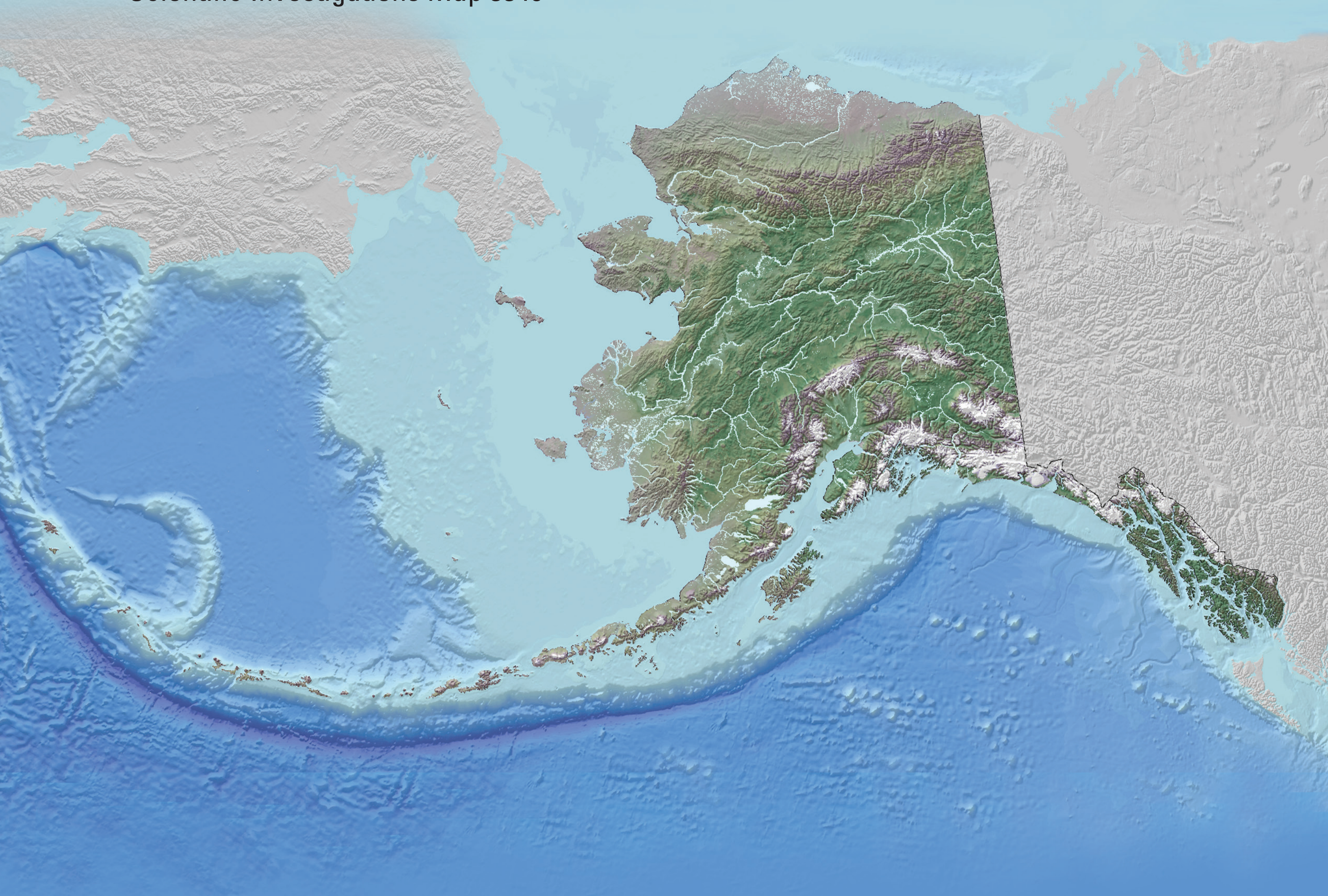
# Geologic Map of Alaska

Compiled by
Frederic H. Wilson, Chad P. Hults, Charles G. Mull, and Susan M. Karl

Pamphlet to accompany
Scientific Investigations Map 3340



2015

**U.S. Department of the Interior**
**U.S. Geological Survey**

**Front cover.** Color shaded relief map of Alaska and surroundings.
Sources: 100-meter-resolution natural image of Alaska, http://nationalmap.gov/small_scale/mld/nate100.html; rivers and lakes dataset, http://www.asgdc.state.ak.us/; bathymetry and topography of Russia and Canada, https://www.ngdc.noaa.gov/mgg/global/global.html.

**Back cover.** Previous geologic maps of Alaska:
**1906**—Brooks, A.H., Abbe, Cleveland, Jr., and Goode, R.U., 1906, The geography and geology of Alaska; a summary of existing knowledge, with a section on climate, and a topographic map and description thereof: U.S. Geological Survey Professional Paper 45, 327 p., 1 sheet.
**1939**—Smith, P.S., 1939, Areal geology of Alaska: U.S. Geological Survey Professional Paper 192, 100 p., 18 plates.
**1957**—Dutro, J.T., Jr., and Payne, T.G., 1957, Geologic map of Alaska: U.S. Geological Survey, scale 1:2,500,000.
**1980**—Beikman, H.M., 1980, Geologic map of Alaska: U.S. Geological Survey Special Map, scale 1:2,500,000, 2 sheets.

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**U.S. Department of the Interior**
SALLY JEWELL, Secretary

**U.S. Geological Survey**
Suzette M. Kimball, Director

U.S. Geological Survey, Reston, Virginia: 2015

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Suggested citation:
Wilson, F.H., Hults, C.P., Mull, C.G., and Karl, S.M., comps., 2015, Geologic map of Alaska: U.S. Geological Survey Scientific Investigations Map 3340, 197 p., 2 sheets, scale 1:584,000, http://dx.doi.org/10.3133/sim3340.

ISSN 2329-1311 (print)
ISSN 2329-132X (online)
ISBN 978-1-4113-4000-8

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# Geologic Map of Alaska

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## Introduction

This map and its associated digital databases are the result of compilation and reinterpretation of published and unpublished 1:250,000-scale and limited 1:500,000- to 1:63,360-scale mapping. Covering the entire state of Alaska, it reflects more than a century of work in the State by a host of geologists and almost two decades of compilation work. There are two versions of this map: a complete, detailed map found in the digital database, and a simplified, "generalized" map for print. Units described here are included in the detailed digital map. At the end of each unit description, we indicate to which generalized map unit it is assigned on the print map.

Compilation of this map began in September 1996, using published 1:250,000-scale maps of central Alaska (Wilson and others, 1998). Description and correlation of geologic units to produce the units for this statewide map was an iterative process, and interim products—a series of regional geologic map compilations—were released as the process continued (see references shown with an * in the references cited). As the process continued and additional geologic data were acquired, previously released data, correlations, and our interpretations were updated as needed. Digital files of the final compilation of the 153 1:250,000-scale quadrangles for the state are available on the Web [http://dx.doi.org/10.3133/sim3340]. The map sources we used are cited in the text and quadrangle codes are listed in table 1, on p. 2; within the digital files every line and polygon is attributed to its respective source.

Many compromises have been made in strongly held perspectives to allow construction of this compilation. The regional compilations mentioned above and cited in the references may show different interpretations of the geology of their respective regions. Each regional map reflects the mapping style and interpretations of its authors. All of these regional compilations, as well as digital versions of primary sources, form an integral part of the database from which this statewide map is constructed. As we built the statewide compilation, we did our best to resolve conflicting interpretations and map data from the regional compilations and from the individual source maps in areas where regional compilations have not been produced. We made every effort to preserve the original geologic map information, incorporating new data where available, but we were careful to not overinterpret the geologic data. Yet even our willingness to make interpretations and compromises does not allow us to resolve all mapping conflicts or to converge different mapping styles in some areas. Therefore, there are several areas on the map where it was necessary to separate map units by "quadrangle boundary faults." More time and fieldwork may allow resolution of these conflicts. Nonetheless, we hope that geologists who have worked in Alaska will recognize that in incorporating their work, our regional correlations have required generalizing and grouping of units. We believe that this map and its problems present a very good argument to justify and support further detailed and regional-scale studies focused on geologic mapping in Alaska. We also hope that the digital data of this map will serve new workers in Alaska for some time into the future.

Compilation this map was complex because the original source maps were made by different generations of geologists, mapping with very different ideas. Several of the older maps were completed before the concepts of accreted (suspect) terranes or even plate tectonics existed. On the other hand, some of the more recent maps were so governed by terrane analysis that conventional stratigraphic nomenclature was not used or is obscured. For the present compilation, we adopted a traditional stratigraphic approach and have avoided use of the sometimes controversial and commonly inconsistently defined or applied term "terrane." Our decision to adopt a traditional approach is evident in a map that emphasizes age and lithology of map units, rather than differences among fault-bounded packages of rocks. For a map of this scope and scale, a traditional approach seems to have more to offer to a wider variety of users. It is far easier to construct a terrane map from a traditional geologic map than vice versa. However, in some cases, usage of the terrane names assigned to rock assemblages is unavoidable. In compiling this map, many of the classic terranes of the literature violate the standard definition of tectonostratigraphic terranes (Berg and others, 1972; Coney and others, 1980; Jones and others, 1983) because, although they commonly are assemblages having a distinct history and possibly distinct stratigraphy, they cannot always be demonstrated as being fault-bounded. Additionally, the distinction between a terrane and an overlap assemblage can be the subject of a long discussion. In northern Alaska, and particularly in the Brooks Range, the concept of allochthons has been an important part of geologic discussion, such that much of northern Alaska has been assigned to one terrane and the focus has been on the allochthons. The allochthons, of which there are at least seven, are reasonably well defined in the western Brooks Range, less so in the eastern Brooks Range, and obscured by metamorphism in the central Brooks Range. We were unsuccessful in devising a schema to show the various allochthons without obscuring the internal geology, which is similar from allochthon to allochthon. A related digital database assigns individual map units to their respective allochthons where possible. Users interested in the history of the names of formal stratigraphic units are

**Table 1.** Quadrangle codes for Alaska.

[Code is the standard two-letter abbreviation used to refer to 1:250,000-scale quadrangles in Alaska. Column called "Quadrangle name" is the full name of the quadrangle, which is used in the text of this document]

| Code | Quadrangle name | Code | Quadrangle name | Code | Quadrangle name | Code | Quadrangle name |
|---|---|---|---|---|---|---|---|
| AC | Arctic | DL | De Long Mountains | MK | Mount Katmai | SO | Solomon |
| AD | Adak | DN | Denali | ML | Mount Michelson | SP | Survey Pass |
| AF | Afognak | DP | Demarcation Point | MA | Marshall | SF | Shishmaref |
| AK | Atka | EA | Eagle | MC | McCarthy | SG | Sagavanirktok |
| AL | Atlin | FB | Fairbanks | MD | Medfra | SH | Shungnak |
| AM | Amukta | FI | Flaxman Island | MF | Mount Fairweather | SI | Sitka |
| AN | Anchorage | FP | False Pass | MG | McGrath | SK | Skagway |
| AR | Ambler River | FY | Fort Yukon | MH | Mount Hayes | SL | Saint Lawrence |
| AT | Attu | GI | Gareloi Island | MI | Middleton Island | SM | Sleetmute |
| BA | Barter Island | GO | Goodnews Bay | MR | Meade River | SN | Simeonof Island |
| BB | Bristol Bay | GU | Gulkana | MS | Mount Saint Elias | SR | Seward |
| BC | Bradfield Canal | HC | Holy Cross | MU | Misheguk Mountain | ST | Saint Matthew |
| BD | Big Delta | HE | Healy | MZ | Melozitna | SU | Seguam |
| BG | Bering Glacier | HG | Hagemeister Island | NB | Nabesna | SV | Seldovia |
| BH | Bethel | HP | Hooper Bay | NG | Nushagak Bay | SW | Sutwik Island |
| BI | Baird Inlet | HR | Harrison Bay | NI | Nunivak Island | TA | Taylor Mountains |
| BL | Black | HU | Hughes | NK | Naknek | TB | Table Mountain |
| BM | Baird Mountains | HW | Howard Pass | NL | Nulato | TC | Tanacross |
| BN | Bendeleben | IB | Icy Bay | NM | Nome | TE | Teller |
| BP | Beechey Point | ID | Iditarod | NR | Norton Bay | TI | Trinity Islands |
| BR | Black River | IK | Ikpikpuk River | NT | Noatak | TK | Talkeetna Mountains |
| BS | Blying Sound | IL | Iliamna | OF | Offshore | TL | Talkeetna |
| BT | Bettles | JU | Juneau | OP | Ophir | TN | Tanana |
| BV | Beaver | KB | Kuskokwim Bay | PA | Port Alexander | TR | Taku River |
| BW | Barrow | KC | Ketchikan | PE | Petersburg | TS | Teshekpuk |
| CA | Candle | KD | Kodiak | PH | Point Hope | TY | Tyonek |
| CB | Cold Bay | KG | Kaguyak | PI | Pribilof Islands | UG | Ugashik |
| CG | Chignik | KH | Kantishna River | PL | Point Lay | UK | Umnak |
| CH | Chandalar | KK | Kiska | PM | Port Moller | UL | Unalakleet |
| CI | Circle | KL | Killik River | PR | Prince Rupert | UM | Unimak |
| CL | Chandler Lake | KN | Kenai | PS | Philip Smith Mountains | UN | Unalaska |
| CM | Cape Mendenhall | KR | Karluk | RB | Ruby | UR | Utukok River |
| CO | Coleen | KT | Kateel River | RI | Rat Islands | UT | Umiat |
| CR | Craig | KW | Kwiguk | RM | Russian Mission | VA | Valdez |
| CS | Christian | KZ | Kotzebue | SA | Samalga Island | WA | Wainwright |
| CV | Cordova | LC | Lake Clark | SB | Stepovak Bay | WI | Wiseman |
| CY | Charley River | LG | Livengood | SC | Saint Michael | YA | Yakutat |
| DE | Dixon Entrance | LH | Lime Hills | SD | Sumdum | | |
| DI | Dillingham | LR | Lookout Ridge | SE | Selawik | | |

encouraged to visit the USGS National Geologic Map Database, Geolex, a lexicon of geologic names (http://ngmdb.usgs.gov/Geolex/geolex_qs.html).

Some of our map units use terms that other geologists have previously applied to terranes. We instead use such terms as “sequence,” “assemblage,” and “complex” for groups of rock units characterized by a common history or environment. Sequences, as used here, are groups of sedimentary rock units that display a coherent and consistent stratigraphy and association. Assemblages consist of a mixture of sedimentary, igneous, and (or) metamorphic rock units within a still-recognizable stratigraphic framework that may be tectonically disrupted internally. Complexes are generally restricted to largely igneous or metamorphic rock assemblages that have no apparent stratigraphic framework. An exception to this is the McHugh Complex, a tectonic mélange in southern Alaska, whose name is in common use.

In general, where terminology for lithologic packages of rock units has come into common usage and where we could justify or support its continued usage, we have used that terminology. An example of such a lithologic association is the rocks of the Angayucham, Tozitna, and Innoko assemblages, originally defined as separate terranes. The ease with which common terminology can be used is, in part, dependent on our knowledge or perceived understanding of the rock units. This packaging occurs at either extreme of our spectrum of knowledge. Thus, packaging very old metamorphic rocks is relatively easy because age and protolith history is unknown. In other cases, such as the Nixon Fork terrane, now part of the White Mountain sequence of Decker and others (1994), we have reasonably good constraints on the nature of the rock units and can confidently package them.

This compilation is unique in that it is associated and integrated with a rich database of information provided in digital spatial datasets and attribute databases on the Web [http://dx.doi.org/10.3133/sim3340]. Included are descriptions of original source maps and a table that links map units from individual maps to a regional code, called NSACLASS. In the spatial datasets and the related attribute databases, the source of every line and polygon is referenced. For every polygon source listed, the original map unit description is preserved in the NSAunits table. Additional attributes concerning lithology, age, and geologic setting for map units are available as well. Databases of radiometric ages also are provided. A readme file describing these databases and their structure is available on the publication’s Web site. The approximately 450 map units presented here are derived by combining the more than 1,300 detailed NSACLASS assignments used to construct the statewide database. An NSAkey table provides a short description for each NSACLASS.

In the following descriptions, units are generally organized by sedimentary, igneous, or metamorphic rock units, and within each category, listed in chronological order from youngest to oldest. However, in several cases, rock units or assemblages of mixed rock types are grouped with the dominant rock unit part of the assemblage; for example, the sedimentary and volcanic rock units of the Orca Group are placed together in the sedimentary rock section of the Description of Map Units (DMU). In the unit descriptions, for sedimentary rock units, the apparent stratigraphic position (lower, upper) is given after the unit label and name. For igneous rock units, the age of the unit (early, late) follows the unit label and name. In the text of the descriptions, lower and upper are used to denote stratigraphic position, whereas late and early indicate age. In general, metamorphic rock units are listed in increasing order of their inferred or interpreted protolith age, which in many cases is subject to significant uncertainty. In the limited number of cases for which we cannot interpret a protolith age, the metamorphic rocks are listed by increasing age of the last metamorphism, either known or inferred.

In most cases, the time scale and terminology used is that of the International Commission on Stratigraphy’s International Chronostratigraphic Chart of 2008 (ICS2008). In a few cases, typically in describing Paleozoic sedimentary rocks, the original sources reported age terms that are not part of the ICS2008 chart; the specific definition of these terms can be defined using the “Geowhen” website: http://www.stratigraphy.org/bak/geowhen/index.html. In general, the descriptions using these other-than-ICS2008 terms provide an approximate equivalent term from ICS2008.

Many of the map sources are drawn with faults forming the boundary between bedrock and surficial or unconsolidated map units. Logically, this indicates that the fault is likely Quaternary in age, offsetting the surficial units as well as the bedrock unit; however, in the majority of cases, we do not believe this was the author’s intention. Nevertheless, in the majority of these cases, we have presented the map data as shown on the source map. Locally, along major fault systems, some authors have mapped broad shear zones, particularly in the Tanana (Reifenstuhl and others, 1997) and the Eagle quadrangles (Day and others, 2014). While the fault systems are typically shown outside of these respective map areas, the shear zones are not mapped, although they presumably are there. We have chosen not to show these shears zones on the printed map; however, they are preserved in the digital data files.

Throughout the text, many locations are described as being within named 1:250,000-scale quadrangles. Figure 1 shows the location of these quadrangles around the state to help guide users to areas of interest. While complete quadrangle names are used in the text and on fig. 1, sheet 1; table 1 provides the standard two-letter abbreviation used within the databases. The alphabetically organized list of map units on the printed map indicates in which loosely defined region or regions each map unit appears; fig. 2 , sheet 1, shows the general area of each region. The regions are defined such that the central region includes both the west-central and east-central subregions. This is similarly true for northern and southern regions and their respective subregions. The Seward Peninsula, Alaska Peninsula, and Aleutian Islands regions are not subdivided.

## Acknowledgments

A compilation on this scale could only be done with the assistance of many geologists, far more knowledgeable about the geology of various regions of Alaska than we are. USGS emeritus scientists and volunteers were important contributors to this effort, providing many insights, much data, and very much appreciated advice. They included Robert Detterman (deceased), William Patton, Jr. (deceased), Donald Richter (deceased), Bill Brosgé (deceased), Robert Chapman (deceased), Donald Grybeck (deceased), Florence Weber, Hank Schmoll, Lynn Yehle, David Brew, Thomas Hamilton, and Warren Coonrad. Active USGS staff who contributed to this effort, providing data and participating in discussions, included Dwight Bradley, Jeanine Schmidt, Alison Till, Julie Dumoulin, Rick Saltus, Marti Miller, Cynthia Dusel-Bacon, and Peter Haeussler. We are extremely grateful for the GIS and general digital support from Nora Shew and Keith Labay that were critical in making this compilation possible. The Alaska Department of Natural Resources Division of Oil and Gas provided strong encouragement and financial support to assist with the preparation of two of the regional maps. Technical (peer) review of the manuscript by Thomas Bundtzen, Cynthia Dusel-Bacon, M.L. (Weecha) Crawford, George Gehrels, Maurice Colpron, and David Houseknecht; geologic names review by Robert B. Blodgett; and editorial reviews by Jan Zigler and Claire Landowski are greatly appreciated and helped to improve the text and map. Finally, the ongoing support of management, including Kate Johnson, Bruce Gamble, Marti Miller, and Larry Meinert, made it all possible.

# DESCRIPTION OF MAP UNITS

[The **Description of Map Units** includes the unit descriptions for the geologic maps (sheets 1, 2) and the accompanying database and detailed digital map. Units shown on the **geologic maps** (sheets 1, 2) are either common to the map sheets and the digital database or represent more detailed component units that are combined to form some generalized units on the maps. The geologic maps (sheets 1, 2) include primarily generalized units appropriate for presentation at map scale; the **Alphabetical List of Map Units** and **table 2** (page 181) list the map units and their component units, as well as the page numbers where the individual unit descriptions are found in the Description of Map Units. See the component unit descriptions for generalized map units not included in the Description of Map Units or the database files. **Horizontal lines**: Groups of units and units with numerous subunits are delineated by horizontal lines at the beginning (solid) and the end (short dash)]

## UNCONSOLIDATED DEPOSITS

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

QTs **Poorly consolidated surficial deposits (Quaternary, Pleistocene, and uppermost Tertiary)**—Silt to coarse-gravel and semi-consolidated sandstone to conglomerate are widespread as an erosional remnant deposits throughout Alaska. Genetically, unit includes deposits of fluvial, glaciofluvial, colluvial, eolian, and shallow-marine deposits and includes local tuffaceous deposits. Unit includes several named formations, including the Faneto Formation of the Aleutian Islands, the Kougarok Gravel of the Seward Peninsula, the Chariot, Saligvik, and Ilyirak Gravels of the Point Hope region, and the Gubik Formation of the North Slope as well as the informally named Holokuk gravel of Bundtzen and others (1999) in southwest Alaska. Some deposits are folded or tilted, reflecting recent tectonic movement. Some marine deposits are richly fossiliferous. Age control is generally sparse; fossils may not be age-diagnostic. The tilted Holokuk gravel of Bundtzen and others (1999) was interpreted by Bundtzen to be an outwash deposit sourced from the glaciated highlands southwest of the Kuskokwim River on the basis of pebble count and clast studies. Boulder-rich conglomeratic deposits on Adak Island, mapped as Tertiary by Coats (1956a), are probably Quaternary in age, certainly no older than Pliocene. Also included in map unit is fossiliferous marine sandstone of northern Adak Island (Coats, 1956a). On Amchitka Island, bedded sand and gravel, composed of hornblende andesite fragments, occurs at an elevation of 180 m. Some beds contain subangular cobbles and boulders, whereas others contain well-rounded cobbles and boulders up to 0.6 m in diameter. Powers and others (1960) interpreted this as a beach and nearshore marine deposit. Also on Amchitka Island, a small area of tilted sedimentary rocks (dipping about 12º SE.) is found at South Bight (Powers and others, 1960). These consist of 60 m of carbonaceous sandy silt, fine to medium sand, and pebbly sand to sandy fine gravel, in random order, a few inches to 0.6 m thick, which grades upward to 45 m of less well bedded gravel. Fragments of carbonized wood are common in silt layers. Semiconsolidated marine beach deposits consist of poorly bedded, soft, pebbly siltstone that caps sea cliffs of volcanic rock on Hagemeister Island and contain shallow-water marine fossils of Pliocene or Pleistocene age. The Gubik Formation consists of marine and fluvial deposits of well to poorly sorted and well to poorly stratified silt, sand, and gravel. Locally includes wood and woody material (Nelson and Carter, 1985). Thickness more than 10.5 m, probably less than 60 m (Reiser and others, 1980). On generalized map, included as part of unit QTs

## SEDIMENTARY ROCKS

### CENOZOIC TO MESOZOIC

#### Quaternary and Tertiary

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

Tertiary to Mesozoic

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

Tng **Nenana Gravel (Tertiary, Pliocene and upper Miocene)**—Yellowish-gray to reddish-brown, well-sorted, poorly to moderately consolidated conglomerate and coarse-grained sandstone that contains interbedded mudflow deposits, thin claystone layers, and local thin lignite beds widely distributed on the north side of the Alaska Range. Unit is more than 1,300 m thick and moderately deformed (Csejtey and others, 1992; Bela Csejtey, Jr., written commun., 1993)

Tkn **Kenai Group, undivided (Tertiary, Miocene to Oligocene)**—Coal-bearing clastic unit in vicinity of Cook Inlet that consists of, in descending stratigraphic order: Sterling, Beluga, and Tyonek Formations and Hemlock Conglomerate. According to Calderwood and Fackler (1972), unit is at least 8,000 m thick in the subsurface of Cook Inlet. Individual formations are typically estuarine and nonmarine clastic sedimentary rocks. Sterling Formation is interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, lignite coal, and minor volcanic ash. Beluga Formation is similarly nonmarine, interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, coal, and minor volcanic ash (Bradley and others, 1999). Calderwood and Fackler (1972) reported that a distinctive feature of the Beluga Formation is its lack of massive sandstone beds and massive coal seams that characterize the underlying Tyonek Formation; however, lignitic to subbituminous coal seams can be as thick as 4 m, though more typically are 2 m thick or less in the upper part of Beluga Formation. The contact between Beluga and overlying Sterling Formation may be an unconformity, but in any case can be difficult to pinpoint (Calderwood and Fackler, 1972; Turner and others, 1980). Tyonek

Formation is carbonaceous nonmarine conglomerate and subordinate sandstone, siltstone, and coal (Winkler, 1992; Bradley and others, 1999) and is identified by massive sandstone beds and lignitic to subbituminous coal beds as much as 9 m thick (Calderwood and Fackler, 1972). Hemlock Conglomerate consists of fluvial conglomeratic sandstone and conglomerate that contains minor interbeds of siltstone, shale, and coal and is lithologically transitional with Tyonek Formation, leading to some confusion; Hemlock Conglomerate is best known from the subsurface. Calderwood and Fackler (1972) included West Foreland Formation within the Kenai Group; however, it was separated as a distinct unit by Magoon and others (1976). Swenson (1997) has proposed an alternative stratigraphic column for Cook Inlet basin that recognizes the time-transgressive nature of the units, wherein all units of Kenai Group and West Foreland Formation overlap somewhat in age. Dallegge and Layer (2004) suggested that the age range of the stratigraphic units be revised based on $^{40}Ar/^{39}Ar$ dating of tephra from within Kenai Group. In particular, they document the time-transgressive nature of the formations and that the Tyonek Formation may be as old as 49 Ma (early Eocene, Ypresian) in the Matanuska Valley, making its lower part age-equivalent with the Hemlock Conglomerate and West Foreland Formation. According to R.G. Stanley (written commun., 2009) the type sections for West Foreland Formation and the subdivisions of Kenai Group are not in outcrop but rather in the subsurface located in several different wells, both onshore and offshore. These wells, in turn, are located many miles from each other in an area of complicated structure and lateral facies changes; therefore, correlation of these subsurface type sections with the surface outcrops is poorly documented, difficult, and controversial. On generalized map, included as part of unit Tknt

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)

Tsf **Sagavanirktok Formation (Tertiary, Miocene to Paleocene)**—Mostly nonmarine, poorly consolidated siltstone, sandstone, conglomerate and lignite of the North Slope of Alaska and present only east of the Colville River. Divided into four members, in descending stratigraphic order: Nuwok, Franklin Bluffs, White Hills, and Sagwon Members. Unit consists of northeasterly prograding, upward-fining sequences that have basal fluvial conglomerate and coarse sandstone grading to mudstone that is commonly bentonitic and contains lignite (Mull and others, 2003). Mull and others (2003) revised the original definition of the Sagwon Member to exclude the lower coal-bearing beds at Sagwon Bluffs (informal name for bluff located along Sagavanirktok River opposite the Sagwon airstrip in the central Sagavanirktok quadrangle), concluding that they more properly belong to the Prince Creek Formation; they defined the base of the Sagwon Member—and therefore the base of the Sagavanirktok Formation—as a white-weathering sandstone and conglomerate that caps ridges in the northern Brooks Range foothills. Conglomerate clasts are generally white quartz, black chert, and light-gray quartzitic sandstone and minor pale-green chert. Sagwon Member is late Paleocene in age (Mull and others, 2003). White Hills Member is lithologically similar, but the finer-grained upper part is poorly exposed. Conglomerate clasts are generally gray quartzitic sandstone, white quartz, black chert, and leached light-gray siliceous tuff and lesser gray to pale-green and maroon to red chert. Its age is considered late Paleocene to early Eocene. Franklin Bluffs Member definition was also revised by Mull and others (2003); its lower part consists of white- to pink-weathering, poorly consolidated sandstone and conglomerate; conglomerate clasts are predominantly black chert and lesser white and gray quartz. Its upper part, generally not exposed and primarily known from well data, consists of poorly consolidated thin-bedded mudstone and siltstone. Age is probably early Eocene to Miocene (Mull and others, 2003) and the fauna suggests a nearshore or estuarine environment. The Nuwok Member is only exposed in northeastern Alaska and consists of unconsolidated pebbly sandstone or conglomerate overlain by pebbly mudstone (Detterman and others, 1975). Its age is late Miocene to Pliocene and character of the sediments and fauna suggest a nearshore or beach environment. In the Harrison Bay quadrangle, Carter and Galloway (2005) report a Paleocene map unit (Tsg) assigned to the Sagavanirktok Formation where "* * * deposits consist of moderately to poorly consolidated conglomerate, sand, gravelly sand, and pebbly shale with thin coal beds and locally common lignitized logs"

Tcb **Coal-bearing sedimentary rocks (Tertiary, Pliocene to Eocene?)**—Widely exposed around the state, unit locally bears formal names, such as Healy Creek, Sanctuary, Suntrana, Lignite Creek, and Grubstake Formations of the Nenana coalfield; more typically, though, the unit is mapped as coal-bearing sedimentary rocks. Located largely north of the Alaska Range, unit includes the sedimentary rocks of the Jarvis Creek coal field of Nokleberg and others (1992a) and similar units in other Tertiary basins;. The following quote from Csejtey and others (1992) can be generally applied to this unit: "The coal-bearing rocks comprise terrestrial cyclic sequences, in varying proportions, of siltstone, claystone, mudstone, shale, generally cross-bedded and pebbly sandstone, both arkosic and quartz-rich, subbituminous coal and lignite, and minor amounts of dominantly quartz- and chert-pebble conglomerate." Locally, volcanic ash is present. Unit is nonmarine and may be faulted and (or) folded. Coal most commonly is lignite but locally is subbituminous. In the Livengood quadrangle consists of poorly to well-consolidated conglomerate, graywacke, siltstone, shale, coal, greenstone, basalt, and tuff in Schwatka-Rampart area of central Alaska. Unit is nonmarine, friable, calcareous, and contains some nodules, lenses, and thin layers of ironstone. Conglomerate has locally derived well-rounded pebble- to boulder-sized clasts of greenstone, black chert, rare white quartz, and colored chert; siltstone and shale less common. In the McGrath quadrangle (Bundtzen and others, 1997a), includes fluvial gravel, silt, sand, and carbonaceous shale interbedded with coal seams as much as 12 m thick. On Saint Lawrence Island (Patton and others, 2011), poorly consolidated sandstone, grit, and conglomerate, carbonaceous mudstone, ashy tuff, volcanic breccia, and seams of lignitic coal as much as 60 cm thick is found in poorly exposed and badly slumped outcrops. Unit contains abundant plant fossils of Oligocene age (J.A. Wolfe, written commun., 1968). Patton and others (2009) reported that poorly consolidated nonmarine deposits also occur in several areas of the Yukon-Koyukuk Basin, some associated with the Kaltag Fault. Pollen samples from these deposits range in age from Oligocene to Pliocene

Tms **Tachilni, Bear Lake, Chuniksak, Nevidiskov, and Chirikof Formations (Tertiary, Miocene and upper Oligocene)**—Exposed on the southwestern Alaska Peninsula and Attu Island, these formations represent a quiescent stage between active volcanism in the Meshik arc (Wilson, 1985) or the informal early series of Marlow and others (1973), (renamed "Lower Series" by Vallier and others [1994]) and the modern Aleutian magmatic arcs and are distinct from other local Tertiary units because of greater abundance of nonvolcanic debris and better sorting. The marine Tachilni Formation consists of about 60 m of gray to brown, poorly consolidated, crossbedded subgraywacke sandstone commonly interbedded with volcanic-pebble conglomerate and siltstone (Waldron, 1961; Detterman and others, 1996). Unit is richly fossiliferous, containing 36 genera of bivalves and 11 genera of gastropods (Detterman and others, 1996) that yield a late Miocene age assignment (Marincovich, 1983). Tachilni is unconformably overlain by late Tertiary and Quaternary volcanic and volcaniclastic rocks that are presumably partially correlative with Milky River Formation (unit QTvs). No lower contact of formation is known, although it may overlie the Belkofski Formation. The Bear Lake Formation (Burk, 1965; Allison and Addicott, 1973), locally 300 to 500 m thick, consists of inner-neritic marine and nonmarine, moderately well-sorted, moderately well-rounded, dark brown to pale yellowish-brown sandstone, conglomerate, siltstone, and shale (Wisehart, 1971; Nilsen, 1984). Conglomerate contains well-rounded clasts that consist of 40 to 55 percent quartz and chert, 20 to 30 percent volcanic fragments, 10 to 15 percent felsic plutonic clasts, and the remainder lithic sedimentary clasts. Bear Lake Formation is also abundantly fossiliferous and contains mainly pelecypods, gastropods, and echinoids of late Miocene age (Louie Marincovich, Jr. [USGS], and C.W. Allison [Univ. of Alaska], written commun., 1978, cited in Detterman and others, 1981a); most lived nearshore in shallow water less than 100 m deep (Marincovich, 1983, and written commun., 1985, cited in Detterman and others, 1996). The contact between Bear Lake Formation and underlying Meshik Volcanics (unit Tmv) or Stepovak and Tolstoi Formations (units Tarcs and Ttk, respectively) varies from disconformity to angular unconformity. Contact between Bear Lake and overlying Milky River Formation (QTvs) generally is disconformable; however, contact locally is an angular unconformity. Chuniksak Formation is at least 600 m of fine-grained, well-bedded, laminated siliceous shale, argillite, calcareous argillite, chert, siliceous siltstone, sandstone, sandy shale, graywacke, and minor pebble conglomerate exposed on Attu Island. Unit ranges widely in color, including dark-gray, yellow, brown, green, purple, and red and weathers to red angular chips and blocks (Gates and others, 1971). Diatoms and foraminifers sparsely scattered throughout unit; fossil mollusks and plants occur in narrow concretion-bearing zones near the middle of the measured section. Best inferred age for the unit is probably Miocene (Gates and others, 1971), although plant fossils, identified by Roland Brown (cited in Gates and others, 1971, p. 736), were suggested to be probably early Tertiary, and possibly Eocene in age. Uppermost part of unit has been removed by erosion, and, locally, unit is highly deformed and faulted. Also included here are the rocks mapped as the basement rocks of Shemya Island (Gates and others, 1971, p. 776), which are lithologically similar to, and coeval with, the Chuniksak Formation. Nevidiskov Formation of Attu Island consists of coarse graywacke and conglomerate in a generally fining-upward sequence (Gates and others, 1971). Conglomerate clasts as much as 0.7 m in diameter are derived from the basement rocks of Attu Island (unit TKkf), which include porphyritic basalt, graywacke, and cherty argillite. In upper part of unit, lenses of argillite are more common, and contact with argillite of the Chuniksak Formation is gradational. Both the Nevidiskov and Chuniksak Formations are less deformed than the basement rocks, whose erosion was probably the source for these two map units. A single *Pecten* fossil from near the base of the Nevidiskov Formation was of indeterminate age. Gates and others (1971) consider the Nevidiskov Formation to be perhaps of early Miocene or late Oligocene age because of its conformable contact with the overlying Chuniksak Formation of probable Miocene age. The Chirikof Formation on Attu Island consists of boulder and pebble conglomerate, coarse sandstone, carbonaceous shale and sandstone, and possibly a single lava flow (Gates and others, 1971). Boulder conglomerate contains rounded boulders, whereas fragments in the pebble conglomerate and coarse sandstone are angular to round. The pebble conglomerate contains fragments "* * * of argillite, basalt, chert, and albite granite in a crudely bedded and poorly sorted sand matrix" (Gates and others, 1971, p. 738). The sandstone contains "* * * grains of quartz, plagioclase, argillite, chert, basalt and carbonaceous fragments cemented by limy, carbonaceous, and siliceous material. Interbedded with the coarse sand are beds of coaly shale with many leaf and stem imprints and a few silicified tree limbs" (Gates and others, 1971, p. 738). Plant fossils from the carbonaceous shale beds include some of the same species found in the Chuniksak Formation and suggest a similar age. On generalized map, included as part of unit Tsmo

