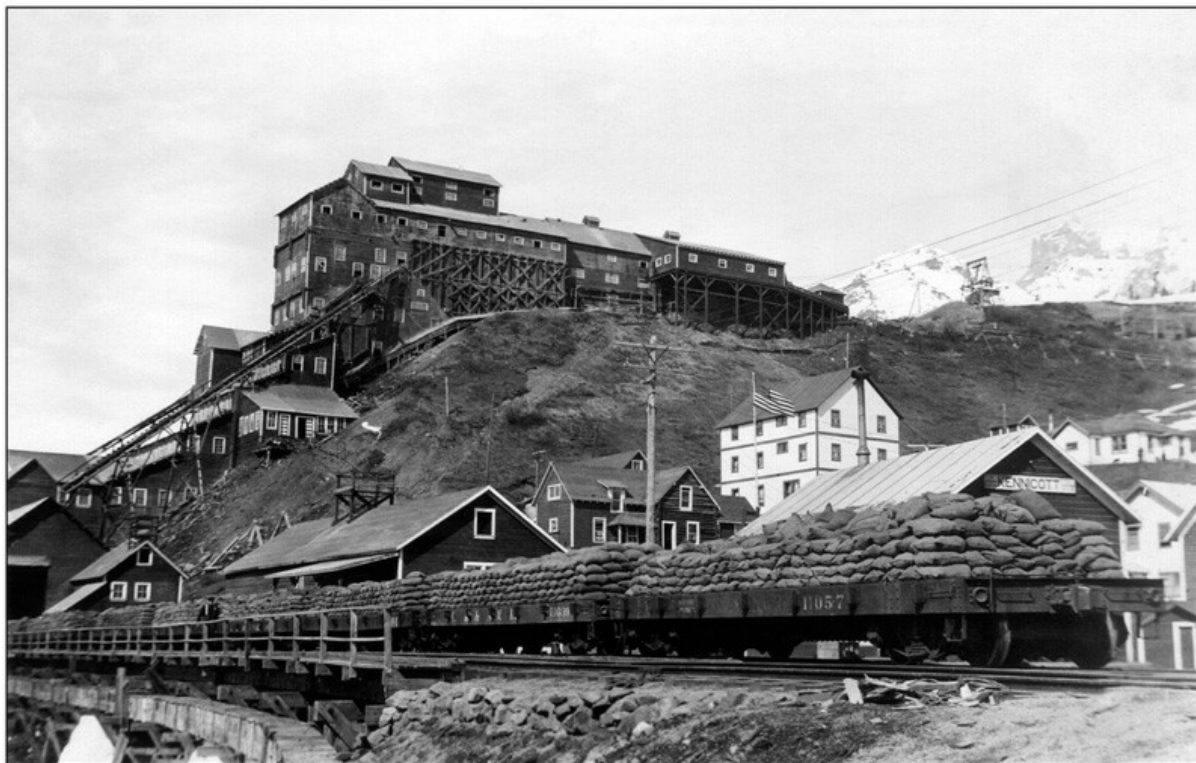


Figure 1. The Kennecott Mine mill building and railroad cars full of copper ore from the Bonanza and Jumbo Mines of the Kennecott mining district, circa 1920. View to northeast. Photo courtesy of Geoff Bleakley.

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Figure 2

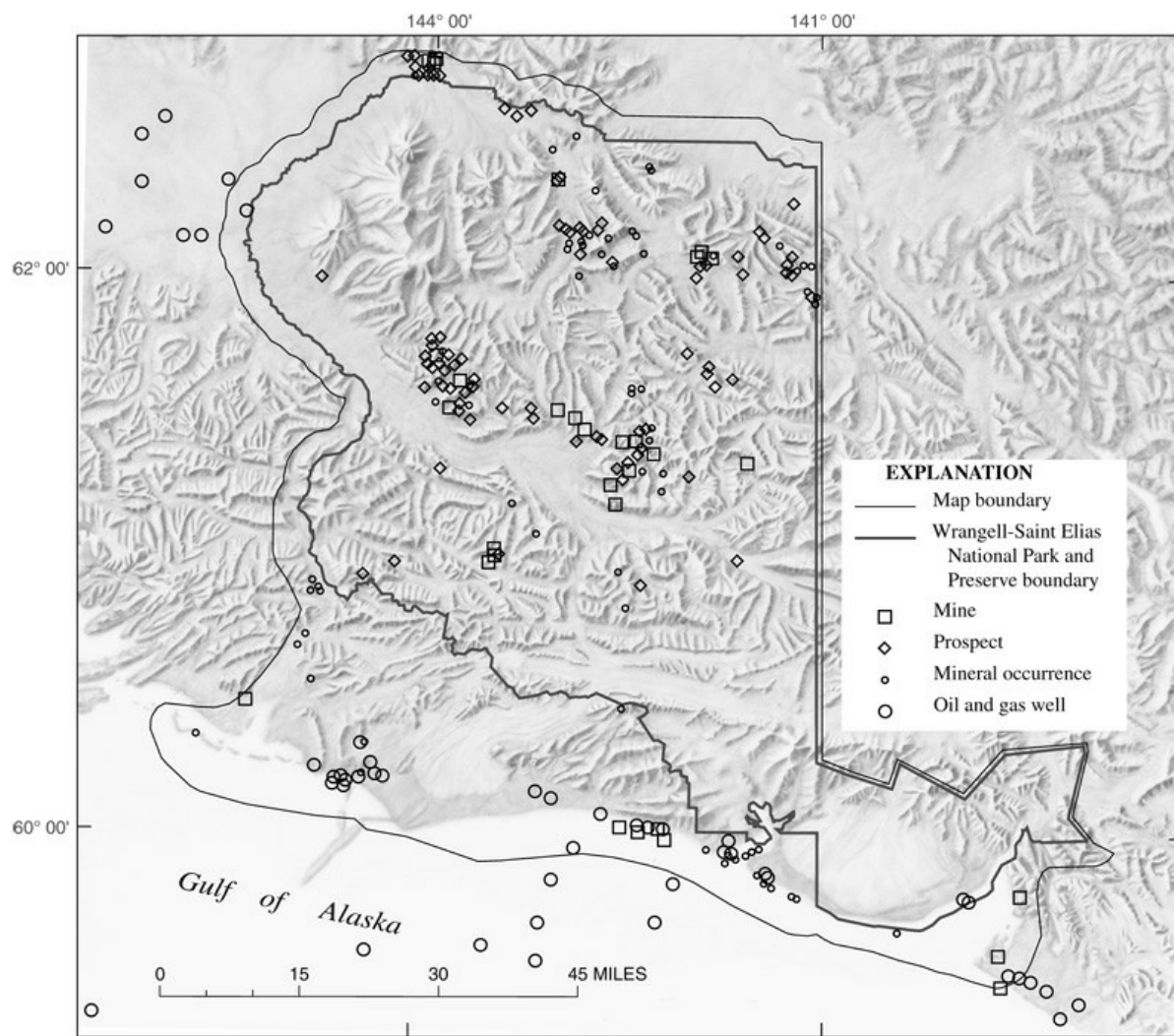


Figure 2. Generalized locations of mines, prospects, mineral occurrences, and exploration oil and gas wells in or near Wrangell-Saint Elias National Park and Preserve. Mining information provided by the U.S. Geological Survey's Alaska Resource Data File (<http://ardf.wr.usgs.gov/>). Oil and gas data provided by the State of Alaska Division of Oil and Gas (<http://www.dog.dnr.state.ak.us/oil/>). Shaded relief image courtesy of the National Park Service.