Tnc **Narrow Cape and Topsy Formations (Tertiary, Miocene)**—Narrow Cape Formation from the Kodiak Island archipelago is 700 m thick. The lower two-thirds consists of sandstone and a few conglomerate beds, and the upper third is siltstone. A basal sedimentary breccia and conglomerate contains clasts derived from the underlying Sitkalidak Formation (Nilsen and Moore, 1979). Overlying the breccia is highly bioturbated, massive, silty, fine-grained sandstone and siltstone that makes up more than 90 percent of the formation (Nilsen and Moore, 1979). Thin conglomeratic layers contain well-rounded granitic and volcanic pebbles, clasts of the underlying Sitkalidak Formation; disarticulated, broken, and partly rounded megafossil fragments (Nilsen and Moore, 1979) occur at irregular intervals. A rich marine fauna is present in the Narrow Cape Formation; Allison (1978) indicated it contains at least 80 taxa including *Acila, Clinocardium*, *Cyclocardia*, *Mya*, *Colus*, *Cryptonatica*, *Anadara*, *Chione*, *Dosinia*, and the gastropod *Ficus*. The range and variety of invertebrate fossils provide strong indication of warm water conditions within the temperate climate belt of Hall (1964, cited in Allison, 1978). The Topsy Formation, exposed only in eastern Prince William Sound, consists of about 75 percent hard calcareous or concretionary siltstone and about 25 percent fine- to medium-grained gray and greenish-gray clayey and carbonaceous sandstone. Thickness ranges from about 350 m in its type section to about 1,300 m at its southern outcrop limit (Brew and others, 1978; D.A. Brew, written commun., 2005). Fossil evidence for age consists of a sparse middle Miocene molluscan fauna that indicates deposition in a shallow marine, cool water environment (Marincovich, 1980) in contrast with the contemporaneous Narrow Cape Formation. On generalized map, included as part of unit Tsmo

Tuu **Unga, Belkofski, and Unalaska Formations (Tertiary, Miocene)**—The Unga Formation (Dall, 1882, 1896; Detterman and others, 1996) is about 275 m thick, 25 percent or more of which is volcanic rocks (lahar deposits, debris-flow deposits, and tuff). Volcanic rocks are dominant in upper part, whereas carbonaceous shale and coal are restricted to lower part; sandstone and conglomerate throughout unit are composed of poorly sorted and typically loosely consolidated volcanic debris. Unit is geographically restricted to Unga Island, the Pavlof Islands, Deer Island, and along the Pacific coast of Alaska Peninsula adjacent to Unga Island. Fossils are locally abundant but are restricted to thin zones that contain numerous specimens of a few genera. Petrified wood, including logs and stumps in growth position, is common and typically associated with debris-flow deposits that engulfed then-existent forests of *Metasequoia* sp. (Eakins, 1970). Neither top nor base of formation is exposed, and, therefore, its relation to other units is not well defined. However, because the formation has similar structural attitudes as underlying and overlying units, we infer that it disconformably overlies Stepovak Formation (unitTs) and is disconformably overlain by late Miocene volcanic rocks (unit Tv). Belkofski Formation (Kennedy and Waldron, 1955; Burk, 1965; see also McLean, 1979), exposed along Pacific coast of the southwestern Alaska Peninsula, is about 1,830 m thick and consists of tuffaceous, volcaniclastic sandstone, siltstone, and conglomerate and contains interbeds of tuff and volcanic breccia. Unit is mainly gray or greenish-gray to gray-brown on mainland; on offshore islands, rocks are dominantly red, pink, and purple and all are very well indurated. Stratigraphic relation to other units on Alaska Peninsula is not known with certainty; however, the most likely correlative unit, on the basis of lithologic similarity and apparent stratigraphic position, is Unga

Formation. Lower contact of Belkofski Formation is nowhere exposed; upper part of unit is unconformably overlain by volcanic flows of late Miocene age. We infer that the Belkofski Formation, which is commonly intruded by plutonic rocks, is a contact-metamorphosed equivalent of the Unga Formation. A K/Ar age determination on a clast from volcanic agglomerate, mapped as Belkofski Formation, is 11.79±0.41 Ma (Wilson and others, 1994). The Unalaska Formation, as mapped by Drewes and others (1961), is "* * * a thick sequence of coarse and fine sedimentary and pyroclastic rocks intercalated with dacitic, andesitic, and basaltic flows and sills, cut by numerous dikes and small plutons * * *." Pillowed flows are common along southern Unalaska Island, as are abundant sills. Age control is sparse and is primarily based on a single collection of a fossil relative of a sea cow identified as the genus Cornwallis or Desmostylus of probable Miocene or late Oligocene age. Also included in this map unit on nearby Umnak Island is bedded argillite and tuff, keratophyre flows, and albitized intrusive rocks; the argillite, which has characteristics possibly suggesting turbidity current deposition, contains carbonized impressions suggestive of leaf fragments (Byers, 1959). Sparse radiometric ages on volcanic or intrusive rocks associated with this unit on Unalaska and Umnak Islands yield late Oligocene ages, suggesting a longer age range for the parts of this unit in the Aleutian Islands, in contrast to the Alaska Peninsula part of the unit. Exposed on the southwestern Alaska Peninsula and Unalaska and Umnak Islands, these units may represent the waning stages of the Meshik or "Lower Series" magmatic arc along the paleo-Aleutian trench. The Aleutian Islands part of the unit potentially may correlate with the rocks of unit Tarcs, such as the Gunners Cove or Banjo Point Formations, although these are thought to be slightly older. On generalized map, included as part of unit Tsmo

Tsti **Siltstone of Trinity Islands (Tertiary, Miocene and Oligocene)**—Highly bioturbated siltstone and very fine-grained sandstone that has sporadic conglomeratic layers (Nilsen and Moore, 1979). Originally included in the Narrow Cape Formation, it is now considered a distinctive, older unit. Nilsen and Moore (1979) report fossils are abundant but of low species diversity. Allison and Marincovich (1981; also Allison, 1978) indicate this unit "* * * was deposited in the outer neritic zone of the continental shelf." Their best interpretation of the depth ranges of the taxa found in the unit suggests deposition was in water depths of 100 to 200 m; the fauna also suggest a cool-temperate marine climate, significantly cooler than that represented by the younger Narrow Cape Formation to which this unit was originally assigned. On generalized map, included as part of unit Tsmo

Tk **Kootznahoo Formation (Tertiary, lower Miocene to upper Eocene)**—Light-greenish-gray, nonmarine, lithofeldspathic sandstone, siltstone, mudstone, and conglomerate that contains coal fragments and lenses in the Zarembo and Kuiu Islands region (Brew and others, 1984) and on Admiralty Island (Lathram and others, 1965) of southeast Alaska. Polymictic conglomerate contains sandstone, argillite, coal, phyllite, limestone, chert, schist, gneiss, granitic rocks, volcanic rocks, and quartz. Includes lignite and subbituminous coal beds up to 1.5 m thick. Outcrop area is wedge-shaped at Kootznahoo Inlet near Angoon, apparently filling an asymmetric graben, and unit is up to 2,000 m thick at south margin of graben. Plant collections from Port Camden on Kuiu Island, on Kupreanof Island, and at Little Pybus Bay on Admiralty Island were assigned an Eocene age by Knowlton in Buddington and Chapin (1929), but were reevaluated as Paleocene by Jack Wolfe in Lathram and others (1965). Plant fossils in Kootznahoo Inlet on Admiralty Island include "*Ulmus*" *pseudobrauni*, *Octea* sp., *Dilleniaceae*, and *Dryophyllum* sp., of late Eocene to earliest Oligocene age (Lathram and others, 1965), *Carya magnifica*, *Juglans orientalis*, *Alnus alaskana*, *Cercidyphyllum* aff. *C. crenatum*, *Vitis atwoodi*, *Populus* sp., and *Ficus alaskana* of Oligocene age, and *Fagus antipofi*, *Quercus furujelmi*, *Comptonia naumani*, and *Populus lindgreni* of early Miocene age (Lathram and others, 1965). Age reported to be Paleocene and Eocene in the Zarembo-Kuiu Islands region and Eocene to Miocene on Admiralty Island (Brew and others, 1984)

Tts **Tsadaka Formation (Tertiary, Oligocene)**—Poorly sorted cobble to boulder conglomerate, interbedded with lenses of feldspathic sandstone, siltstone, and shale (Winkler, 1992), at least 200 m thick. Unit is terrestrial and of local provenance and shows rapid lateral lithologic and thickness changes; deposited on alluvial fans and in braided streams from a northerly source (Winkler, 1992). Clasts in the conglomerate are largely plutonic, which is in contrast to the underlying Wishbone Formation (Winkler, 1992). Correlative with the Hemlock Conglomerate of the Kenai Group. Age considered Oligocene in Anchorage quadrangle (Winkler, 1992) on the basis of plant fossils described by Wolfe (1977). On generalized map, included as part of unit Tknt

Tarcs **Volcaniclastic sedimentary rocks (Tertiary, Oligocene to Eocene)**—Unit includes rocks of the Gunners Cove, Banjo Point, and Andrew Lake Formations of the Aleutian Islands and the Stepovak Formation of the Alaska Peninsula. Tuffaceous conglomerate and sandstone, crystal-vitric basaltic tuff, thin basalt flows, and basaltic dikes (Lewis and others, 1960) form two-thirds of Hawadax (formerly "Rat") Island (Gunners Cove Formation) and are also exposed on Amchitka Island (Banjo Point Formation). Sandstone and conglomerate contain moderately to well-rounded mafic volcanic clasts, primarily basalt, in a matrix of basaltic glass and fragments of marine shells. One conglomerate outcrop along the north shore of Gunners Cove was especially rich in fragmentary barnacles, crinoids, echinoids, and pectinid bivalve fossils. Basalt occurs in crudely bedded masses of glassy scoria, in thin dike swarms and in thin flows, some of which have pillows and local columnar jointing (Lewis and others, 1960). Identified fossils include *Isocrinus* aff. *I. oregonensis* (Moore and Vokes) and *Chlamys* aff. *C. washburnei* Arnold of probable Oligocene or early Miocene age. Andrew Lake Formation of Adak Island consists of tuffaceous sandstone and siltstone and siliceous and cherty shale interbedded with mafic flows or penecontemporaneous sills. "Graded sandstone beds as much as 0.3 m thick are common and alternating beds of sandstone and shale * * * form graded sequences 3 to 4 m in thickness" (Scholl and others, 1970, p. 3586). Stepovak Formation of the southwestern Alaska Peninsula was divided into two informal members by Detterman and others (1996). An incomplete reference section has 2,030 m exposed, approximately evenly divided into a lower siltstone member and an upper sandstone member (Detterman and others, 1996). Lower member is deep-water turbidite deposit composed of dark brown laminated siltstone and shale, as well as interbedded sandstone that commonly shows graded bedding and rip-up clasts. Upper member, rich in unaltered volcanic debris, was deposited in a shallow-water shelf environment; megafauna distributed throughout upper member are characteristic of water depths no greater than 30 to 50 m (Louie Marincovich, Jr., written commun., 1983 to 1986). Unit is age equivalent of volcanic rocks mapped as Meshik Volcanics (unit Tmv). Upper and lower contacts of Stepovak Formation are structurally conformable with Unga and Tolstoi Formations (units Tuu and Ttk, respectively) but are considered disconformities because considerable time gaps exist between younger and older units. On generalized map, included as part of unit Tvcs

Tvs **Volcanic and sedimentary rocks, undivided (Tertiary, Oligocene and Eocene)**—An isolated unit in the western Tyonek quadrangle, unit consists of light-green to gray, bedded volcaniclastic sedimentary rocks; some beds contain volcanic breccia clasts. Volcanic rock clasts are light green. LA-ICPMS detrital zircon dates have youngest grain ages of 58 to 55 Ma (D.C. Bradley, written commun., 2008). On generalized map, included as part of unit Tvcs

Ttk **Nearshore and nonmarine sedimentary rocks (Tertiary, Eocene to Paleocene)**—Unit includes several similar formations in southern Alaska. These include the Tolstoi Formation of the southwestern Alaska Peninsula, the West Foreland Formation of the Cook Inlet region, the Wishbone, Arkose Ridge, and Chickaloon Formations of the Matanuska Valley, and scattered other occurrences. Sandstone is the dominant lithology of the Tolstoi Formation; sandstone intervals grade upward from light gray to olive-gray and tend to become more thin-bedded. Siltstone intervals in section are consistently thin bedded and are usually light olive-gray. Plant debris, including well preserved leaves, is present throughout unit, whereas megafauna are only reported from the lower 280 to 290 m of type section. Lithic clasts in conglomerate and conglomeratic sandstone are dominantly granitic and arkosic detritus but also include as much as 30 percent volcanic clasts. Most volcanic clasts are altered or weathered, which is in sharp contrast to most overlying units (Detterman and others, 1996); additionally, presence of granitic and arkosic detritus suggests a Mesozoic source rather than derivation from contemporaneous magmatic activity. Rocks of Tolstoi Formation are characteristic of a shallow marine environment succeeded northward and stratigraphically upward by rocks characteristic of nonmarine delta-plain and fluvial deposits, mainly reflecting braided streams (Detterman and others, 1996). West Foreland Formation is exposed only on west side of Cook Inlet, where unit consists of tan to light-yellow-brown cobble conglomerate interbedded with lesser sandstone, laminated siltstone, and silty shale (Detterman and Hartsock, 1966). Thin coal beds are interbedded with the siltstone and shale. Conglomerate clasts are mainly rounded to subrounded quartz diorite, volcanic rock, argillite, sandstone, siltstone, quartzite, tuff, and coal fragments. Intrusive and volcanic rock fragments each make up about 35 percent of the clasts in conglomerate. Medium- to coarse-grained arkosic sandstone forms the conglomerate matrix and forms distinct lenticular beds. Siltstone and shale interbedded with conglomerate is very fine-grained subarkosic equivalent of the sandstone. Unit assigned Oligocene age by Kirschner and Lyon (1973) and later reassigned early Eocene and late Paleocene age by Magoon and others (1976), presumably on the basis of plant fossils. Zircon from an interbedded tuff about 1 m thick yielded an age of 43 Ma, middle Eocene (P.J. Haeussler, written commun., 2008). Unit may be equivalent to Arkose Ridge Formation and represent a transtensional basin along the Castle Mountain Fault System. Arkose Ridge Formation is fluvial and alluvial feldspathic and biotitic sandstone, conglomerate, siltstone, and shale that contains abundant plant fragments (Csejtey and others 1977; Winkler, 1992). Coarsening-upward sequence was deposited on alluvial fans and by braided streams carrying sediment derived from rapid erosion of uplifted mountains to the north (Winkler, 1992). Thickness is as much as 700 m. Age control is largely based on late Paleocene fossil plants and radiometric ages on locally associated volcanic flows and dikes. Age is considered broadly coeval with Chickaloon Formation and is based on whole rock K/Ar ages from volcanic rocks that range from 56 to 46 Ma in lower part of formation and a whole rock K/Ar age on basalt dike from the middle of formation of 46.1±2.8 Ma, as well as the presence of late Paleocene plant fossils (Silberman and Grantz, 1984; Winkler, 1992). Chickaloon Formation is more than 1,500 m thick and is predominantly fluvial and alluvial carbonaceous mudstone, siltstone, conglomeratic sandstone, and polymictic conglomerate (Winkler, 1992).

Locally, upper and middle parts of unit contain numerous beds of bituminous coal (Winkler, 1992). Upper part of Chickaloon Formation contains a diverse fossil assemblage of Eocene age, including abundant leaf imprints, petrified tree trunks, and large mammal track ways (Barnes and Payne, 1956; Winkler, 1992). Lower part of unit is largely conglomerate and lithic sandstone derived from erosion of the Talkeetna Formation (Winkler, 1992). Unit includes a strongly deformed, "southerly derived, green-weathering, noncarbonaceous basal sequence of poorly sorted, massive to crudely stratified cobble and boulder conglomerate * * *" which grades "upward into well-stratified, thick-bedded sandstone and conglomerate with a chloritic matrix" (Winkler, 1992). Little (1988, 1990, cited in Winkler, 1992) interpreted this sequence as a prograding alluvial fan derived from uplift and erosion of the Chugach accretionary complex (Chugach terrane) to the south (Winkler, 1992). Age control for the Chickaloon Formation is derived from the presence of Paleocene fossil leaves (Wolfe and others, 1966; Triplehorn and others, 1984) and from K/Ar and fission-track determinations on ash partings within coal beds, which range from 56 to 52 Ma (Triplehorn and others, 1984; Winkler, 1992). Unnamed rock units from other areas also included within this unit include an intercalated fluvial sequence of conglomerate, sandstone, siltstone, and mudstone, and a few thin, interlayered flows of basaltic andesite found in the Healy quadrangle (Csejtey and others, 1992), fluviatile conglomerate, sandstone, and claystone with a few interbeds of lignitic coal in the Talkeetna Mountains quadrangle (Smith and others, 1974; Csejtey and others, 1978), and brown-weathering sandstone and shale, pebble to granule conglomerate associated with the Holokuk Basalt of southwest Alaska. Unit also includes a similar unit in the McGrath quadrangle (unit Tvs, volcaniclastic sandstone and lacustrine silt of Bundtzen and others, 1997a). On generalized map, included as part of unit Tknt

Tsk **Sitkinak Formation (Tertiary, Oligocene)**—Conglomerate and cross-bedded sandstone and siltstone that contain coal fragments. Unit is 1,500 m thick in its type section along the south shore of Sitkinak Island. According to Nilsen and Moore (1979), the outcrops of the Sitkinak Formation consist of different facies on Sitkalidak and Sitkinak Islands. On Sitkalidak Island, the lower part of the unit is conglomerate that contains rounded clasts of volcanic rocks, graywacke, chert, and carbonate rocks. The upper section of the unit is turbidite sandstone and interbedded shale. The overall sequence represents and inner fan or lower slope environment with channel or canyon fill conglomerate (Nilsen and Moore (1979). On Sitkinak Island, "* * * the formation consists of alternating conglomerate-sandstone units and fine-grained sandstone and siltstone units with some coal and carbonaceous shale strata" (Nilsen and Moore, 1979, p. 19–20). The conglomerate contains well-rounded clasts of volcanic rocks, vein quartz, argillite, graywacke, red chert, and granite. The section probably represents conglomerate-sandstone channels enclosing interchannel, lagoonal, and interdistributary bay deposits (Nilsen and Moore, 1979). Very few marine fossils are known from the unit, whereas abundant plant fragments and fossil leaves have been collected from the siltstone-coal strata (Nilsen and Moore, 1979). On generalized map, included as part of unit Tski

Tsi **Sitkalidak Formation (Tertiary, Oligocene to Eocene)**—Uniform sandstone and siltstone in graded beds and a few conglomerate beds for a total thickness of about 3,000 m. A fossil crab, *Callianassa* aff. *C. porterensis*, indicates an Oligocene age (Moore, 1969); Moore (1969) assigned an Eocene and Oligocene age based on this fossil and evidence from superposition; Clendenen and others (1992) report Eocene foraminifers but only report an Eocene age for the unit. Because of the reported presence of an Oligocene crab fossil in this map unit, the unit age is herein revised to conform to Moore's (1969) original age assignment. On generalized map, included as part of unit Tski

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 non-marine 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

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

TKkf **Krugoli Formation, undifferentiated (Tertiary, Paleogene, or Cretaceous)**—Bedded argillite, siltstone, chert, basaltic and spilitic lava flows, tuff, tuff-agglomerate, and conglomerate about 2,250 m thick on Agattu Island (Gates and others, 1971). Coarse graywacke and conglomerate interbedded with pillow lava flows, pyroclastic rocks, and fine siliceous rocks. Clasts consist of sandstone, fine-grained siliceous sedimentary rocks, basalt, and tuff; no schistose or granitic clasts were observed (Gates and others, 1971). A single sequence of volcanic rocks about 730 m above base of unit consists of 60 m of massive green tuff and tuffaceous sandstone overlain by a 15-m-thick porphyritic basalt flow or by porphyritic basalt pillow lava, in turn overlain by 21 m of coarse tuff and thin- to well-bedded, fine-grained sedimentary rocks and an amygdaloidal pillow lava flow (Gates and others, 1971). Lithologically similar to the basement rocks of Agattu and Attu Islands (unit TMzu), this map unit has a lower proportion of volcanic components than the basement rocks (Gates and others, 1971). The contact with the basement rocks is gradational on Agattu Island, recognized by a greater proportion of coarse clastic to finer grained sedimentary rocks in the Krugoli Formation than in the basement rocks. According to Gates and others (1971), coarse sandstone and pebble conglomerate make up two-thirds of the sedimentary part of the unit

TKs **Conglomerate, sandstone, and lignite (lower Tertiary to Upper Cretaceous)**—Sandstone, mudstone, thin coal seams, and conglomerate exposed in the Charley River and Rampart areas. In the Charley River area, the unit consists of poorly consolidated sandstone, grit, pebble-to cobble-conglomerate, and carbonaceous mudstone with coal seams and occurs just east of the Kandik basin and along the Tintina Fault Zone. Late Cretaceous, Paleocene, and Eocene pollen have been recovered from exposures within and immediately south of the map area (Miyaoka, 1990) and from shallow core holes (unpublished oil industry data, 2002, cited in Till and others, 2006a). In the western Rampart area, along the Victoria Creek Fault Zone, quartz- and chert-rich fluvial conglomerate, sandstone, and mudstone are typical, and palynoflora of probable Maastrichtian age (Farmer and others, 2003) as well as of early Tertiary age (Chapman and others, 1982) have been collected. Younger part of the unit likely correlative to rocks of unit Tsu, sedimentary rocks, undivided. Rocks of this unit also occur in a 25-m-thick section along the Sethkokna River in the northeast Medfra quadrangle (Patton and others, 1980). There, the conglomerate contains clasts of quartz, chert, felsic volcanic rocks, and talc schist, which Patton and others (1980) provisionally assigned a latest Cretaceous age (Campanian-Maastrichtian) on the basis of pollen in the lignite beds. Unit is overlain by rhyolite and dacite flows. On the Seward Peninsula, Till and others (2011) mapped two separate sedimentary sequences as their unit TKs. Here, only the more northern Late Cretaceous to Tertiary rocks are included; the older middle-Cretaceous rocks are assigned to map unit Kcc of this map. The rocks included here from the unit TKs of Till and others (2011) consist of gray and brown siltstone, mudstone, sandstone, coal, and minor conglomerate poorly exposed in narrow slices along the Kugruk Fault Zone in the northeastern and southeastern Bendeleben quadrangle; it has been explored for coal and uranium (Retherford and others, 1986; Dickinson and others, 1987). Pollen assemblages of Late Cretaceous and Tertiary (Eocene to early Miocene?) ages have been found in finer grained parts of the sequence (Till and others, 1986; Haga, in Retherford and others, 1986)

TMzu **Basement rocks, undifferentiated, Aleutian Islands (Tertiary or older)**—On Agattu Island, consists of marine argillite, sandstone, graywacke, and conglomerate, submarine pyroclastic rocks, and columnar-jointed and mostly basaltic pillow lava flows. On Attu Island, rocks were subdivided by Gates and others (1971) into fine- and coarse-grained units; the fine-grained unit consists of fine-grained, thin-bedded, sedimentary rocks, chert, siliceous siltstone, argillite, limestone, and fine tuffaceous graywacke and the coarse-grained unit consists of coarse graywacke and conglomerate, which are interbedded with pillow lavas, pyroclastic rocks, and some fine-grained siliceous rocks (Gates and others, 1971). Some of the beds were graded and show turbidite characteristics as well as evidence of soft-sediment deformation. Overall unit thickness is unknown; Gates and others (1971) suggested it is possibly 3,000 to 4,500 m or more thick. Lacking fossils and age control, Gates and others (1971) assigned an early Tertiary or possibly late Mesozoic age to this unit. K/Ar dates (DeLong and McDowell, 1975; DeLong and others, 1978) yielded ages of approximately 30 Ma that they interpreted as reset and therefore only suggest a minimum age. Gates and others (1971) point out that the outstanding characteristic of the basement rocks is their heterogeneity. All of the lithologies of the unit are interbedded and grade laterally into each other. They interpret that this "* * * reflects heterogeneity in the environment of deposition, in the source area, and in the processes of deposition. Rounded pebbles imply subaerial sources; the characteristics of the volcanic rocks clearly indicate widespread submarine volcanism; and the slumping, chaotic bedding, and structures formed by turbidity currents imply steep gradients, which, in turn, suggest tectonic movements and perhaps also that these rocks may have been volcanic islands or submarine peaks. However, the finely laminated, primarily siliceous sedimentary rocks suggest quiet deposition at some depth in basins free from currents, wave action, and the dumping of detrital sediments" (Gates and others, 1971, p. 728–729). This map unit is part of the Attu Basement Series of Yogodzinski and others (1993)

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

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

Tcl **Copper Lake Formation (Tertiary, Eocene to Paleocene)**—Clastic nonmarine sedimentary rocks 1,025 m thick in a measured section that consists of upper and lower conglomerate members bounding a middle sandstone and siltstone member on the northern Alaska Peninsula (Detterman and Reed, 1980; Detterman and others, 1996). Upper conglomerate unit consists of red-weathering pebble-cobble conglomerate that consists mainly of volcanic rock clasts and contains minor tuff (Detterman and Reed, 1980). This upper member may be an agglomerate rather than conglomerate; clasts are 50 to 100 percent fresh-appearing volcanic rock. Clasts of quartzite, schist, greenstone, rose quartz, limestone, and granitic rocks are present in lower parts of this upper conglomerate member. Sandstone and siltstone intervals vary from thin-bedded to massive and are typically dark- to medium-gray; they are fine- to medium-grained lower in section and become medium- to coarse-grained toward top. Middle member is chiefly medium-gray to greenish-gray lithic graywacke sandstone and siltstone. More fine-grained clastic parts of formation contain considerable carbonaceous debris and minor coaly material. Grains in the sandstone include abundant quartz, schist, volcanic, and granitic rock fragments. Interbedded siltstone is similar in color and composition to the sandy facies, whereas claystone interbeds are mainly micaceous clay and contain a small amount of montmorillonite. Lower conglomerate member is red-weathering pebble-cobble conglomerate that consists mainly of volcanic rock clasts and contains minor tuff. Volcanic clasts constitute about 25 percent of member, and these appear to be derived from the Talkeetna Formation rather than the Tertiary volcanic units, which have a fresher appearance. Copper Lake Formation was derived from erosion of a Mesozoic source area and is terrestrial. In the southern part of its exposure area, the source area is underlain by the Alaska-Aleutian Range batholith (Reed and Lanphere, 1973) and associated Mesozoic sedimentary and metamorphic rocks. Towards the north, Copper Lake Formation undergoes transition from rocks of Mesozoic provenance to fresh volcanic clasts of probable Tertiary age (Detterman and Reed, 1980, p. B47). Age of the Copper Lake Formation is poorly constrained; sparse megaflora in type section and abundant megaflora on the Alaska Peninsula are restricted to sandstone and siltstone intervals in middle part of unit (Detterman and others, 1996). Detterman and others (1996) correlated the Copper Lake Formation with the Tolstoi Formation of the southwest Alaska Peninsula, where an early Eocene megaflora was collected from a section of sandstone and siltstone. Beneath the sandstone and siltstone, a basal conglomerate contains a late Paleocene flora; beds overlying the sandstone and siltstone contain a middle Eocene flora. By analogy, a Paleocene(?) to early Eocene age was assigned to the Copper Lake Formation. Parrish and others (2010) proposed a new formation they named the Ketavik [sic] Formation whose rocks, we believe, more properly belong to the Copper Lake Formation; the lithology and age assignment they gave to the Ketavik is consistent with the age of the Copper Lake Formation. Upper and lower contacts of the Copper Lake Formation are disconformities with Hemlock Conglomerate and Kaguyak Formation, respectively

TKpc **Prince Creek Formation (lower Tertiary, Paleocene, to Upper Cretaceous, Campanian)**—Consists of light colored nonmarine sandstone interbedded with carbonaceous mudstone, coal, and bentonite (Mull and others, 2003). Sandstone is dominantly very fine- to fine-grained and variably tuffaceous and contains grains primarily of quartz and black to gray chert (Mull and others, 2003). Lower part of formation contains distinctive beds of medium- to coarse-grained sandstone that locally contains lenses of pebble to cobble conglomerate. According to Mull and others (2003), unit represents a fluvial, meandering stream environment with interbedded marginal- and shallow-marine intervals. Includes dinosaur-bone-bearing beds at Ocean Point on the Colville River. Includes rocks of the now-abandoned Kogosukruk Tongue and the lower part of the Sagwon Member of the Sagavanirktok Formation as revised by Mull and others (2003) in northern Alaska. Unit originally included two nonmarine tongues, the lower of which is now defined as the Tuluvak Formation (unit Ktu herein)

TKcf **Canning Formation (lower Tertiary, Oligocene?, to Cretaceous, Albian)**—Consists of gray shale and siltstone containing interbeds of mostly thin-bedded, very fine- to fine-grained lithic sandstone. Unit informally divided in two facies: a turbidite sandstone facies and a slope-and-shelf facies. Turbidite facies are present throughout age range and areal distribution of unit; slope and shelf facies apparently entirely Tertiary in age and present only in eastern part of unit (Bird and Molenaar, 1987). Unit is 1,500 to 1,800 m thick in wells west of the Canning River and thinner to the east (Bird and Molenaar, 1987). Unit becomes younger from west to east: at Canning River it is entirely Cretaceous; in easternmost exposures, unit is Eocene and possibly as young as Oligocene in the subsurface. Lateral equivalent, in part, of the Sagavanirktok (unit Tsf) and Prince Creek Formations (unit TKpc). Unit is a time-transgressive turbiditic sandstone and shale as described by Molenaar and others (1987) and is recognized on the surface only in northeastern Alaska. In the subsurface west of the Canning River, unit may be equivalent to the Torok Formation (unit Kto, here; Molenaar and others, 1987). To the east and offshore, Houseknecht and Schenk (1999) suggest the Canning Formation may become as young as Miocene

TKgrs **Ghost Rocks sedimentary rocks (Tertiary, Paleocene, and Upper Cretaceous)**—Consists of thick sections of argillite and local massive sandstone and chert-rich pebble conglomerate; locally contains tuff beds in Kodiak Island region. Limestone containing pelagic foraminifers occurs locally at depositional contacts with pillow basalt, both of which typically occur southeast of the sandstone-rich unit and yield Late Cretaceous and early Tertiary ages. Sandstone beds show Bouma sequences indicative of deposition by turbidity currents. Locally, channelized conglomerate units as much as 100 m thick contain clasts up to 30 cm in diameter that are chert, sandstone, limestone, or greenstone. Interbedded andesite is locally present. Moore and others (1983) described the Ghost Rocks as complexly deformed sandstone and shale interbedded volcanic rocks and local hypabyssal intrusive rocks metamorphosed to prehnite-pumpellyite facies. Byrne (1981) mapped a distinctive subunit of the Ghost Rocks that consists of "* * * medium-bedded (10–40 cm thick beds) sandstone interbedded with similar thicknesses of shale. The sandstones and shales are rhythmically bedded and sole markings and graded beds indicate turbidite deposition." Byrne (1981) interpreted these rocks as "slope basin sequences" and indicated that the subunit is distinctive in the Ghost Rocks because of its lack of metamorphism and presence of only rare thick-bedded (>1 m) sandstone. In addition, Byrne (1981) noted the absence of conglomerate and pebbly mudstone, igneous rocks, and the relative lack of deformation; these rocks may be lithologically similar to the basin-plain facies association of Nilsen and Moore (1979) that we describe as part of the Kodiak Formation (unit Kaf). On generalized map, included as part of unit Tkgr

## CENOZOIC TO PALEOZOIC

### Tertiary to Devonian

#### *Tertiary to Jurassic*

Kcs **Chignik Formation and similar units in southern Alaska (Upper Cretaceous)**—Consists of the Chignik Formation of the Alaska Peninsula, the Summit Island Formation of southwest Alaska (Hoare and others, 1983), and the Saddle Mountain section of Magoon and others (1980) in the Cook Inlet region. Named by Atwood (1911, p. 41–48), the Chignik Formation is a cyclic, nearshore marine, tidal flat, and nonmarine floodplain and fluvial deposit (Fairchild, 1977; Detterman, 1978) as much as 600 m thick between Port Moller and Chignik Bay. Unit is dominantly light-olive-gray to olive-gray sandstone that has interbedded olive-gray to olive-black siltstone and conglomerate. Conglomerate is composed of multicolored chert, white quartz, felsic plutonic, and minor volcanic clasts. Nonmarine part locally contains coal beds as much as 2 m thick. Marine fossils, mainly pelecypods, indicate late Campanian and early Maastrichtian age (J.W. Miller, written commun., 1983–85). Chignik Formation unconformably overlies all older units on the Alaska Peninsula and conformably interfingers with and underlies its deep-water-facies equivalent Hoodoo Formation (unit Khk) (Mancini and others, 1978; Molenaar, 1980; Detterman and others, 1996). As shown here, unit also includes rocks mapped as undivided Chignik and Hoodoo Formations in Ugashik 1:250,000-scale quadrangle by Detterman and others (1987a). Summit Island Formation of southwest Alaska consists of lenses and inter-tonguing beds of nonmarine conglomerate, sandstone, carbonaceous siltstone, mudstone, and shale that contain abundant plant detritus and a few coal seams (Hoare and others, 1983). In the type section, the unit "consists of about 200 m of massive and thick-bedded pebble [to] cobble conglomerate overlain by about 650 m of interbedded sandstone, siltstone, and mudstone and a few conglomerate beds" (Hoare and others, 1983). At the reference section of the unit, its character changes to consist of "about 75 percent carbonaceous mudstone, siltstone, and shale and 25 percent interbedded sandstone and pebble grit" (Hoare and others, 1983). Conglomerate clasts are well-rounded, generally not larger than 10 cm, and primarily derived from flows, tuffs, and sedimentary rocks of Jurassic and Early Cretaceous age (Hoare and others, 1983), as well as white quartz and sparse schist and plutonic clasts; they suggest the schist clasts are derived from tectonically metamorphosed rocks that occur locally along major faults in the region. Noting two contrasting sandstone compositions, Box (1985) divided the unit into two subbasins along the trace of the Togiak-Tikchik Fault; both subbasins contain more than 1 km of section. Sandstone of Summit subbasin (southeast of Togiak-Tikchik Fault) is composed mostly of slaty sedimentary lithic fragments, similar to underlying Jurassic sedimentary rocks. Rocks in this subbasin consist of a lower conglomeratic member (200 m) that probably originates from alluvial fans and braided streams, and an upper carbonaceous shale member that probably originates from meandering streams and floodplains and has channelized sandstone bodies that become finer grained and thinner upward. Sandstone of Hagemeister subbasin (northwest of Togiak-Tikchik Fault) is composed of nonfoliated volcanic detritus similar to underlying Jurassic rocks and consists of a lower channelized sandstone member (600 m) that probably originates from meandering streams, and an upper sandy member (400 m) that has cycles that coarsen and thicken upwards in section, beginning with laminated siltstone-coal intervals that are possibly lacustrine delta deposits. Plant fossils from the base of the reference section indicate a latest Cretaceous or early Tertiary age (J.A. Wolfe, oral commun., 1974, cited in Hoare and others, 1983). A dike that cuts the formation yielded a K/Ar age of 64.6±2 Ma, which suggested to Hoare and others (1983) that a Late Cretaceous age for the Summit Island Formation was more probable. Subsequent dating of a dike cutting the formation yielded an older age of 76.6±4.5 Ma (Box, 1985), further supporting a Cretaceous age assignment for the unit. The Saddle Mountain section of Cook Inlet consists of dominantly nonmarine fine- to medium-grained sandstone that becomes finer grained upward and lesser conglomerate, minor siltstone, and coal in a section 83 m thick (Magoon and others, 1980) found northeast of Chinitna Bay in the Seldovia quadrangle. Unit is soft and friable except where cemented by calcite. Conglomerate contains volcanic and plutonic rock boulders as large as 30 cm in diameter in a sandy matrix. Coal beds, which tend to occur in the upper part of the section, are as much as 2.7 m thick and locally have underclay (Magoon and others, 1980). Sporomorphs *Cranwellia striata* (Couper) Srivastava, *Balmeisporites* spp., *Wodehouseia spinata* Stanley, *Proteacidites* spp., *Aquilapollenites bertillonites* Funkhouser, *A. reticulatus* Mtchedlishvili, and *A. delicatus* Stanley (Magoon and others, 1980) indicate Maastrichtian age. The Saddle Mountain section was assigned to Kaguyak Formation by Bradley and others (1999), but is distinctly different than Kaguyak Formation (unit Khk). Unit overlies the Upper Jurassic Naknek Formation with angular unconformity and is overlain by West Foreland Formation with angular unconformity. On generalized map, included as part of unit Knmt

Khk **Hoodoo and Kaguyak Formations (Upper Cretaceous)**—These two similar Alaska Peninsula units are typically dark-gray to black or brown, thin-layered and rhythmically bedded, splintery to pencil-fracturing shale, siltstone, and fine sandstone. Hoodoo Formation was named by Burk (1965; see also Detterman and others, 1981a) for exposures on the southern Alaska Peninsula. In the vicinity of the type section, the Hoodoo Formation contains ammonite-bearing channel conglomerate composed of clasts of plutonic and volcanic rocks, chert, and quartz. In general, sandstone beds are 0.3 to 1 m thick, and siltstone and shale beds are 1 to 2 m thick, although individual layers are as thin as 1 cm (Detterman and others, 1981). Depositional environment for most of unit is characteristic of lower slope of a submarine fan; structures imply submarine slumping and turbidity current flow. Locally, thick sandstone and conglomerate in upper part of unit imply an upper fan environment. Detterman and others (1996) indicate that the Hoodoo may be considerably thicker than where it was measured at a 630-m-thick reference section, but complex folding and faulting, including well-developed olistostromes, and absence of good marker beds make it difficult, if not impossible, to determine true thickness of formation. Hoodoo is, in part, age equivalent to Chignik Formation (unit Kcs), which can be considered a shallow-water-facies equivalent of the Hoodoo (Mancini and others, 1978; Molenaar, 1980; Detterman and others, 1996). However, where the two units are in contact, the Hoodoo conformably overlies the Chignik Formation, which indicates a generally transgressive sequence. Sparse megafauna indicate an age of late Campanian to early Maastrichtian for Hoodoo (J.W. Miller, written commun., 1983–85).

Kaguyak Formation has a measured thickness of more than 1,200 m (Detterman and others, 1996). Named by Keller and Reiser (1959), unit is mapped on south side of Kamishak Bay at the northern end of the Alaska Peninsula. Similar to the Hoodoo Formation, the proportion of sandstone increases up section. Load and flute casts are common; in upper part of unit, graywacke is graded with numerous rip-up clasts. Overall depositional environment was midfan within multichanneled system, but uppermost part of unit may have been deposited in upper-fan regime (Detterman and others, 1996). In general, fossils are sparse, but they are locally abundant in lower part of unit. Ammonites are most common and range in size to as much as 1 m across. Fossils indicate latest Campanian and early Maastrichtian age. On generalized map, included as part of unit Knmt

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

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

Kcv **Chert and volcanic sequence (Upper Cretaceous)**—Consists of varicolored brown, gray, and green bedded chert; pillow lava and tuff; and thin (5–10 cm) medium-gray, medium- to fine-grained sandstone interbedded with dark-gray mudstone on northeast coast of Long and Clifford Islands in the Sanak Islands at the southwest end of the Alaska Peninsula (Moore, 1974b). Maximum exposed thickness reported by Moore (1974b) is 250 m; however, as no base of unit is exposed, total thickness of unit is unknown. Clasts of chert, presumably derived from this unit, are found in overlying massive sandstone of Shumagin Formation (unit Kaf herein). Radiolaria extracted from chert samples yielded a Campanian or Maastrichtian age (C.D. Blome, written commun., 2000). No other locality on Alaska Peninsula or adjacent islands has similar lithology, except for parts of the Early Cretaceous Uyak Formation (Moore, 1969; Fisher, 1979) on Kodiak Island, with which Moore (1974b) made only lithologic correlation. On generalized map, included as part of unit Tkgr

Ksb **Schrader Bluff Formation (Upper Cretaceous, Maastrichtian to Santonian)**—Dominantly marine sandstone and shale, locally and variably tuffaceous. "Lower and upper parts * * * commonly contain varying amounts of bentonite interbedded with bentonitic shale, tuffaceous mudstone, and bentonitic, fine-grained fossiliferous sandstone, as well as beds of relatively pure bentonite * * *" (Mull and others, 2003). Lower and upper parts of unit are not well exposed; middle part of unit is notable for a resistant interval of tuffaceous sandstone and tuff (Mull and others, 2003). Bivalves and microfauna (Detterman and others, 1963; Brosgé and Whittington, 1966) and palymorphs (Mull and others, 2003) yield a Santonian to Maastrichtian age. Unit is exposed in the Ikpikpuk River, Chandler Lake, and Umiat quadrangles of northern Alaska

Kcct **Cape Current terrane (Upper Cretaceous)**—Informal unit described by Connelly (1978) that consists principally of slightly metamorphosed and moderately deformed, medium- to thick-bedded arkosic and lithic sandstone that contains occasional sections of vesicular pillow lava and pillow breccia. Crops out in a small area on northern end of Shuyak Island in Afognak quadrangle. Two bodies of red pelagic limestone that contain many siliceous layers are present within unit along southern shore of Shuyak Island. Limestone is thinly bedded and tightly folded; contains sparse coccoliths of indeterminate age and Late Cretaceous foraminifera (approximately Turonian to early Santonian age, according to W.V. Sliter, written commun., cited in Connelly, 1978). On generalized map, included as part of unit Kumc

Kmf **Minto unit (Upper Cretaceous?)**—Interbedded yellowish-gray, iron-stained siltstone; light-gray to light-yellowish-gray mudstone that locally contains pyritized plant fragments; light- to medium-olive-gray, very fine-grained to medium-grained graywacke; hard quartzo-feldspathic sandstone; light-yellowish-gray shale; and medium- to dark-gray clay shale. Grain size fines and bedding thins upsection. Load casts, bioturbation, and burrows occur locally. Unit reflects deltaic to continental shelf depositional conditions. Age control is imprecise, but unit thought to be post-Albian in age. Unit exposed in Livengood and Charley River quadrangles of east-central Alaska. On generalized map, included as part of unit Knmt

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

TKis **Intricately intruded areas of volcanic graywacke and mudstone (Tertiary or Upper Cretaceous)**—Unit is mapped in areas where numerous small hypabyssal bodies of rhyolite and dacite intrude the Ksd unit. Igneous complexes are composed of small, closely-spaced rhyolite, dacite, andesite, granite, granodiorite, tonalite, and monzonite porphyry bodies. Intrusive bodies are too small and too numerous to be mapped separately. Sedimentary host rocks are altered to erosion-resistant hornfels. A felsic hypabyssal body belonging to the complex in the southwestern part of Unalakleet quadrangle yielded a single K/Ar isotopic cooling age of 68.8±3 Ma (Patton and Moll-Stalcup, 1996). On generalized map, included as part of unit Knmt

Kk **Kuskokwim Group, undivided (Upper Cretaceous to upper Lower Cretaceous)**—Interbedded graywacke and shale that has local interbeds of argillite and conglomerate. Graywacke fine- to medium-grained, gray, commonly micaceous and locally silty; in places it is crossbedded or contains siltstone partings. Contains rare argillite pebbles. Originally described by Cady and others (1955), the Kuskokwim Group is widespread in southwestern Alaska and, although largely a flysch deposit, represents a range of local depositional environments. A number of workers (Patton and others, 1980; Bundtzen and others, 1992; Box and others, 1993; Miller and Bundtzen, 1994) have subdivided the Kuskokwim Group into two facies: a predominantly deep-water, turbidite-dominated facies; and a shallow-marine and fluvial facies (unit Kkn, here). Box and others (1993) subdivided the upper part of the unit in the Bethel quadrangle on the basis of provenance and depositional environment, but data are insufficient to carry those distinctions throughout the exposure area. Box and others (1993) described three depositional environments: outer-fan turbidite, inner-fan turbidite, and deltaic; and they described three packages of rock that provide material to the depositional environments—provenances that they called chert-clast, volcanic, and mixed. We have chosen to subdivide the Kuskokwim Group into two subunits that reflect the depositional environments represented (nearshore or outer fan), but we retain Box and others' (1993) distinctions of clast provenance. Box and others' (1993) deltaic environment, which is consists only of chert clasts, has been placed in the nearshore facies subdivision (unit Kkn) of this map. The other chert-clast provenance rocks are described as outer-fan facies and consist of thin-bedded, fine-grained, quartzose sandstone and shale with lesser thin- and thick-bedded medium-grained sandstone (Box and others, 1993). Volcanic provenance rocks consist of interbedded shale, siltstone, sandstone, and conglomerate composed of rounded clasts of volcanic, volcaniclastic, and plutonic rocks deposited in slope and inner-fan environments (Box and others, 1993). The rocks having clasts of mixed provenance represent two depositional environments: an outer-fan turbidite facies that consists of a shale-rich sequence and lesser thin- to thick-bedded, medium-grained sandstone sections; and an inner-fan-channel facies that consists of mixed shale-rich and sandstone-rich sections, and coarse sandstone and pebbly sandstone in thick-bedded, amalgamated sequences containing minor interbedded shale (Box and others, 1993). Age of the Kuskokwim Group is not well constrained because of the multiple provenances and potentially multiple depositional systems that are represented by the map unit. Cady and others (1955) assigned an early Late Cretaceous age on the basis of 38 fossil collections, but acknowledged fossil collections outside their map area that might indicate an age older than Late Cretaceous or as young as Tertiary. Elder and Box (1992) and Box and others (1993) assigned a late Cenomanian to early Turonian age based on inoceramid fossil collections in the Bethel quadrangle, whereas Hoare and Coonrad (1959a) reported Albian and Cenomanian to Coniacian fossils from the same area, and Murphy (1989) reported an Albian collection. Other age assignments have ranged as young as Santonian (Decker and others, 1994) and Campanian(?) (Miller and Bundtzen, 1994)

Kkn **Nearshore facies (Upper Cretaceous, Santonian to Cenomanian)**—Consists of well-sorted, quartz-rich, cross-bedded sandstone interbedded with siltstone and shale. Includes the thick-bedded quartzose sandstone, pebbly sandstone, and subordinate siltstone and shale of the deltaic facies that consist of chert clasts, which was described by Box and others (1993). Also includes pebble to boulder conglomerate, coarse sandstone, and minor interbedded medium-grained sandstone, siltstone, and shale of the basal conglomerate of Box and others (1993). As described by Hoare and Coonrad (1959a), this nearshore facies chiefly consists of conglomerate facies of interbedded graywacke and siltstone, with lesser amounts of pebble grit conglomerate and a small amount of coal. Well-indurated, commonly light- to dark-gray, and weathers brown. Varies from volcanic wacke to quartz-chert-feldspar-rich sandstone. Fossils collected from basal conglomerate member of Box and others (1993) are considered Late Cretaceous (Cenomanian) age and fossils from the deltaic facies of Box and others (1993) are considered Late Cretaceous (Turonian). Murphy (1989) reported an Albian ammonite, *Paragastroplites*, from this unit in the Bethel quadrangle. This informal subdivision of the Kuskokwim Group was originally defined by Platt and Muller (unpub. data, 1957, cited in Wilson and others, 2006a, in press [a]) in the northeastern Taylor Mountains quadrangle; subsequent mapping in the Iditarod quadrangle to the north (Miller and Bundtzen, 1994) also described a nearshore facies. On generalized map, included as part of unit Ksmd

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 Ksmd

Ksg **Sitka Graywacke, undivided (Cretaceous)**—Consists of sandstone and mudstone turbidites and subordinate conglomerate on Baranof, Chichagof, Kruzof, and Yakobi Islands (Loney and others, 1975; Decker, 1980; Johnson and Karl, 1985). Part of what is commonly called the Chugach accretionary complex, the Sitka Graywacke is lithologically similar to the Chugach flysch (see unit Kaf, above). Detrital zircon studies (Haeussler and others, 2006) suggest the unit includes two age-distinct subunits. The youngest and western part of the unit yields detrital zircons that have minimum age populations equivalent to the Late Cretaceous fossil ages of the Chugach flysch, which indicates a maximum depositional age of Campanian(?) or Maastrichtian. The eastern part of the unit yields an Albian maximum age on the basis of detrital zircon populations, suggesting the presence of an earlier depositional system. As originally described, the Sitka Graywacke was thought to be Jurassic, in part; however, the detrital zircon data suggests this is unlikely. Strata represent deep-water marine trench, slope-basin, and fan deposits. Sitka Graywacke is moderately deformed and disrupted, regionally metamorphosed to as high a grade as greenschist facies in some areas, and thermally upgraded to hornblende-hornfels facies locally (Decker and others, 1979; Johnson and Karl, 1985). Common rock types in metamorphosed regions south of Cross Sound include metagraywacke and argillite. Early Cretaceous fossils were found in the Sitka Graywacke on Kruzof Island (Reed and Coats, 1941), and the detrital zircon data (Haussler and others, 2006) suggests a long depositional history for the Sitka Graywacke; minimum age of these strata is constrained by Eocene granodiorite (unit Toegr) on Baranof Island (Loney and others, 1975; Reifenstuhl, 1986; Bradley and others, 2003; S.M. Karl, unpub. data). On generalized map, included as part of unit Kchf

Kcc **Carbonate-rich conglomerate and sandstone deltaic rocks (Cretaceous)**—Tan to light-gray siltstone, sandstone, and pebbly sandstone, and light-gray-weathering conglomerate mostly composed of marble, metalimestone, and dolostone clasts. Carbonate-rich sandstone and siltstone typically occur as rubble-covered hills but are best exposed in river-cliff outcrops (Till and others, 2011). Abundant plant debris and thin seams of bituminous coal (Patton and others, 2009) are typical. Clast-supported cobble to boulder conglomerate, composed almost entirely of carbonate rocks, grades eastward into trough cross-bedded, medium- to coarse-grained sandstone and pebble conglomerate fan-delta deposits. These fan-delta desposits, in turn, grade eastward into cross-bedded, fine- to coarse-grained, inner and outer shelf sandstone and shale. Chert, volcanic rock, quartz, and schist detritus are present in subordinate amounts. Unit contains sparse palynomorphs of Cretaceous(?) age in the Norton Bay quadrangle (Patton and others, 2009). Unit is found on the Seward Peninsula and other parts of northwest Alaska, and is probably of mid-Cretaceous age. Unit derived in large part from Paleozoic carbonate rocks of the Seward Peninsula (Till and others, 1986; Patton and others, 2009). On generalized map, included as part of unit Knmt

KJyh **Graywacke of the Yenlo Hills (Cretaceous? and uppermost Jurassic)**—Consists of graywacke containing "extremely angular, and oscillatory zoned plagioclase, volcanic rock fragments, hornblende, epidote, and calcite grains" (Reed and Nelson, 1980). According to Reed and Nelson (1980), this unit differs significantly from the other sedimentary rocks in the vicinity, which are mapped as part of the Kahiltna assemblage (unit Kfy) flysch. The plagioclase, volcanic rock fragments, hornblende, epidote, and calcite are more abundant in the Yenlo Hills, and Reed and Nelson (1980) suggest "that the sandstone may have been derived from the Jurassic magmatic arc (Reed and Lanphere, 1973) now covered by younger rocks in Cook Inlet basin. Contemporaneous volcanism is suggested by rare interbedded light tuffaceous sediments in the Yenlo Hills" (Reed and Nelson, 1980). New detrital zircon analyses indicate a significant peak at 150 Ma, which suggests unit has a maximum age of uppermost Jurassic or is younger in age (Hults and others, 2013)

KJs **Fine-grained sedimentary and metasedimentary rocks (Cretaceous or Jurassic)**—Gray and yellow, conchoidal fracturing, locally ferruginous, very-fine- to fine-grained quartz sandstone; minor black fine-grained sandstone, black siltstone, and green chert in the Black River and Coleen quadrangles of east central Alaska. These rocks were assigned to the informal Christian River and Porcupine River sequences of Brosgé and Reiser (1969). Bivalves of Jurassic or Cretaceous age reported (Brosgé and Reiser, 1969)

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 volcaniclastic 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)

Kqc **Quartz-pebble conglomerate, west-central Alaska (lower Upper Cretaceous to upper Lower Cretaceous)**—Composed chiefly of well-sorted and well-rounded clasts of white quartz and (or) metagraywacke in a quartzose and micaceous matrix; schist, chert, greenstone, and limestone clasts occur in subordinate amounts. Conglomerate is interbedded with quartzose, cross-bedded sandstone and carbonaceous and micaceous mudstone. Contains rare interbeds of ashy tuff. Plant fossils and thin bituminous coal seams are locally abundant. Unit composed chiefly of debris eroded from the Arctic Alaska and Ruby terranes. Grades downward into unit Kipc, reflecting the progressive unroofing of Arctic Alaska and Ruby terranes beneath Angayucham-Tozitna terrane (Patton and others, 2009). Unit regionally metamorphosed, resulting in stretched-pebble conglomerate, semischist, and phyllite in northeastern part of the Shungnak quadrangle and in adjoining parts of the Ambler River and Hughes quadrangles. Sparse plant fossil collections from this unit range in age from late Early Cretaceous to Late Cretaceous. A K/Ar biotite cooling age of 86 Ma (corrected age is 85.4±2.2 Ma) was reported by Patton and others (2009) and Till and others (2008a) from interbedded ash-fall tuff in the Baird Mountains quadrangle. On generalized map, included as part of unit Knmt

Ktu **Tuluvak Formation (Upper Cretaceous, Coniacian to upper Turonian)**—Fine- to coarse-grained to granular sandstone and quartz- and chert-pebble conglomerate occur in several relatively resistant intervals, some of which consist of conspicuously well-rounded and well-sorted pea gravel with no interstitial matrix. Lower part typically medium- to coarse-grained, well-sorted sandstone. Clasts are dominantly quartz and chert, and the sandstone is interbedded with bentonite, bentonitic shale, carbonaceous shale, and coal. Upper part of unit dominantly fine-grained sandstone. In southwest part of exposure area, formation is thicker and contains more resistant sandstone and conglomerate; to the east and northward, formation thins and becomes finer grained as it transitions from nonmarine braided-stream deposits to marine sandstone. Forms prominent bluffs along the north and northwest side of the Colville River downstream from Umiat, and scattered exposures along the Chandler and Anaktuvuk Rivers. Mudstone, siltstone, and shale are end members of a continuum of lithologies that are typically medium- to dark-gray, fissile in parts, and bentonitic in parts. Conglomerate is locally found in basal part of unit and consists of well-rounded pebbles of white to light-gray quartz, quartzite, and medium- to dark-gray chert and has a sandstone matrix and quartz cement. Sandstone, siltstone, and shale of upper part of unit are poorly exposed; sandstone is gray, probably mostly quartz and chert and prominently cross-bedded; siltstone and shale are gray and brownish gray and poorly indurated. Tuff beds, coal, and ironstone are found locally (Kelley, 1990a). Unit defined by Gryc and others (1951), Whittington (1956), and Brosgé and Whittington (1966) as part of Prince Creek Formation and elevated to formation status by Mull and others (2003). Redefined unit also contains the now-abandoned Ayiyak Member of the Seabee Formation. Lower part of unit interfingers with the Seabee Formation (D.W. Houseknecht, written commun., 2014). On generalized map, included as part of unit Knmt

Ksbf **Seabee Formation and Hue Shale (Upper Cretaceous, Coniacian to Turonian)**—Bentonitic mudstone, silty mudstone, and medium- to dark-gray to black, fissile, organic-rich shale containing interbedded bentonite and some thin, silicified tuff beds. Some localities characterized by large, yellowish-brown-weathering ovoid concretions greater than 3 ft (90 cm) in diameter. Unit consists only of rocks formerly mapped as Shale Wall Member of the Seabee Formation by Detterman and others (1963); other members have been abandoned. Unit defined by Gryc and others (1951) and Whittington (1956) and revised by Mull and others (2003). Map unit here also includes Hue Shale of Molenaar and others (1987), which consists of dark-gray, bentonitic shale in which fine-grained pyroclastic rock fragments weather yellow and greenish gray, and, in areas surrounding Sadlerochit Mountains, bright red. As mapped in Ignek Valley, includes some interbedded turbiditic shale and sandstone assigned to the Canning Formation. Interpreted by Molenaar and others (1987) to be a distal marine deposit and a condensed section; its upper parts may be equivalent, in part, with the lower part of the Canning Formation. The rocks of now-abandoned Ignek Formation are also included here; it consisted of a lower member of siltstone, shale, and locally fossiliferous subgraywacke sandstone; and an upper member, predominantly shale and lesser sandstone and siltstone beds, characterized by abundant pyroclastic deposits (Keller and others, 1961)

Kfy **Flysch (Upper and Lower? Cretaceous)**—Monotonous sequence in central Alaska of intensely deformed and locally highly metamorphosed turbidites; includes dark-gray to black argillite; fine- to coarse-grained, generally dark-gray graywacke, siltstone, and shale turbidites; thinly bedded and dense cherty argillite; dark-gray polymictic pebble conglomerate; subordinate black chert pebble conglomerate; a few thin layers of dark-gray to black radiolarian chert; and thin, and dark-gray impure limestone interbeds described by Csejtey and others (1992) and Reed and Nelson (1980), among others. Commonly referred to as the Kahiltna terrane or assemblage (Nokleberg and others, 1994) or “black crap.” Includes rocks mapped by Reed and Elliot (1970) as units Km, Mzu, and Mzs. In Tyonek quadrangle, coquina beds yielded *Buchia sublaevis* Keyserling of Valanginian age (Solie and others, 1991b). *Inoceramus hobetsensis* Nagao and Matsumoto, of middle Turonian age, was also found within unit (W.P. Elder, written commun. to D. Bradley, 1989). Csejtey and others (1992) reported additional fossils from unit ranging from Valanginian to Cenomanian as well as several collections of radiolarians that could only be described as Jurassic or Cretaceous. Fossils indicate unit contains both Lower and Upper Cretaceous rocks; $^{40}Ar/^{39}Ar$ age determinations on hornblende from igneous clasts in the conglomerate yield Cenomanian ages (Layer and Solie, 2008), which suggests a maximum age of latest Early Cretaceous age. Detrital zircon studies by Dwight Bradley and Peter Haeussler (see Wilson and others, 2009, 2012; and Hults and others, 2013) have yielded a variety of minimum age results from Barremian to Aptian and Turonian to Santonian. Studies by Ridgway and others (2002), Kalbas and others (2007), and Hampton and others (2007) provided information indicating multiple provinces for unit and reported detrital zircon analyses that suggest the Kahiltna assemblage is, at least in part, Aptian or Albian or younger in age. Hults and others (2013) suggest unit represents multiple discrete basins separated by a major suture zone. In Talkeetna quadrangle, similar rocks were assigned a Jurassic and Cretaceous age (unit KJs of Reed and Nelson, 1980), however, the Jurassic fossils were derived from spatially and lithologically distinct rocks not part of this Kfy map unit. The Kahiltna assemblage, as generally mapped, is widespread in southern Alaska, and often the repository for miscellaneous dark-colored sedimentary rock units, and as such, does not represent a coherent package of rocks

Kcvg **Calcareous graywacke and mudstone, volcanic graywacke, and conglomerate (lower Upper or upper Lower Cretaceous)**—Cyclically interbedded fine- to coarse-grained, highly calcareous graywacke; hard, fine- to medium-grained, carbonaceous, volcanic graywacke; and dark carbonaceous mudstone in west-central Alaska (Patton and others, 2009). Also includes turbidite deposits of fine-grained to gritty graywacke and laminated micaceous mudstone, which are composed largely of carbonate detritus and lesser quartz, chert, volcanic rock, and mica clasts. Graywacke is typically graded and sole-marked. Contains abundant carbonized plant debris. Mudstone intervals typically display fine, convolute, cross laminations and current ripple marks. Unit grades from a high graywacke-to-mudstone ratio in the southwest of its exposure area to a low graywacke-to-mudstone ratio in the northeast part of its exposure area (Patton and others, 2009). Patton and others (2009) interpreted unit to represent middle and outer submarine fan lobe deposits; some locally thick sections of mudstone probably represent basin plain deposits. Paleocurrents generally indicate transport to northeast. Poorly preserved marine mollusks of late Early Cretaceous(?) age present in unit in Selawik quadrangle. A single collection of palynomorphs from Norton Bay quadrangle is Cretaceous in age, possibly late Early or early Late Cretaceous (Albian or Cenomanian). Abundance of detrital carbonate, quartz, and mica fragments suggest that the unit was derived largely from carbonate and schist units of the Seward terrane of Patton and others (2009) (units Pzcn and PzPnc here)

Kmss **Marine sandstone and siltstone (Cretaceous, Cenomanian to Albian)**—Shallow marine deposits along the Yukon River and in a belt to the west extending from the southern edge of the Norton Bay quadrangle to the western Kateel River quadrangle consist of fine- to coarse-grained, crossbedded, lenticular sandstone grading down into fine-grained sandstone and interbedded dark-gray siltstone and shale (Patton and others, 2009). In the belt to the west, unit is composed predominantly of siltstone and shale. These shallow marine deposits contain an abundant molluscan fauna of late Early (Albian) and early Late (Cenomanian) Cretaceous age

Knf **Nanushuk Formation (Cretaceous, Cenomanian to Albian)**—Consists of a regressive depositional sequence as thick as 2,750 m that includes marine, transitional, and nonmarine intervals (Alhbrandt and others, 1979) and has the most extensive exposure area of any unit in northern Alaska. Upper part consists of numerous thick horizons of typically nonmarine fine- to medium-grained and, locally, coarse-grained, gray to light-gray lithic arenite and quartz- and chert-pebble conglomerate interbedded with poorly exposed dark-gray carbonaceous shale and coal. Lower part is dominantly marine, greenish-gray, very fine- to fine-grained and locally fossiliferous sandstone and minor conglomerate. Alhbrandt (1979) reported that paleo-transport data from outcrops as well as from seismic and dipmeter data in wells on the North Slope indicate a generally northeast progradation of the Nanushuk, away from the Brooks Range. He hypothesized at least two river-dominated deltas for the onshore Nanushuk: “a western Corwin delta and, in the central North Slope, the Umiat delta.” Huffman (1985) described the slightly older (early Albian or late Aptian? origin) Corwin delta as prograding from west to east onto a shelf consisting of fine-grained sediment of the Torok Formation. The Umiat delta developed in mid-Albian time and has an elongate to lobate form that prograded northward from the vicinity of the Endicott Mountains (Huffman, 1985). Having different source areas, the deposits of the two deltas are compositionally different: the Corwin delta sourced sedimentary rocks, shale, limestone and chert, whereas the Umiat delta sourced metamorphic rocks of the central Brooks Range (Huffman, 1985) that includes detrital blueschist facies minerals (Till, 1992). Huffman (1985) reported that petrographic analyses indicate sediment of the Torok Formation is closely related to the sources of the Corwin delta and quite different than the Umiat delta. LePain and others (2009) report a detailed study in the central part of the North Slope that led to recognition of 20 facies in the unit that are combined “to form ten facies associations, including (1) offshore–prodelta, (2) storm-influenced shoreface, (3) distributary channel and mouth-bar successions, (4) tidal inlet, (5) bayfill–estuarine, (6) crevasse channel, (7) crevasse splay, (8) sandy fluvial channel fill, (9) conglomeratic fluvial sheet, and (10) alluvial flood basin successions. Facies associations 1, 2, and 3 record deposition in open marine settings; facies associations 4 and 5 record deposition in open marine and marginal-marine settings; facies associations 6 and 7 are interbedded in both marginal-marine and nonmarine deposits of the bayfill–estuarine association and alluvial flood basin associations, respectively; facies associations 8, 9, and 10 record deposition in nonmarine settings. The abundance of storm-wave-generated structures, such as hummocky and swaley cross-stratification in marine deposits, demonstrates deposition in high-energy, storm-wave-modified deltas and associated inter-deltaic shoreface settings.” Unit “is time transgressive, becoming younger to the north and northeast away from the Brooks Range” (Alhbrandt and others, 1979). The Nanushuk in northwestern Alaska consists of eastward-prograding deltaic rocks that overlie and interfinger with the Torok Formation and, together, the Torok and the Nanushuk prograde across the Colville Basin (Mull and others, 2000). Abundant and varied megafauna of pelecypods and lesser gastropods and ammonites are reported. Plant fossils common in nonmarine beds and microfauna recovered from shale. Although unit ranges in age, it is primarily Albian (Mull and others, 2003). Includes former Kukpowruk, Tuktu, Grandstand, Corwin, Chandler, and Ninuluk Formations of northern Alaska, all now abandoned. On generalized map, included as part of unit Kns

Kto **Torok Formation (Cretaceous, Cenomanian to Aptian)**—Thick sequence of dominantly nonresistant, dark-gray to black silty shale, mudstone, and clay shale that has interbedded thin-bedded siltstone and lesser amounts of greenish-gray, thin-bedded siltstone and fine-grained sandstone as thick as 5,700 m (Mull and others, 2003). Unit is generally exposed only in discontinuous stream cutbanks, where most exposures are tightly folded; lower part of unit interfingers with Fortress Mountain Formation (Mull and others, 1994). Upper part of the Torok Formation is age equivalent with the Nanushuk Formation (unit Knf here). Locally, in the western Brooks Range, the Torok and Fortress Mountain Formations are mapped undivided, where they consist of at least 500 m of dark-gray shale, subgraywacke and wacke sandstone lithologically similar to the Torok Formation and to the sandstone member of the Fortress Mountain Formation, but contain intermediate proportions of those rocks. This may represent a relatively proximal facies of the Torok Formation (Sable and

Mangus, 1984, Sable and others, 1984a, b, c). The Torok Formation is a thick slope-to-prodelta deposit derived from a western source that is gradational and interfingers with both overlying and underlying units (Mull and others, 2000, 2009). The Torok is relatively incompetent and is generally poorly exposed; it acts as a detachment surface for decollement folding of the overlying competent Nanushuk Formation (Mull and others, 2009). On generalized map, included as part of unit Kns

*Lower Cretaceous to Devonian*

Kfm **Fortress Mountain Formation (Cretaceous, Albian)**—Cyclic marine and nonmarine units of polymictic conglomerate, dusky yellow-green to dark-gray lithic wacke, dark-gray siltstone and shale; rocks in upper cycles generally finer grained and thinner bedded than those in lower cycles (Brosgé and others, 1979). Fortress Mountain includes nonmarine, shallow marine, marine slope, and deep basin facies. It contains lenticular and crossbedded beds, shows locally prominent pebble imbrication, rip-up clasts, scarce mud cracks in thin, discontinuous mudstone intervals, and has plant debris ranging from small carbonized wood to coalified logs. Conglomerate clasts include varieties of chert, varieties of mafic igneous rocks, limestone, argillite, organic shale, and granitic rocks. Conglomerate is also interbedded with bioturbated marine sandstone and with sandstone that shows local ripple and wave crossbedding, gravel lenses, abundant wood debris and, locally, marine mollusks (Kelley, 1990a). Common turbidite features in the marine and deep marine facies are graded bedding, sole marks, and flute, groove, and striation casts. Very small-scale crossbedding is common in most wacke beds. Rocks are texturally and compositionally immature and have clasts of chert, quartz, claystone, carbonaceous and kerogenous rocks, igneous rocks, and carbonate rocks in a matrix of chlorite, calcite, quartz, and clay minerals. Thickness is as much as 1,300 m (Brosgé and others, 1979; Sable and Mangus, 1984). Includes Mount Kelly Graywacke of Mull (1985), which is divided into upper and lower parts. The upper part consists of fine- to medium-grained, dark brownish-gray to greenish-gray sandstone that contains interbedded, poorly exposed, slightly micaceous silty shale; unit generally forms poorly exposed, low, rubble-covered ridges. The lower part of the Mount Kelly Graywacke consists predominantly of fine- to medium-grained sandstone and some coarse-grained, medium gray-green to brown sandstone, interbedded with poorly exposed dark-gray silty shale and local conglomeratic channels and contains abundant carbonaceous plant material on the top of some beds (Mull and others, 2000). Mull and others (2000) posit that the Mount Kelly Graywacke's abundant detrital muscovite and carbonate grains suggest a provenance in the southern Brooks Range schist belt (units D₽aqm and D₽acs); T.H. Nilsen, (consulting geologist, written commun., 1996, cited in Mull and others, 2000) suggests a storm-dominated shelf setting, mainly on the basis of wave-generated sedimentation features. Houseknecht and Wartes (2013) suggest that the Fortress Mountain Formation spans the boundary between an orogenic wedge (Okpikuark Formation) and foredeep, with proximal strata onlapping the tectonic wedge-front and distal strata downlapping the floor of the foreland basin. In the Noatak, De Long Mountains, and Misheguk Mountain quadrangles *Inoceramus* and *Aucellina* (Mayfield and others, 1987; Curtis and others, 1990) and rare ammonites of Albian age (Sable and others, 1984a) provide the age control for the Fortress Mountain Formation, as do Albian pelecypods collected in the Philip Smith Mountains quadrangle (Brosgé and others, 1979). On generalized map, included as part of unit Kns

Kof **Okpikruak Formation and similar units (Lower Cretaceous)**—Dark-gray to grayish-tan mudstone, siltstone, graywacke sandstone, and minor conglomerate. Locally, unit contains interbeds of distinctive reddish-gray coquinoid limestone, is intensely deformed and, in places, the base is structurally detached. Thickness is unknown. Locally, this unit has been mapped as mélange or olistrostrome between thrust sheets (see, for example, Curtis and others, 1990; Mayfield and others, 1990). The Okpikruak Formation has been dated by fossils to be as young as Valanginian (see, for example, Dover and others, 2004). Locally, the Fortress Mountain Formation is not separated in mapping (Curtis and others, 1990; Mayfield and others, 1990) and is included here; where included it consists primarily of the deep marine facies of the Fortress Mountain and, as discussed above, is also mapped separately when possible (unit Kfm).

In the Howard Pass quadrangle, Dover and others (1994) describe a unit of predominantly volcaniclastic rocks and subordinate associated mafic to intermediate volcanic rocks to which they assigned a Jurassic and Early Cretaceous age. They further indicate that it has some lithologic similarities to the Okpikruak Formation in other thrust sequences and has a similar degree of induration. We include it here with some uncertainty.