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Figure 3

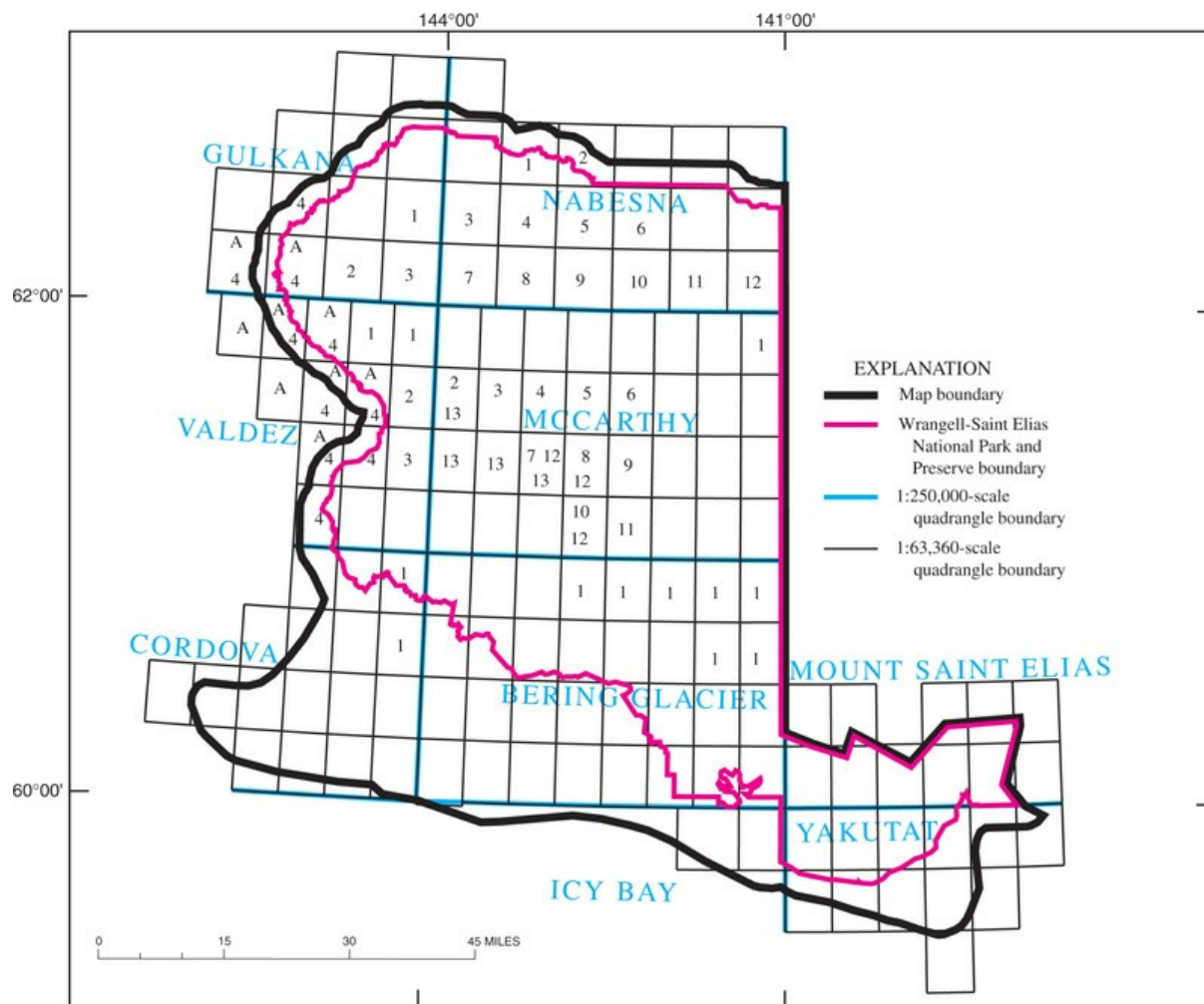


Figure 3. Index map showing sources of information used to compile the geologic map of Wrangell-Saint Elias National Park and Preserve, Alaska. Numbers and letters correlate to 1:63,360-, 1:125,000-, and 1:250,000-scale maps listed in the "Sources of Information" references.

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Figure 4

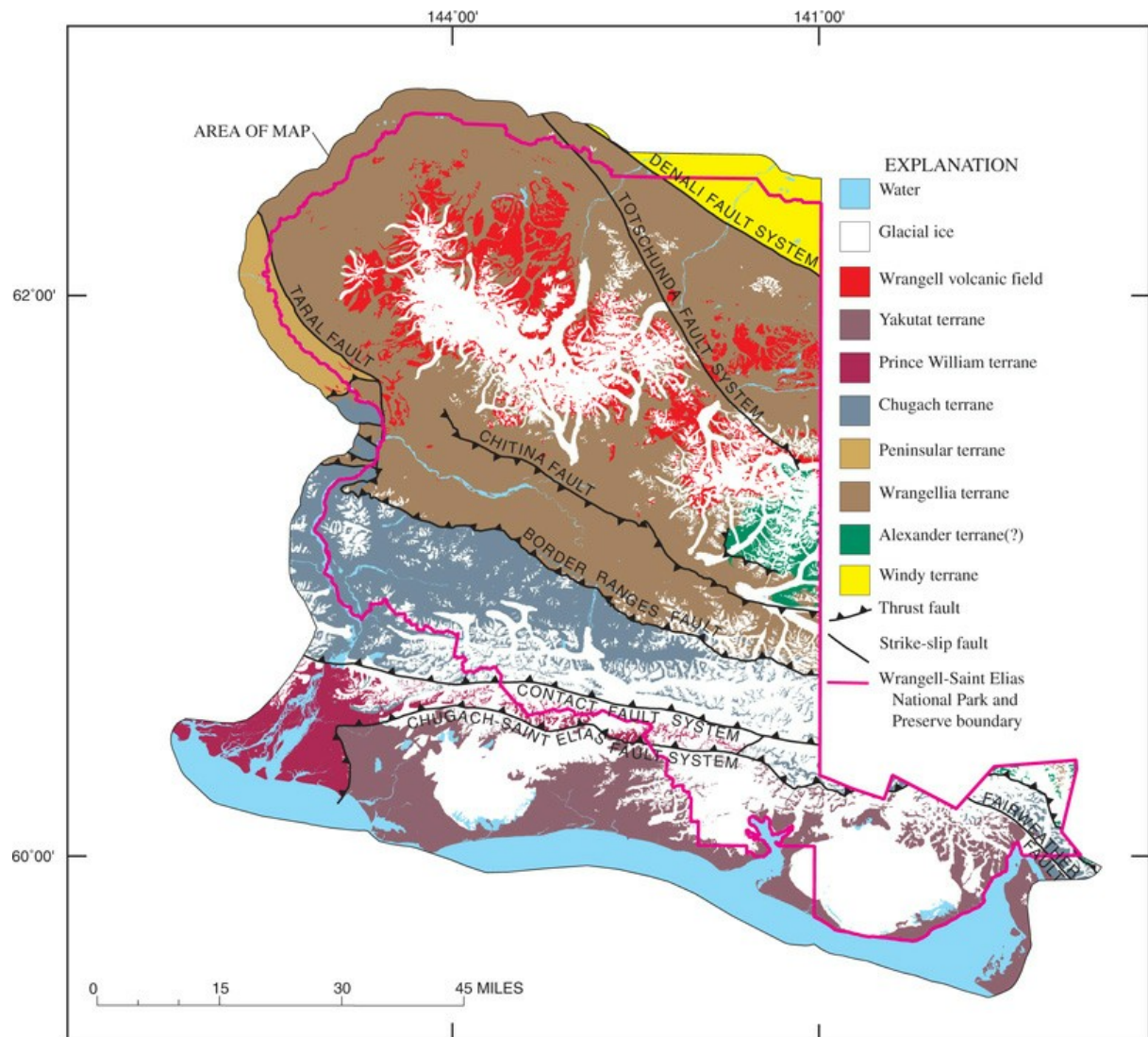


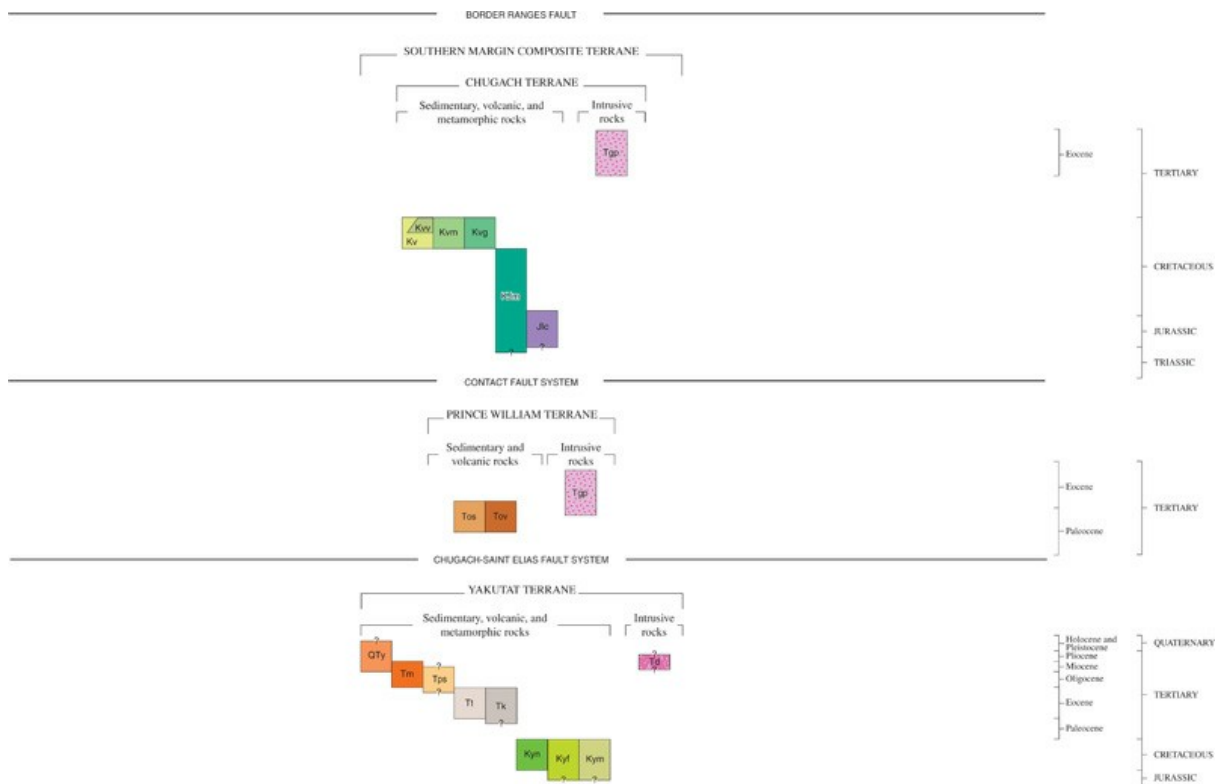
Figure 4. Index map showing the collage of terranes that formed Wrangell-Saint Elias National Park and Preserve, Alaska. Each color represents a unique stratigraphic package, bounded by thrust or strike-slip faults.