As shown here, this map unit, Kof, includes the Kisimilok Formation of Campbell (1967). The eastern exposures of Okpikruak Formation we show in the Noatak quadrangle (C.G. Mull and H.S. Sonneman, Exxon unpub. report, 1968–1974) may be better assigned to the mélange of the Angayucham assemblage (unit KJm here). As shown here, the Okpikruak Formation also includes small areas of sedimentary rocks in the De Long Mountains, Howard Pass, and Misheguk Mountain quadrangles that most likely belong to the Okpikruak Formation. The Kongakut Formation (unit Kgk) was originally defined by Detterman and others (1975) as a lateral (northern) equivalent of Okpikruak Formation. Also included in this unit is the undivided Arctic Foothills assemblage of Kelley (1990a) in the Chandler Lake quadrangle, which was described as follows: "consists of 7 previously recognized units; Lower Cretaceous coquinoid limestone, undivided Upper Jurassic and Cretaceous strata, Jurassic mafic igneous rocks, Permian and Triassic chert, the Nuka Formation (Carboniferous), marble and mélange." The unit includes an indeterminate proportion of Cretaceous rocks. As mapped, Kelley's (1990a) Arctic Foothills assemblage is thrust interleaved with rocks of the undivided Torok and Fortress Mountains Formations (unit Kft) and thrust over rocks of the Otuk Formation (JŦo) and Lisburne Group (Clg). It is interpreted by some (for example, Peapples and others, 2007; Mull and others, 2009; D.W. Houseknecht, written commun., 2014) as part of the Okpikruak mélange. On generalized map, included as part of unit Kok

Kpf **Pedmar Formation (Lower Cretaceous, Albian)**— Thin sequence (82 m thick) of thick-bedded, fine- to medium-grained, gray to olive-gray sandstone named by Detterman and others (1996) and exposed along coast of Katmai Bay near Mount Pedmar in Mount Katmai quadrangle. Carbonaceous debris is present throughout, and pebbles as large as 4 cm in diameter are found in tabular crossbedded sandstone in middle part of formation. Clasts are typically quartz; volcanic rock clasts are conspicuously absent. Two poorly exposed siltstone and shale intervals are present in upper part of formation; siltstone is much more common locally. Abundant ammonite and *Aucellina* sp. fossils help to establish well-controlled Albian age for formation. Upper contact of formation is disconformity with overlying by Kaguyak Formation (unit Khk). In type section, lower contact is a fault that juxtaposes Pedmar and Naknek (Jn) Formations. Locally, formation disconformably overlies Herendeen Formation (Khe). This is the only Albian-age unit known from the Alaska Peninsula

Kipc **Mafic igneous-clast conglomerate, sandstone, and mudstone (Lower Cretaceous)**—Massive, poorly stratified and poorly sorted conglomerate composed of pebble- to cobble-size clasts in a graywacke and mudstone matrix in west-central Alaska (Patton and others, 2009). Clasts are predominately mafic intrusive and extrusive rocks, varicolored chert, and locally, metagraywacke. Limestone, quartz, and granitic rock clasts present in subordinate amounts. Conglomerate is interbedded with mafic- and calcareous-clast graywacke and mudstone. Unit composed chiefly of debris thought to be eroded from the Angayucham-Tozitna terrane (Patton and others, 2009). Unit stratigraphically underlies unit Kqc. Contains marine mollusks of Early Cretaceous(?) age in the Selawik quadrangle

Kyg **Volcanic graywacke and mudstone (Lower Cretaceous)**—Hard, well indurated, fine- to medium-grained, locally tuffaceous sandstone and micaceous mudstone. Some sandstone beds have a distinctly mottled appearance owing to the presence of laumontite, which commonly occurs in tuffaceous layers (Hoare and Condon, 1966). Unit widely exposed in a broad belt that extends from the southeastern corner of the Saint Michael quadrangle to the south-central part of the Kwiguk quadrangle. Also includes fine-grained graywacke thinly interbedded with siliceous argillite (Patton and others, 1975) on Saint Matthew Island. Graywacke composed of angular to subrounded feldspar, volcanic lithic, and quartz grains in an altered argillaceous matrix (Patton and others, 1975). Argillite is siliceous, dense, breaks with conchoidal fracture, shows small-scale crossbedding and convolute laminations, and is interpreted as a distal facies of a marine turbidite (Patton and others, in press). In the Yukon-Koyukuk Basin, unit has yielded marine mollusks of late Early Cretaceous age (Patton and others, 2009). Unit correlates with unit Kygv of Patton and others (2009; Wilson and others, 2013)

Kcgc **Calcareous graywacke and conglomerate (Lower Cretaceous, Albian to Aptian)**—Hard, fine-grained to conglomeratic, locally tuffaceous graywacke and dark-gray finely laminated mudstone, typically exposed in western Alaska from Kuskokwim Bay to the southern Brooks Range. Graywacke contains matrix-supported clasts of intermediate and mafic extrusive and intrusive rocks and chert; quartz clasts and metamorphic and granitic rock clasts are present in subordinate amounts. Some graywacke beds are characterized by a distinctly mottled appearance owing to the presence of laumontite, which occurs most commonly in fine-grained, tuffaceous-rich layers (Patton and others, 2009). Metamorphic detritus is increasingly abundant towards top of unit. Graywacke beds commonly display Bouma-sequence grading from massive at the base to laminated in the middle to cross-laminated at the top. Mudstone rip-up clasts are common at the base of the graywacke beds. Unit has a high graywacke-to-mudstone ratio and is interpreted to represent middle and outer submarine fan deposits (Patton and others, 2009). It appears to correspond with similar rocks that extend in a broad belt from the southeast corner of the Saint Michael quadrangle and the northwest corner of the Holy Cross quadrangle to the south-central part of the Kwiguk quadrangle (map unit Kygc of Patton and others, 2009, in press). Marine mollusks of late Early Cretaceous (Albian) age were identified in this unit in the Bettles, Hughes, and Kateel River quadrangles (Patton and others, 2009). Although no fossils have been found in these rocks in the Saint Michael and Holy Cross quadrangles, the similar rock assemblages in the Yukon-Koyukuk Basin are thought coeval (Patton and others, in press)

Kgk **Kongakut Formation (Lower Cretaceous, Hauterivian and younger)**—Upper part mostly dark-gray to black, locally manganiferous pebbly shale (pebble shale member) and dark-olive-gray brownish-gray-weathering siltstone

(siltstone member) that contains minor interbedded sandstone, as shown by Reiser and others (1980) and Brosgé and others (1979). Lower part is mostly dark-gray fissile shale ("clay shale member" of Reiser and others, 1980) that has nodules and lenticular beds of red-weathering clay ironstone and is overlain by thin interval of quartz arenite, the Kemik Sandstone Member (shown here, where possible, as unit Kke). Thickness is more than 300 m. Unit is restricted to northeast Alaska and is thought to be lateral (northern) equivalent of Okpikruak Formation (Brosgé and others, 1979). Unit contains Early Cretaceous (Neocomian) pelecypods. Pebble shale unit, which is sometimes mapped separately (see, for example, Bader and Bird, 1986), is thin-bedded, tan to dark-brown, gray-weathering pebbly silty shale, siltstone, sandstone, and quartzite. Worm borings are locally abundant (Reiser and others, 1971). It is distinctive, as a non-bentonitic shale about 100 m thick that contains matrix-supported, well-rounded, frosted quartz sand grains and common to rare chert and quartzite pebbles (Bader and Bird, 1986). In the Ignek Valley region, the lower part of the Kongakut Formation was subsequently reassigned (Molenaar, 1983) to the Kingak Shale (unit KJks here), extending the age range of the Kingak Shale into the Early Cretaceous (Valanginian). On generalized map, included as part of unit Kok

Kke **Kemik Sandstone (Lower Cretaceous, Hauterivian)**—Very fine- to fine-grained, light- to medium-gray quartzose sandstone exposed in the northern foothills of the Brooks Range and correlated with discontinuous sandstone bodies known in the subsurface of the North Slope (Mull, 1987). Unit is thought to represent a high-latitude barrier island complex (Mull, 1987), in part on the basis of paleoenvironmental interpretations of fossils in the unit (R.C. Allison, Univ. of Alaska, Fairbanks, cited in Mull, 1987). Originally defined as part of the now abandoned Ignek Formation of Jurassic age, it was later placed in the Kongakut Formation (Detterman and others, 1975) and then raised to formation status by Mull (1987). Locally it remains mapped as a member of the Kongakut Formation (Molenaar and others, 1987, Mull, 1987). It has been correlated with the basal part of the Mount Goodenough Formation in the Yukon (Mull, 1987) and with the Pebble shale unit is considered the upper part the Ellesmerian sequence of northern Alaska (Moore and others, 1994). As it has not generally been distinguished from the Kongakut Formation on most published maps, its distribution is likely to be somewhat wider than shown here

Kkg **Flysch and quartzite, Kandik Group and equivalents (Lower Cretaceous, Albian to Valanginian)**—Kandik Group consists of the Keenan Quartzite, Biederman Argillite, and Kathul Graywacke in the Charley River quadrangle of east-central Alaska. Keenan Quartzite (Brabb, 1969) is medium-gray, white-weathering, massive, resistant, ridge-forming quartzite and sandstone containing a few interbeds of dark-gray siltstone and argillite. Thickness varies from 30 to 300 m and it locally contains abundant *Buchia sublaevis* of Valanginian age. Biederman Argillite (Brabb, 1969) is at least 1,500 m thick, rhythmically interbedded, dark-gray argillite and medium-gray, quartz arenaceous, carbonate-cemented siltstone and sandstone. Includes a few beds of chert-pebble conglomerate, siliceous shale, chert-limestone breccia and limestone. Convolute structures and cross-laminations are common. Contains very few pelecypods of Valanginian age near base. Kathul Graywacke (Brabb, 1969) consists of several thousand feet dark-greenish-gray, feldspathic graywacke, conglomerate, and dark-gray argillite and minor olive-gray shale and mudstone. Conglomerate clasts include chert, volcanic rocks, argillite, and sandstone in a matrix of graywacke or argillite. Contains a few stratigraphically long-ranging marine pelecypods. May be correlative with nonmarine rocks in Eagle quadrangle that contain plants of probable Albian age. Unit includes Wilber Creek unit of Weber and others (1992) in the Livengood quadrangle, which consists of interlayered siltstone, shale, sandstone, and conglomerate originally subdivided into coarse- and fine-grained units in the Livengood quadrangle. Siltstone and sandstone are medium- to medium-dark-gray and greenish-gray, moderately sorted, and very fine- to medium-grained. Conglomerate is dark-olive-gray to medium-dark-gray, iron-stained, polymictic, unsorted, subangular to well rounded, and grain size ranges from granules to cobbles. Clasts are of local derivation and consist of quartzite, limestone, mafic and felsic igneous rocks, greenstone, diorite and other intrusive rocks, sandstone, siltstone, phyllite, chert, rare grit, shale rip-ups, and very rare carbonatite. Beds are typically internally massive, thick- to medium-bedded, graded, and amalgamated and have planar tops and bases. Local small-scale trough-crossbeds internally fill large-scale troughs and fining-upward cycles are common. Conglomeratic graywacke occurs within lenses in unit. Minor small-scale scour fills locally fine upward into ripple-laminated medium-gray to black siltstone and dark-gray to black shale. Presence of *Paragastroplites flexicostatus* indicates an Albian age. Graywacke rich in volcanic detritus is locally characteristic of the Kathul Graywacke (Dover and Miyaoka, 1988). Wolverine quartzite of Weber and others (1992), which is exposed in the Livengood, western Circle, and eastern Tanana quadrangles, is light- to dark-gray, very fine- to medium-grained, well-sorted quartzite that contains interbedded black to dark-gray shale and medium-light- to medium-gray siltstone. Rare coquina-like beds contain poorly preserved fragments of *Buchia* and other fossils that provide limited age control. Includes Vrain unit of Weber and others (1992), which consists of dark-gray to black, pyritiferous shaly slate, or black fissile shale and minor medium- to dark-gray, olive- or greenish-gray siltstone. Closely resembles upper part of the Glenn Shale in the Charley River quadrangle, which is also included here. Upper part of Glenn Shale is a carbonaceous shale that contains minor thin beds (up to 5 m thick) of fine-grained sandstone. Early Cretaceous megafossils have been collected from several localities within the unit (Miyaoka, 1990). The Wilber Creek, Wolverine quartzite, and Vrain units are thought to be offset from the Kandik Group along the Tintina Fault System

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

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 (Lathram 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 volcaniclastic rocks. Rocks of its older part consist primarily of volcaniclastic 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

KTRvs **Volcanic and sedimentary rocks of southwest Alaska (Cretaceous to Triassic?)**—Thick unit that consists of low-grade metamorphic or contact-metamorphosed marine volcanic and sedimentary rocks; restricted to mainland part of southwest Alaska. According to Hoare and Coonrad (1978), "* * * the volcanic rocks range in composition and type from mafic pillow basalts to more abundant andesitic and trachytic flows, tuffs, and breccias. Interbedded with the volcanic rocks are thick sections of tuffaceous siltstone, tuffaceous cherts, and massive or thin-bedded argillite. Tuffs and tuffaceous sedimentary rocks associated with the intermediate composition volcanic rocks are commonly laumontized." Radiolarians of Late Jurassic to Early Cretaceous age and fragmentary ammonites of Jurassic age have been collected from this unit in the Goodnews Bay quadrangle (Hoare and Coonrad, 1978). In the Bethel quadrangle, Box and others (1993) subdivided this unit into their units KJc, KJb, Ja, and Jvs, whereas, in the Hagemeister Island and southern Goodnews Bay quadrangles, Box (1985) subdivided this unit into Jlt, Jvt, and JTrcv. Units KJc and KJb of Box and others (1993) are included herein; unit KJc consists of thin-bedded green to brown argillite with occasional 1- to 4-cm-thick tuffaceous chert, siltstone, and fine-grained tuff interbeds. A Late Jurassic and (or) Early Cretaceous age is suggested from poorly preserved radiolarians (Box and others, 1993). Unit KJb, south of Crooked Mountain in the Bethel quadrangle, is a highly altered pillow basalt sequence exposed along a narrow trend about 1 km wide and 10 km long (Box and others, 1993) and interbedded with the argillite and chert. Unit also includes olivine basalt flows and fragmental mafic volcanic rocks in the Dillingham quadrangle. Locally subdivided here into units Jvs and JTrvs

KTrs **Restricted Gemuk Group (Lower Cretaceous to Triassic?)**—Unit consists of marine volcaniclastic, gray to gray-green argillite, cherty argillite, calcareous argillic graywacke, and minor mudstone, tuffaceous sandstone, limestone, and chert. Unit description is largely derived from the field notes and maps of J.M. Hoare, W.H. Condon (1969–1970), and W.M. Cady (1943–1944), as well as from fieldwork and mapping of Miller and others (2007). Primarily occurs in the northwest Taylor Mountains and southwest Sleetmute quadrangles. Unit was originally considered part of the Gemuk Group (now Togiak-Tikchik Complex) and is distinguished from the Kuskokwim Group because of the more common presence of silty limestone, calcareous graywacke, cherty argillite, and chert and limited fossil data (Hoare and Coonrad, 1959a). Map unit also includes limited areas of multi-colored chert and gray to gray-green argillite, graywacke, and mudstone. The presence of sparse tuff or tuffaceous sedimentary rocks and the absence of other volcanic rocks distinguish this unit from similarly aged rocks to the south in the Dillingham quadrangle. Miller and others (2007) reexamined and mapped the area where the Gemuk Group was originally defined by Cady and others (1955) in the northwestern Taylor Mountains and southwestern Sleetmute quadrangles. Following abandonment of the name "Gemuk Group," (Wilson and Coonrad, 2005), Miller and others (2007) newly defined these rocks as the Restricted Gemuk Group. Miller and others (2007) estimate that the redefined Restricted Gemuk Group is at least 2,250 m thick and consists of Upper Triassic pillow lavas, siltstone, chert, and limestone overlain by Jurassic siltstone and chert, in turn overlain by Lower Cretaceous greywacke. Locally, may include areas of Kuskokwim Group (map unit Kk) where data are insufficient to distinguish these units. Cady and others (1955) reported a single collection of *Buchia* [*Aucella*] *crassicollis* as well as nondiagnostic Cretaceous *Inoceramus* from this unit in the Sleetmute quadrangle, and Box and others (1993) reported poorly preserved radiolarians of Early Cretaceous and Jurassic age from rocks correlated with this unit in the Bethel quadrangle. Cady and others (1955), Sainsbury and MacKevett (1965), and Miller and others (2007) reported twelve new fossil determinations that range in age from Late Triassic to Early Cretaceous, 2 U/Pb zircon ages (~140 Ma) from tuff, and 110 U/Pb detrital zircon age determinations. Radiolaria from siltstone and chert yielded Cretaceous to Triassic ages, whereas graywacke and tuffaceous rocks yielded detrital zircons as young as 130 Ma (Early Cretaceous) (Miller and others, 2007). The Triassic (Norian and Carnian) fossils are from a volcanic and sedimentary sequence in the northwestern Taylor Mountains quadrangle originally defined as part of the Gemuk Group of Cady and others (1955); those rocks are included in unit Trvsw here. On generalized map, the Restricted Gemuk Group is included as part of unit KTrvs

Jvs **Marine volcaniclastic and arkosic sandstone (Jurassic)**—Consists of two units of Box and others (1993): (1) volcaniclastic sandstone and (2) arkosic sandstone and shale, both turbidite facies. Volcaniclastic strata is generally sandstone, but locally is as coarse as fine-grained pebble conglomerate and consists of predominantly volcanic rock fragments of intermediate composition and detrital feldspar, quartz, clinopyroxene, and hornblende. Minor rock fragments of plutonic, felsic volcanic and hypabyssal, sedimentary, and low-grade metamorphic rocks are consistently present components (Box and others, 1993). Unit also contains arkosic sandstone and shale primarily composed of detrital plagioclase, quartz, and potassium feldspar, as well as minor hornblende, biotite, and clinopyroxene apparently derived from weathering of plutonic rocks (Box and others, 1993). Arkosic sandstone is on strike with volcaniclastic part of unit (Box and others, 1993). Age control is based on stratigraphic position above Early Jurassic and Late Triassic phyllite and chert of map unit JTrp of Box and others (1993) and below Early Cretaceous and (or) Late Jurassic argillite and tuffaceous chert of their map unit KJc. On generalized map, included as part of unit KTrvs

JTrvs **Coarse volcaniclastic sedimentary rocks (Jurassic and (or) Triassic)**—Dense green tuff, tuff breccia, pillow breccia, minor basaltic pillows, and associated sedimentary rocks (Box, 1985) including banded to finely laminated crystal-lithic tuff that has interbedded green, white, and black tuffaceous chert. Breccia clasts are mostly angular, commonly vesicular, aphanitic or plagioclase-clinopyroxene porphyritic. Aquagene tuff and crystal tuff that commonly consists of devitrified glass shards are also interbedded. Rocks of unit are altered to prehnite-pumpellyite facies mineral assemblages and locally altered to hornblende and biotite hornfels around gabbroic plutons. Unit is exposed on both sides of Togiak-Tikchik and Kulukak Faults; age northwest of Togiak-Tikchik Fault constrained by underlying Upper Triassic basalt and crosscutting plutons of early Middle Jurassic age; southeast of Togiak-Tikchik Fault, constrained only to pre-Valanginian age (Box, 1985). Unit is highly deformed, commonly having folded slaty or spaced cleavage. Several chert samples yielded Jurassic Radiolaria, one identified as upper Kimmeridgian to upper Tithonian (latest Jurassic) (see Box, 1985). Unit also includes rocks on Hagemeister Island mapped as Jlvs by Hoare and Coonrad (1978) and as Jlv by Box (1985). These rocks are similar in character to rocks associated with the Togiak-Tikchik and Kulukak Faults described above; they are a marine unit of mafic flows, volcanic breccia, and massive fine- to medium-grained volcanogenic sedimentary rocks (Hoare and Coonrad, 1978). Basaltic to dacitic volcanic rocks, locally pillowed, are typically plagioclase±clinopyroxene±hornblende porphyries and are interbedded with pyroclastic and epiclastic rocks (Box, 1985). Grades from a lower unit of massive angular pebbly mudstone, sub-wave-base deposits, to upper unit of abundantly fossiliferous, well bedded sandstone and shale, locally cross-bedded, shallow marine deposits. Intruded (after folding?) by Early Jurassic Hagemeister pluton (unit Jegd). Divergent structural attitudes suggest polyphase folding history (Box, 1985). Contains *Weyla* pelecypods of Early Jurassic age (Hoare and Coonrad, 1978). On generalized map, included as part of unit K₮vs

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**Angayucham, Tozitna, and Innoko assemblages and Rampart Group (Cretaceous? to Devonian)**—Widely distributed in northern, central, western, and southwestern Alaska, this group of rock units contains a variety of lithologic units. The Tozitna and Innoko assemblages have been mapped by some workers as distinct terranes, but, together with the Angayucham terrane, are all thought to represent parts of a late Paleozoic and younger ocean basin (see, for example, Patton and others, 1994a). The Rampart Group is similar to the Angayucham, Tozitna, and Innoko assemblages both lithologically and in age. Rocks of the Togiak-Tikchik Complex (unit KDt here; formerly called the Gemuk Group) in southwest Alaska may, in part, be derived from the same environment. Subdivided here into predominantly sedimentary and igneous rock units, these subdivisions are typically are interfingered. A mélange facies (unit KJm) is commonly associated with these assemblages and is included also. In the source map descriptions, it is locally difficult to separate the mélange facies from the igneous unit, and some overlap between the units on the map is to be expected. A second mélange-like facies (unit KMmu) is distinguished here, exposed somewhat to the south of other units of this assemblage in the Unalakleet, Holy Cross, and Russian Mission quadrangles. Best described by Patton and others (2006, in press) this mélange-like facies consists of a wide variety of the rocks of these assemblages and may transition into rocks included in the Togiak-Tikchik Complex. Subdivided into units KJm, KMmu, JDoc, JMct, ₮Dtz, and ₽Mch:

KJm **Mélange facies (Cretaceous or Jurassic?)**—Tectonic assemblage of blocks of carbonate rocks, chert, metagraywacke, and altered mafic extrusive and intrusive rocks in a matrix of phyllite exposed in low hills surrounding the Yukon-Koyukuk Basin. The mélange locally varies in metamorphic grade from pumpellyite to greenschist facies (Patton and others, 2009; Till and others, 2008a). Till and others (2008a) report a block of mafic schist on the Baird Mountains and Ambler River quadrangle boundary that contains abundant blue amphibole, probably crossite. Age of the mélange is not well controlled; Till and others (2008a) report Mississippian radiolarians from metachert and metalimestone bodies yielding Middle and Late Devonian and Ordovician conodonts (Pallister and Carlson, 1988, cited in Till and others, 2008a). Patton and others (2009) suggested that the mélange probably formed during time of tectonic emplacement of Angayucham-Tozitna terrane structurally above the Arctic Alaska and Ruby terranes during the Early Cretaceous. Includes unit KJm of Patton and others (2009), but does not include that part of unit KJm of Karl and others (1989a) in the northwest part of the Baird Mountains quadrangle, which has been assigned here to the Okpikruak Formation (unit Kofm). The outcrop pattern of this part of unit KJm of Karl and others (1989a) projects into the adjoining Noatak quadrangle, where it was mapped as Okpikruak Formation at the top of the Kelly River allochthon by C.G. Mull and H.S. Sonneman (Exxon unpub. report, 1968–1974). On generalized map, included as part of unit KMm

KMmu **West-central Alaska mélange-like rocks (Cretaceous or older)**—"Unit composed of a wide variety of mafic and intermediate volcanic and intrusive rocks including basalt, andesite, diabase, gabbro, and volcaniclastic rocks that are weakly metamorphosed to prehnite-pumpellyite and locally to greenschist facies assemblages. The volcanic and intrusive rocks are interbedded with varicolored radiolarian chert, chert breccia, chert pebble conglomerate, argillite, graywacke, and small limestone bodies. The chert, argillite, graywacke, and limestone are locally metamorphosed to metachert, slate, pelitic schist and marble" (Patton and others, 2006). Unit contains locally abundant Mississippian to Triassic fossils, chiefly from scattered limestone bodies in southwestern Holy Cross and northwestern Russian Mission quadrangles. Unit may also include rocks that probably represent unit KJiv, elsewhere mapped separately and known to contain mollusks of Early Cretaceous (Hauterivian and Valanginian) age. "A small body of amphibolite from near the northwestern border of the Russian Mission quadrangle yielded a K/Ar isotopic cooling age of 349.27±10.48 Ma" (Patton and others, 2006). This unit is located in one of the least-mapped parts of the state and has only been mapped at a reconnaissance level. It primarily occurs in fault blocks surrounded by younger rock units. On generalized map, included as part of unit KMm

JDoc **Igneous rocks (Jurassic to Devonian)**—Dominantly basalt, greenstone, gabbro, diabase, and chert, and lesser ultramafic rocks. Minor basaltic tuff, volcanic breccia, and carbonate rocks. Basalt and greenstone include pillow basalt and metamorphosed spilitic basalt. Unit consists of discontinuous and large unsheared blocks and lenses of incipiently recrystallized mafic rocks in a low metamorphic grade, blastomylonitic, metasedimentary matrix. Matrix is bedded chert of Triassic age; argillite, slate, and limestone of Mississippian age; and andesitic and basaltic tuff. (Note: much of the description of this unit, in particular the Angayucham part, is derived from Till and others, 2008a.) Hitzman and others (1982) and Pallister and Carlson (1988) recognized several distinct subunits within the package, although the subunits are lithologically similar and each is internally imbricated. Primary igneous and sedimentary textures in the metabasalt and metagabbro are partially overprinted by metamorphic minerals, which indicate prehnite-pumpellyite- to greenschist-facies metamorphism. Some metabasalt is foliated and lineated in the western Ambler River quadrangle (A.B. Till, unpub. data) and in the Angayucham Mountains in the Survey Pass quadrangle. Barker and others (1988) also reported albite-epidote-amphibolite-facies assemblages in metabasalt in the Bettles quadrangle. A sliver of mafic schist in the Angayucham Mountains retains relict hornblende and garnet from an amphibolite-facies metamorphic assemblage, contains a foliation-forming greenschist-facies assemblage, and is cut by prehnite-bearing veins (Pallister and Carlson, 1988). Locally, glaucophane is present, indicating high-pressure metamorphism (Till and others, 2008a). Devonian, Mississippian, Triassic, and Jurassic radiolarians, conodonts, and megafossils have been collected from chert, cherty tuff, metalimestone layers, interpillow sedimentary rocks, and fault slivers of carbonate rocks and chert (Pallister and Carlson, 1988; Jones and others, 1988; Till and others, 2008a). Conodonts of late Silurian to Early Devonian age are the oldest fossils collected from the unit, and Early Jurassic radiolarians are the youngest (Pallister and Carlson, 1988; Jones and others, 1988). Pennsylvanian-Permian, Permian, and early Permian radiolarians were collected near the southeast corner of the Wiseman quadrangle (Jones and others, 1988). Contrasting ages within the unit could reflect structural juxtaposition of rocks of different ages or reworking of older fossils into younger strata (Till and others, 2008a). The Tozitna and Rampart assemblages are characterized by variably altered and metamorphosed flows and shallow intrusive rocks of basalt, diabase, and gabbro interbedded with varying proportions of chert, argillite, slate, phyllite, volcaniclastic rocks, graywacke, and carbonate rocks. Sparse megafossils from these carbonate rocks range in age from Devonian to Permian (Patton and others, 2009). The basalt, diabase, and gabbro are weakly metamorphosed to prehnite-pumpellyite facies and generally increase in metamorphic grade structurally downward. Greenschist facies metamorphism and locally high-pressure blueschist metamorphism, as indicated by the presence of glaucophane and lawsonite, occur near the base assemblage where it structurally overlies the Ruby terrane (Till and others, 2008a). The chert includes both interpillow and bedded varieties and ranges from pure radiolarian and spiculitic chert to cherty tuff. In the southeastern part of the Nulato quadrangle and adjoining parts of the Ruby quadrangle, the unit is characterized by sill-like bodies of diabase and gabbro, argillaceous rocks, fine-grained to conglomeritic graywacke, and chert. Associated with these extrusive and shallow intrusive rocks are ultramafic complexes that consist of serpentinized peridotite, dunite, and harzburgite, associated layered gabbro and anorthosite, and, locally, garnet-amphibolite tectonite, possibly derived from eclogite. K/Ar hornblende ages on hornblende gabbro and hornblende-bearing dikes range from 172 to 138 Ma and dates on garnet-amphibolite range from 172 to 155 Ma (Patton and others, 1977, 1994a). These are considered cooling ages related to tectonic emplacement of the ultramafic and mafic rocks. Gabbro in the Rampart Group yielded a K/Ar age of 210±6 Ma (Brosgé and others, 1969; age recalculated using constants of Steiger and Jager, 1977). In the Angayucham Mountains, where the unit has been mapped in detail, the basalts are tholeiitic and fall into “within-plate” fields on trace element discrimination diagrams; the light rare earth elements (LREE) are enriched relative to chondrite in some basalts and gabbros, but show little to no enrichment in other rocks (Barker and others, 1988; Pallister and others, 1989, Till and others, 2008a). Based on these characteristics, the mafic rocks are thought to have been parts of oceanic plateaus or islands. The Angayucham assemblage, along with the other related assemblages here, may compose a part of a collapsed ocean basin (Till and others, 2008a). It was emplaced in a high structural position during the Brooks Range orogeny. Angayucham metabasalt along the southern flank of the Brooks Range, the “Narvak panel” of Patton and Box (1989), is typically correlated with basalt of the “Copter Peak allochthon” which is exposed at the crest of the range (Moore and others, 1994). One interpretation considers these rocks as part of a dismembered ophiolite derived from the root of a volcanic arc, rather than the more typical mid-ocean ridge setting for an ophiolite (Loney and Himmelberg, 1985; Patton and others, 1994a; see also Patton and others, 1994b)

JMct **Cherty tuff and breccia (Jurassic? to Mississippian)**—Dark greenish, very fine-grained cherty tuff that grades into greenish-gray radiolarian chert in west-central Alaska; commonly considered part of the Innoko assemblage. Unit also contains fine- to coarse-grained crystal and lithic tuff, as well as volcanic breccia and conglomerate composed of poorly sorted clasts of mafic volcanic rocks and cherty tuff in a crystal and lithic tuff matrix. Unit includes several small bodies of slightly recrystallized limestone and a few small intrusive bodies of gabbro and diabase. Age assignment is from widely distributed Radiolaria and conodonts in the cherty beds and range in age from Mississippian to possibly as young as Jurassic (Patton and others, 1980). Unit is unique in this group of assemblages (Angayucham, Tozitna, and Innoko) because of its tuffaceous character. Unit crops out in a distinctive band east of the more typical Innoko terrane rocks. Unit is similar in age and lithology to unit JŦRct of the Chulitna sequence, but there is little reason to assert that these are the same unit

ŦRDtz **Sedimentary rocks (Triassic to Devonian)**—Includes thinly and rhythmically interbedded dark-gray argillite and platy, laminated, gray siltstone; very fine- to fine-grained, gray, chert-rich, turbiditic sandstone; quartz- and chert-bearing granule-to-pebble conglomerate. Locally calcareous and fossiliferous (Weber and others, 1992). Unit also includes chert, which is dominantly medium-dark- to dark-gray, thin-banded, bedded, and radiolarian-bearing, and contains thin interbeds of slaty argillaceous rocks including argillite, slate, and phyllite. In addition, locally includes fine- to coarse-grained sandstone, limy sandstone, sandy limestone, siltstone, and shale. Sandstone ranges from clean quartz arenite to a lithic arenite that contains as much as 25 percent muscovite and metamorphic rock fragments. Also includes subordinate intermediate to basaltic volcanic and volcaniclastic rocks including lithic and water-laid tuff; fossiliferous shallow-water limestone; grit; and arkosic sandstone lenses. Where it can be determined from source maps that rock packages are predominantly igneous, they are mapped as units JMoc and JMct. Age range based on probable Permian microfossils and bryozoan and echinoderm fragments collected in the Ruby quadrangle (Chapman and Patton, 1978); Permian foraminifera, conodonts, and brachiopods (Weber and others, 1992); and Mississippian Radiolaria, conodonts, and foraminifera collected from unit in the Ruby and Medfra quadrangles (Chapman and Patton, 1979). Latest Devonian Radiolaria were collected in two localities in the southwestern Ruby quadrangle (Chapman and Patton, 1979) and are the only Devonian fossils known from rocks that are unequivocally Innoko assemblage; Patton and others (1994a) also report Devonian palynflora from the Wiseman and Christian quadrangles in the similar Angayucham assemblage. Around the Yukon-Koyukuk Basin, unit also includes "Interbedded white to light-gray banded quartzite, dark phyllite, and gray laminated limestone. * * * Thin layers of white mica folia give the quartzite a faint foliation. The white and light-gray banding, the purity of the quartzite, and the even texture of the quartz grains suggest that the quartzite is a recrystallized chert (metachert). The quartzite is locally interlayered with dark-gray, finely laminated, slightly foliated siliceous argillite, dark phyllite, and talc-chlorite schist. In the Nulato quadrangle, the limestone is partly recrystallized and silicified and locally contains unidentifiable coral and crinoid fragments. In the Melozitna quadrangle, thin marble beds contain conodonts and crinoids of Devonian age (Anita Harris, written commun., 1983). Some of the metachert may be as young as Mesozoic and correlative with the Mesozoic chert in unit JDv [JMoc here]" (Patton and others, 2009). A K/Ar age of 302±9 Ma on amphibole from tuff suggests a Pennsylvanian age in, at least, part of the unit (Miller and Bundtzen, 1994). Parts of unit were originally described by Chapman and Patton (1979). Corresponds to the Rampart Group of Brosgé and others (1969) in the Tanana quadrangle, the TrMra, TrMrb, TrMrs, and TrMrl units of Reifenstuhl and others (1997) in the Tanana B-1 quadrangle, the TrMrs unit of Weber and others (1992) in the Livengood quadrangle, and unit ℙMc of Foster and others in the Circle quadrangle. Corresponds to the TrMc and TrMs units of Chapman and others (1985) in the Ophir quadrangle and unit TrMc of Miller and Bundtzen (1994) in the Iditarod quadrangle. Includes the IPMc unit of Patton and others (1980) in the Medfra quadrangle. In Livengood quadrangle, includes interlayered black shale or slate; light, olive-greenish-gray thinly bedded to massive and thickly bedded radiolarian-bearing chert; and light greenish-gray tuff (Weber and others, 1992, 1994). In the Coleen quadrangle, unit includes shale and chert as thick as 600 m, previously mapped as part of the Strangle Woman and Christian River sequences of Brosgé and Reiser (1969), who presumed a Triassic or Permian age. Unit also includes 3 to 8 m of cherty limestone, which is possibly equivalent to the Lisburne Group (C.G. Mull, written commun., 2012)

ℙMch **Chert (Carboniferous and older)**—Varicolored radiolarian chert, lenticular beds of fossiliferous limestone and interbedded argillite. Subordinate beds of sandy limestone, grit, and arkosic sandstone. Unit contains abundant Radiolaria, conodonts, and foraminifera that range in age from latest Devonian to possibly as young as Triassic (Patton and others, 2009). Similarly described chert and limestone (Patton and others, 1980) or chert and argillite (Chapman and Patton, 1979) units have been mapped in the Medfra and Ruby quadrangles; these yield Carboniferous and Devonian ages. Patton and others (2009) included these rocks in a unit of chert, argillite, and volcaniclastic rocks, to which they assigned an age range of Devonian to Triassic(?). However, as the Triassic age is uncertain and there are no reported Permian ages, we have assigned a Carboniferous and older age range to this map unit. On generalized map, included as part of unit ŦRDtz

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Kqcs **Quartz-carbonate sandstone and pebbly mudstone (Lower Cretaceous, Aptian to Valanginian)**—Lithic sandstone, conglomerate, and shale about 5 km thick (Hoare and Coonrad, 1983), informally called the graywacke of Buchia Ridge by Hoare and Coonrad (1978). Lower part of unit is about 2,400 m thick, composed mainly of well-bedded, fine- to medium-grained sandstone with siltstone interbeds and pebble-cobble conglomerate. In lowest part of section, beds range from 0.1 to 3 or 4 m thick; the upper part of this lower section consists of 1,400 m of increasingly massive conglomerate (Hoare and Coonrad, 1983). Well-rounded clasts, as large as

10 cm, consist of "graywacke and siltstone, cherty tuff, and less abundant porphyritic volcanic rocks" (Hoare and Coonrad, 1983); graywacke clasts resemble graywacke of Kulukak Bay (unit Jk here). Lithic conglomerate, near the top of Buchia Ridge, contains coquinas of *Buchia crassicollis* shells (Hoare and Coonrad, 1983). Upper part of unit, about 2,500 m thick, is "mostly shale and thin-bedded sandstone" (Hoare and Coonrad, 1983) that is poorly exposed. It is "dominantly fine-grained * * * calcareous black shale, thin-bedded calcareous siltstone, sandstone, calcarenite, and minor gritstone" (Hoare and Coonrad, 1983). Box (1985) interpreted lower part of the unit to be of shallow marine origin and the upper part of the unit as probable deeper marine origin. According to Hoare and Coonrad (1983), the graywacke of Buchia Ridge "is the thickest, least deformed section of Lower Cretaceous sedimentary rocks known in southwestern Alaska." Outcrop area covers approximately 350 $km^2$ in a thrust plate (Hoare and Coonrad, 1983). Lower part of section contains abundant Valanginian fauna, primarily *Buchia crassicollis*; upper part of section yields sparse *Inoceramus*, belemnites, and a single Hauterivian ammonite, according to Hoare and Coonrad (1983). On generalized map, included as part of unit Kcca

Kcm **Calcareous mudstone (Lower Cretaceous)**—Dark-gray, fossiliferous, calcareous mudstone that has lenses of aragonitic fossil hash and limestone concretions as large as 20 cm, and contains subordinate beds of calcareous wacke (Johnson and Karl, 1985). Unit restricted to a small area of outcrop east of Chichagof Island and is significant in southeast Alaska on the basis of its unique lithology and fossil assemblages. Fossils included Hauterivian to Barremian belemnites, and *Inoceramus* prisms (W.P. Elder, written commun., 1998, to S.M. Karl). On generalized map, included as part of unit Kcca

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 crassicollis* 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 crassicollis* has also been reported from the Nelchina Limestone. The coquinoid limestone of the northern Alaska is a "[d]istinctive 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 T̶Rn) 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

KPu **Kingak Shale, Shublik Formation, and Karen Creek Sandstone, undivided (Lower Cretaceous to Permian)**—This undivided unit, mapped in northeast Alaska, consists of the Kingak Shale, Shublik Formation, and Karen Creek Sandstone. It may also include rocks generally assigned to the Siksikpuk Formation. Elsewhere in northern

Alaska, the constituent units are mapped separately and described below as units KJks, ₮kc, and ₮gs; all are included as part of unit KPss on the generalized map

KJks **Kingak Shale and similar units (Lower Cretaceous to Lower Jurassic)**—Dark-gray to dark-olive-gray shale and subordinate siltstone, claystone, and clay ironstone (Detterman and others, 1975). Upper part is clay shale, silty shale, and siltstone that has red, rusty-weathering ironstone beds. Lower part is dark-gray to black fissile paper shale, dark-gray clay shale, minor claystone, and beds and nodules of red-weathering ironstone (Reiser and others, 1980). Molenaar (1983) extended the age range of the unit from its originally defined Jurassic age (Detterman and others, 1975) to Early Cretaceous on the basis of rocks assigned to this unit exposed south of the Sadlerochit Mountains, which Detterman and others (1975) had assigned to the Kongakut Formation. As mapped here, includes the Ipewik Formation of the De Long Mountains area (Moore and others, 1986; Curtis and others, 1990; Ellersieck and others, 1990; Mayfield and others, 1990), a significant component of which is either the same as or equivalent to the Kingak Shale. Ipewik Formation consists of maroon and gray shale, coquinoid limestone, siltstone, and clean quartz sandstone. Shale locally contains sparse well-rounded pebbles that consist of quartz, chert, gabbro, and granite and contains local light-weathering clay beds (bentonite?) and volcanic rocks of intermediate composition. The Telavirak and the underlying Ogotoruk Formations of the Point Hope quadrangle are also included here. The Telavirak Formation (Campbell, 1967) consists of rhythmically interbedded mudstone and siltstone or very fine- to medium-grained sandstone in nearly equal proportions. The Ogotoruk Formation is similar; it consists of chiefly dark-gray mudstone interbedded with variable amounts of siltstone and very fine- to medium-grained, dark-gray and brown sandstone. Rocks are generally classified as arkosic or feldspathic wackes

Kit **Tingmerkpuk Member of the Ipewik Formation (Lower Cretaceous, Valanginian)**—Where map data allows, the quartz sandstone in the Ipewik Formation, informally known as the Tingmerkpuk sandstone (see Mull, 2000 and included references), is distinguished here. It is mapped separately because of its importance in potential interpretations of “the tectonic evolution and hydrocarbon potential of the Colville Basin” (Mull, 2000) and because of its apparent northern source and composition, consisting of ~96 percent monocrystalline quartz (Reifenstuhl and others, 1998a)

₮kc **Karen Creek Sandstone (Upper Triassic)**—Dark gray, fine- to very fine-grained, quartzitic sandstone and siltstone, locally calcareous or dolomitic, and commonly contains phosphatic nodules. Conformably overlies Shublik Formation; disconformably(?) underlies Kingak Shale (Reiser and others, 1980). Detterman and others (1975) report that “Beds that are probably lithologically equivalent to the Karen Creek Sandstone are penetrated in drilling along the Arctic Coast. In the subsurface, similar-looking sandstones were named the Sag River Sandstone (Rickwood, 1970; Fackler and others, 1971).”