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Figure 5

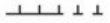
Figure 5. Malaspina Glacier, the world's largest piedmont glacier, is clearly visible from this 1989 space shuttle mission photo. Draining off the Bagley ice field, it covers over 3,000 sq. miles (5000 sq. kilometers). Image courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center, <http://eol.jsc.nasa.gov>, photo number STS028-97-082.

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)



Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Map Legend

	Contact —Known and approximately located. Dotted where concealed
	Normal and strike-slip fault —Known, approximate, and inferred. Dotted where concealed
	Thrust fault —Known approximate, and inferred. Dotted where concealed. Teeth on upper plate
	Dikes —Andesitic dike swarm, Capital Mountain volcano
	Dikes —Chiefly andesite and dacite
	Caldera wall —Known and approximate. Dotted where inferred or concealed. Hachures on caldera side
	White River Ash —Western and southern limits of readily discernible (thickness approximately greater than 10 cm) White River Ash erupted from Mount Churchill about 1,920 and 1,280 yr B.P. (Lerbekmo and others, 1975; Richter and others, 1995)
	Glacier ice boundary —Bounding clean ice from bedrock, supraglacial moraines, and rock glaciers
	Supraglacial moraine —Rock debris on existing glacier
	Submerged end moraine —Hachures on glacial side 970 A.D.
	Historic ice recession in Icy Bay —Recession lines are from Post (1988). Year represents historical maximum. Historic recession lines for other glaciers not shown
	Wrangell-Saint Elias National Park and Preserve boundary
	Road
	Town

Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

Index Map



Graphic from source map: [Geologic Map of Wrangell-Saint Elias](#)

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Geologic Map of Alaska

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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 text and web links 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](#).

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. The geologic features in the GRI digital geologic-GIS data and many of the unit descriptions listed in this document are from 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. The USGS SOURCE code consists of the 2-letter quadrangle code and a three digit number that relates to the source references used in the production of the Geologic Map of Alaska (USGS SIM-3340). The value of 001 is reserved for the topographic map or other source of hydrologic spatial data for each quadrangle and is not include in this list. Values in the SOURCE field in the GRI data correspond to the codes that precede each of the following references.

BG002 Plafker, George, in prep, Geology of Bering Glacier and Icy Bay quadrangles: U.S. Geological Survey Miscellaneous Investigations Map scale 1:250,000, in press.

BG004 Richter, D.H., Preller, C.C., Labay, K.A., and Shew, N.B., 2005, Geology of Wrangell-Saint Elias National Park and Preserve, southcentral Alaska: U.S. Geological Survey Scientific Investigations Series Map SIM-2877, scale 1:350,000.

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Alaska Paleontologic Database

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ARDF, 1' x 3' Bering Glacier Quadrangle

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Hudson, T.L., 2002, Alaska Resource Data File, Bering Glacier Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-02-115, scale 1:250,000 (*GRI Source Map ID 55228*).

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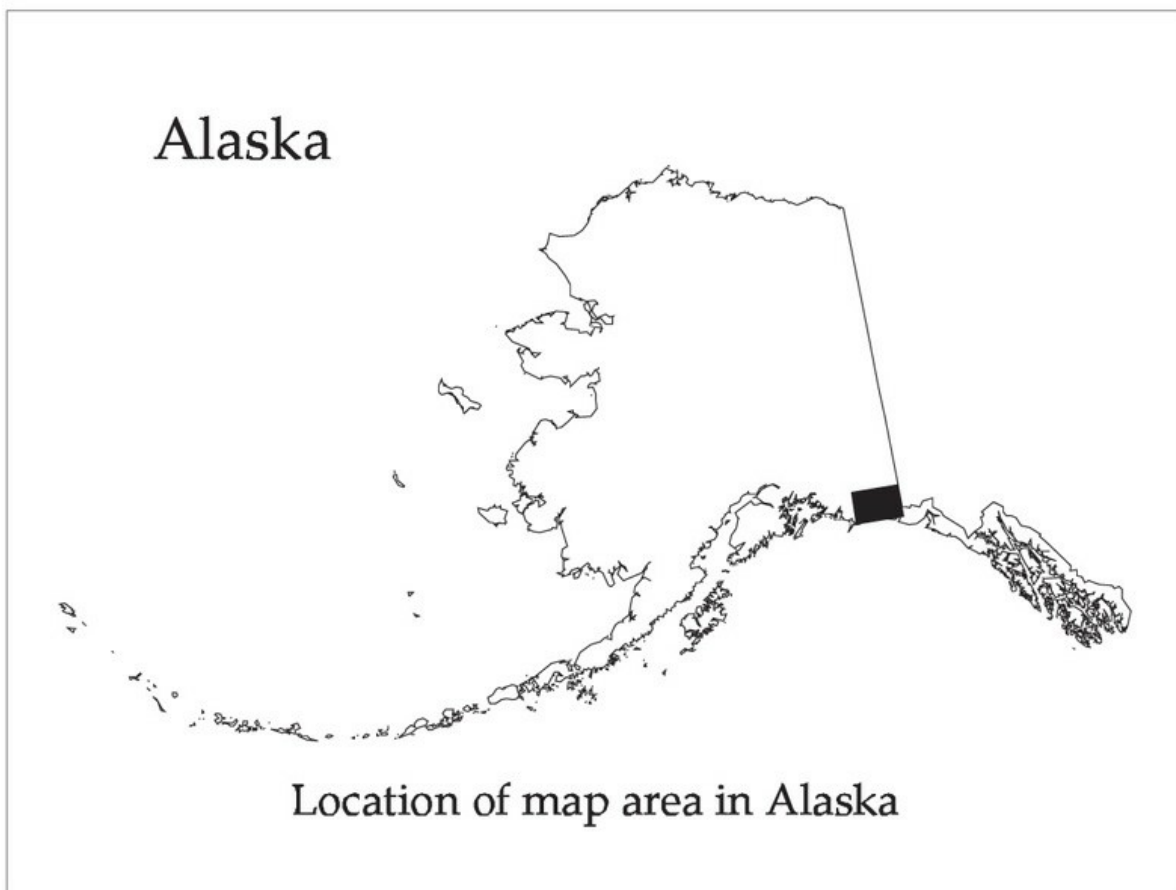
Report

The Alaska Resource Data File (ARDF) report for the Bering Glacier Quadrangle, Alaska (OFR 02-115) is available for download at the following link: [Report PDF](#)

Data

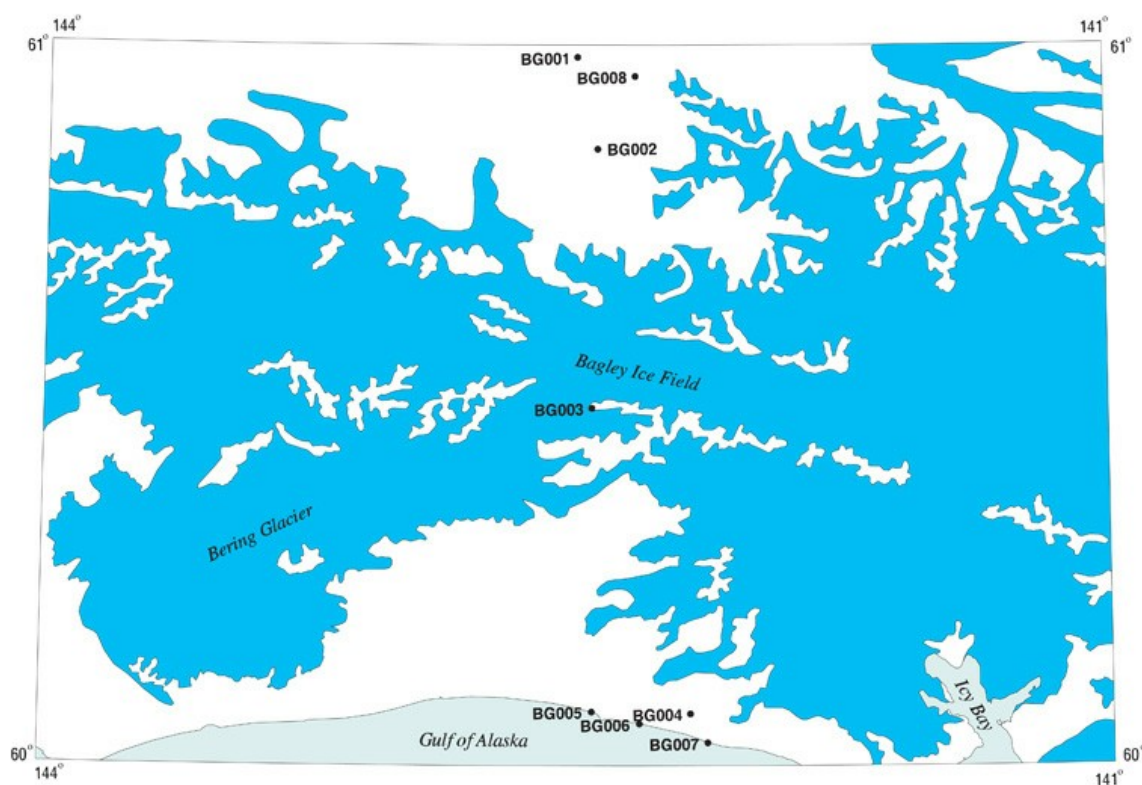
The Alaska Resource Data File (ARDF) data for the Bering Glacier Quadrangle, Alaska (OFR 02-115) is available for download at the following link: [ARDF Data](#)

Index Map



Graphic from source map: [ARDF, 1' x 3' Bering Glacier Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Bering Glacier
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Bering Glacier Quadrangle](#)

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ARDF, 1' x 3' Cordova Quadrangle

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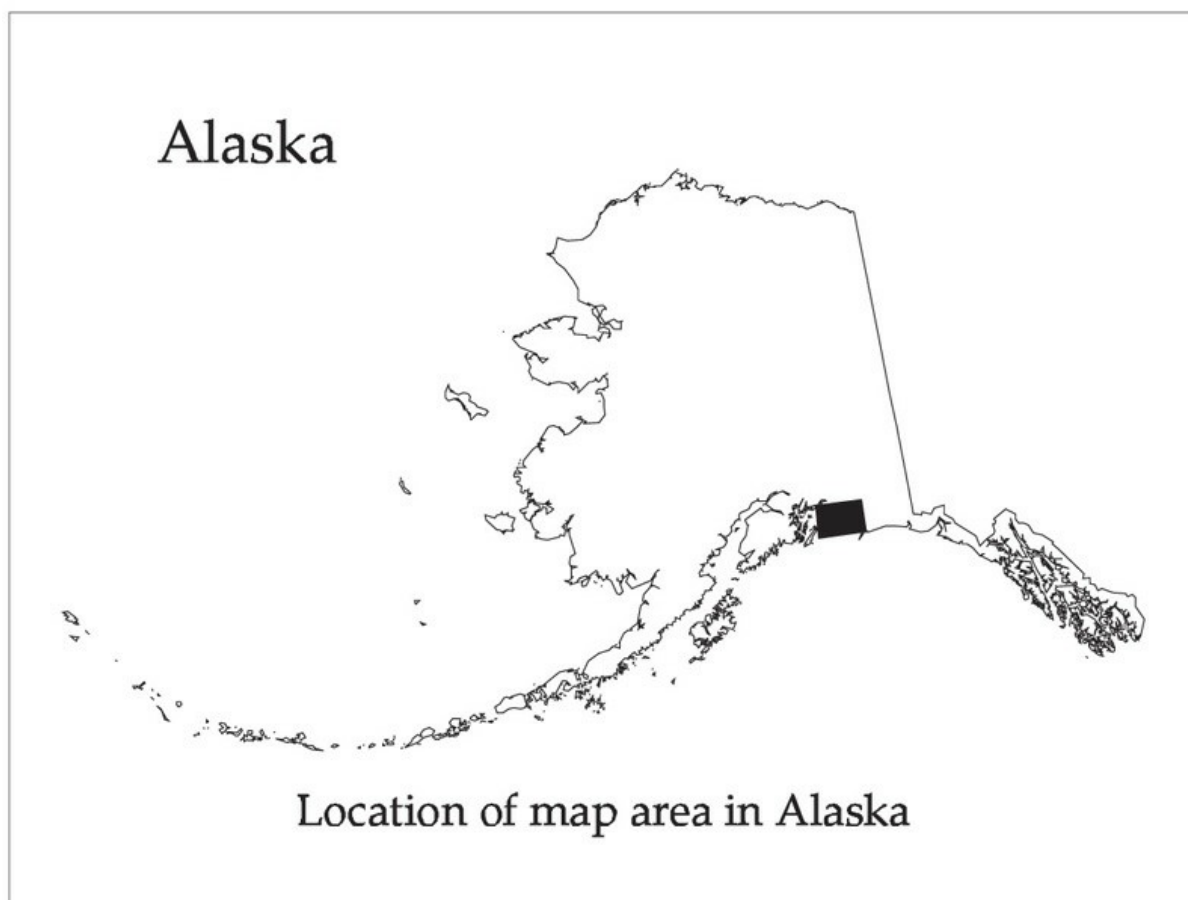
Report

The Alaska Resource Data File (ARDF) report for the Cordova Quadrangle, Alaska (OFR 01-110) is available for download at the following link: [Report PDF](#)

Data

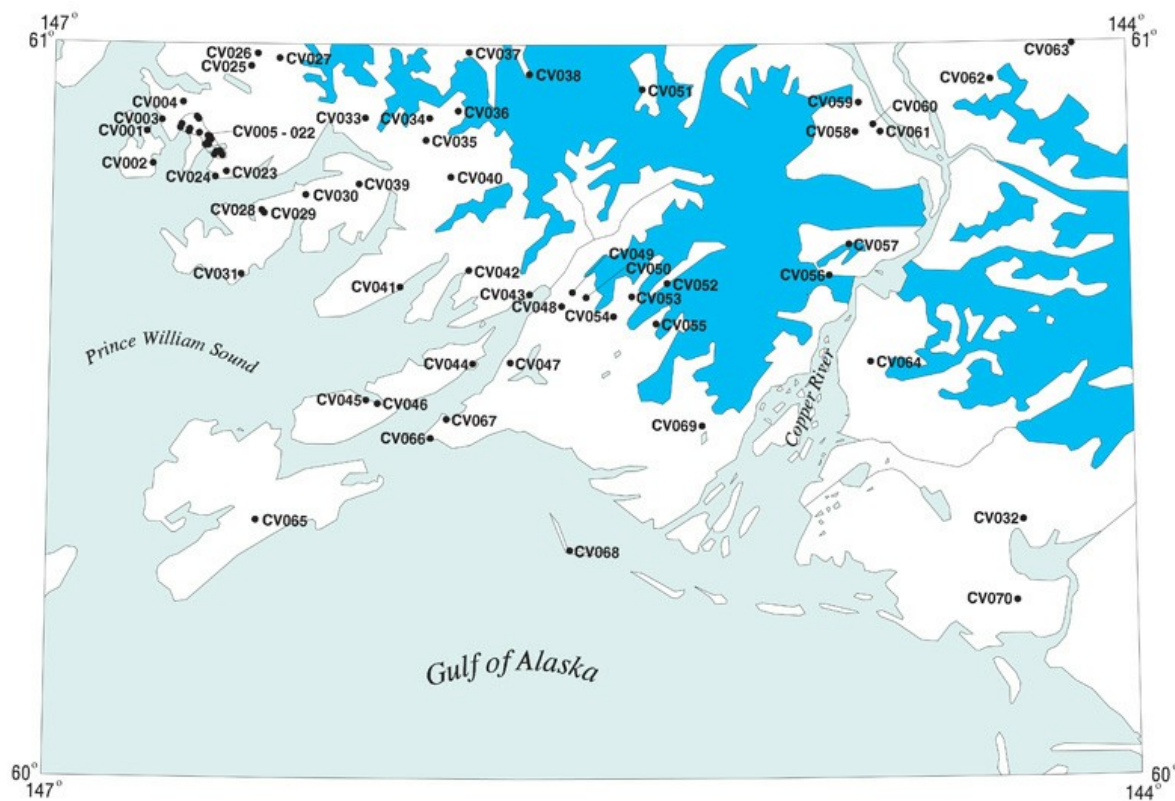
The Alaska Resource Data File (ARDF) data for the Cordova Quadrangle, Alaska (OFR 01-110) is available for download at the following link: [ARDF Data](#)

Index Map



Graphic from source map: [ARDF, 1' x 3' Cordova Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Cordova
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Cordova Quadrangle](#)

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ARDF, 1' x 3' Gulkana Quadrangle

The formal citation for this source.

Ellis, W.T., 2001, Alaska Resource Data File, Gulkana Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-01-191, scale 1:250,000 (*GRI Source Map ID 3003*).