₮gs **Shublik Formation (Triassic)**—Black, marine, carbonaceous, partly calcareous shale and thin-bedded limestone. Upper part is dark gray to black, calcareous, phosphatic siltstone and shale, and contains thin gray limestone interbeds. Locally, varicolored chert beds are present, as are locally abundant limestone concretions within the siltstone and shale. Lower part is black clay shale that contains limestone concretions and laminated silty limestone beds. Shale locally weathers rust-colored. Unit contains abundant fossils including Triassic pelecypods, such as *Halobia* and *Monotis*, and ammonites. Thickness is about 30 to 150 m. Unit locally may include rocks of the Karen Creek Sandstone and the Siksikpuk Formation (Brosgé and others, 1979). Generally exposed in the autochthonous part of the eastern Brooks Range and known from the subsurface of the North Slope, unit is exposed in the Surprise Creek anomaly of Mull and others (2000) in the De Long Mountains quadrangle, where it is contrasted with the Otuk Formation (unit J₮o), which is more commonly exposed in the western Brooks Range. “Unit is interpreted to record deposition in a low-energy, restricted marine environment characterized by high organic productivity. * * * Organic-rich shale and limestone contain up to ~4 percent total organic carbon characterized by Type I and II kerogen, and constitute excellent potential hydrocarbon source beds” (Mull and others, 2000). The Shublik is considered to be the main source rock for oil in Arctic Alaska (D.W. Houseknecht, written commun., 2014)

Kvgc **Volcanic graywacke and conglomerate (Lower Cretaceous, Hauterivian and older)**—Consists of a variety of lithologies including thin-bedded tuffaceous chert, massive graywacke, conglomerate, argillite, a few volcanic flows and impure limestone beds, and massive, coarse-grained crystal-lithic tuff (Hoare and Coonrad, 1983) in southwest Alaska in the Bethel and Goodnews Bay quadrangles. Rocks range widely in color, mostly green and gray but also red, yellow, brown, or black (Hoare and Coonrad, 1983). Most distinctive rock type in unit in southwest Alaska is massive andesitic crystal-lithic tuff, which is at least 1,000 m thick (Hoare and Coonrad, 1983). Fine-grained tuff and some graywacke is commonly laumontized. Unit also includes turbidites composed of highly calcareous sandstone interbedded with non-calcareous micaceous siltstone and shale. Hoare and Coonrad (1983) inferred the unit to be coarsening upward from sandstone and shale to conglomerate. Generally thick-bedded to massive, with alternating sandstone and shale intervals 5 to 20 m thick, unit locally has thin-bedded sections (Hoare and Coonrad, 1983). Base of unit was not recognized, and, as such, Hoare and Coonrad (1983) suggested that rocks of Jurassic age may be present in the unit. Rocks are strongly folded and commonly overturned (Hoare and Coonrad, 1983). Box and others (1993) reported the presence of lithic clasts likely derived from the Kanektok metamorphic complex (Xio), as well as other local units. *Buchia crassicollis* of Early Cretaceous Valanginian age is found in calcareous graywacke, conglomerate, and impure limestone. In cherty tuff, Radiolaria of Early Cretaceous age have been found at three localities (Hoare and Coonrad, 1983). Presence of *Buchia crassicollis* indicates these rocks are, in part, coeval with the graywacke of Buchia Ridge (unit Kqcs)

Kst **Staniukovich Formation (Lower Cretaceous)**—Composed of 246 m of light-olive-gray siltstone and contains two light-olive-brown sandstone intervals, which are overlain by shaly olive-gray siltstone that contains numerous calcareous nodules and concretions (Detterman and others, 1996). Upper part of formation erodes readily and, therefore, is typically not well exposed. Upper part of unit contains few age-diagnostic fossils, whereas lower part has abundant megafauna, particularly the pelecypod *Buchia*, which indicate Berriasian and Valanginian age (J.W. Miller, written commun., 1982–88; Detterman and others, 1996). Upper and lower contacts of Staniukovich are conformable with Herendeen (unit Khe) and Naknek (Jn) Formations, respectively. Originally named Staniukovich Shale by Atwood (1911, p. 25, 38) for exposures on Staniukovich Mountain on the southern Alaska Peninsula. Burk (1965) changed name to Staniukovich Formation and mistakenly included within unit a variety of rocks of latest Jurassic and Early Cretaceous age; however, Detterman and others (1996) stratigraphically restrict the formation to original usage of Atwood (1911), and, as so restricted, its age is Early Cretaceous. On generalized map, included as part of unit KJsnk

Jurassic to Mississippian

Jnk **Naknek Formation and Kotsina Conglomerate (Upper Jurassic, Tithonian to Oxfordian)**—Sandstone, conglomerate, and siltstone whose clasts have a primarily plutonic provenance. Unit is widespread in southern Alaska, in a long belt that ranges from south-central Alaska (Wilson and others, 1998) to the southwest end of the Alaska Peninsula (Wilson and others, 1999, 2015)—about 1,150 km (Detterman and others, 1996). Aggregate thickness of the unit members exceeds 3,000 m, though the average thickness is more typically 1,700 to 2,000 m (Detterman and others, 1996). Megafossils, particularly the pelecypod *Buchia* and ammonites (Detterman and others, 1996), are age diagnostic and provide excellent control. Detterman and others (1996; see also, Detterman and Hartsock, 1966; Martin and Katz, 1912) subdivided unit into the following formal members, top to bottom: Pomeroy Arkose, Katolinat Conglomerate, Indecision Creek Sandstone, Snug Harbor Siltstone, Northeast Creek Sandstone, and Chisik Conglomerate. The Naknek is conformable with the overlying Staniukovich Formation (unit Kst) and unconformably overlies the Middle Jurassic Shelikof Formation (included here in unit Jsc). The Jurassic portion of the Alaska-Aleutian Range batholith (unit Jgr) was main source of sedimentary debris for Naknek Formation, which, on faunal evidence, ranges in age from about 163.5 to 145 Ma; hence, uplift and erosion of batholith occurred during and shortly after emplacement. The Kotsina Conglomerate is a stratigraphic equivalent of the Naknek and consists mainly of well-indurated massive cobble and pebble conglomerate and minor boulder conglomerate, with some arenitic sandstone and siltstone interbeds. Conglomerate clasts in it are derived from Triassic limestone, Nikolai Greenstone, and the Skolai Group, reflecting local uplift and erosion (MacKevett and others, 1978). On generalized map, included as part of unit KJsnk

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 KJsnk

Jvc **Volcaniclastic and volcanic rocks (Upper and Middle Jurassic)**—Basaltic and andesitic volcanic and volcaniclastic rocks on Hagemeister Island that have been extensively altered to prehnite-pumpellyite facies (Hoare and Coonrad, 1978; Box, 1985). Volcanic rocks, characterized by plagioclase and clinopyroxene±hornblende porphyritic rocks are more common in lower third of exposed section. Interbedded clastic rocks composed almost entirely of volcanic lithic clasts, except lower conglomerate, which contains a minor proportion of granitic plutonic rock clasts similar to adjacent pluton. Sedimentary facies range from fluvial deltaic to nearshore marine to sub-wave-base turbidites. The contact between this unit and similar older volcanic and sedimentary rocks that are structurally and stratigraphically below it on Hagemeister Island (unit JTRvs) was mapped by Box (1985) as a low-angle thrust(?), which he suggested may be a faulted unconformity. Fossils of Middle Jurassic age are locally common (Box, 1985). Conglomerate includes clasts of granitic rocks similar to nearby granodiorite of the Middle Jurassic Hagemeister Island pluton (Box, 1985), mapped herein as unit Jegd. More northern exposures of this unit are tuffaceous marine sandstone, shale, and conglomerate (Box and others, 1993; Patton and others, in press) that contain minor basaltic and andesitic lava flows. Felsic pyroclastic rocks are found locally in the middle part of the unit in the Bethel quadrangle and near base of unit northward in the Russian Mission quadrangle. Unit is as much as 2 km thick; coarser parts are composed primarily of rounded clasts of basalt and andesite and minor plutonic rock fragments of mafic to intermediate composition (Box and others, 1993). Marine pelecypods of Bajocian age (Middle Jurassic) are found near the base of the sequence and marine pelecypods of late Kimmeridgian to early Tithonian age (Late Jurassic) were reported from the Russian Mission quadrangle (Box and others, 1993). On generalized map, included as part of unit KTRvs

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**Chulitna sequence of Jones and others (1980) (Jurassic to upper Paleozoic)**—The Chulitna sequence or terrane of central Alaska has been described variously as an allochthonous ophiolite sequence (Jones and others, 1980), a series of stacked allochthonous blocks (“Chulitna district,” Csejtey and others, 1992), or as a displaced part of the Wrangellia terrane (Clautice and others, 2001). Csejtey and others (1992) and Clautice and others (2001) describe a unit of Jurassic and Cretaceous argillite, chert, and rare coquinoid sandstone they considered to be part of the Chulitna district (Csejtey and others, 1992) or older assemblage (Clautice and others, 2001); however, our interpretation is that some of these sedimentary rocks could be more appropriately assigned to the Gravina-Nutzotin unit of this map (unit KJgn) and others to the Alaska Range mélange (unit Kmar). Older parts of the Chulitna sequence, described below (units JTRct, JTRrb, TRlb, and TRPzvs), were interpreted by Clautice and others (2001) to “represent only minor modifications of the late Paleozoic to Mesozoic stratigraphy seen throughout southern Alaska, including a mid-Paleozoic oceanic arc, a late Paleozoic to Early Triassic volcanic-sedimentary sequence, a Late Triassic rift-related basalt plus limestone sequence, and a Jurassic-Cretaceous flysch-dominated section.” However, as shown below, the Chulitna sequence includes distinctive rock units not seen elsewhere in southern Alaska

JTRct **Crystal tuff, argillite, chert, graywacke, and limestone (Upper Jurassic to Upper Triassic?)**—Unit dominantly light- to dark-gray tuff and minor argillite, chert, graywacke, and limestone. Csejtey and others (1992) interpreted these as a moderately deep- to deep-marine sequence of tightly folded and internally faulted tuff and other rocks at least several thousand meters thick; tuff constitutes about 80 percent of the sequence. Mapped in southwest Healy and northwest Talkeetna Mountains quadrangles. Csejtey and others (1992) indicate that the argillite, chert, graywacke, and limestone occur only in a narrow belt along the western part of the outcrop area and that the boundary between these rocks and the dominant tuff portion may be tectonic. In the Healy quadrangle, a thin interbed of volcaniclastic sandstone in the tuff yielded ammonites and *Weyla* sp. fossils of late Sinemurian (Early Jurassic) age (R.W. Imlay, written commun., cited in Csejtey and others, 1992). Csejtey and others (1992) indicate that, because these fossils were from near the top of the tuffaceous section, the section may be as old as Late Triassic. Chert beds in other parts of the unit have yielded Late Jurassic (Callovian to early Tithonian) Radiolaria, and the calcareous rocks yielded early Sinemurian fossils at several localities. An alternative interpretation for these rocks by Clautice and others (2001) results in the assignment of these rocks to five separate units. They assigned the fossil-bearing western part to either a Middle to Late Jurassic cherty argillite and tuff unit or to an Early Jurassic calcareous sandstone, limestone and argillite unit; the remainder of the unit they assigned to three upper Paleozoic tuff, argillite and tuff, and locally chert, argillite, and graywacke units. They based age assignment of rocks to these older units on Silurian to late Paleozoic radiolarians in chert; Csejtey and others (1992) assigned the same rocks to their Cretaceous mélange unit (unit Kmar here). All of these upper Paleozoic units are found east of the Broad Pass Fault of Csejtey and others (1992), which defines the western boundary of the mélange unit. On generalized map, included as part of unit JPzc

JTRrb **Red and brown sedimentary rocks and basalt (Lower Jurassic and Upper Triassic)**—Red-bed sequence of sandstone, siltstone, argillite, and conglomerate that grades upward into highly fossiliferous brown sandstone and brownish-gray siltstone. Thickness is more than 2,000 m. Mapped only in the Healy and Denali quadrangles, unit is part of the Chulitna sequence of Csejtey and others (1992) (see also unit TRPzvs). Red-bed sequence contains a few thin interbeds of brown fossiliferous sandstone, pink to light-gray dense limestone, and intercalated basalt flows. Clasts in the red beds are dominantly basalt cobbles and pebbles derived from underlying basalt and from flows within the sequence. Quartzite pebbles and flakes of white mica and red radiolarian chert pebbles and grains are present in subordinate amounts. Fossils indicate a Late Triassic and Early Jurassic age.

Also includes thin- to medium-bedded, brown-weathering calcareous sandstone, sandy limestone, and argillite. Unit is locally phosphatic and fossiliferous and contains ammonites of Sinemurian (Early Jurassic) age (Blodgett and Clautice, 2000). On generalized map, included as part of unit JPzc

TRlb **Limestone and basalt sequence (Upper Triassic, Norian)**—Interlayered limestone and amygdaloidal basalt flows. Limestone is medium-gray, massive to thick-bedded, and locally metamorphosed to fine- to medium-grained marble. Basalt is dark- to greenish-gray, aphanitic, and contains numerous amygdules. Csejtey and others (1992) suggested that the unit was deposited in shallow water and that the chemistry of the basalts suggests an ocean island shield volcano. Unit is mapped as thrust slivers in Chulitna sequence in the Healy quadrangle (Csejtey and others, 1992) and extends a short distance into the Talkeetna and Denali quadrangles (Wilson and others, 1998). Included here is a slightly metamorphosed and unevenly sheared sequence of shallow marine, interbedded dark-greenish-gray amygdaloidal metabasalt flows and dark-gray to black argillite and slate. *Monotis subcircularis* and *Heterarstridium* sp., of late Norian age, have been collected from argillite (Csejtey and others, 1992). On generalized map, included as part of unit JPzc

TRPzvs **Volcanic and sedimentary rocks (Lower Triassic to upper Paleozoic)**—Intercalated greenish-gray to black tuffaceous chert, volcanic conglomerate and lesser maroon volcanic mudstone, basaltic breccia, laminated flysch-like graywacke and shale, large lenses of light-gray thick-bedded limestone, and poorly exposed beds of ammonite-bearing limestone (Csejtey and others, 1992) mapped in the Healy and Talkeetna quadrangles. Clautice and others (2001) included and described an ammonite-bearing limestone as thin-bedded, light-gray, light-brown-weathering mudstone and packstone recognized only within small, high-angle fault slivers at two localities. Both exposures are less than 4 m in strike length and 1–2 m thick. In the easternmost exposure, Nichols and Silberling (1979) recognized at least 13 species of ammonite fossils in a single 10-cm-thick bed. The collection is significant because the closest rocks of similar Lower Triassic (Olenekian) age and apparent equatorial paleolatitude (10 degrees) are found in northern Washington. The second locality, about 2 km to the west, is orange-brown weathered, silicified packstone to wackestone with poorly-preserved fossil material in rubbly outcrop over a few square meters (loc. 23 in Blodgett and Clautice, 2000). Fossils include Devonian and Carboniferous fossils in the chert, Permian fossils including brachiopods in the thick-bedded limestone, and Early Triassic ammonites and conodonts from the limestone. Considered the stratigraphically lowest part of the Chulitna sequence. On generalized map, included as part of unit JPzc

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JDmc **Mystic structural complex, undivided (Jurassic to Devonian)**—"A depositionally and structurally complex terrane of chiefly marine flysoid sedimentary rocks which include (1) trench assemblages (and possibly intra-oceanic arc deposits) characterized by terrigenous turbidites, cherty pelagites, and basaltic pillow lavas (all of which underwent complex undersea sliding and later multiple thrusting and folding), (2) slope and shelf assemblages that include chert, shale, reefoid limestone, and, locally, terrestrial conglomerate and redbeds, and (3) a thick, locally terrestrial conglomerate and sandstone assemblage. These dissimilar middle and late Paleozoic depositional environments are now juxtaposed by large dislocated nappes and thrusts on all scales" (Reed and Nelson, 1980). Unit includes rocks in the Healy, Denali, and Talkeetna quadrangles, which are separated and offset along a strand of the Denali Fault System an apparent 110 to 160 km, depending on the piercing point chosen. Lithologies in the Healy and Denali quadrangles include medium- to dark-gray, thinly graded, bedded to laminated, medium- to fine-grained sandstone; dark-gray to black argillite; intercalated dark-gray, generally thinly bedded limestone and dark-gray argillite; and medium- to light-gray, massive, fine- to medium-crystalline, partly dolomitic limestone (Csejtey and others, 1992). These rocks in the Healy and Denali quadrangles, in the past, have been assigned to either the Nixon Fork or Dillinger terranes (both now abandoned and considered part of the Farewell terrane [Decker and others, 1994]); we assign them to the Mystic structural complex because of their mixed lithologic character and similar structural disruption. An alternative correlation suggested for the classic Mystic terrane rocks may be in the Yanert Fork unit (Dmvs) of the eastern Healy and western Mount Hayes quadrangles. Other units traditionally assigned to the Mystic terrane in the Lime Hills and McGrath quadrangles (Bundtzen and others, 1997a) do not include the mafic volcanic rocks here; these units have been assigned to units Dls and DЄd here. Unit locally subdivided here into map units JTRmv, JTRv, PDmc, and Dls

JTRmv **Tatina River volcanics of Bundtzen and others (1997a) and similar mafic volcanic rocks (Jurassic and Triassic)**—The informally defined Tatina River volcanics of Bundtzen and others (1997a) consists of three members: a lower volcanic member, a phosphatic shale and volcaniclastic sandstone member, and a conglomerate and volcanic sandstone member. The lower volcanic member consists of dark-greenish-gray elongate bodies of pillow basalt that include interbeds and lenses of mudstone, shale, and siltstone. Locally, gabbro bodies, interpreted by Bundtzen and others (1997a) as feeders to the pillow basalt flows, are included in the unit. In the western Talkeetna quadrangle, includes basaltic rocks mapped by Reed and Nelson (1980) as units KJb and Pzbs. Also includes a thick submarine sequence of several hundred—and perhaps several thousand—meters of basalt flows, mostly pillowed, and associated sills and dikes of diabase and gabbro and subordinate dark-gray to dark-grayish-green, fine-grained sandstone, siltstone, and argillite, some having abundant angular tuffaceous material. Mapped by Csejtey in the Healy and Denali quadrangles (Csejtey and others, 1992; Bela Csejtey, Jr. written commun., 1993). Each of these units has similar reported major element oxide contents and also shows similar copper content, between 200 and 500 ppm. Age control is lacking; assignment is based on association with the sedimentary members. Laterally gradational with the volcanic member is a volcaniclastic member (unit Trs of Bundtzen and others, 1997a), which consists of tan to greenish-gray, buff- to orange-weathered, pebble rich, immature conglomerate, coarse volcaniclastic sandstone, distinctly brown silty shale, and light-gray, green, and black chert. Bundtzen and others (1997a) reported the occurrence of *Monotis subcircularis*, and *Halobia* cf. *H. fallax*, which indicates a Late Triassic (Norian) age. The three uppermost members of the unit are medium- to very dark-gray, bluish-white bleached phosphatic shale; green, medium-grained, concretion-rich, volcaniclastic sandstone; and minor tan chert-cobble pebble conglomerate. Bundtzen and others (1997a) report *Entolium* sp. and *Eopecten*(?) sp. of Jurassic age. Includes Lower Jurassic brachiopod, pelecypod, and ammonite-bearing, reddish-brown-weathering sandstone and dark-gray shale in the western Talkeetna quadrangle (Reed and Nelson, 1980), as well as Early Jurassic silty shale and siltstone in the western Lime Hills quadrangle (Blodgett and others, 2000a). Unit occurs on both sides of the Denali Fault System

JTRv **Tatina River volcanics of Bundtzen and others (1997a), gabbro and diorite (Jurassic and Triassic)**—Dark-green, rust-weathering coarse-grained altered gabbro, diorite, and minor quartz diorite. These intrusive rocks, mapped in the McGrath and Talkeetna quadrangles, and likely also present in the Denali quadrangle, intrude the calcareous sedimentary rocks of unit TRcs, located between strands of the Denali Fault System. Inferred by Bundtzen and others (1997a) to represent feeder pathways for the Tatina volcanics; however, these rocks are found only between strands of the Denali Fault System and spatially separate from the volcanic rocks of the Tatina volcanics of Bundtzen and others (1997a). On generalized map, included as part of unit JTRmv

PDsc **Sheep Creek formation of Bundtzen and others (1997a) and correlative siliciclastic units of the Mystic structural complex (Permian to Devonian)**—Clastic-dominated but heterogeneous middle third of the Mystic structural complex. Consists of sandstone, conglomerate, siltstone, and argillite, and lesser chert and limestone. Depositional environments are dominantly fluvial, but carbonate platform and deep marine environments are also represented by subordinate rock types in this grouping of units. Includes the clastic parts of the informal Sheep Creek formation of McGrath and Lime Hills quadrangles, an argillite and chert unit thought equivalent to the Sheep Creek formation of Bundtzen and others (1997a; T.K. Bundtzen, DGGS, unpub. data, 1997, 1998), and the conglomerate of Mount Dall in the Talkeetna quadrangle (Reed and Nelson, 1980), which is a “dark-brown to yellowish-brown-weathering sequence of conglomerate, sandstone, siltstone, and shale mainly of continental origin that forms a broad, open, east-plunging syncline.” Unit is chiefly massive lenticular beds of conglomerate and sandstone with numerous cut and fill channels, which have yielded a Permian plant assemblage of Siberian affinity (Mamay and Reed, 1984). Conglomerate of Mount Dall of Reed and Nelson (1980) contains clasts of Devonian limestone, as well as chert, chert-pebble conglomerate, and graded sandstone, presumably derived from the White Mountain sequence of Decker and others (1994). Age control is provided by conodonts, fusulinids, brachiopods, corals, and plants. Unit tentatively includes an unnamed shale and chert (T.K. Bundtzen, DGGS, written commun., 1998) that occurs in a limited area in the Lime Hills quadrangle and that hosts the Gargaryah bedded-barite deposit (Bundtzen and Gilbert, 1990) as well as includes dark gray-green to distinctly maroon, pyrite-rich volcanogenic phyllite, and white-weathering, gray-green, banded phyllitic ribbon chert (Bundtzen and others, 1997a) exposed between strands of the Denali Fault System in the eastern McGrath quadrangle. The ribbon chert has yielded Permian through Pennsylvanian Radiolaria and Permian through Mississippian conodonts (Bundtzen and others, 1997a). On generalized map, included as part of unit PDms

Dls **Limestone of the Mystic structural complex (Devonian)**—Chiefly algal-laminated limestone and dolostone of shallow-marine origin. In eastern McGrath quadrangle, includes two members of the informal Saint Johns Hill formation of Bundtzen and others (1997a): Dls, which consists of brown to terra-cotta, micaceous, slightly pyritic, thinly laminated limestone, mudstone, siltstone, and lithic sandstone; and uDl, which consists of medium-gray, massive- to thick-bedded, micritic limestone that contains crypto-algal laminations, thin, black chert partings, and dolomitic nodules. Also includes two members of the informal Sheep Creek formation of Bundtzen and others (1997a): lDl, which consists of massive, thick-bedded, medium-gray limestone, rich in algal laminations and *Amiphipora* sp.; and lDd, which consists of light gray, dolomitized, algal(?) limestone. In the western McGrath and western Lime Hills quadrangles, includes unit uDl of Bundtzen (T.K. Bundtzen, Pacific Rim Geologic Consultants, written commun., 1997, 1998). In the Talkeetna quadrangle, Reed and

Nelson (1980) describe thin-bedded gray micrite grading upward into fossiliferous, massive to reefoid biostromal beds of colonial rugose corals and massive stromatoporoids, which contain shelly faunas of late Middle and early Late Devonian age and locally faunas of late Early or Middle Devonian age. The stromatoporoid beds are overlain by dark-brown to black shales and thin limestone interbeds in the shale that contain conodonts of Late Devonian (upper half of Frasnian) age. On generalized map, included as part of unit Dls

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JMpu **Younger strata of the Porcupine River sequence of Brosgé and Reiser (1969), undivided (Jurassic to Mississippian)**—Unit consists of poorly known clastic rocks and limestone in the Coleen quadrangle in the northeastern part of the state. Youngest part of the sequence included here is red and green laminated chert; partly silicified siltstone and shale; and ferruginous very fine-grained sandstone of presumed Jurassic age. The most common unit of the Porcupine River sequence is gray to black, locally pyritic siltstone and silty shale that has nodules of siltstone of Jurassic and Permian age; Brosgé and Reiser (1969) estimated that it is about 300 m thick. Underlying this is Permian and Carboniferous gray, cherty limestone and dark-gray shaly limestone and chert about 60 to 180 m thick that contains a local basal shale and sandstone. This basal shale and sandstone may be equivalent to unit Css of Brosgé and Reiser (1969), which they describe as yellow, coarse-grained conglomeratic, poorly sorted, partly carbonaceous sandstone and fine-grained hematitic sandstone; as much as 60 m thick; Carboniferous in age. Also includes thick beds of gray chert breccia and minor very fine-grained limonitic sandstone of Jurassic or Permian age. They thought that this part of the unit, which is at least 60 m thick, may be, in part, a silicified dolomite breccia. A Permian brachiopod-bearing gray nodular siltstone and yellow-weathering silty limestone at least 120 m thick is the remaining part of unit. Also included here are several thousand feet of poorly described quartzite or chert, argillite, and dark-gray limestone in the Black River and Charley River quadrangles (Brabb and Churkin, 1969; Brabb, 1970). Till and others (2006a) noted lithologic and faunal similarities of parts of this map unit to the Siksikpuk (unit ŦꟼPeg) and Kuna Formations (part of the Lisburne Group, unit ꟼMlg) as described in Dumoulin and others (2004), which suggests ties between this unit and correlative rocks of northern Alaska. Faunal similarities also tie this unit to strata to the south, such as the Tahkandit Limestone (unit Ptl). On generalized map, included as part of unit JMps

JMsu **Strangle Woman Creek sequence of Brosgé and Reiser (1969), undivided (Jurassic to Mississippian)**—Rock types include very fine-grained to conglomeratic sandstone; gray limestone and dolostone; dark-gray, very fine-grained, thin-bedded limestone and black chert; and coarse-grained, conglomeratic, quartz sandstone that contains minor potassium feldspar. Exposed in the northern part of the Porcupine province in the Coleen quadrangle. The carbonate rocks of this unit were assigned to the Lisburne Group by Brosgé and Reiser (1969). Dark, fine-grained quartzite contains Early Jurassic (Hettangian) ammonites (Brosgé and Reiser, 1969). Unit also contains Permian or Carboniferous brachiopods and corals and Late Mississippian corals (Brosgé and Reiser, 1969), as well as conodonts of Carboniferous age. Conodont faunas range from earliest Mississippian to Middle Pennsylvanian in age; they indicate chiefly shallow-water, locally high-energy depositional settings, but the oldest sample suggests a slope environment (A.G. Harris, USGS emeritus, written commun., 2000; Till and others, 2006a). On generalized map, included as part of unit JMps

Jk **Graywacke of Kulukak Bay of Hoare and Coonrad (1978) (Upper to Middle Jurassic)**—Thick marine sedimentary unit that consists of very hard dark-green or gray, massive graywacke and siltstone and contains local coarse pebble conglomerate horizons. Compositionally, “varies from quartz- and plagioclase-rich wackes to quartz-poor volcanic wackes. Generally contains black argillite or tuff chips” (Hoare and Coonrad, 1978). Unit is a thick marine sedimentary unit earlier referred to as the “Weary graywacke” by Hoare and others (1975). Unit is widely exposed in the southern Goodnews Bay and Nushagak Bay quadrangles as well as the adjacent southeastern Dillingham quadrangle (Hoare and Coonrad, 1978). *Buchia*, *Inoceramus*, belemnites, and rare ammonite fragments that range in age from Middle to early Late Jurassic age have been found in this unit. Unit may be correlative with the Koksetna River sequence of Wallace and others, 1989, which is mapped as unit KJgn here. Locally subdivided by Box (1985) into a coherently and pervasively deformed volcaniclastic turbidite unit

Jsc **Shelikof and Chinitna Formations (Middle Jurassic, Callovian)**—Primarily consists of siltstone that is best exposed along the west side of Cook Inlet and in the Anchorage quadrangle within fault splays that are the eastern end of the Castle Mountain Fault System. The Chinitna Formation, found on the west side of Cook Inlet, is subdivided into two members: the upper Paveloff Siltstone Member, which is approximately equivalent to the Shelikof Formation; and lower Tonnie Siltstone Member (Detterman and Hartsock, 1966). Paveloff Siltstone Member is massive, dark-gray arenaceous siltstone in its upper part and thick graywacke sandstone at its base and ranges in thickness from about 275 m to more than 400 m (Detterman and Hartsock, 1966). Large ellipsoidal concretions and lenticular beds of limestone occur throughout, and thin interbeds of sandstone occur in the siltstone. Limestone concretions and interbeds common; fresh surfaces are very dark-gray, but weather buff to cream colored. Locally the limestone is bioclastic (Detterman and Hartsock, 1966). Siltstone is well indurated; uppermost part is thinly bedded and fractures into angular fragments. Graywacke of the lower part is "…thin bedded to massive, locally lenticularly bedded, fine to coarse grained, gray to greenish gray" (Detterman and Hartsock, 1966, p. 43). Ammonites within upper part of unit include species of *Cadoceras*, *Stenocadoceras*, *Pseudocadoceras*, *Kepplerites*, *Kheraiceras*, and *Lilloettia* (Detterman and Hartsock, 1966) and indicate Middle Jurassic (Callovian) age. Paveloff Siltstone Member is the age equivalent of Shelikof Formation of the Alaska Peninsula, but the Shelikof contains a higher proportion of coarse volcanic debris and is thought to have been deposited in a deep- to shallow-water environment (Detterman and others, 1996). Megafauna are locally abundant in the Shelikof, although, in general, formation is not fossiliferous. Many lithic intervals in upper part of section have a fining-upward sequence from conglomerate to sandstone or from sandstone to siltstone (Allaway and others, 1984). Tonnie Siltstone Member of the Chinitna Formation is massive, marine, gray arenaceous shale and siltstone that contains numerous large limestone concretions, typically about 250 m thick but thickens to as much as 400 m in southern exposures. Contains mixture of plutonic and volcanic detritus, which is thought to be derived from erosion of the Talkeetna Formation (unit Jtk) and related plutonic rocks of the Early to Middle Jurassic magmatic arc. Lower part of type section is mainly thick-bedded to massive, dusky-yellowish-green graywacke and conglomerate, and minor siltstone, whereas upper part is mainly volcanic sandstone interbedded with massive and laminated brownish-gray siltstone containing calcareous sandstone clasts. Contact with underlying Kialagvik Formation is considered conformable (see Detterman and others, 1996). Upper contact is an unconformity. In the northeastern Anchorage quadrangle, the Chinitna Formation is not subdivided and may be as thick as 600 m. On generalized map, included as part of unit Jsct

Jt **Tuxedni Group (Middle Jurassic)**—Fossiliferous, light- to dark-gray and green marine graywacke, conglomerate, siltstone, and shale (Detterman and Hartsock, 1966). Graywacke ranges from feldspathic to lithic to laumontitic conglomerate composed mainly of volcanic clasts in a graywacke matrix. Unconformably overlies Talkeetna Formation and is disconformably overlain by Chinitna Formation. Unit locally subdivided into, in ascending stratigraphic order: the Red Glacier Formation, Gaikema Sandstone, Fitz Creek Siltstone, Cynthia Falls Sandstone, Twist Creek Siltstone, and Bowser Formation. Red Glacier Formation is about 40 percent thin-bedded to massive, red-brown weathering dark-gray to moderate olive-gray siltstone concentrated in the upper part of the unit; underlying this is light-tan to buff arkosic sandstone that consititutes about 25 percent of the unit and a thick, black, silty to arenaceous, very fissile shale that constitutes the rest of the unit. Gaikema Sandstone is resistant, cliff-forming, massive to thin-bedded graywacke sandstone and cobble conglomerate that has graded bedding 150 to 260 m thick. Fitz Creek Siltstone is a thick sequence (up to 400 m thick) of massive, bluish dark-gray, arenaceous coarse- to fine-grained siltstone that commonly weathers rusty orange and contains many small limestone concretions. Cynthia Falls Sandstone is massive to thick-bedded graywacke sandstone and pebble conglomerate about 200 m thick. Twist Creek Siltstone is soft, poorly consolidated, thin-bedded to massive siltstone and silty shale as much 125 m thick. Bowser Formation is a heterogeneous assemblage of sandstone, conglomerate, shale, and siltstone characterized by rapid facies changes. Age of Tuxedni Group was revised to lower Bathonian to Aalenian by Detterman and Westermann (1992). In Talkeetna Mountains quadrangle, this unit is included in an undivided Tuxedni Group–Chinitna Formation unit (Csejtey and others, 1978). In the Anchorage quadrangle (Winkler, 1992), it is mapped as undivided Tuxedni Group. See Detterman and Hartsock (1966) and Detterman and others (1996) for a fuller description of each of the included formations. On generalized map, included as part of unit Jsct

JIPe **Etivluk Group, undivided (Middle Jurassic to Pennsylvanian)**—Includes Otuk and Siksikpuk Formations and Imnaitchiak Chert; consists of maroon, red, green, gray, black, and variegated chert and siliceous argillite, minor maroon calcareous siltstone and argillite, and rare maroon or gray limestone lenses (Karl and others, 1989a; Mayfield and others, 1987). Original definition suggested Etivluk Group is present only on allochthonous sheets in the Brooks Range, and not present on autochthonous rock units (Mull and others, 1982). Locally, the Otuk and Siksikpuk Formations are mapped separately as units JŦo and ŦIPeg, but all are shown together on generalized map as part of unit JIPe

JŦo **Otuk Formation (Middle Jurassic to Triassic)**—Interbedded fossiliferous black chert, limestone, and shale in four lithogenetic units: (1) a basal, poorly exposed black organic shale, (2) a cherty member of black silicified mudstone, chert and shale, (3) a thinly interbedded shale and thin-bedded black- and light-gray banded limestone and silicified limestone member, and (4) the formally defined Blankenship Member, which is organic-rich black shale and thin bedded chert. The Blankenship Member is thought to represent condensed deposition of Early and Middle Jurassic age (Mull and others, 1982). Bedding surfaces in the silicified limestone member weather cream-colored or light-brown to green, and it has a few beds that contain *Monotis* fossils. Chert member is well-bedded and contains *Halobia* fossils in shaly layers. Lower black shale member, which is only locally present, contains Early Triassic conodonts (Curtis and others, 1990; Ellersieck and others, 1990; Mayfield and others, 1990). Unit is less than 100 m thick. In the past, some maps assigned rocks of this unit to the Shublik Formation (unit ₮gs)—see, for example, Campbell (1967), Grybeck and others (1977), Sable and others (1984a, b, c), or Sable and Mangus (1984). The coeval Shublik Formation is confined to the autochthonous part of northern Alaska in northeastern Alaska and the subsurface of the North Slope; the Otuk—in particular the Blankenship Member—is also coeval with the lower part of the Kingak Shale