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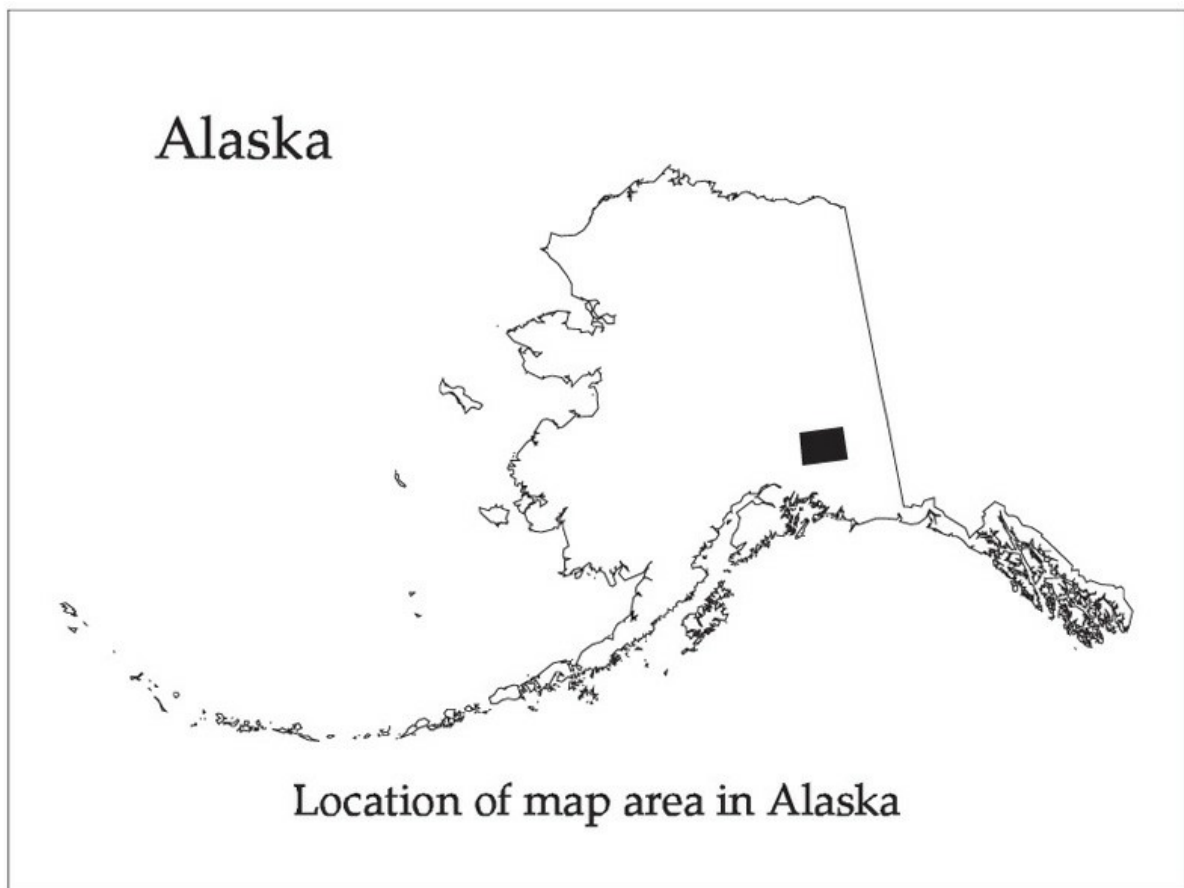
Report

The Alaska Resource Data File (ARDF) report for the Gulkana Quadrangle, Alaska (OFR 01-191) is available for download at the following link: [Report PDF](#)

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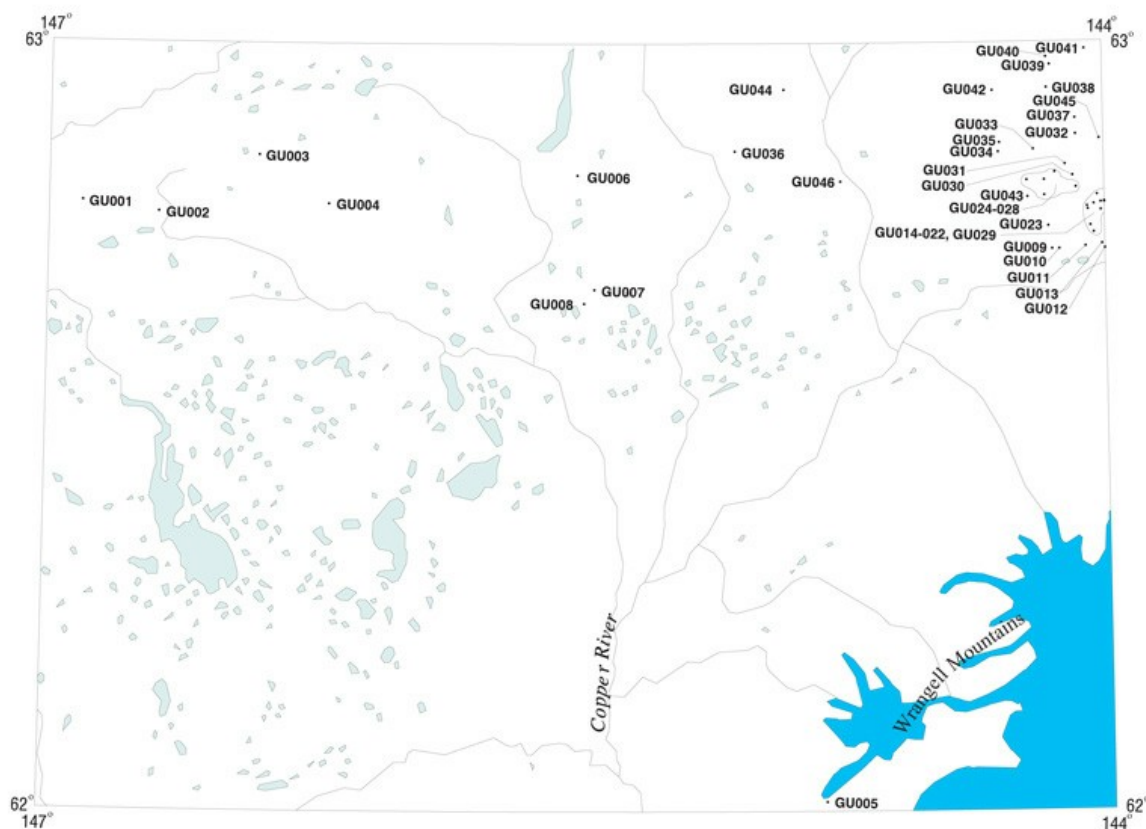
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Index Map



Graphic from source map: [ARDF, 1' x 3' Gulkana Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Gulkana
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Gulkana Quadrangle](#)

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ARDF, 1' x 3' Icy Bay Quadrangle

The formal citation for this source.

Hudson, T.L., 2002, Alaska Resource Data File, Icy Bay Quadrangle, Alaska: U.S. Geological Survey, Open-File Report, OF-02-116, scale 1:250,000 (*GRI Source Map ID 55229*).

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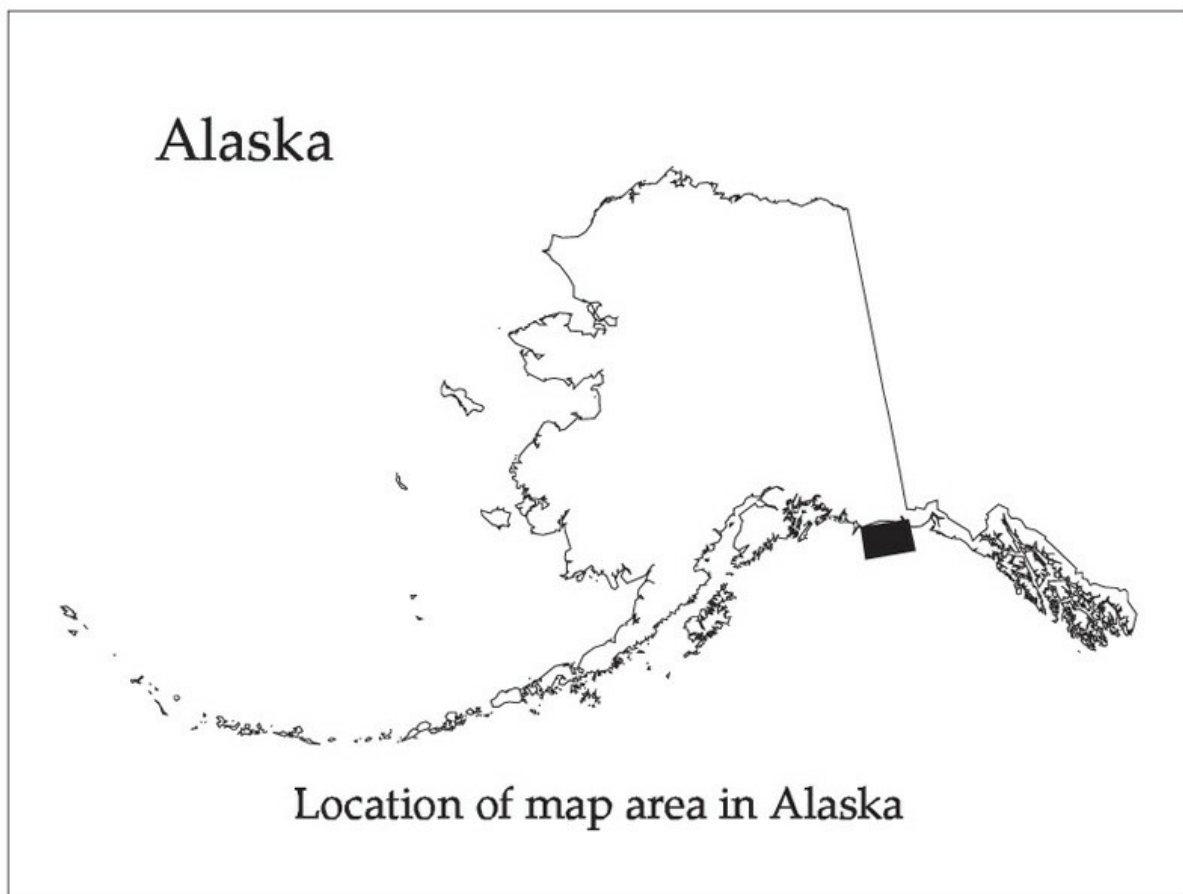
Report

The Alaska Resource Data File (ARDF) report for the Ice Bay Quadrangle, Alaska (OFR 02-116) is available for download at the following link: [Report PDF](#)

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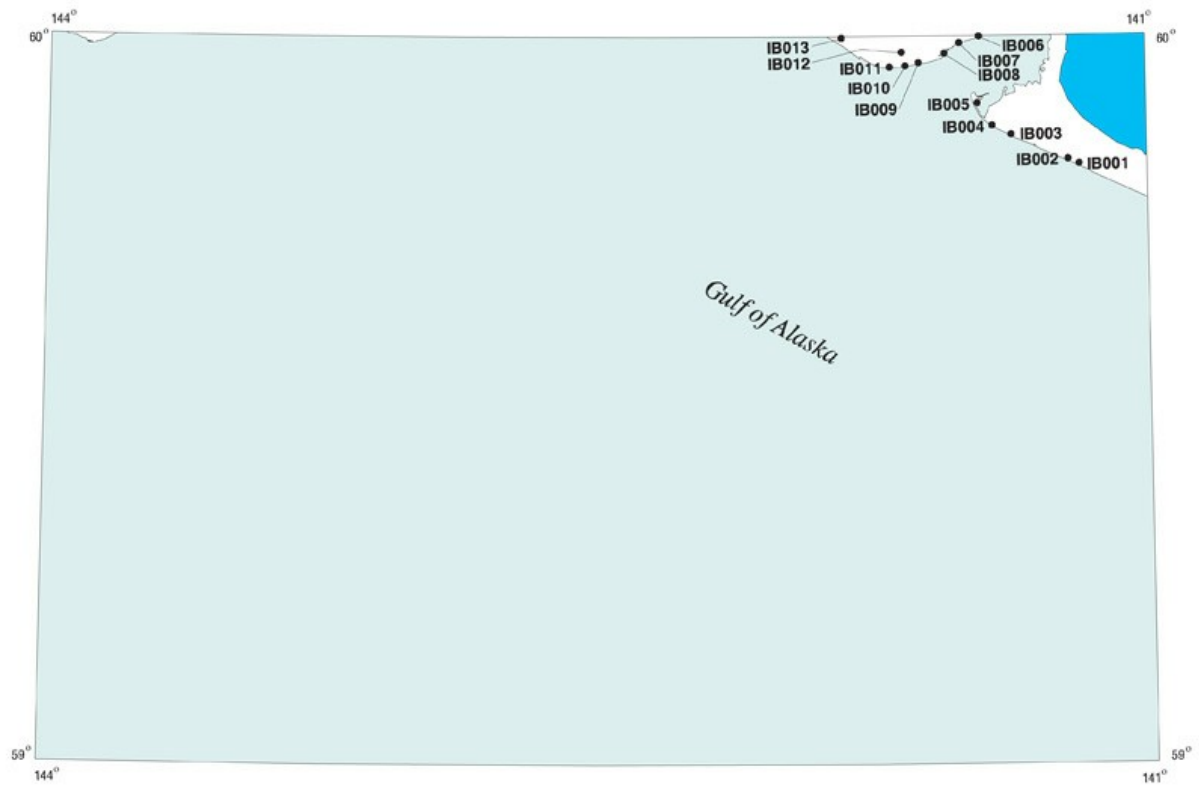
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Index Map



Graphic from source map: [ARDF, 1' x 3' Icy Bay Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Icy Bay
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Icy Bay Quadrangle](#)

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ARDF, 1' x 3' McCarthy Quadrangle

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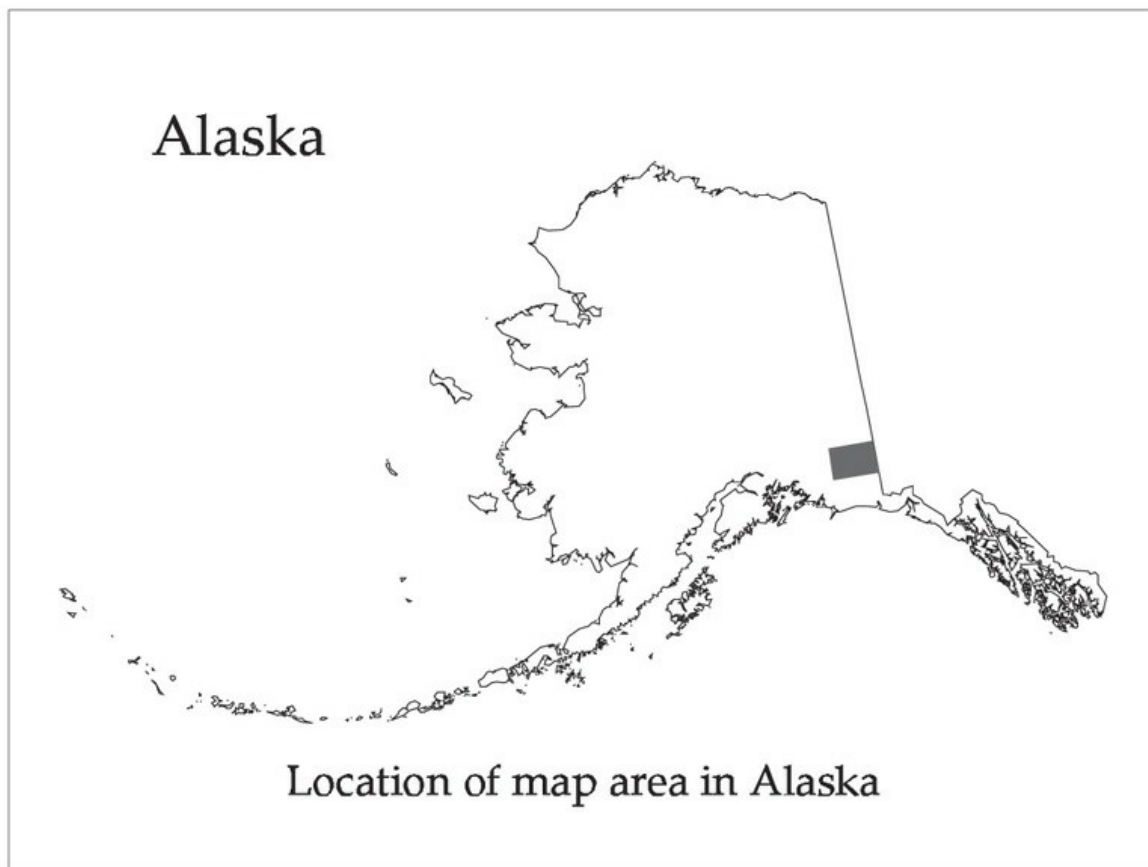
Report

The Alaska Resource Data File (ARDF) report for the McCarthy Quadrangle, Alaska (OFR 03-404) is available for download at the following link: [Report PDF](#)

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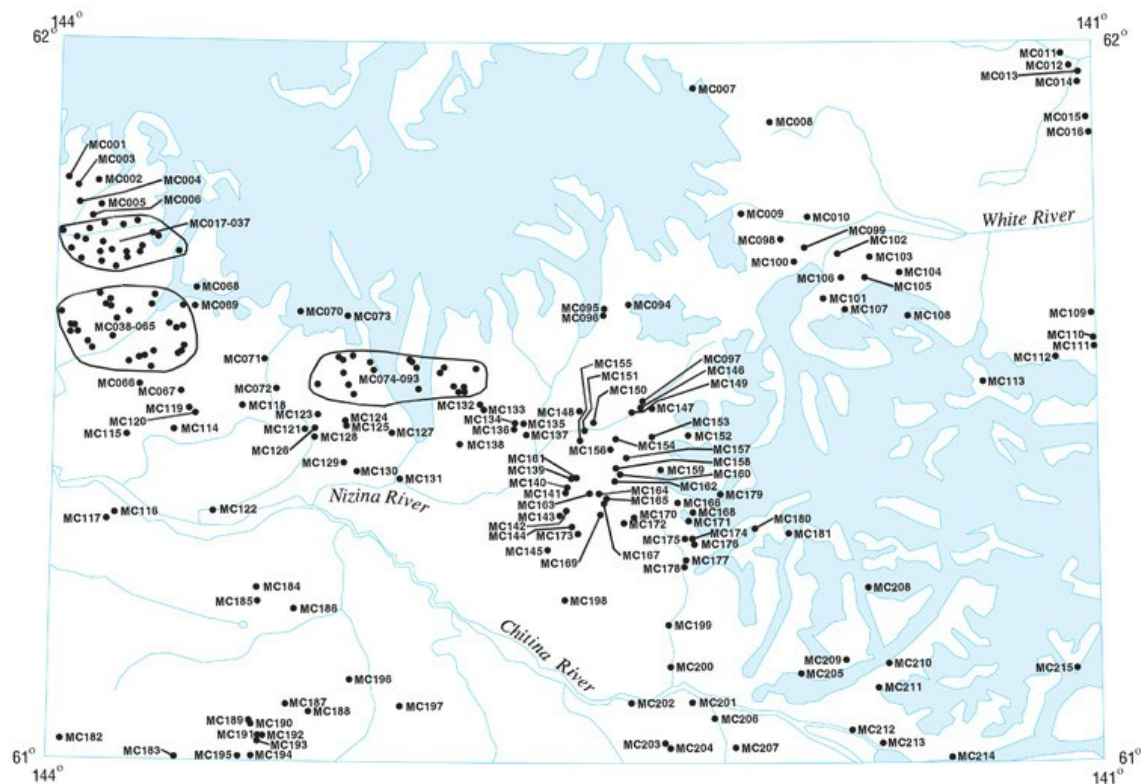
The Alaska Resource Data File (ARDF) data for the McCarthy Quadrangle, Alaska (OFR 03-404) is available for download at the following link: [ARDF Data](#)