₮IPeg **Siksikpuk Formation and Imnaitchiak Chert (Triassic to Pennsylvanian)**—Predominantly greenish-gray argillite; contains variable but generally very minor amounts of quartz-rich siltstone and very fine sandstone in beds 2–15 cm thick (Curtis and others, 1990; Ellersieck and others, 1990; Mayfield and others, 1990; Mull and others, 1994; Dover and others, 2004). Base contains a distinctive dark-gray, evenly laminated, glauconitic, phosphatic siltstone bed up to 1 m thick (Mull and others, 1994). Greenish-gray chert is common as interbeds in the argillite at several horizons, the most striking of which is the topmost zone of the formation where argillite is greatly subordinate to chert. Thickness is less than 100 m (Mull and others, 1994). Contains mainly Pennsylvanian to Late Triassic radiolarians but locally has yielded Early Jurassic radiolarians, which may properly belong to the Blankenship Member of the Otuk Formation (unit J₮o). Ages of radiolarian collections from this unit include Permian (possibly middle and late Permian), Middle and Late Triassic (probably Ladinian, Carnian, and Norian), and Early Jurassic (Hettangian or Sinemurian) (Dover and others, 2004). As mapped, locally may include rocks of the Sadlerochit Group

J₽zs **Northern Alaska sedimentary rocks (Middle Jurassic to Carboniferous)**—Unit includes two similar rock assemblages in the Wiseman and Chandalar quadrangles and a large part of the central Chandler Lake quadrangle. These assemblages include stratigraphic units common to the Brooks Range that are not separately mapped. The first assemblage, spatially associated with the Doonerak Window (see below, units S€s and O€dv), is composed of quartzite, phyllite, siltstone, conglomerate, shale, sandstone, limestone, argillaceous limestone, dolomitic limestone, and cherty dolostone of Triassic to Carboniferous age that unconformably overlies lower Paleozoic rocks (unit S€s) (Dillon and others, 1986). Formal rock units included, but not separately mapped in this assemblage, are the Kekiktuk Conglomerate (Mek) and Kayak Shale (Mk) of the Endicott Group, the undivided Lisburne Group (Clg), the Echooka Formation (Pe) of the Sadlerochit Group, Shublik Formation (₮gs, KPu) and Karen Creek Sandstone (₮kc). This assemblage was mapped as unit TrCs by Till and others (2008a). Exposed to the northwest of this assemblage is a second assemblage, mapped by Till and others (2008a) as JCs, which is composed of "sandstone, shale, argillaceous limestone, limestone, dolostone, mudstone, chert, and siltstone in north-central Wiseman quadrangle. The unit conformably overlies the Kanayut Conglomerate * * *" (Till and others, 2008a). (The Kanayut Conglomerate of the Endicott Group is mapped as part of unit MDegk herein). This second assemblage consists of the Kayak Shale (Mk) of the Endicott Group, the Lisburne Group (Clg), and the Siksikpuk (₮IPeg) and Otuk Formations (J₮o) of the Etivluk Group. Both of these assemblages of Till were included in unit TrCs of Dillon and others (1986). "Various workers (e.g., Dutro and others, 1976; Mull, 1982; Mull and others, 1987a; Adams and others, 1997) have suggested that the general stratigraphy of TrCs is more like that of coeval parautochthonous rocks in the northeastern Brooks Range * * * than that of equivalent strata in the central part of the range that have been assigned to the Endicott Mountains allochthon (EMA; Moore and others, 1994). TrCs does differ from JCs, the nearest coeval strata in the EMA [Endicott Mountains allochthon]; the most notable contrast is the presence of somewhat deeper water facies in parts of both the Carboniferous and Permian successions in JCs. However, Lisburne Group facies in TrCs are generally similar to coeval rocks exposed to the northeast in the central Chandler Lake quadrangle (Dumoulin and others, 1997)" (Till and others, 2008a)

Jms **Micaceous graywacke (Lower Jurassic)**—Marine unit of micaceous, fine-grained black graywacke, siltstone, and slate, and gritty limestone known only from the Taylor Mountains quadrangle of southwest Alaska. Contains *Weyla* pelecypods of Early Jurassic age. Crops out near Lake Chauekuktuli, these rocks occur between exposures of Paleozoic rocks on the adjacent ridges and are structurally lower than the surrounding Paleozoic rocks. On generalized map, included as part of unit K₮vs

J₮p **Phyllite and chert (Lower Jurassic to Upper Triassic)**—Gray, green, and black phyllite, fine-grained tuff, and tuffaceous chert described as part of the Togiak-Tikchik Complex by Wilson and others (in press [a]; Wilson and Coonrad, 2005). Unit crops out in the southeast corner of the Bethel quadrangle near the heads of Upnuk and Chikuminuk Lakes and trends north-northeast where it continues into the adjacent Taylor Mountains quadrangle. Box and others (1993) constrained age based on underlying Triassic pillow basalt and an Early Jurassic age derived from a single radiolarian collection. On generalized map, included as part of unit K₮vs

J₮ls **Limestone, shale, and chert (Lower Jurassic and Upper Triassic, Norian)**—Medium-gray to yellowish-gray-weathering, medium- to thick-bedded, dominantly chert and sandstone unit with locally abundant phosphatic nodules developed in more cherty phases (Wilson and others, in press [a]; R.B. Blodgett, 2005, unpub. data). These rocks are exposed along the periphery of and intercalated with the Paleozoic limestone of the Farewell terrane in the northeastern Taylor Mountains quadrangle. Sandstone beds dominate in lower part of section; chert-rich beds dominate upper part of unit. Contains megafauna (mostly bivalves and belemnites) of undifferentiated Early Jurassic age (R.B. Blodgett, 2005, unpub. data) and radiolarians of undifferentiated Early Jurassic age (C.D. Blome, written commun., 2000; E.A. Pessagno Jr., Univ. of Texas, written commun. to M.L. Miller, 2005) as well as fossils of Norian age. Minimum estimated thickness of unit is 100 m. On generalized map, included as part of unit KŦvs

JŦmc **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 Ŧsl). On generalized map, included as part of unit JŦsr

Triassic to Pennsylvanian

Ŧsl **Spiculite and sandy limestone (Upper Triassic, Norian)**—Quartz-carbonate sandstone and conglomerate in west-central Alaska. Sandstone and conglomerate in the lower part of the unit consist of detrital carbonate, quartz, and chert clasts, and calcareous fossil debris. Spiculitic chert in the upper part is composed of chert, fine quartz grains, and as much as 60 percent sponge spicules. Unit contains marine mollusks (*Monotis ochotica*, *M. scutiformis*, *Halobia*, and *Heterastridium*) of Late Triassic (Norian) age in the lower part and Radiolaria of probable Triassic age in the upper part. Silberling and others (1997) interpreted these rocks as debris flow deposits in a deep ocean basin. Similar rocks occur in the McCarthy Formation (unit JŦmc) of east-central Alaska. On generalized map, included as part of unit JŦsr

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**Shuyak Formation (Upper Triassic)**—Volcanic and volcaniclastic sequence that consists of vesicular pillowed greenstone and thin- to medium-bedded lithic sandstone that contains lesser conglomerate, argillite, and siliceous tuff (Connelly and Moore, 1979) on Shuyak and Kodiak Islands. The Shuyak Formation structurally overlies the schist of Kodiak Island (unit Jsch) and Uyak Complex (unit Kmc), but is generally separated from them by the Afognak pluton (part of unit Ŧqd). Subdivided into two members, described below: a sedimentary member, unit Ŧsy, and a volcanic member, unit Ŧsyv

Ŧsy **Sedimentary member**—Thin- to medium-bedded lithic sandstone that contains lesser conglomerate, argillite, and siliceous tuff that has been intruded by mafic dikes and sills (Connelly and Moore, 1979). Unit is rich in primary andesitic material and displays flute casts and complete Bouma sequences, which indicate deposition by turbidity currents. Rocks either are broadly folded or dip homoclinally to southeast and have undergone prehnite-pumpellyite-facies metamorphism (Connelly and Moore, 1979). Pelecypod *Halobia halorica* of Late Triassic (Norian) age, as identified by N. Silberling, was reported by Connelly and Moore (1979). This sedimentary member of the Shuyak Formation is in fault contact with the volcanic member (unit Ŧsyv) that it is inferred to stratigraphically overlie (Connelly and Moore, 1979). On generalized map, included as part of unit Ŧsf

Ŧsyv **Volcanic member**—Tholeiitic vesicular pillow greenstone; locally contains beds of pillow-breccia agglomerate, tuff, and argillite (Connelly and Moore, 1979). Also includes diabasic bodies intruding Shuyak Formation on west side of Shuyak Island that do not have visible thermal aureoles (Connelly and Moore, 1979). On generalized map, included as part of unit Ŧsf

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ŦPsf **Flysch-like sedimentary rocks (Triassic to Pennsylvanian)**—Intensely folded and fault-bounded sequence of dark-gray to black, massive to thin-bedded marine flysch-like rocks in the Healy and Denali quadrangles and including conglomerate, sandstone, siltstone, and argillite, a few thin interbeds of limestone, and thin interbeds of chert in the upper part of unit (Csejtey and others, 1992). Age based on Triassic Radiolaria and conodonts from chert and calcareous units and on a reported collection of Pennsylvanian brachiopods (see Csejtey and others, 1992, p. 28). Unit is thought to be at least several hundred meters thick. Overlain by and locally interbedded with Late Triassic pillow basalt (unit JŦv). Csejtey and others (1992) did not assign either this unit or the basalt to known packages or assemblages because of the discontinuous and fault-bounded nature of their occurrence

Ŧgsl **Glenn Shale, lower unit (Triassic)**—Grayish and brownish-black carbonaceous and calcareous shale (Van Kooten and others, 1996) and thin-bedded fossiliferous limestone in lower part of unit; rare thin oil shale (Brabb and

Churkin, 1969); unit exposed in east-central Alaska. Unit overlies Tahkandit Limestone (unit Pkl) or the Step Conglomerate (unit Pstc) with a significant time gap and is overlain unconformably by the upper member of the Glenn Shale (included here in unit Kkg). Unit is abundantly fossiliferous, containing *Monotis*, *Halobia*, *Daonella* cf. *D. degeeri*, *Discophylittes*, and *Nathorsites* of Middle (Ladinian) and Late (Norian) Triassic age (Brabb, 1969). A similar and possibly equivalent unit of calcareous phosphatic shale, limestone, and minor calcareous sandstone and granule conglomerate was mapped in the Livengood quadrangle (Weber and others, 1992). The lower unit of the Glenn Shale is possibly equivalent to the Shublik Formation (unit ₮gs) of northern Alaska. In the Livengood quadrangle the exposures that are lithologically similar to the lower Glenn Shale have yielded Permian to Triassic conodonts (Weber and others, 1994), which Weber and others (1992) had interpreted were most likely Triassic; these conodonts support correlation with the lower Glenn Shale. Unit may locally include rocks of the Tahkandit Limestone (unit Ptl); on generalized map, included as part of unit ₮gs

₮hg **Hyd Group, undivided (Upper and Middle Triassic)**—Includes carbonaceous argillite, slate, and subphyllite, tuff, volcaniclastic wacke, conglomerate, mafic flows, and limestone. The volcanic rocks consist of basaltic pillow flows, pillow breccia, and breccia, rhyolitic tuff that has calcareous interbeds, flow breccia, banded ash-flow tuff, and subordinate andesitic breccia and aquagene tuff. Unit ranges from marine mafic volcanic and deep marine sedimentary rocks in northern southeast Alaska to more felsic volcanic rock and shallow-water limestone and conglomerate to the south (Taylor and others, 2008). On Admiralty Island, group includes volcanic breccia and deformed, locally metamorphosed, massive and thick-bedded mafic to intermediate flows that have pillows and columnar jointing (Lathram and others, 1965; Brew and Ford, 1985). Volcanic flows are interbedded with, but mostly overlie, gray to black limestone, graywacke, slate or argillite, black chert, and conglomerate (Lathram and others, 1965). In the Petersburg to Ketchikan area, group includes mafic volcanic rocks that generally overlie felsic volcanic rocks that consits of latite to rhyolite flows, aquagene tuff, and tuff breccia (Brew and others, 1984; Berg and others, 1988; Karl and others, 1999). The volcanic rocks are interbedded with, and commonly overlie, carbonaceous argillite, limestone, and volcaniclastic wacke; all overlie a basal conglomerate or breccia (Brew and others, 1984; Berg and others, 1988; Karl and others, 1999; Taylor and others, 2008). The Hyd Group is 200 to 800 m thick and is thought to have been deposited in a rift basin (Taylor and others, 2008). As shown here, the Hyd Group consists of the Nehenta Formation on Gravina Island near Ketchikan, the Barlow Cove Formation on Admiralty Island (Lathram and others, 1965), basalt of the Chapin Peak Formation and rhyolite of the Puppets Formation (Berg and others, 1988), the Hound Island and Keku Volcanics (Brew and others, 1984) in southern southeast Alaska, and the Glacier Creek volcanic rocks of Redman and others (1985) in northern southeast Alaska. Age control is largely based on fossils, which are primarily late Carnian to Norian and there are local occurrences of younger Rhaetian fossils (Green and others, 2003). Karl and others (1999) report an occurrence of uppermost Anisian to Ladinian(?) (Middle Triassic) conodonts from the Duncan Canal area. Premo and others (2010) report a 210.3±0.3 Ma $^{40}Ar/^{39}Ar$ alteration age on fuchsite that they interpreted as age of intrusion of Hyd Group feeder plutons. Green and Greig (2004) reported a 213±5 Ma U/Pb zircon age on rhyolite from the northern part of the unit near the Canadian border. Gehrels and others (1987) reported a 225±3 Ma U/Pb zircon age from rhyolite on Gravina Island. Where possible, subdivided into the following two units, ₮hgs and ₮hgv:

₮hgs **Hyd Group sedimentary rocks, undivided (Upper Triassic)**—Includes rocks locally mapped separately as the Burnt Island Conglomerate (Muffler, 1967), conglomerate and carbonate rocks of the Nehenta Formation, the Hamilton Island and Cornwallis Limestones, and argillite and limestone of the Hyd Group (Karl, 1992; Karl and others, 1999). Breccia and conglomerate of variable composition, locally called the Burnt Island Conglomerate, is as much as 200 m thick and clast composition reflects directly underlying units (S.M. Karl, unpub. data). Locally, where the Hyd Group sedimentary rocks overlie limestone and dolostone of the Pybus Formation (unit Plps), breccia consists of unsorted angular blocks of limestone and dolostone in calcareous matrix, but where the Hyd Group sedimentary rocks overlie chert of the Pybus Formation, breccia is clast-supported chert pebble-cobble conglomerate in a calcareous matrix. Where it overlies the Cannery Formation, the breccia is a matrix-supported debris flow deposit that has angular blocks of chert, argillite, graywacke, volcanic rocks, white vein quartz, and schist that are as large as 20 m. Breccia and conglomerate are commonly at or near base of Hyd Group, but the position is variable. At Keku Strait, the Hamilton Island Limestone consists of highly folded, generally very thin-bedded, aphanitic, dark-gray, locally dolomitic limestone that contains thin to medium beds of dark-green calcarenite and minor black claystone layers (Brew and others, 1984). Cornwallis Limestone, on Kuiu Island, consists dominantly of medium- to very thick-bedded, medium-gray oolitic limestone and contains chert clasts derived from the underlying Pybus Formation (Brew and others, 1984). The Hamilton Island Limestone reflects a deep-water slope facies environment and is coeval with the shallow-water shelf facies of the Cornwallis Limestone. Other limestone in the Hyd Group varies from dark- to medium-gray, bluish-gray, or dark-brown, massive to medium-bedded limestone that may be graphitic, argillaceous, dolomitic, carbonaceous, or conglomeratic. Argillite of the Hyd Group is dark-gray to black, carbonaceous, locally siliceous or calcareous and rhythmically bedded. Subordinate chert, limestone, graywacke, and conglomerate are also present. Limestone may occur in lenses as much as 12 m thick. Carbonaceous beds and limestone locally contain well preserved Middle Triassic (Ladinian) ammonites and *Daonella*, Ladinian or Carnian conodonts, Late Triassic (late Carnian to early Norian) *Halobia*, crinoids, corals, mollusks, pelecypods, gastropods, ammonites, *Monotis*, early Norian *Halobia alaskana*, middle Norian *Halobia* cf. *H. fallax*, *H. lineata*, and late Norian *Heterastridium* (Muffler, 1967; Berg and others, 1988). On generalized map, included as part of unit Ꞧhg

Ꞧhgv **Hyd Group igneous rocks, undivided (Upper Triassic)**—Basaltic pillow flows, pillow breccia, flow-banded rhyolite, and rhyolitic tuff, which intertongue with calcareous interbeds, flow breccia, banded ash-flow tuff, and subordinate andesitic breccia and aquagene tuff. Locally, unit consists of massive greenstone, pillow greenstone, pillow breccia, and volcanic breccia that contain lenses of mafic to intermediate tuff, felsic tuff that has quartz crystals, as well as limestone, conglomerate, sandstone, argillite, and rare bedded chert. Amygdaloidal basalt flows that contain calcite-, chlorite-, and chalcedony-filled amygdules are locally present. Rocks in most areas are moderately metamorphosed and deformed and may be altered, bleached, or spilitic, and contain zones of hydrothermal alteration. Locally, greenstone is augite and (or) hornblende phyric and commonly pyritic (Karl and others, 1999). Unit consists of rhyolite on Annette Island (Berg, 1982; Gehrels and others, 1987), rhyolite of the Puppets Formation and basalt of the Chapin Peak Formation on Gravina Island (Berg, 1982; Berg and others, 1978, 1988; Gehrels and others, 1986, 1987); and rhyolite and subordinate basalt of the Keku Volcanics and basalt and andesite of the Hound Island Volcanics in Keku Strait (Muffler, 1967; Brew and others, 1984). Unit also includes small metagabbro bodies in the Petersburg quadrangle (Karl and others, 1999). On generalized map, included as part of unit Ꞧhg

Ꞧpg **Port Graham formation of Kelley (1980) (Upper Triassic, Norian)**—Informal unit that dominantly consists of dark-gray, carbonaceous limestone and silty limestone that has varying amounts of silica cement (Kelley, 1980). Other common lithologies include fine-grained, dark-gray, siliceous to limy mudstone, silty sandstone, and dark-gray to dark-olive-gray, thin- to medium-bedded chert that has mudstone partings (Kelley, 1980). Limy beds tend to be most common in the lower (middle Norian) part of the unit (R.B. Blodgett, written commun., 2007; and unpub. data of Humble Oil Company [now Exxon-Mobil] reported by R.B. Blodgett); whereas the upper part, of late Norian age, is composed of considerably more volcaniclastic fragment-rich and shaly beds. Volcaniclastic fragment-rich beds contain a diverse, but uncommon molluscan fauna that consists of both bivalves and gastropods; shaly beds tend to have a monotaxic fauna of monotid bivalves. Fossils are locally abundant, as reported by Kelley (1980): mostly thin-shelled mollusks, but also corals, echinoids, ammonites, and trace fossils. Martin and others (1915) and Martin (1926) reported bivalves *Halobia* cf. *H. superba* Mojsisovics, *Pseudomonotis* (now placed in genus *Monotis*) *subcircularis* Gabb, *Nucula*?, and coral *Astrocoenia*? sp. Silberling and others (1997) provided a detailed analysis of Late Triassic bivalve fauna known from the Port Graham area southwest of Seldovia and reported that middle Norian age *Halobia lineata* and *H. dilitata* are in collections reported by Martin (1915). Two different species of Late Triassic *Monotis* were reported by Silberling and others (1997), *Monotis* (*Pacimonotis*) *subcircularis* and *Monotis* (*Monotis*) *alaskana*, and late middle Norian ammonite *Steinmannites*. Silberling and others (1997) indicated rocks of this unit are unique because both middle Norian and late Norian strata represent pelagic strata, whereas elsewhere, for example in the Kamishak Formation, middle Norian strata represent shallow water facies (Whalen and Beatty, 2008; Blodgett, 2008). Kelley (1984) and Bradley and others (1999) assigned an upper age limit of Early Jurassic to unit, although no fossils of this age are known. Early Jurassic fossils do occur in upper part of the overlying Pogibshi formation of Kelley (1980). On generalized map, included as part of unit JꞦkp

Ꞧcs **Calcareous sedimentary rocks (Upper Triassic, middle? Norian and upper Carnian)**—Thin-bedded, dark- to medium-gray, commonly cross-bedded, carbonaceous, intercalated, calcareous shale, argillite, sandstone, siltstone, and sandy-to-silty and argillaceous limestone; generally intensely deformed. Basal beds are predominantly fine-grained gray sandstone and siltstone and subordinate cherty limestone that has black chert clasts (Bundtzen and others, 1997a). Age established by conodonts *Negondolella polynathiformis* and *Epigondolella primitia* and the occurrence of the pelecypod *Monotis* cf. *M. subcircularis* (Csejtey and others, 1992; Bundtzen and others, 1997a). Extensively exposed both north and south of the McKinley strand of the Denali Fault System. Distinguished from other Late Triassic carbonate units, such as the Chitistone and Nizina Limestones, by turbiditic depositional character, lack of evaporite or sabkha facies rocks, inclusion of clastic debris, and intense deformation. Rocks in eastern and southern exposures are metamorphosed to greenschist and amphibolite facies in the MacLaren metamorphic belt of Smith and Turner (1974), and we tentatively include unit sq of the MacLaren terrane of Nokleberg and others (1992a) in this unit. Metamorphosed sedimentary rocks in the Mount Hayes quadrangle of the Aurora Peak terrane of Nokleberg and others (1992a, unit as) are correlated with these rocks and are shown as such here. Associated with this unit are large dikes, sills, and plugs of altered diabase and gabbro

ЋIs **Carbonates and associated rocks (Triassic)**—This unit is exposed in southwest Alaska in isolated small outcrops associated with a variety of poorly described rock assemblages. In the northeast part of the Taylor Mountains quadrangle, a cream-colored to dark-gray limestone, silty limestone, and chert outcrops along the boundary between early Paleozoic calcareous rocks and the younger flysch of the Kuskokwim Group (unit Kk). Potentially divisible into two subunits, but grouped here; consists of a lower subunit of massive- to thick-bedded, light-gray to cream-colored limestone that contains common scleractinian corals, spongiomorphs, and few brachiopods (Blodgett and others, 2000a); this lower unit has a minimum thickness 50 m and grades upward to a subunit of thinner bedded platy limestone, silty limestone, and minor chert that contains a locally well-developed silicified megafauna (brachiopods, bivalves, gastropods) of late Norian age (see McRoberts and Blodgett, 2002; Blodgett and others, 2000a); minimum thickness estimated at 100 m. Upper subunit represents slightly deeper, more offshore environment. Many of the gastropods present in upper subunit (for example, *Chulitnacula alaskana* Smith and *Andangularia wilsoni* Blodgett) are also known from coeval rocks in the Hyd Group of southeastern Alaska. A marine unit that consists of chert, tuffaceous cherty rocks, argillite, siltstone, volcanic wacke, conglomerate, limestone, and mafic flows and breccia occurs in what are possibly fault-bounded occurrences along the south shore of Nuyakuk Lake in the northwest Dillingham quadrangle and in the northwestern Taylor Mountains quadrangle (Sainsbury and MacKevett, 1965; J.M. Hoare and W.H. Condon, unpub. data, 1970). The limestone is generally white to cream colored and recrystallized; however, locally it is dark-gray and only finely crystalline. Triassic (Norian) fossils were reported by Mertie (1938) and others in written communications cited in Hoare and Coonrad (1978). Includes map unit Trvs of Hoare and Coonrad (1978) and, as mentioned by them, was only shown "* * * in the vicinity of fossil localities because the rocks resemble other rocks of Paleozoic and Mesozoic ages with which they are tectonically associated" (Hoare and Coonrad, 1978). On generalized map, included as part of unit Ћmls

Ћcnk **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 JЋmc). The upper Chitistone and cherty Nizina were deposited in a shallow to moderately deep marine neritic environment, transitioning from an intertidal to supratidal setting with local sabkha facies full of algal-mat chips, stromatolites, and evaporate relics typical of the dolostone-rich lower Chitistone rocks (Richter and others, 2006). Sparse fossils characterized by the ammonite genus *Tropites* indicate a late Carnian age for the Chitistone (MacKevett, 1971). Fossils are also sparse in the Nizina; those that are found consist mainly of pelecypods of the genus *Halobia*. Paleontologic studies by N.J. Silberling (written commun., 1962, to E.M. McKevett) indicate that the Nizina Limestone is Late Triassic and ranges in age from late Karnian or early Norian to early middle Norian. Along with the underlying Nikolai Greenstone, these limestone units are defining parts of the Wrangellia terrane (Jones and others, 1977). Kamishak Formation consists of limestone, chert, porcellanite, and minor tuff and volcanic breccia that are divided into two formal members and an informal middle member; they are, in descending order: the Ursus, middle, and Bruin Limestone Members (Detterman and Reed, 1980). Unit primarily found along west side of Cook Inlet, east of the mountain range crest where a measured reference section is about 800 m thick. Depositional environment of Kamishak Formation was shallow water and high energy; intervals of unit include both reefs and biohermal buildups. Fossils found within the middle and Bruin Limestone Members of the Kamishak Formation yield a Norian age (Detterman and Reed, 1980; C.D. Blome, oral commun., 1981). As mapped here, unit also includes a small area of Triassic limestone and chert associated with the Chilikadrotna Greenstone in the central Lake Clark quadrangle. Kamishak Formation is cut by abundant dikes and sills that are related either to the Cottonwood Bay Greenstone or the Talkeetna Formation (Detterman and Reed, 1980). On generalized map, included as part of unit Ћmls

Ћwm **Whitestripe Marble of southeast Alaska (Triassic?)**—A long narrow belt of nonfossiliferous, massive to thick-bedded, white to light-gray, fine-grained marble. Composed of nearly pure calcite, but locally contains accessory chlorite, sericite, graphite, quartz, albite, and pyrite (Johnson and Karl, 1985). Plafker and others (1976) and Jones and others (1977) correlate the Whitestripe Marble with the Chitistone Limestone (unit Ћcnk) in the Wrangell Mountains and therefore considered it to be a part of the Wrangellia terrane along with the Goon Dip

Greenstone (unit T̵Rn). Unit was assigned a Triassic(?) age by Loney and others (1975) on the basis of a fossil found in float. Unit also includes the informally defined marble of Nakwasina Sound (unit Trm of Karl and others, 2015), which consists of light-gray, medium- to thin-bedded metalimestone, which is locally fossiliferous and retains primary bedding structures as well as massive to banded white marble, locally interlayered with volcanic rocks. Unit ranges up to tens of meters in thickness and is associated with volcanic and volcaniclastic rocks mapped in Nakwasina Sound (unit T̵Rvs). On generalized map, included as part of unit T̵Rmls

T̵Rrs **Red beds (Triassic, Norian and older?)**—Predominantly volcanic and volcaniclastic unit of red-colored lithic tuff, lithic conglomerate, graywacke, and finely laminated tuffaceous siltstone and mudstone. Also contains minor basalt to dacite flows similar to unit JT̵Rrb, but distinct from it because of the occurrence of clasts of gabbro, serpentinite, and fossiliferous Permian(?) limestone (Csejtey and others, 1992; Clautice and others, 2001). Found only in thrust slivers in the southwestern Healy quadrangle. Unconformably overlies volcanogenic and sedimentary rocks of Triassic to Devonian age (unit T̵RDv). Volcanic members are predominantly calc-alkalic andesite tuff and tuff breccia, but compositions range from calc-alkaline basalt to dacite. Coarser volcaniclastic rocks are frequently calcareous and have a predominantly medium- to very coarse-grained, poorly sorted matrix that contains occasional feldspar, clinopyroxene, and hornblende crystals. Lithic clasts are predominantly mafic volcanic rock fragments altered to chlorite, hematite, and calcite. Other lithic fragments include felsic volcanic, plutonic, and metamorphic rocks. Mineral grains are monocrystalline and polycrystalline quartz. An isolated fault-bounded(?) exposure in Broad Pass (Csejtey and others, 1992) in the Healy quadrangle is included here. Lower part of this section consists of cobble to boulder conglomerate that contains clasts of green volcanic rocks and red radiolarian chert. Chert clasts have yielded Permian Radiolaria. Finer grained volcanogenic conglomerate, higher in the section, locally contains abundant *Heterastridium* sp., which indicate a Late Triassic, late Norian age (Csejtey and others, 1992). The uppermost part of the section is massive volcanic sandstone. No Permian source area is known for the chert clasts in this unit. On generalized map, included as part of unit JP̵zc

T̵RPsg **Sadlerochit Group, undivided (Lower Triassic to Permian)**—A “heterogeneous assemblage of rocks that includes orthoquartzite, chert, limestone, sandstone, siltstone, and shale” (Detterman and others, 1975) that has been divided into two formations: an upper Ivishak Formation and a lower Echooka Formation, each of which is subdivided into formal members. Largely restricted to northeast Alaska and in the subsurface of the North Slope, it begins as a regressive sequence sourced from the north (Wilson and others, 2001) and transitions upward from shelf to fluvial deposits. A third formation, stratigraphically in the middle of the group, the Kavik Shale is recognized in the subsurface and is a medium to dark gray silty shale with minor siltstone and sandstone (Jones and Speers, 1976; Crowder, 1990; Wilson and others, 2001). The Kavik Shale of the subsurface is considered equivalent to the Kavik Member of the Ivishak Formation on the surface. The Sadlerochit Group includes the main reservoir rocks for the Prudhoe Bay oil field, which is estimated to hold as much as 25 billion barrels of oil and 46 trillion cubic feet (tcf) of natural gas (British Petroleum, 2013). Unit locally subdivided into the following two units, T̵Rif and Pe

T̵Rif **Ivishak Formation (Lower Triassic)**—Consists of three lithologic units. The uppermost unit, the Fire Creek Siltstone Member, is medium-dark-gray, thin-bedded to massive, commonly laminated siliceous siltstone, minor silty shale, and argillaceous sandstone. The middle unit, the Ledge Sandstone Member, is clean, light-gray, massive sandstone that weathers red to reddish-brown and is locally conglomeratic. The lowermost unit, the Kavik Member, is dark-colored, laminated to thin-bedded silty shale and siltstone that has minor argillaceous sandstone interbeds; some workers (Jones and Speers, 1976; Wilson and others, 2001) consider this a distinct formation in the subsurface as mentioned above. Total thickness of the three members is about 85 m at the type section (Detterman and others, 1975). Crowder (1990) describes the basal Kavik Member as an upward-fining and then coarsening depositional assemblage that records a retrograde then prograde migration of prodelta environments. The overlying Ledge Sandstone Member records the evolution of delta-fringe, distributary-channel, and crevasse-splay environments of the lower delta plain. The uppermost Fire Creek Siltstone Member is an aggradational and transgressive assemblage deposited in shallow-marine environments that reworked sediment originally deposited on the lower delta plain. In the subsurface, the Ivishak Formation is considered of fluvial origin—possibly braided stream deposits on a coastal plain—and becomes finer grained and marine southward (Jones and Speers, 1976; Melvin and Knight, 1984; Tye and others, 1999; Wilson and others, 2001). The Kavik Member contains an ammonite and pelecypod fauna of Early Triassic age; the upper members are more sparsely fossiliferous (Detterman and others, 1975; Reiser and others, 1980). On generalized map, included as part of unit T̵RPsg

Pe **Echooka Formation (Permian)**—Composed of two formal members. The upper Ikiakpaurak Member is red-weathering, resistant, ferruginous orthoquartzite, quartzitic sandstone, and siltstone. According to Detterman and others (1975), “the Ikiakpaurak Member consists mainly of dark highly quartzose sandstone and siltstone with minor interbeds of silty shale. Locally, in the Sadlerochit and Shublik Mountains, well-defined basal channel conglomerates are present. The pebble- to cobble-sized clasts in the channel conglomerate are all well rounded, about 95 percent black chert derived from the underlying cherty limestone of the Lisburne Group." Fossils in the Ikiakpaurak Member define a Guadalupian age for the unit. The lower Joe Creek Member consists of thin- to medium-bedded quartzose calcarenite and biogenetic limestone that includes brachiopod coquinas. This part is underlain by medium- to thick-bedded chert and siliceous siltstone overlying a lowest dusk-yellow, thin-bedded limy mudstone and calcareous siltstone. Fossils of Wolfcampian (Cisuralian) to Guadalupian age, especially brachiopods, are found in unit (Reiser and others, 1980). Thickness is about 110 m to 260 m (Brosgé and others, 1979). Unit contains a prominent interval of light gray-weathering, fossiliferous, crinoidal limestone up to 30 m thick (Detterman and others, 1975); it forms prominent ledges and ridges interbedded with calcareous shale, siltstone, and sandstone (C.G. Mull, personal data, 2011). Late early Permian age for part of Sadlerochit Group is substantiated by brachiopod fauna including *Attenuatella* sp. and *Anidanthus* sp. found in Sagavanirktok quadrangle (Detterman, 1976). This unit overlies the Lisburne Group and was deposited in a shallow marine shelf environment (Crowder, 1990). As shown here, also includes shale and siltstone in the Table Mountain quadrangle that is similar, but in addition to Permian fossils, also contains Pennsylvanian fossils (Brosgé and others, 1976). On generalized map, included as part of unit ŦPsg

## PALEOZOIC TO PROTEROZOIC

Ꝑzls **Limestone and marble (Paleozoic)**—Unit consists of poorly known limestone and associated rocks generally found as lenses accompanying rocks of unit ꝐzꝒrqm in central Alaska, in isolated exposures ranging from the southern Brooks Range to the Kaiyuh Mountains south of the Yukon River. Best described part of unit is "gray to white, partly to wholly recrystallized limestone, marble, dark-gray dolomitic marble, and impure schistose limestone. Unit occurs in layers as much as 25 m thick intercalated with quartz-mica schist, mica schist, graphitic schist, metabasite, and quartzite. Some contacts are gradational; others are sharp and may be faulted. Unit contains conodonts of Middle Ordovician age in the Nulato quadrangle and poorly preserved corals of Ordovician to Late Mississippian age in Ruby quadrangle" (Patton and others, 2009). In the Tanana quadrangle, unit is light- to medium-gray or tan platy limestone and massive-bedded silicified limestone and dolostone and has extensive locally developed boxwork silica and contains sparse conodonts of Famennian age (J.N. Dover, written commun., 1997). In the southeast Circle quadrangle of central Alaska, small bodies of coarse-grained marble are present in the Paleozoic or Precambrian pelitic schist of the region (unit ꝐzꝒyqm)

### Permian to Devonian

Pls **Limestone (Permian)**—Only known exposure is 40 m of thin- to thick-bedded, medium-grained, crystalline, tan to gray limestone that contains thin interbeds of chert, located on a small islet (100 by 200 m) at entrance to Puale Bay on Alaska Peninsula. Hanson (1957) reported age of late mid-Permian (early Guadalupian) for these rocks on the basis of poorly preserved and silicified coral, brachiopod, and foraminifer fossils. No contacts are exposed, although the highly contorted beds dip about 40° NW., which places them structurally beneath Triassic rocks that are located on other islands about 1 km away. On generalized map, included as part of unit Plss

Plps **Pybus Formation and correlative? limestone (Permian)**—Characteristically "light-brownish-gray to white, medium-bedded, fossiliferous, fine- to medium-grained dolomite [dolostone], which contains irregular layers and scattered angular fragments of bluish-white chert. The chert content increases upward and near the top of the formation constitutes as much as 90 percent of the rock" (Lathram and others, 1965). On northern Kuiu and Kupreanof Islands and Admiralty Island, unit consists of medium-bedded dolostone, limestone, and subordinate gray chert beds and nodules (Lathram and others, 1965; Muffler, 1967; and Brew and others, 1984). The Pybus Formation contains very late early Permian conodonts (Premo and others, 2010), Cisuralian (early Permian) brachiopods (Muffler, 1967; Brew and others, 1984), and Guadalupian (middle Permian) conodonts (Karl and others, 1999). In the Glacier Bay area, light- to medium-brownish-gray, fine- to medium-grained crystalline, fossiliferous limestone contains sparse, paper-thin, reddish brown separations and is overlain by nodular, bedded, light-brownish-gray, fine- to medium-grained limestone interbedded with light-greenish-brown chert. The upper limestone and chert varies along strike from an interbedded sequence to apparent limestone-chert conglomerate, which is, in turn, overlain by dark-gray slate, interbedded with very fine-grained and silty calcareous graywacke (Brew and Ford, 1985). On generalized map, included as part of unit Plss