Index Map



Graphic from source map: [ARDF, 1' x 3' McCarthy Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the McCarthy
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' McCarthy Quadrangle](#)

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ARDF, 1' x 3' Nabesna Quadrangle

The formal citation for this source.

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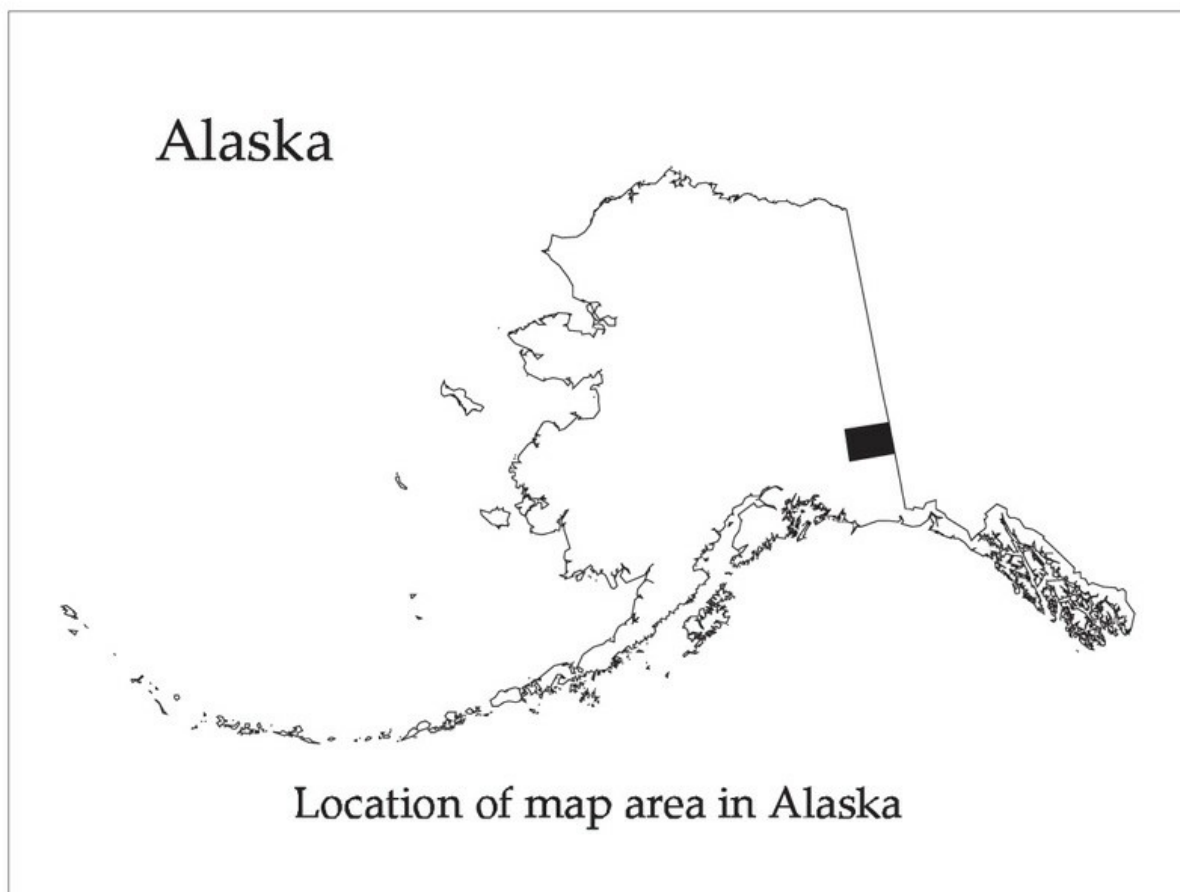
Report

The Alaska Resource Data File (ARDF) report for the Nabesna Quadrangle, Alaska (OFR 03-446) is available for download at the following link: [Report PDF](#)

Data

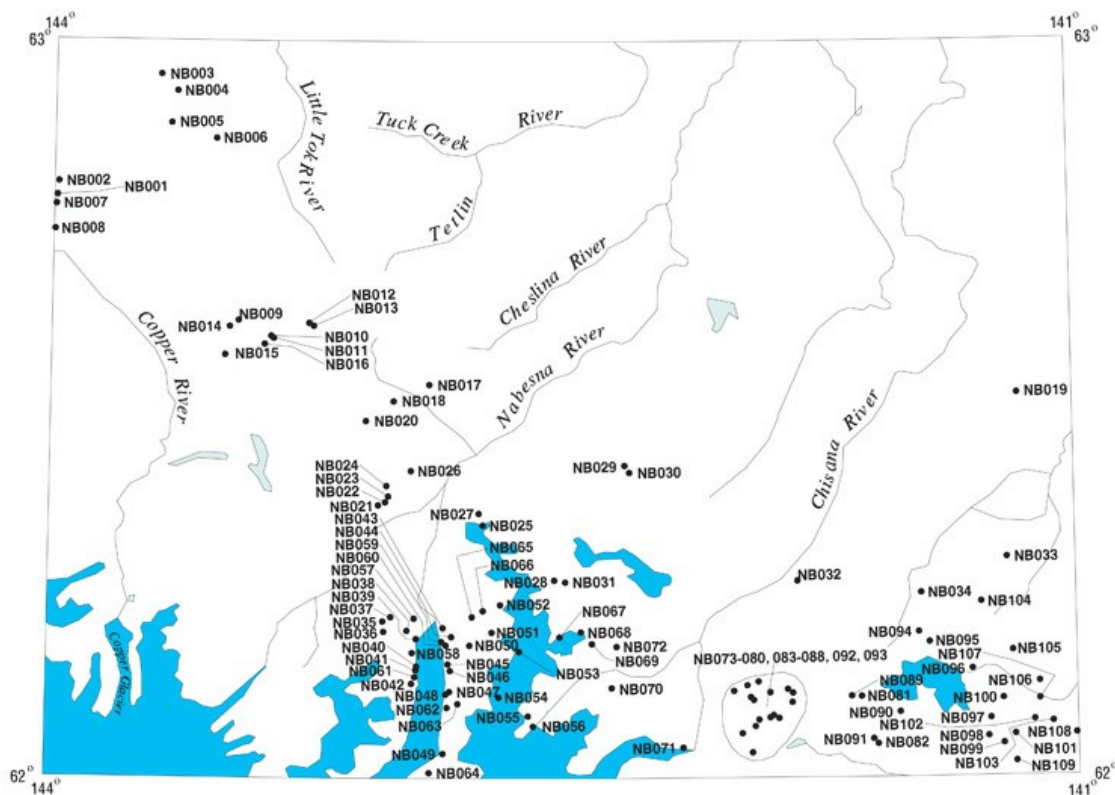
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Index Map



Graphic from source map: [ARDF, 1' x 3' Nabesna Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Nabesna
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Nabesna Quadrangle](#)

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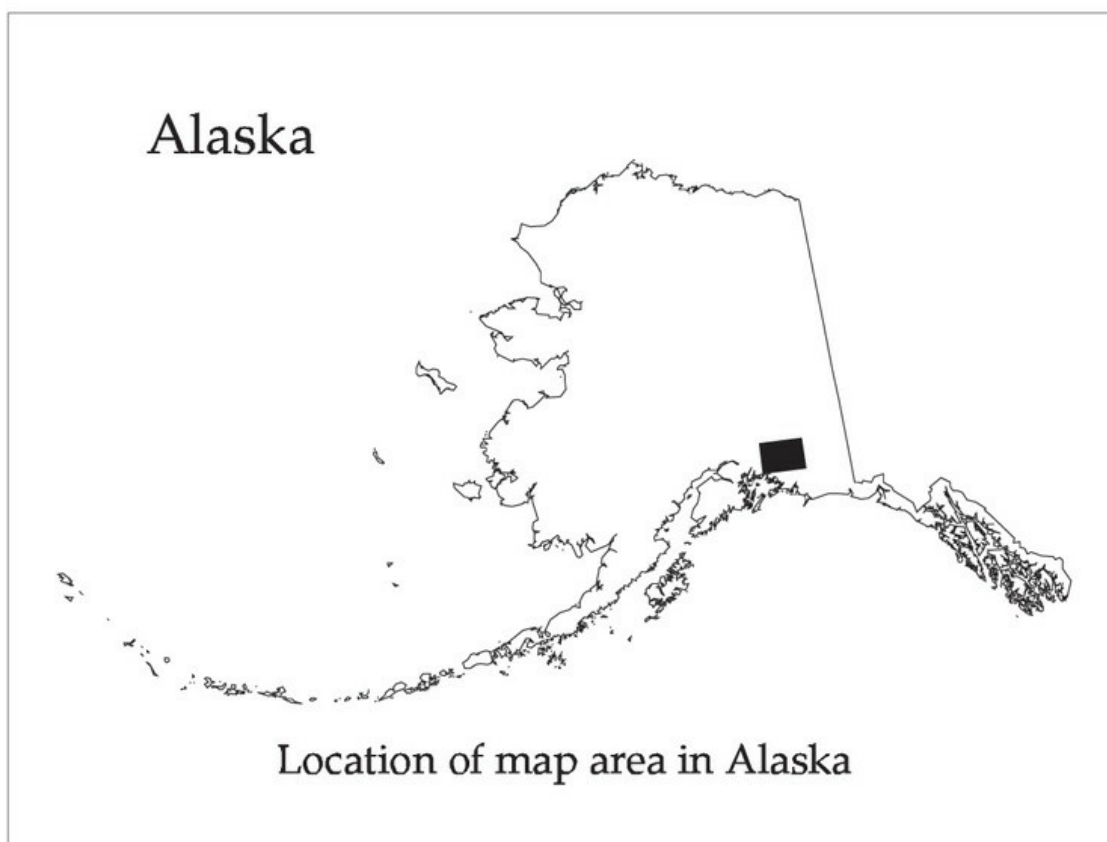
Report

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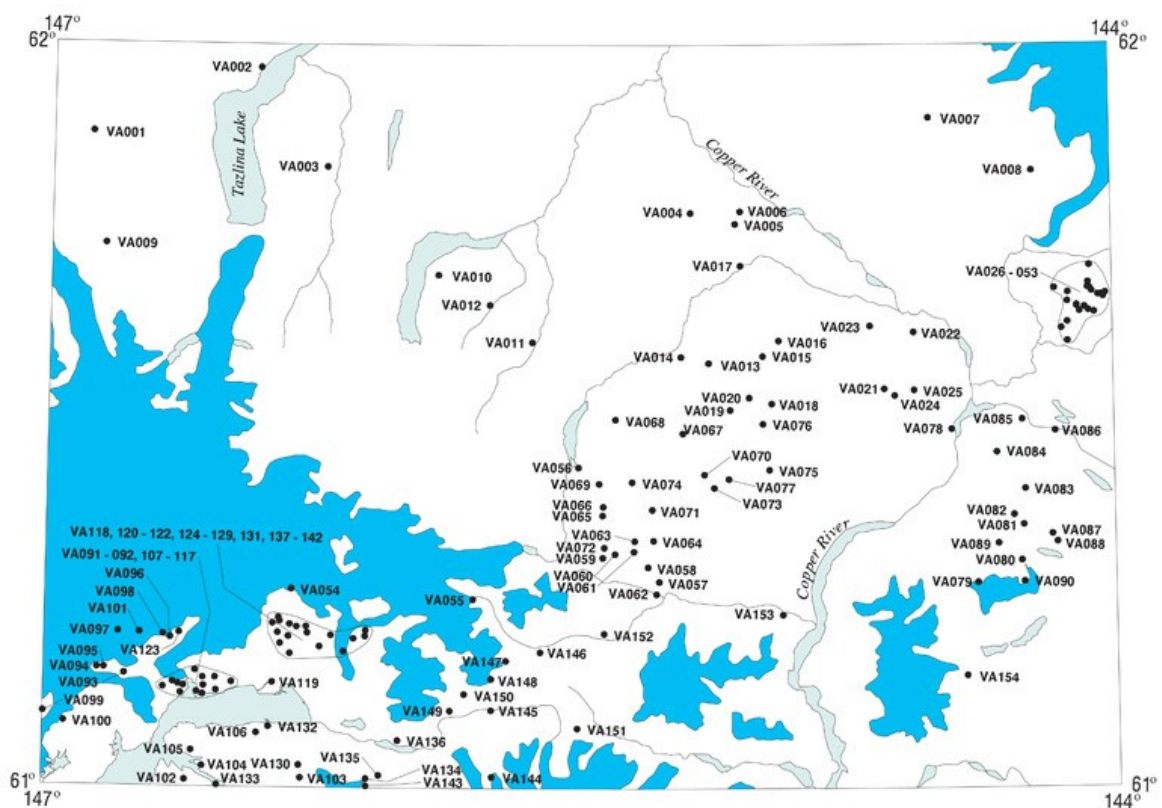
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Graphic from source map: [ARDF, 1' x 3' Valdez Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Valdez
1:250,000-scale quadrangle, Alaska*

Graphic from source map: [ARDF, 1' x 3' Valdez Quadrangle](#)

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ARDF, 1' x 3' Yakutat Quadrangle

The formal citation for this source.

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Prominent graphics and text associated with this source.

Report

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Data

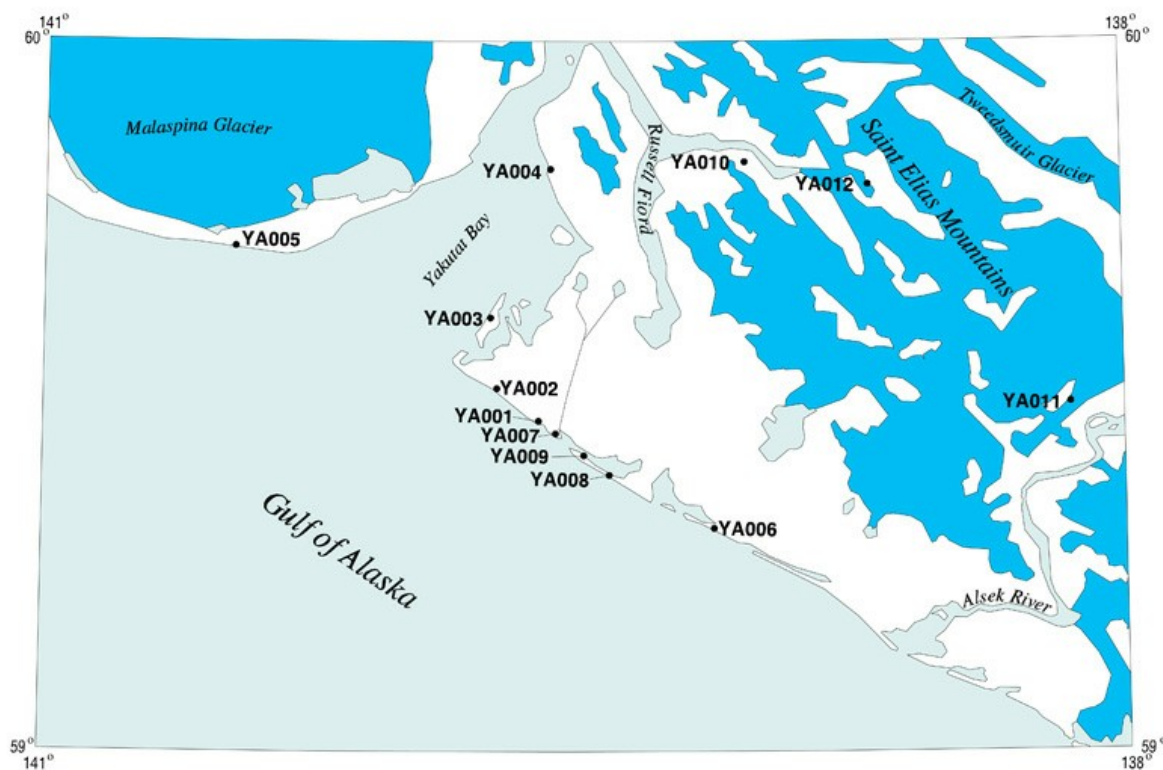
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Index Map



Graphic from source map: [ARDF, 1' x 3' Yakutat Quadrangle](#)

Mineral Occurrence Map



*Distribution of mineral occurrences in the Yakutat
1:250,000-scale quadrangle, southeastern Alaska*

Graphic from source map: [ARDF, 1' x 3' Yakutat Quadrangle](#)

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References from source map: [ARDF, 1' x 3' Yakutat Quadrangle](#)

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The information in this document was compiled from GRI source maps, and is intended to accompany the digital geologic-GIS map and other digital data for Wrangell-Saint Elias National Park and Preserve, Alaska (WRST) developed by Ron Karpilo (Colorado State University) (see the [GRI Digital Map and Source Map 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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