Ph **Halleck Formation and similar sedimentary rock units (Permian)**—Consists of calcareous siltstone and sandstone, silty limestone, and polymictic pebble and cobble conglomerate (Muffler, 1967; Brew and others, 1984) in the Petersburg and Port Alexander quadrangles. Conglomerate contains clasts of chert, volcanic rock, and limestone derived from the underlying Cannery Formation (Brew and others, 1984). In the Skagway quadrangle, unit consists of phyllite, slate, and metagraywacke of the informal Sitth-gha-ee Peak formation of Brew

(Brew and others, 1978, written commun., 1999). Fossils in the Halleck Formation are of Cisuralian (early Permian) age and include early Permian *Parafusulina* and fenestrate bryozoans, brachiopods, rugose corals, and conical *Conichnus*? trace fossils (Muffler, 1967). Brew and Ford (1985) noted that these fossils are similar to those found in the Pybus Formation (unit Plps), also early Permian in age. Overlies Saginaw Bay Formation and is conformably overlain by Pybus Formation. On generalized map, included as part of unit Plss

Pstc **Step Conglomerate (lower Permian)**—Chert-pebble conglomerate that grades upward to light-gray, very fine-grained chert arenite and contains minor bioclastic limestone in lower part of unit (Brabb, 1969; Clough and others, 1995). Conglomerate is clast-supported and chert clasts are subangular to rounded, medium-gray, dark-gray, and black. Clasts include fossil debris (coral, crinoid, brachiopod, pelecypod, and bryozoan) and organic imprints to 8 cm long (Clough and others, 1995). Unit is facies equivalent of Tahkandit Limestone. Western and northern exposures are nonfossiliferous and generally of uncertain age. Thickness about 600 m. Unit originally named and described by Brabb (1969)

Ptl **Tahkandit Limestone (lower Permian)**—Tan to light-gray, fine- to coarse-grained bioclastic limestone that weathers to gray to dark-gray. Locally cryptocrystalline and nonfossiliferous, but generally contains abundant brachiopods, solitary corals, crinoids, and bryozoan fragments (Brabb and Grant, 1971). Unit is a facies equivalent of the Step Conglomerate (unit Pstc). Where interbedded with Step Conglomerate, unit contains abundant rounded chert pebbles (Clough and others, 1995). As shown here, includes gray nodular siltstone and yellow-weathering silty limestone, at least 120 m thick, as mapped by Brosgé and Reiser (1969) in the Coleen quadrangle. On generalized map, included as part of unit Ptl

PDcf **Cannery Formation and Porcupine slate of Redman and others (1985), undivided (Permian to Devonian)**—Cherty graywacke and argillite that contains subordinate conglomerate, limestone, and volcanic rock interbeds; locally metamorphosed to slate, phyllite, marble, greenstone, and hornfels; intensely folded (Loney, 1964; Lathram and others, 1965; Muffler, 1967; Brew and others, 1984; Redman and others, 1985; Karl and others, 2010). Includes the Porcupine slate of Redman and others (1985) and undifferentiated chert, marble, and argillite mapped by Gilbert (1988). Graywacke, tuff, and chert are commonly interbedded, deposited as turbidites. Graywacke beds are up to 5 m thick and dominantly consist of volcanic and calcareous rock fragments. Limestone occurs in beds up to 50 cm thick, and pillow basalt and tuff-breccia horizons are as thick as 100 m. Total thickness of the Cannery Formation is estimated to be greater than 500 m (Karl and others, 2010). Limestone of the Cannery Formation contains Permian bryozoans and crinoids on Admiralty Island (Lathram and others, 1965). Chert contains Mississippian to Permian radiolarians (Karl and others, 2010). On Kupreanof Island, chert and limestone contain Early Pennsylvanian to early Permian radiolarians, early Permian conodonts, and Upper Mississippian conodonts (Karl and others, 1999). Here, also includes calcareous schist and semischist on northwestern Admiralty Island that were previously mapped as part of the Retreat Group by Lathram and others (1965). The Cannery Formation is likely correlative with the Porcupine slate of Redman and others (1985) (unit Pzps). Also included here is a unit of siliceous phyllite and metachert on Admiralty Island of similar age to rocks at the base of the defined Cannery Formation (Karl and others, 2010) of Late Devonian age. Co-author S.M. Karl considers these siliceous phyllites and metacherts to be a separate unit, but we include them here

PPms **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 PPt, 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 Strelna Metamorphics (unit PPsm, here; Nokleberg and others, 1994). Locally mapped as units Peh, Pehls, and PPt, described below; on generalized map, all are included as part of unit TrPms

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

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 Strelna Metamorphics (unit PPsm). 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)

PPt **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 volcaniclastic 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 volcaniclastic 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 volcaniclastic 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 (Ŧn) following more detailed mapping (J.M. Schmidt, written commun., 2007)

Carboniferous to Devonian

Psb **Upper Saginaw Bay Formation and similar rocks of southeast Alaska (Pennsylvanian)**—Unit includes the upper members of the Saginaw Bay Formation, the Ladrones Limestone, and the Klawak Formation. Upper two members of the Saginaw Bay Formation are silty limestone and chert and limestone. Silty limestone is thin- to medium-bedded, medium-gray, brown-weathering limestone that contains variable amounts of terrigenous cherty debris. Light-gray-weathering biotherms are present locally throughout the member, and a conglomerate near the base has chert and limestone cobbles. Worm borings are conspicuous on bedding surfaces (Muffler, 1967). Chert and limestone member is thin- to medium-bedded, light-brown-weathering calcareous chert and subordinate thin-bedded, locally dolomitic, brown-weathering, medium-gray cherty limestone. Ladrones Limestone is massive limestone and minor dolostone that contains oolites and light-gray chert nodules and is more than 300 meters thick (Eberlein and others, 1983). Klawak Formation is 150–300 m of mainly calcareous, orange-weathering sandstone and siltstone that has chert pebbles and nodules and minor limestone and chert pebble conglomerate (Eberlein and others, 1983). Fossils indicate that the chert and limestone member of the Saginaw Bay Formation, at least, was deposited during Middle and Early Pennsylvanian time. Black chert and volcanic rocks at base of Saginaw Bay Formation are included here in unit MDls

PMn **Nuka Formation (Carboniferous)**—Medium-gray, light-gray-weathering, arkosic limestone and sandstone, and interbedded black clay shale. Sandstone is fine- to medium-grained and calcareous, in thickening- and coarsening-upward beds; section has turbidite characteristics with graded beds up to 1 m thick and has convolute bedding and large flute casts at the base of some beds; base of section is dominantly black clay shale. Contains locally abundant glauconite and rare hematite-cemented beds. Depositional thickness is estimated to range from a few meters to as much as 300 m (Dover and others, 2004). Crinoids and brachiopods of Late Mississippian to Early Pennsylvanian age are conspicuous fossils in scattered localities (Mayfield and others, 1987; Mull and others, 1994). Also contains Late Mississippian foraminifers (Sable and others, 1984a, b, c; Mayfield and others, 1987) and Early Pennsylvanian conodonts (Curtis and others, 1984)

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Clg **Lisburne Group, undivided (Carboniferous)**—Carbonate and chert unit widely distributed in northern Alaska. As thick as 1,800 m, chiefly limestone and dolomite, in part cherty, with variable but generally minor amounts of interbedded shale. Exposed throughout the Brooks Range, it is also a well-developed horizon in the subsurface of the North Slope. The Lisburne Group is formally divided into several units. In eastern Alaska, in ascending order, these are the Wachsmuth Limestone, Alapah Limestone, and Wahoo Limestone. In western Alaska, the Lisburne Group includes, in ascending order, the Nasorak and Utukok Formations, Kogruk Formation, and Tupik Formation. Two other formations of the group, the Akmalik Chert and the Kuna Formation, are locally mapped, primarily in the central and western part of northern Alaska. The unit descriptions here, after the Kuna Formation, list the western units first followed by the eastern units of the group. The Lisburne Group is a component of most of the allochthons of the Brooks Range, and its various formations and their facies are important tools used in defining the allochthons. In general, the Mississippian rocks consist of crystalline and hydroclastic limestone, which locally is oolitic and lithographic. The limestone ranges from thin-bedded to massive. The massively bedded limestone is generally lighter in color than the somewhat siliceous blue-gray thin-bedded variety. Chert lenses and nodules, both primary and diagenetic, are common throughout. Phosphate-rich shale and limestone are present in the Lisburne Group, typically in the Tupik, Kuna, or Kogruk Formations or the Alapah Limestone (see Dumoulin and others, 2008, 2011). The entire sequence of rocks in the group has a strong organic odor and is generally fossiliferous. The carbonates of the Lisburne Group represent a variety of marine environments, and the portion of deep-water units increases westward; the eastern third of the Brooks Range exposures are almost entirely shallow water facies (J.A. Dumoulin, oral commun., 2012). In the Philip Smith Mountains quadrangle, the mapped upper part of the Lisburne Group contains Late Mississippian corals and brachiopods, Pennsylvanian brachiopods, and in upper 30m near Galbraith Lake, brachiopods that may be early Permian (Brosgé and others, 1979; although this age assignment is considered unlikely, J.A. Dumoulin, oral commun., 2012). Late Mississippian and Early Pennsylvanian foraminifera are common (Brosgé and others, 1979). In some areas, the Lisburne Group is mapped as informally recognized upper and lower units. Locally subdivided into the following eight formal units: Mlgk, Clgt, Clgk, Mlgac, Mlgnu, IPlgw, Mlga, Mlgw

Mlgk **Kuna Formation (Mississippian)**—Predominantly black siliceous mudstone and sooty, carbonaceous shale, including minor light-gray bioclastic limestone interbeds and concretions. Siliceous beds are rich in sponge spicules and radiolarians. Thin carbonate layers are chiefly dolomitic mudstone and calcified radiolarite. Sedimentological and faunal evidence suggests that the Kuna was deposited in a deep-water setting in which low oxygen conditions prevailed. Maximum thickness about 100 m (Mull and others, 1982). Conodonts from carbonate layers near base of type section in Howard Pass quadrangle are early middle Osagean, or approximately Middle Mississippian (Dover and others, 2004); conodont-bearing layers also contain rare cephalopods of Osagean and Meramecian (approximately Middle Mississippian) age. Siliceous beds in the uppermost Kuna yield radiolarians of Late Mississippian to Early Pennsylvanian age (Mull and Werdon, 1994; Dover and others, 2004). Unit is considered Mississippian, although an early Pennsylvanian age is locally possible for the uppermost beds. Unit is primarily exposed in the western Brooks Range, but as mapped here includes small exposures of similar rocks in northeast Alaska

**Western Brooks Range**

Clgt **Tupik Formation (Pennsylvanian and Upper Mississippian)**—Uppermost formation of the Lisburne Group in northwestern Alaska; consists primarily of interbedded grayish-black chert, dark- to medium-dark-gray carbonate mudstone, and subordinate greenish-black to dark-greenish-gray chert, and very fine to finely crystalline dolomite (Campbell, 1967). Also includes dark-gray to black, micritic, silty, mostly thin-bedded, very finely crystalline to microcrystalline limestone with thin chert interbeds. Sable and Dutro (1961) report a sparse fossil fauna that includes Mississippian sponge spicules and cephalopods and Late Mississippian foraminifers. Upper part of formation is missing at type section. Campbell (1967) geographically extended formation to the Point Hope quadrangle and speculated that the “absence of fauna of Pennsylvanian age contributes to interpretation of disconformity with overlying Siksikpuk; on other hand, no fossils have been found at higher stratigraphic position than about 150 ft [45 m] below top; it is possible that Pennsylvanian Period is represented by rather thin zone of nonfossiliferous rocks.” Unit is 100–200 m thick (Sable and others, 1984a, b, c). Base is gradational with the Kogruk Formation (Curtis and others, 1984; Mayfield and others, 1984; Ellersieck and others, 1984). On generalized map, included as part of unit Clgtk

Clgk **Kogruk Formation (Upper Mississippian)**—Light-gray-weathering limestone and lesser light-brown weathering dolostone that contain less than 25 percent black chert nodules and lenses (Curtis and others, 1984;

Ellersieck and others, 1984; Mayfield and others, 1990). Depositional thickness ranges from about 30 m in the southeastern part of Misheguk Mountain quadrangle to more than 300 m in southwestern part of Misheguk Mountain quadrangle. Base is gradational into the Utukok Formation (unit Mlgnu) (Curtis and others, 1984; Ellersieck and others, 1984). Common and abundant fossils are Late Mississippian corals, crinoids, brachiopods, foraminifers, and conodonts (Sable and Dutro, 1961; Patton and Dutro, 1969, Armstrong and Mamet, 1977, Lane and Ressmeyer, 1985) reflecting shallow-water deposition. Includes deformed and metamorphosed limestone and marble on the Seward Peninsula (Till and others, 2011) and Saint Lawrence Island (Patton and others, 2011) that are thought to correlate with this unit. On the eastern part of Saint Lawrence Island, unit is composed of an upper and lower member. Upper member consists chiefly of light- to medium-gray, coarsely bioclastic limestone that contains interbedded limey mudstone in its upper part. Lower member is composed of dark-gray thin-bedded limestone that contains abundant dark chert nodules. Total thickness of the unit is estimated to be between 400 and 500 m. Unit is metamorphosed to a coarse-grained marble near the contacts with granitic plutons (Patton and others, 2011) on Saint Lawrence Island. On generalized map, included as part of unit Clgtk

Mlgac **Akmalik Chert and other black chert of the Lisburne Group (Mississippian)**—Bedded black chert in beds as much as 10 cm thick, having thin, black siliceous shale partings; locally contains barite deposits and rare interbeds of calcareous radiolarite. In the northwest Howard Pass quadrangle, unit includes abundant interbeds 2–7 cm thick of brownish-black dolostone. These rocks formed in a deep-water, basinal setting. Chert contains abundant radiolarians and lesser sponge spicules. Radiolarians are chiefly Late Mississippian but locally may be as old as late Early Mississippian (Blome and others, 1998; Dover and others, 2004). In the Killik River quadrangle, unit consists of bedded black chert that contains finely disseminated pyrite in beds up to 10 cm thick and has thin siliceous shale partings; contains two laterally persistent thin micritic limestone beds up to 1 m thick near base. Locally includes underlying thin Kayak Shale, which is generally poorly exposed and not mappable at scale of map. Contains Osagean (Middle Mississippian) to Morrowan (lowest Pennsylvanian) or younger conodonts; in Howard Pass quadrangle, contains Osagean conodonts. Thickness about 75 m (Mull and others, 1994). In most areas, units explicitly called the Akmalik Chert are restricted to the Picnic Creek allochthon (see, for example, Mull and Werdon, 1994, or Mull and others, 1994). As shown here, unit also includes small exposures of black chert in the Arctic and Table Mountains quadrangles of northeast Alaska

Mlgnu **Nasorak and Utukok Formations (Mississippian)**—These formations represent the lowest part of the Lisburne Group in northwestern Alaska. The Nasorak is the more western of the two units, which are generally equivalent in age and stratigraphic position. The Nasorak is divided into three members. Upper member of the Nasorak Formation is about 550 m thick and is characterized by rhythmically interbedded thin- to medium-bedded dark-gray limestone and by thin-laminated to very thin-bedded silty calcareous shale. Shale interbeds decrease both in abundance and thickness progressively upward through the member. The Cape Thompson Member, about 70 m thick, is the middle member of the Nasorak Formation and consists of massive light-gray limestone, chiefly a crinoid biosparite that is almost entirely coarse sand- to fine-pebble-sized crinoid stem fragments and columnals. Unit locally contains very minor very fine-grained quartz silt (Campbell, 1967). Lower member consists of 50 m of interbedded dark-gray to grayish-black, locally calcareous, silty clay shale and medium-gray to dark-gray cherty limestone. Dark-gray limestone is predominantly medium-to coarse-grained biomicrite (Campbell, 1967). The Utukok Formation is a buff-weathering limestone and fine-grained, locally calcareous sandstone, locally as thick as 1,400 m in the western De Long Mountains quadrangle and possibly structurally thickened (Sable and others, 1984a, b, c). Elsewhere the Utukok is typically less than 100 m thick and may represent a thin, discontinuous tongue below the Kogruk Formation (unit Clgk), or may have not been deposited locally within this sequence. Base is probably gradational into Devonian limestone (Dover and others, 2004). Upper part contains light-gray, medium-bedded ferruginous sandy limestone, which weathers to a distinct dark-yellowish-brown and yellowish-orange rust color and is commonly blocky-weathering on talus slopes. Lower part contains sandy limestone, calcareous siltstone, shale, and fine-grained sandstone, less resistant to erosion than the Kogruk Formation (unit Clgk) or Baird Group (unit D€bg), thus commonly forms saddles or recessive zones. Contains Late Mississippian foraminifers and conodonts (Dumoulin and others, 2004, 2006); common megafossils are crinoids and brachiopods and locally contains abundant spiriferoid brachiopods, gastropods, pelecypods, cephalopods, trilobites, and crinoidal debris of Early Mississippian age (Sable and others, 1984a, b, c; Mayfield and others, 1987; Dutro, 1987)

**Eastern Brooks Range**

₽lgw **Wahoo Limestone (Middle and Lower Pennsylvanian and Upper Mississippian?)**—Consists of light-colored either coarse-grained or micritic limestone, informally divided into lower and upper members. Thickness ranges from as much as 415 m at type section to 0 m (Brosgé and others, 1962). Also includes oolitic and glauconitic limestone; weathers light-gray and cream colored (Reiser and others, 1971). Unit is uppermost part of the Lisburne Group in eastern Alaska and likely extends into the Yukon where the Lisburne Group adjacent to the Alaska-Yukon border is mapped as an undivided unit; elsewhere in the Yukon, equivalent rocks are mapped as the Ettrain Formation. A Late Mississippian age was reported by Armstrong and Mamet (1977), whereas Dutro (1987) suggested age was Pennsylvanian only. On generalized map, included as part of unit Clgne

Mlga **Alapah Limestone (Upper Mississippian)**—As described by Reiser and others (1971), unit is gray to dark-gray-weathering bioclastic limestone and dolostone and minor black chert. Robinson and others (1989) subdivided unit into two informal parts in the Sadlerochit and Shublik Mountains. The upper member is light- to medium-gray, thin- to medium-bedded limestone and lime mudstone that weathers into small, buff-colored, shard-like irregular pieces. Formation is poorly exposed in Sadlerochit Mountains where it forms distinctive talus aprons below the Wahoo Limestone. In the Shublik Mountains, the upper Alapah is thicker and consists of dark-gray to medium-gray interbedded lime mudstone. At the top of the Alapah is a massive bed of yellow-brown-weathering limestone. Upper unit ranges between 105 and 190 m thick. Lower unit is medium-light-gray to gray and tan, thin- to massive-bedded limestone that consists predominantly of pelletoidal packstone and grainstone that is a distinctive cliff-forming unit below the upper Alapah Limestone. Bedding ranges from less than 1 m to more than 10 m. Locally, massive-bedded pelletoidal grainstone contains large-scale foreset crossbeds that are capped by ferruginous interbeds of hematite-stained sand and shale. Dark-gray to green and red shale is also present locally. Lower unit ranges from 35 to 155 m thick (Robinson and others, 1989) and is mapped only in Mount Michelson quadrangle. On generalized map, included as part of unit Clgne

Mlgw **Wachsmuth Limestone (Mississippian)**—Bioclastic (crinoidal) limestone, dolostone and dolomitic limestone, black nodular chert; lower part contains abundant argillaceous and shaly limestone and minor shale. Differentiated only where mapped by Bowsher and Dutro (1957) in the Philip Smith Mountains quadrangle (Brosgé and others, 1979). The lower part of the Lisburne Group as mapped by Wartes and others (2011) is assigned to this unit in the Mount Michelson quadrangle. Type section about 375 m thick. On generalized map, included as part of unit Clgne

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PDcf **Calico Bluff and Ford Lake Shale, undivided (Lower Pennsylvanian to Devonian)**—Calico Bluff Formation consists of rhythmically interbedded, dark-brownish-gray and brownish-black limestone and shale, and laminated siliceous shale and chert. Its thickness is about 450 m. Ford Lake Shale is "* * * predominantly grayish-black siliceous shale and laminated grayish-black chert. Brownish-black phosphate concretions, some as large as 4 inches (10 cm) in maximum dimension and very pale orange carbonate concretions a few feet (~1 m) in length are common. Several limestone and dolomite beds and lenses occur in the upper part of the formation" (Brabb, 1969). Ford Lake Shale is about 600 m thick and grades upward to Calico Bluff Formation. Calico Bluff Formation is equivalent to Hart River Formation of the Yukon and is Late Mississippian to Early Pennsylvanian in age, whereas Ford Lake Shale is Late Devonian to Late Mississippian in age. Unit is restricted to the Charley River and northeast Eagle quadrangles

Mgq **Globe quartzite of Weber and others (1992) (Mississippian)**—Light-gray, fine- to medium-grained, bimodal to moderately sorted quartzite, weathers light- or medium-gray and iron stained; is dense, vitreous, and contains well-rounded to subrounded monocrystalline quartz grains and scanty chert grains. Age based on lithologic and stratigraphic similarities to Keno Hill Quartzite in Yukon, Canada, and, to a lesser extent, a date on intruding mafic rocks (unit Ŧmi) (Weber and others, 1992; Dover, 1994). Occurs in the Livengood and Tanana quadrangles and is exposed in a thin sliver along one of the splays of the Tintina Fault System and in limited exposures in the Circle quadrangle (F.R. Weber, unpub. data, 1998)

MDip **Iyoukeen and Peratrovich Formations (Mississippian and Devonian)**—Iyoukeen Formation (Loney and others, 1963) consists of three informal members: lower member is 130 m of thin-bedded, dark-gray limestone that contains thin, dark-gray chert innerbeds; middle member is about 200 m of dark-gray, sparsely fossiliferous, partly calcareous shale; upper member is as much as 1,000 m of medium-bedded, dark-gray, fossiliferous limestone that contains dark-gray chert nodules. Fossils indicate shallow, warm, marine environment. Lower and middle members have Early Mississippian conodonts, corals, brachiopods and gastropods, whereas upper member contains conodonts of Late Mississippian age (Karl, 1999). Peratrovich Formation (Eberlein and Churkin, 1970) also has three informal members: lowest member consists of about 60 m of thin-bedded grayish-black chert that contains rare lenses of medium-dark-gray, aphanitic limestone, dolostone, and crinoidal limestone; middle member, about 120 m thick, is mainly medium- to thick-bedded, massive, medium-gray limestone and grayish-black chert nodules and lenses that may form up to 25 percent of the middle member; uppermost member is about 75 to 90 m of thick-bedded massive limestone and minor dolomitic limestone that is as much as 25 percent black chert nodules and lenses. Limestone is composed largely of echinoderm, bryozoan, and foraminiferal fragments and oolites (Churkin and Eberlein, 1975). Peratrovich Formation contains abundant shelly fossils, especially rugose corals (Eberlein and others, 1983), which indicate an age range of Middle to Late Mississippian for the Peratrovich Formation. Unit also includes the black chert and limestone member of the Saginaw Bay Formation, which consists of thin-bedded black chert and minor thin-bedded, dense, dark-gray limestone (Muffler, 1967). Muffler (1967) was uncertain about the nature of the contact between this unit and the other members of the Saginaw Bay Formation because outcrops are poor, and the rocks locally exhibit complex folds. The upper members of the Saginaw Bay Formation are of Pennsylvanian age (unit IPsb), whereas the lower volcanic rocks are of Lower and Middle Devonian age. The age of the black chert is not known directly; volcanic rocks yielded earliest Late to latest Early Devonian conodonts (Dutro and others, 1981; Brew and others, 1984)

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MDe **Endicott Group, undivided (Mississippian to Devonian)**—Clastic sequence that consists of seven formally defined formations. Herein, also includes the informally defined Ulungarat formation of Anderson (1991a) at its base. Typically composed of shale, sandstone, and conglomerate (Tailleur and others, 1967). Extends throughout the Brooks Range and also known in the subsurface of the North Slope. As shown here, represents undifferentiated parts of the Endicott Group. Defined unit age extends into the early Permian, however, Pennsylvanian and Permian rocks of the unit are not exposed at the surface and only known from the subsurface of the North Slope. The Mississippian Itkilyariak Formation of Mull and Mangus (1972) is the uppermost formation of the Endicott Group in Sadlerochit Mountains of the northeast Brooks Range. There it overlies the undivided Kayak Shale and Kekiktuk Conglomerate. The Itkilyariak Formation consists of red and maroon sandstone, conglomerate, breccia, and limestone interbedded with maroon and greenish-gray shale and light-gray quartzitic sandstone about 45 m thick. Extent of unit is not mapped but, according to Mull and Mangus (1972), unconformably overlies undated and unnamed shale and sandstone at its type locality, and, in some areas, overlies—unconformably or gradationally—undivided Kayak and Kekiktuk Formations. The Itkilyariak Formation gradationally underlies the Alapah Limestone (unit Mlga) of the Lisburne Group. Age is Late Mississippian on the basis of biostratigraphic dating of early Late Mississippian fauna. Armstrong and Bird (1976) described the Itkilyariak Formation as part of a transgressive depositional suite of Carboniferous rocks of Arctic Alaska and proposed that redbeds and evaporites in the formation may represent a slowing in rate of transgression, perhaps reflecting local progradation and development of mudflats and (or) change of climate from humid to arid. On the Lisburne Peninsula between Cape Thompson and Cape Dyer, the Endicott Group consists of (ascending) the informal Mississippian Kapaloak sequence (marine and fluvial) and an unnamed Upper Mississippian (marine) shale (Moore and others, 1984)

Mk **Kayak Shale (Mississippian)**—Widely exposed across northern Alaska, the Kayak Shale is commonly the uppermost exposed unit of the Endicott Group. It consists of dark-gray to black fissile clay shale with yellowish-brown-weathering thin fossiliferous limestone beds near top. Commonly contains conspicuous reddish-brown-weathering nodules; lower part contains thin interbeds of gray and brown, irregularly bedded fine- to medium-grained, impure, partly worm-burrowed sandstone near base. Unit disconformably overlies the Kanayut Conglomerate (unit MDegk) in its type area and the central Brooks Range and the Neruokpuk (unit €Pwn) in northeast Alaska. It is complexly deformed by isoclinal folding and shearing; its lower contact is commonly a thrust fault; it acted as a detachment zone for the overlying Lisburne. Thickness is probably more than 500 m (Brosgé and others, 1976, 1979; Mull and others, 1994). Bioclastic limestone beds are generally less than 1.8 m thick and are reddish- and yellowish-brown-weathering fossil hash. Crinoids, brachiopods, bryozoan, and corals are locally abundant (Kelley, 1990a). Siderite concretions are characteristic in places. Locally contains felsic to intermediate intrusive, extrusive, and volcaniclastic rocks (Dover and others, 2004), as well as red- and green-weathering slaty phyllite and argillite and minor semischistose quartz-rich siltstone and marble (Nelson and Grybeck, 1980)

Mek **Kekiktuk Conglomerate (Mississippian)**—Resistant massive quartzite and granule to cobble quartzite and quartz conglomerate; clasts are well-rounded gray chert, quartz, and quartzite (Mayfield and Tailleur, 1978). Quartzite generally light-gray, clean, well-indurated and weathers light-gray; locally iron-stained. Conglomerate is interbedded and lenticular in quartzite beds; clasts of the conglomerate predominantly quartzite and chert. Locally contains anthracite (Reiser and others, 1980). Unit is considered Early Mississippian on the basis of plant fossils and trace fossils *Scalarituba* and *Skolithos* (Nilsen, 1981; Dutro, 1987). In the Ambler River, Survey Pass, and Wiseman quadrangles, consists of conglomerate that contains clasts of quartz, chert, quartzite, slate, and minor thin layers of metasandstone and phyllite (Till and others, 2008a). According to Till and others (2008a), “Quartz and chert clasts are most common; chert clasts are varicolored. The matrix of the conglomerate is composed of quartz, white mica, and chlorite, and clasts are typically stretched. Phyllite may be gray, green, or red.” Unit is typically mapped in the central Brooks Range, but also included here are areas mapped as

Kekiktuk or Kanayut Conglomerate in the Table Mountain and Coleen quadrangles (Brosgé and Reiser, 1969, Brosgé and others, 1976). On generalized map, included as part of unit MDe

Meks **Kapaloak sequence of Moore and others (2002) (Mississippian)**—Consists of interfingering thin- and medium-bedded marine and nonmarine sandstone, siltstone, and shale. Sandstone consists largely of quartz and chert; at base of unit a pebble conglomerate has clasts of chert and locally derived argillite. Upper part of unit is "dark-brown carbonaceous shale and siltstone and interbedded sandstone and local coal" (Moore and others, 2002). Unit contains significant amounts of coal in its upper part and contains plant fossils of Early Mississippian age and marine fossils near top as young as Late Mississippian. On generalized map, included as part of unit MDe

Mes **Kurupa Sandstone (Lower Mississippian)**—Sandstone, light- to medium-gray, in beds up to 1 m thick. Unit contains abundant amalgamated graded beds, abundant flutes and grooves, and well developed Bouma sequences. Sand-sized grains, in declining order of abundance, are quartz, chert, and feldspar. Weathers reddish brown, forms resistant ridges or spurs on valley walls. Well exposed at type locality in Kurupa Hills and in Akmalik Creek in the Killik River quadrangle. Contains abundant plant fossils, particularly near top of formation, and has scattered brachiopods near Otuk Creek in the western Killik River quadrangle. Thickness less than 40 m; grades downward into Hunt Fork Shale (unit Degh; Mull and others, 1994). Unit is primarily mapped in the central Brooks Range. Also included here, on the basis of lithologic similarity, are rocks mapped by Brosgé and others (1979) as the shale and sandstone member of the Kayak Shale in the Philip Smith Mountains quadrangle

MDegk **Kanayut Conglomerate and Noatak Sandstone, undivided (Lower Mississippian and Upper Devonian)**—Kanayut Conglomerate is one of the most widely exposed units of the Endicott Group. Nilsen and Moore (1984) locally divided it into three formal members (in ascending order): the Ear Peak, Shainin Lake, and Stuver Members. It is also commonly mapped as an undivided unit with the Noatak Sandstone. Kanayut Conglomerate has been mapped across the breadth of the Brooks Range, from the east end, by Brosgé and others (1962), to the westernmost Brooks Range, by Nilsen and Moore (1984). Where Kanayut Conglomerate and Noatak Sandstone are mapped undivided, the lower marine part of section corresponds to the Noatak Sandstone and upper parts of section represent the Kanayut Conglomerate. The lowermost member, the Ear Peak, is a sequence of fining-upward fluvial cycles of conglomerate, sandstone, and shale as thick as 1,160 m, deposited by meandering streams. The Shainin Lake Member is a sequence of fining-upward couplets of conglomerate and sandstone as thick as 530 m, deposited by braided streams. The Stuver Member is a sequence of fining-upward fluvial cycles of conglomerate, sandstone, and shale as thick as 1,300 m, deposited by meandering streams. Mull and others (1987b) suggest that the proportion of conglomerate decreases southward in the Kanayut Conglomerate. Metamorphic grade increases towards the metamorphic core of the Brooks Range (Central Belt of Till and others, 2008a). Age control based on plant fossils, largely of Late Devonian age, but including Early Mississippian plants. Noatak Sandstone described below where it is mapped separately

Degn **Noatak Sandstone (Upper Devonian)**—Gray to greenish-gray, medium-bedded quartzose sandstone, generally fine-grained, calcareous, finely micaceous, probably more than 500 m thick; contains abundant yellow-orange limonitic spots and commonly contains conspicuous cross beds and ripple marks; beds are up to 2 m thick and interbedded with gray silty micaceous shale and, locally, with thin silty limestone. Locally contains massive, thick-bedded, white to light-gray-weathering pebble conglomerate, which contains matrix-supported white quartz and black and gray chert pebbles to 2 cm diameter. Unit was mostly deposited on a marine shelf (Mull and others, 1994). Conformably overlies Hunt Fork Shale. Conformably underlies Ear Peak Member of the Kanayut Conglomerate). Thickness ranges from 0 to 560 m. Contains late Late Devonian (middle Famennian) marine megafossils, including brachiopods, gastropods, pelecypods, and echinoderms, and trace fossils such as *Skolithos* (Nilsen and others, 1985). As mapped here, includes a unit informally described as wacke sandstone and quartzite members of the Hunt Fork Shale (Nelson and Grybeck, 1980; Brosgé and others, 1979). This unit is grayish green, brown, and black micaceous manganiferous clay shale and shaly siltstone that contains interbedded thin- to medium-bedded, fine- to medium-grained, limonitic quartzitic quartz-chert wacke that weathers orange and brown; green fine-grained wacke; and minor amounts of gray quartzite and calcareous sandstone. Wacke is composed of fragments of quartz, chert, muscovite and biotite schist, and minor amounts of plagioclase feldspar. Ferruginous lenses contain brachiopod coquina and pebbles of chert and shale and ironstone (Brosgé and others, 1979; Kelley, 1990a). Nelson and Grybeck (1980) reported brachiopods, gastropods, pelecypods, echinoderms, other mollusks, plants, feeding tracks, and trails. Brosgé and others (2000) mapped dark-gray wacke and brown calcareous sandstone containing coquina lenses as part of this unit. As mentioned above, unit is much more widely exposed than shown here because it is commonly mapped as a unit within the Kanayut Conglomerate

Degh **Hunt Fork Shale (Devonian)**—Mostly shale and sandstone; shale is medium-dark- and olive-gray; sandstone is grayish-green and greenish-gray, mostly fine- to medium-grained, micaceous, and locally ripple crossbedded and or graded, widely distributed across northern Alaska. Unit locally subdivided into three informal members: a shale member that consists of mudstone, shale, and sandstone; a wacke member; and a limestone member (Brosgé and others, 2001; Harris and others, 2009). Shale member weathers black to brown; where locally pyritic, weathers rusty and contains a few ironstone concretions. Mudstone and shale are medium- to medium-dark-gray, very silty, fissile, and interbedded with sandstone. Interbedded sandstone is as much as 25 percent brown-weathering, thin-bedded, fine-grained, partly calcareous sandstone and graywacke that includes both quartz-chert arenite and quartz-chert wacke; sandstone is schistose in southern part of its exposure area, and has minor thin beds of ferruginous, argillaceous, fossiliferous limestone. Unit displays a cyclic depositional pattern with siltstone grading upward into shale; limestone occurs in upper parts of some cycles (Brosgé and others, 1979; Kelley, 1990a). Wacke member is included here with the Noatak Sandstone, unit Degn. Informal dark-gray limestone member weathers yellow, brown, and gray and is thin- to medium-bedded or nodular and has common algal lumps. Commonly includes some orange-weathering, partly calcareous siltstone and fine-grained sandstone above or below the limestone. Unit is metamorphosed in core of Brooks Range and, where found, thrust imbricated in the Doonerak Window. Where metamorphosed, it consists of dark-gray to black phyllite and lesser gray-green phyllite with thin layers of siliceous or calcareous metasiltstone, lithic wacke, metasandstone, and minor layers of fossiliferous metalimestone. Locally massive mafic sills and dikes up to 10 m thick are common. Mafic bodies in the unit (both strongly and weakly foliated parts) display lower greenschist-facies minerals (Till and others, 2008a). Fossils include brachiopods (late Frasnian to early Famennian), mollusks, echinoderms, and Middle to Late Devonian conodonts (Brosgé and others, 1979; Till and others, 2008a)

Du **Mangaqtaaq formation of Anderson and Watts (1992) and Ulungarat formation of Anderson (1993) (Upper Devonian)**—These units are considered the base of the Ellesmerian sequence; however, it is not clear if they belong to the Endicott Group or represent a precursor. The Mangaqtaaq formation of Anderson and Watts (1992) is interpreted as a restricted marine or lacustrine limestone. Anderson and Watts (1992) described it as consisting of as much as 200 m of black algal limestone, sandstone, and interbedded mudstone, where the lower 80 to 100 m consists of cyclic repetitions of 3- to 10-m-thick intervals of interbedded algal limestone and sandstone with thin intervals of black mudstone; the upper part of the unit is rhythmically interlaminated black mudstone and siltstone. Anderson (1991b) described the unit in the Demarcation Point quadrangle; Reiser and others (1971) describe a roughly similar unit in the Mount Michelson quadrangle to the west, where it is mapped underlying the Kayak Shale (unit Mk) and reported as pre-Mississippian. The Mangaqtaaq overlies the Ulungarat formation of Anderson (1991a) at a sharp contact interpreted by Anderson to be an unconformity and it is, in turn, unconformably overlain by the Kekiktuk Conglomerate (Mek). Age is poorly constrained as Late Devonian or Early Mississippian (Anderson, 1991b) on the basis of plant fossils in its lower part. The Ulungarat formation of Anderson (1991a) consists of a coarsening- and thickening-upward, shallow-marine to nonmarine fluvial sequence, not unlike some other formations of the Endicott Group, in particular, the Ear Peak Member of the Kanayut Conglomerate. As redefined by Anderson (1993), the unit has four informal members. The lowermost, unit A, is marine, green-gray-weathering mudstone and black phyllite that gradually contains an upward-increasing proportion of chert arenite and calcarenite sandstone that contains variable amounts of shallow-marine invertebrate skeletal material. The second member, unit B, consists of "* * * chert granule to pebble conglomerate, chert arenite, and siltstone in channelized fining-upward intervals in an overall coarsening-upward sequence" (Anderson, 1993). The third member, unit C, a cliff-former, consists of poorly sorted, clast-supported chert pebble to cobble conglomerate in thick channel-fill deposits (Anderson, 1993). "Brown-red mudstone and interbedded thin sandstone beds underlie, are lateral to, and overlie the cliff-forming conglomerates" (Anderson, 1993). The uppermost member consists of mottled red mudstone that has sparse, laterally discontinuous sandstone lenses. The lowest member contains abundant Middle Devonian marine invertebrate fossils, whereas the upper nonmarine members contain undated plant fossils, whose age is only constrained by the overlying, unconformable Mississippian Kekiktuk Conglomerate. As much of the mapping of the eastern Brooks Range predates the definition of this unit, it is possible that this unit is potentially equivalent to the lower member of the Kanayut Conglomerate as mapped in the Arctic and Killik River quadrangles. On generalized map, included as part of unit MDe

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Devonian to Neoproterozoic

Pzcu **Black chert (lower Paleozoic, Devonian or older)**—Predominantly black and gray chert, but also includes rare white, buff, red, or green bedded to massive chert. Occasionally vitreous, banded, or fractured. Interbedded or structurally interleaved with minor amounts of limestone, amygdaloidal basalt, and thin intervals of pitted calcareous graywacke. Occurs in the southwest corner of the Taylor Mountains quadrangle and northwest corner of Dillingham quadrangle (Wilson and others, 2006a, in press [a]). This map unit is distinguished from the rainbow chert of this map (unit Crc) by the dominance of black and gray chert and, based on field notes of J.M. Hoare and W.H. Condon, the uncommon red and green chert, which is much more common in the rainbow chert unit. Hoare and Jones (1981) reported lower Paleozoic (Devonian? and pre-Devonian) and Paleozoic(?) radiolarians in the area shown for this unit as well as Permian megafossils. The limited geologic information provided in Hoare and Jones (1981) does not indicate the nature of the occurrence of the Permian fossils, and we suggest that these locations may be due to inclusion of fault-bounded blocks or slivers of the mélange (unit KMmu) or units KMt and Pcs that cannot be resolved with the available map data. Based on lithology and crude age, the black chert may correlate with the Ordovician chert and phyllite of the Medfra quadrangle (unit Oc; Patton and others, 2009)

Dbf **Beaucoup Formation, undivided (Devonian)**—Heterogeneous unit that consists of carbonaceous, siliceous, and calcareous sedimentary rocks and felsic volcanic rocks broadly distributed across the Brooks Range and especially in Central Belt of Till and others (2008a). The name Beaucoup Formation has come to include many rocks of the Brooks Range stratigraphically below the Hunt Fork Shale (unit Degh) and above the loosely defined Skajit Limestone (here mapped as parts of unit P̶zm and O€ls). Multiple map units of Till and others (2008a) have been assigned to the Beaucoup Formation here. Till and others (2008a) divided their unit Pzw into northern and southern parts whose outcrops straddle the northern part of the Wiseman-Chandalar quadrangle boundary. "The northern belt is composed of metasandstone and argillite; in its eastern part, metasandstone contains abundant detrital white mica that yielded a Late Ordovician $^{40}Ar/^{39}Ar$ cooling age (Moore and others, 1997a). The northern belt is equivalent to the Trembley Creek phyllite of Moore and others (1997b), and Rocks of Whiteface Mountain of Dillon and others (1986). The southern belt * * * is composed of phyllite, metasandstone with volcanic clasts, argillite, sandstone, pebble conglomerate and rare marble" (Till and others, 2008a). This division into two parts or belts cannot be extended throughout the Brooks Range. "In the northeast Baird Mountains quadrangle, laminated to massive porphyritic rhyolite plugs, flows, and pyroclastic rocks are closely associated with siliceous and calcareous sedimentary rocks (Karl and others, 1989a). Along the northern part of the boundary between the Wiseman and Chandalar quadrangles, felsic to intermediate porphyries, metavolcaniclastic rocks, and rare massive hypabyssal rocks are associated with purple and green phyllite, lithic, quartz, feldspar metasandstone, and meta-argillite pebble conglomerate (Moore and others, 1997b). Elsewhere, volcanic-clast sandstone and conglomerate, feldspathic volcanic wacke or graywacke, and tuffaceous metalimestone occur with other sedimentary rocks of the unit" (Till and others, 2008a). Unit also includes "phyllite, carbonate, and clastic rocks of the Nakolik River, undivided" of Karl and others (1989a). Megafossils and conodonts collected from calcareous black phyllite and metalimestone interlayered with purple and green phyllite in the Chandalar quadrangle are Middle and early Late Devonian in age (Dumoulin and Harris, 1994); Middle and Late Devonian conodonts were recovered from the unit in the northwest Wiseman quadrangle (Till and others, 2008a, table A-1). A foliated felsic metavolcaniclastic rock collected in the northwestern Chandalar quadrangle yielded a U/Pb zircon crystallization age of 393±2 Ma (Aleinikoff and others, 1993, cited in Till and others, 2008a). This unit records the transition from early Paleozoic platform carbonate sedimentation to voluminous, widespread clastic sedimentation represented by rocks of the Endicott Group (Till and others, 2008a). Some rocks that should be assigned to this map unit are likely included in the metamorphosed part of the Hunt Fork Shale in the Chandalar quadrangle and elsewhere. Unit subdivided into the following two units, Dbfl and Dbfw, which, on the generalized map, are included as part of unit Dbf

Dbfl **Limestone and similar rocks (Upper and Middle Devonian)**—Light- and dark-gray limestone and dolostone, locally cherty; weathers to gray, orange, or brown (Mayfield and Tailleur, 1978; Nelson and Grybeck, 1980; Brosgé and Reiser, 2000; Dover and others, 2004). As mapped, unit includes the limestone of Nakolik River of Karl and others (1989a), which consists of fossiliferous metalimestone and marble and subordinate quartz-carbonate metasandstone, metasiltstone, and phyllite. Descriptions vary, but unit is locally distinguished from Lisburne Group by lack of chert. Adjacent to the Arrigetch pluton in the Survey Pass quadrangle, unit contains calc-silicate skarn (Nelson and Grybeck, 1980). Megafossils are locally abundant and include brachiopods, corals, pelmatozoans, and stromatoporoids. Megafossils and conodonts, where most precisely dated, are of Middle and early Late Devonian age (Dover and others, 2004)

Dbfw **Wacke member (Upper Devonian)**—Gray and green, thin-bedded wacke, brown and gray sandstone and quartzite, siltstone, shale, and calcareous sandstone and shale. Contains coquina lenses (Brosgé and others, 2000). Apparently contains less green shale and siltstone, and more calcareous sandstone, than wacke member of Hunt Fork Shale (unit Degh) (Brosgé and others, 1979). Contains Late Devonian (Frasnian) brachiopods, pelecypods, crinoids, and corals (Brosgé and others, 1979; 2001). Includes wacke member of Rocks of Whiteface Mountain of Dillon and others (1986), which consist of fine-grained wacke, graywacke, calcareous shale-chip and granule conglomerate with some volcanic clasts, and thin fossiliferous limestone

**Sedimentary rocks of the Yukon Flats Basin (Devonian and older)**—These rocks, primarily exposed in the Beaver and Christian quadrangles, have, in the past, been assigned to a variety of geologic units, including the Slate Creek terrane (Moore and others, 1994) and the Angayucham-Tozitna terrane (Patton and others, 1994a), as well as part to the Hunt Fork Shale of Venetie terrane (Brosgé and Reiser, 2000). The coarser clastic rocks bear some similarity to the lower part of the Kanayut Conglomerate (unit MDegk) and the Nation River Formation (unit Dnr) of the eastern Yukon Flats basin and possibly the Ulungarat formation of Anderson (1991a) (unit Du, here). Subdivided below:

Dnr **Nation River Formation (Upper and Middle? Devonian)**—Commonly graded, rhythmically interbedded mudstone, sandstone, gritstone, and conglomerate. Mudstone is olive-gray and nearly everywhere contains plant fragments and spores of Late Devonian age. Sandstone is olive-gray chert arenite and wacke, commonly with carbonate cement. Gritstone and conglomerate are mostly composed of varicolored chert granules and pebbles. Total thickness ranges from approximately 650 to 1,300 m (Brabb and Churkin, 1969). According to Clough and others (1995), in the northern part of the Charley River quadrangle, the Nation River Formation is yellow-brown to light-brownish to medium-gray chert arenite sandstone and chert pebble to cobble conglomerate. Conglomerate is clast-supported, contains rounded to subangular clasts, and has gray, dark-gray, and black chert in a quartz and chert sand-size matrix; locally white-weathering tripolitic chert clasts are common. Nation River conglomerate is less sorted, has more rounded clasts, more chert clasts, is more siliceous, and is more clast-supported than Step Conglomerate (unit Pstc). Dover and Miyaoka (1988) mapped a large expanse of the western Charley River quadrangle as conglomerate of the Nation River Formation, whereas Brabb and Churkin (1969) considered these rocks to more likely be the Permian Step Conglomerate (Pstc), which is how they are shown here. On generalized map, included as part of unit DZyf

Dcr **Cascaden Ridge and Beaver Bend combined correlative units (Devonian)**—Cascaden Ridge unit of Weber and others (1992) is chiefly rhythmically interbedded gray and olive-gray shale, gray siltstone, and graywacke exposed in Livengood quadrangle. Less abundant components are gray limestone and polymictic granule- and pebble-conglomerate that has a graywacke matrix. Conglomerate clasts include mafic and ultramafic rocks, chert, dolomite, and shale (Weber and others, 1992). Limestone interbeds contain Middle Devonian gastropods, conodonts, brachiopods, and corals (Blodgett, 1992; Weber and others, 1992). Beaver Bend unit of Weber and others (1992) is conglomerate, graywacke, siltstone, and slate in the Livengood quadrangle. Conglomerate is polymictic, clast-supported granule- to pebble-sized and has clasts that include chert, quartz, quartzite, mafic and felsic volcanic rocks, argillite, slate, siltstone, and sandstone. Graywacke is fine- to medium-grained; framework grains are mostly chert and quartz, and subordinate slate. The Beaver Bend unit has yielded unidentifiable plant fragments; it was assigned a probable Devonian age by Weber and others (1992). In the western Circle quadrangle, nonfossiliferous chert-pebble conglomerate that was mapped as part of the MzPzat unit by Foster and others (1983) was considered to be equivalent to the Beaver Bend unit of Weber and others (1992) (F.R. Weber, unpub. data, cited in Wilson and others, 1998). In the north-central Circle quadrangle, north of the Tintina Fault, two units mapped by Foster and others (1983) are included here: unit Pzcg, chert-pebble conglomerate; and unit Pzcc, chert, chert-pebble conglomerate, and minor limestone. Limestone of unit Pzcc yielded Late Devonian (Famennian) conodonts. On generalized map, included as part of unit DZyf

Dq **Quail unit of Weber and others (1992) (Upper Devonian)**—Gray and green phyllite interlaminated with calcareous siltstone, quartzose sandstone, graywacke, and granule- to boulder conglomerate exposed in the Livengood quadrangle was described as the Quail unit by Weber and others (1992). Clasts in conglomerate include chert, dolostone, serpentinite, intermediate and mafic igneous rocks, quartzite, argillite, phyllite, slate, volcanic rocks, sandstone, and white quartz. At base are localized carbonate buildups of coral-bearing lime mudstone and wackestone of Late Devonian (Frasnian) age (Weber and others, 1992). Unit also includes light- and medium-gray to silvery gray phyllite, slate, siliceous siltstone, and argillite and also includes some thin limestone and calcareous siltstone (Chapman and others, 1975; Wilson and others, 1998). The Quail unit is slightly higher in metamorphic grade than the age- and lithologically similar Cascaden Ridge unit of Weber and others (1992), mapped here as part of unit Dcr. Weber and others (1992) correlated the Quail unit with the Nation River Formation (Dnr) of the Charley River quadrangle (Brabb and Churkin, 1969); they believed it to be offset from the Nation River area by the Tinitna Fault System. However, the Quail unit and the Nation River Formation are somewhat different lithologically and in metamorphic grade, though they do correlate in age (R.B. Blodgett, oral commun., 2012). On generalized map, included as part of unit DZyf

Dyp **Phyllite, slate, and black shale (Devonian?)**—Dark-gray to black phyllite and schistose siltstone interbedded with subordinate amounts of quartz wacke and sheared slate- and chert-pebble conglomerate (Brosgé and others, 1973; Brosgé and Reiser, 2000) in northeast Alaska. In the Coleen quadrangle, unit consists of laminated dark-gray, light-gray, and greenish-gray clay and silt phyllite; minor very fine-grained, thin-bedded sandstone

(Brosgé and Reiser, 1969). In the Christian quadrangle, Brosgé and Reiser (2000) subdivided the unit along the East Fork of the Chandalar River; on the east the unit contains more siltstone, is darker-colored, and locally recrystallized. Brosgé and Reiser (2000) assigned the entire unit to the Venetie terrane in the Christian quadrangle, whereas Moore and others (1994) assigned the unit to the slate- and graywacke-bearing Slate Creek terrane of the southern Brooks Range. The rocks in the Beaver quadrangle were assigned to the Slate Creek thrust sheet of the Angayucham-Tozitna terrane by Patton and others (1994a). As shown here, all of the rock units assigned to this map unit are spatially associated with the Angayucham, Tozitna, and Innoko assemblages and Rampart Group units of this map. On generalized map, included as part of unit DZyf

Dyss **Clastic and calcareous clastic rocks (Devonian)**—Lithic- and quartz-rich clastic sedimentary and low-grade metamorphic rocks found along the northwest and northern margin of the Yukon Flats basin. Brosgé and others (1973) and Brosgé and Reiser (2000) report gray-green, brown-weathering, fine- to medium-grained, thin- to medium-bedded lithic wacke interbedded with lesser amounts of gray and brown quartz wacke and black micaceous shale and silty shale. Faintly schistose in many exposures, weathers brown to rusty. “Rare gritty beds contain chips of shale. The quartz wacke is also fine- to medium-grained and thin- to medium-bedded. Black shale occurs in thin partings and in beds as much as 25 to 50 feet thick (8 to 15 m) that may form 30 to 50 percent of the unit. The total thickness of the unit is uncertain, but is probably about 4,000 feet (1200 m) * * *. Graywacke and shale on the upper Christian River contains Devonian plants and spores” (Brosgé and Reiser, 2000). Brosgé and Reiser (2000) also describe a schistose wacke unit, which they suggest is probably a “slightly more metamorphosed facies” of their wacke and quartzite and slate units. Till and others (2006a) assigned these rocks to the Brooks Range phyllite and graywacke belt, the so-called Slate Creek terrane. However, just across the Yukon Flats basin to the east is the Nation River Formation (unit Dnr), which has some lithologic and age similarity with these rocks. On generalized map, included as part of unit DZyf

Pzpr **Older clastic strata of the Porcupine River sequence of Brosgé and Reiser (1969) (lower Paleozoic)**—Light-gray, fine-grained orthoquartzite, pyritic laminated quartzite, quartz-rich siltstone, and olive micaceous shale at least 600 m thick. Also includes brown-weathering, dark-gray, silty micaceous shale and fine-grained, thin-bedded, pale yellow ferruginous sandstone, which are in an uncertain stratigraphic position relative to the quartzite. Unit is highly sheared along the Coleen River (Brosgé and Reiser, 1969). Similar quartzite, calcareous slate, argillite, and phyllite were mapped as part of the Strangle Woman Creek sequence, which is included here as part of units ЄPwn and Dyp. No precise age control exists for these rocks, but they are spatially associated with carbonate rocks of Devonian and older age (unit DЄkb). On generalized map, included as part of unit DZyf

DZkb **Older carbonate strata of the Porcupine River sequence of Brosgé and Reiser (1969) and equivalent units (Middle Devonian to Neoproterozoic?)**—Poorly known unit that consists of a thick sequence of limestone and dolostone and minor calcareous shale and black chert, located largely on the northeast side of the Yukon Flats basin. The only formally defined unit of the sequence is the Salmontrout Limestone (Churkin and Brabb, 1965; Oliver and others, 1975), a dark-gray, massive, biohermal limestone of Early or Middle Devonian age that is about 600 ft thick. Brosgé and Reiser (1969) also included several other carbonate rock units in the Porcupine River sequence, which cover much of the southern part of the Coleen quadrangle and which likely extend into the northern Black River quadrangle. These consist of their unit Dd, about 300 m of dark-gray, fine- to medium-grained dolostone that contains minor black chert; light-gray limey dolostone and limestone; and yellow and gray very fine-grained laminated dolostone and chert that contains minor red and green shale and sandstone; as well as their unit SOCl, which is an interbedded gray, laminated-to-mottled limey dolostone and dark gray dolostone that contains minor black chert, light gray coarse-grained dolostone, and light- to dark-gray calcilutite. This subunit, SOCl, which includes light-gray coral and limestone cobble conglomerate, is at least 600 m thick and includes Silurian and Ordovician corals and snails and Cambrian(?) trilobites. Gray, foliated, thin-bedded, platy, and recrystallized micritic limestone of early(?) Paleozoic age in the Table Mountain quadrangle (C.G. Mull, written commun., 2012) was suggested by Mull to possibly be equivalent to the Ogilvie Formation of the adjacent Yukon (which is mapped here as unit Dof), but seems a better fit here. Other map units included here are (1) unit Pzl of Brosgé and Reiser (1969), which consists about 120 m of black silty calcareous shale, black fine-grained, thin-bedded limestone, and brown siltstone which contain siltstone concretions and nodular cherty dolostone; (2) unit DCl of Brabb (1970) that consists mainly of massive limestone and dolostone several thousand feet thick, minor red and green argillite, and black chert that includes a few hundred feet of quartzite along Lower Ramparts of Porcupine River; and (3) units Dl and Sl of Brabb (1970), which are medium-gray to grayish-black, fine- to coarse-grained, locally dolomitic, crinoidal limestone. The Amy Creek unit of Weber and others (1992) is tentatively included here, but it also bears some affinity with units on this map such as the Jones Ridge Limestone (OЄjr) and possibly the Nanook Limestone (included in unit DZnl) and Katakturuk Dolomite (Pls) of northern Alaska. As defined by Weber and others (1992), the Amy Creek unit of inferred Silurian to Proterozoic age consists of light- to medium-gray, medium-grained; mudstone, wackestone, and packstone that all contain interbedded chert; black carbonaceous argillite; and dolostone. The Amy Creek unit contains interbedded and interlayered minor lime mudstone, light- and dark-gray chert, gray marble, gray, fine-grained quartzite, basaltic greenstone, lenses of tuff, tuffaceous siltstone, shale, and minor volcaniclastic graywacke. Basaltic flows and flow breccia at least 100 m thick occur locally in shaly rocks. Lithology and algae strongly resemble Proterozoic or early Paleozoic dolostone of the western part of the Charley River quadrangle. In the Circle quadrangle (Foster and others, 1983), the igneous part of the unit consists of dark-greenish- or bluish-gray, medium-fine-grained calcareous basalt that locally has well-developed pillows. Thin limestone layers at the base of the basalt. Upper units in basalt are amygdaloidal, overlain by greenish-brown breccia of calcareous basalt that has an opaline matrix. Black, moderately coarsely crystalline limestone overlies basaltic portion of unit. Much of this unit corresponds to unit DCpu of Till and others (2006a), who stated that "lithofacies and faunal data suggest that most of DCpu formed in a relatively shallow-water shelf or platform setting, but upper Silurian and Lower Devonian graptolitic shale, limestone, and chert in the Porcupine River area (Churkin and Brabb, 1967; Coleman, 1987) accumulated in a slope or basin environment and may correlate with the Road River Formation (Churkin and Brabb, 1965; Brabb and Churkin, 1969), which is included in unit DOka in the southern part of the province. Conodonts and megafossils in DCpu have chiefly Laurentian (North American) affinities (Oliver and others, 1975; Rohr and Blodgett, 1994; Dumoulin and others, 2002; Blodgett and others, 2002)." On generalized map, included as part of unit DZyf

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**White Mountain sequence of Decker and others (1994) (Devonian to Proterozoic)**—Consists of the geologic units originally assigned to the Nixon Fork and Dillinger terranes of southwest Alaska. The rocks of these terranes were reassigned to the Farewell terrane and the units of the former two terranes recognized as the platform and basinal facies, respectively, of a common continental margin sequence (Decker and others, 1994). Subdivided below into a basinal facies (unit D€d and subunits DSbr, DSpf, Stc, and S€pl) and a platform facies (unit D€wp and subunits DSwc, Ols, and €Zls)

D€d **White Mountain sequence, basinal facies (Devonian to Cambrian or older)**—Finely laminated limestone and dolomitic limestone and subordinate chert and siliceous siltstone indicative of deep-water deposition. Rocks included here were originally considered part of the now-abandoned Holitna Group and later were assigned to the Dillinger terrane, now considered the basinal facies of the White Mountain sequence of the Farewell terrane (Decker and others, 1994). They were originally assigned an Ordovician to Devonian age on the basis of a sparse conodont fauna (Dutro and Patton, 1982). More recent work, however, indicates that the unit also contains conodonts of Cambrian age (Dumoulin and others, 1997). Includes East Fork Hills, Post River, and Lyman Hills Formations, Terra Cotta Mountains Sandstone, and Barren Ridge Limestone, all interpreted as slope or basinal deposits (Patton and others, 2009). Includes lime-rich sedimentary rocks in unit Pzd of Reed and Nelson (1980) in the Talkeetna quadrangle; unit Pzs of Gamble and others (2013) in eastern Lime Hills quadrangle; and unit Pzdu of Bundtzen (written commun., 1998) in western Lime Hills quadrangle. In the northwestern Denali quadrangle, includes chert and slate that yielded Ordovician graptolites, and, in the southern Denali quadrangle, quartz-rich turbiditic sandstones and minor interbedded limestone yielded early Silurian (Llandovery) conodonts (Dumoulin and others, 1998), and quartzite that yielded Silurian to Devonian corals (William Oliver, written commun., 1997). On generalized map, included as part of unit D€wbl. Where subdivided, includes the following units, DSbr, DSpf, Stc, and S€pl:

DSbr **Barren Ridge Limestone and correlative units (Devonian to Silurian?)**—As defined by Churkin and Carter (1996), unit consists of "* * * two more-or-less pure limestone members separated by a siltstone member of calcareous siltstone and sandy limestone." Lower limestone is medium-dark-gray, medium-gray-weathering, well-bedded, thick- to thin-bedded, and has orange-weathering silty beds in upper half of member that form less than 50 percent of section, which is about 100 m thick. Siltstone member is about 200 m thick and is composed of very thin-bedded, cross-laminated, yellowish-orange-weathering, silty and sandy limestone and calcareous siltstone, which contain occasional 3-m-thick pure limestone interbeds and rare argillaceous beds. Uppermost member is massive, indistinctly bedded to laminated, medium-dark-gray, finely crystalline limestone more than 100 m thick and contains minor lighter gray dolostone (Churkin and Carter, 1996). Unit is known from the McGrath quadrangle and correlative rocks are found in the Lime Hills quadrangle; the unit undoubtedly extends into the Talkeetna quadrangle, where is it included in unit D€d. Bundtzen and others (1997a) reported late Silurian to Late Devonian conodonts from unit, based on a report in Bundtzen and others (1994) where the reported conodont has an age range of middle Silurian to Early Devonian. Churkin and Carter (1996) interpreted the lower contact of the Barren Ridge Limestone with the underlying Terra Cotta Sandstone as a thrust fault and noted that rocks of latest Silurian age are not present. On generalized map, included as part of unit D€wbl

DSpf **Paradise Fork Formation and correlative units (Lower Devonian and Silurian)**—"Deep-water turbiditic and hemipelagic deposits of dark, thin-bedded, fissile to laminated limestone, limy shale, and siltstone. The formation has an abundant graptolite, conodont, and ostracode fauna. It was originally assigned an Early to Late Silurian age by Dutro and Patton (1982), but subsequent investigations by Dumoulin and others (1997) indicate that it ranges from Silurian to Early Devonian" (Patton and others, 2009). The type area of the Paradise Fork Formation is in the Medfra quadrangle, and similar rocks are present in the Taylor Mountains quadrangle (Blodgett and Wilson, 2001) and in the Lime Hills, Talkeetna, and McGrath quadrangles (Wilson and others, 1998). In the Taylor Mountains quadrangle, unit is primarily thin- to medium-bedded, laminated, dark-gray to dark-brown, platy lime mudstone, and has a strong petroliferous odor (Blodgett and Wilson, 2001). Coarse-grained limestone debris-flow deposits that have clasts of algal boundstone reef material are common in uppermost part of the unit (Blodgett and Wilson, 2001). In the Talkeetna quadrangle, unit includes Silurian limestone mapped by Reed and Nelson (1980) that consists of light-gray to light-brown, massive-weathering metalimestone and local thin-bedded to laminated limestone. On generalized map, included as part of unit D€wbl

Stc **Terra Cotta Mountains Sandstone (Silurian)**—Mainly composed of sandstone and mudstone and divided into three prominent limestone members. Best described by Churkin and Carter (1996), the Terra Cotta Mountains Sandstone is distinguished from other formations in the area by abundant rhythmically interbedded sandstone and mudstone; more than three-quarters of its total thickness consists of calcareous sandstone interbedded with mudstone. In addition, the formation contains three mappable limestone members (although they are not distinguished here). Stratigraphically lowest part of unit is approximately 90 to 120 m of thick-bedded and massive sandstone that has subordinate argillite or mudstone interbeds. Overlying this part of the unit is a medium-dark-gray, thick-bedded, and relatively pure limestone about 45 to 60 m thick; locally has very pale brown mottling. Most of the limestone is massive or blocky, but its basal part is laminated and platy. No megafossils have been found in it. A second sandstone interval, 150 m thick, is interbedded with cross-laminated mudstone and argillic shale and is overlain by the middle limestone member, a dark-gray, generally thin-bedded, platy, laminated limestone usually about 35 m thick, but as much 60 m thick. The laminations in the limestone are accentuated by silt, mica, and argillaceous impurities. In contrast to other limestone of the Terra Cotta Mountains Sandstone, the middle limestone member contains shelly fossils at several localities. These fossils include pelecypods and straight-shelled cephalopods that are so poorly preserved that they have not been identified by genus or age (Churkin and Carter, 1996). Churkin and Carter (1996) indicate that, because of structural complications, the middle limestone member may be a repetition of the lower limestone member. Overlying the middle limestone is another interval of sandstone, siltstone and argillite as thick as 90 m that contains, near its base, a distinctive knobby limestone section 7.5 to 15 m thick (Churkin and Carter, 1996). The third, or upper, limestone member is medium-dark-gray, weathers medium-gray, is generally thick-bedded and massive, and is as thick as 120 m. Locally, where thinner bedded and evenly laminated, the limestone is slabby weathering. This upper limestone member contains dome-shaped structures that may represent stromatolites. Otherwise no fossils were noted (Churkin and Carter, 1996). Stratigraphically highest is a 90- to 150-m-thick calcareous siltstone and sandstone interval that appears to be a finer grained equivalent of the basal, more sandstone-rich lowest interval. Shale beds with phyllitic partings are common, as are slabby weathering argillaceous and silty limestone beds. Sedimentary structures such as graded bedding, flute casts, and cross-lamination indicate that the Terra Cotta Mountains Sandstone was deposited by turbidity currents in a deep marine setting (Churkin and Carter, 1996; Wilson and others, 1998). On generalized map, included as part of unit S€wbc

S€pl **Post River Formation and correlative units (middle Silurian, Wenlock, to Upper Cambrian)**—Best described by Churkin and Carter (1996), the Post River Formation consists mainly of fissile shale, mudstone, and silty and argillaceous limestone divided into five members. At the base is (1) a lower siltstone member, as thick as 300 m, characterized by thin beds of cross-laminated calcareous siltstone and argillaceous limestone rhythmically interbedded with shale and argillite. Above this is (2) a relatively noncalcareous mudstone member, at least 75 m thick, overlain by (3) another calcareous siltstone and argillaceous interval only 30 m thick that is thinner than, but otherwise closely lithologically resembles, the lower siltstone member. Overlying these is (4) the formally defined, 220-m-thick Graptolite Canyon Member, a nearly pure, dark-gray shale and siliceous shale that contains abundant graptolites and forms most of the upper two-thirds of the formation. The uppermost part of the Post River Formation is (5) the limestone member, a dark, laminated limestone, probably not much more than 18 m thick, interbedded with thin beds of black graptolitic shale (Churkin and Carter, 1996). Age control from graptolites indicates that most of the Ordovician and early Silurian is represented. The Lyman Hills formation of Bundtzen and others (1997a), equivalent to the lower siltstone of the Post River Formation as defined by Churkin and Carter (1996), consists of silty limestone and shale, is commonly cross-laminated, and locally contains Bouma 'cde' intervals. Age of the Lyman Hills formation of Bundtzen and others (1997a) is constrained by uppermost Cambrian conodonts and Ordovician and Silurian graptolites.

Exposed primarily in the Lime Hills and McGrath quadrangles, unit likely extends into Talkeetna quadrangle where it is mapped as part of undivided unit D€d. On generalized map, included as part of unit D€wbc

DZwp **Farewell platform facies (Upper Devonian, Frasnian, to Neoproterozoic)**—Shallow-marine limestone, dolostone, and less common chert; also contains algal reefs of various ages. Trilobites, conodonts, corals, stromatoporoids, and brachiopods indicate a Middle Devonian to Middle Cambrian age range; a nonfossiliferous dolostone unit below the Middle Cambrian strata has been assigned to late Proterozoic (St. John and Babcock, 1997; R.B. Blodgett, written commun., 1998). Where possible, unit is subdivided into three units (DSwc, Ols, and €Zls), described below; however, available map data are inadequate to derive the distribution of each of these subdivisions throughout the range of outcrop. Included in this undivided unit are rocks of the Ordovician to Cambrian(?) Novi Mountain Formation, which consists of limestone that is variably argillaceous, locally orange-weathering, and locally oolitic; it is overlain by the Telsitna Formation, which is composed of peloidal lime micrite and lesser dolostone. These units had a marine shelf depositional setting that was locally very shallow (Dutro and Patton, 1982). Unnamed units in the western McGrath quadrangle include breccia, argillite, laminated limestone, and mudstone, some of which may have been deposited in deeper-water settings. Also includes dolostone that rests on crystalline basement in the northernmost Medfra quadrangle, which Dutro and Patton (1982) assigned to the Middle and Upper Ordovician Telsitna Formation. However, these strata have yielded gastropod steinkerns that allow the possibility of an age as old as Late Cambrian for this dolostone. Blodgett (written commun., 1998) reports a thin- to medium-bedded, commonly finely laminated, dark-gray platy limestone estimated to be at least 300 to 400 m thick in the southern Sleetmute quadrangle. This unit contains minor distinctive flat-pebble limestone conglomerate that forms distinctive marker beds. Near the top of the unit, immediately below the transition into the algal reef facies of unit Ols (described below), platy limestone contains many thick-bedded, fining-upward, debris-flow deposits, which suggest that the depositional environment rapidly shallowed. Conodonts from uppermost beds of the platy limestone indicate a Middle Ordovician age (N.M. Savage, written commun., 1999). Contact of this platy limestone with the overlying Ols unit appears to be gradational but rapid. Ols is lithologically similar to unit Ol of Gilbert (1981) in the McGrath quadrangle and, in part, is similar to the Novi Mountain Formation and the lower part of the East Fork Hills Formation of Dutro and Patton (1982) in the Medfra quadrangle, which are not mapped separately here. Similar coeval rocks also are exposed in the low hills on the west side of Lone Mountain in the McGrath C-4 quadrangle in west-central Alaska. The undivided shallow marine carbonate units of the now-abandoned Holitna Group were, in the past, typically assigned to the Nixon Fork terrane and are now considered part of the Farewell terrane

DSwc **Whirlwind Creek Formation and correlative units (Upper Devonian, Frasnian, through Silurian, Ludlow)**—Several repeated cycles of shallow-marine limestone and dolostone. In the lower part of the formation, the cycles grade from algal-laminated dolostone into pelletoidal limestone and then into silty limestone and siltstone. In the upper part, the cycles grade from thick-bedded reefy limestone to thin-bedded limestone. The formation contains an abundant late Silurian and Devonian conodont, brachiopod, coral, and ostracode fauna. In the Taylor Mountains and adjacent Sleetmute quadrangles, rocks representative of the lower part of the Whirlwind Creek Formation consist of thick- to massive-bedded, locally dolomitized, light-gray algal boundstone; composed primarily of spongiostromate algal heads (including abundant oncoid forms). Unit represents a barrier reef complex on the outer or seaward margin of the Silurian carbonate platform (Blodgett and Clough, 1985; Blodgett and Wilson, 2001). Contains scattered pockets of brachiopods, which mostly belong to the superfamily Gypiduloidea. Locally abundant are aphrosalppingid sponges (notably *Aphrosalpinx textilis* Miagkova; Rigby and others, 1994), which are known elsewhere only from the Ural Mountains of Russia and the Alexander terrane of southeastern Alaska. Equivalent to unit Sl of Gilbert (1981) as well as the Cheeneetnuk Limestone (Blodgett and Gilbert, 1983) and Soda Creek Limestone (Blodgett and others, 2000b). On generalized map, included as part of unit DZwp

Ols **Lime mudstone (Ordovician)**—Limestone and lime mudstone exposed in the northeast Taylor Mountains and southeast Sleetmute quadrangles. Unit consists of distinctive limestone lithologies, boundstone and packstone to wackestone, interspersed with the mudstone: the stratigraphically lowest part of the unit is thin- to medium-bedded, dark-gray, yellow-gray-weathering, burrow-mottled lime mudstone and lesser peloidal mudstone. Age control based on poorly preserved low-spired gastropods and conodonts including *Drepanoistodus*? sp., *Fryxellodontis*? n. sp. and other conodonts. This is apparently overlain by medium- to thick-bedded, dark-gray to brown algal-thrombolitic boundstone interbedded with light-gray-weathering, thin- to medium-bedded lime mudstone (Blodgett and Wilson, 2001). Trilobites and conodonts (identified by N.M. Savage, written commun., 1985), including fossils of the genus *Hystricurus*, indicate an Early Ordovician age for this boundstone. Overlying this is an extremely poorly exposed brown and dark gray 'chippy' shale, silty shale and minor silicified limestone exposed in very small areas in the Taylor Mountains quadrangle, where exposures consist only of frost-boil chips of shale and rubbly outcrop; a better exposed area of rubble contains numerous diplograptid graptolites. The uppermost part of unit Ols consists of brown, medium- to thick-bedded skeletal lime packstone to wackestone (Blodgett and Wilson, 2001), which contains abundant pentameroid brachiopods (*Tcherskidium*, *Proconchidium* [or *Eoconchidium*] and a new smooth genus aff. *Tcherskidium*). Karl and others (2011) provides a comprehensive database of fossil data for the Taylor Mountains quadrangle and adjacent areas to the southwest. On generalized map, included as part of unit DZwp

€Zls **Dolostone, limestone, orthoquartzite, and minor chert (Cambrian and Neoproterozoic?)**—Exposed in the Sleetmute and Taylor Mountains quadrangles are two separate Middle Cambrian limestone subunits and in the Sleetmute quadrangle is a presumed upper Proterozoic unit of mixed lithology (Blodgett and others, 2000, and unpub. data). Also included, in the McGrath quadrangle, are red beds and carbonate rocks of the Khuchaynik Dolostone, Lone Formation, Big River Dolostone, and Windy Fork Formation of Babcock and others (1994). The uppermost and thickest of the Middle Cambrian limestone subunits in the Taylor Mountains quadrangle is composed of medium- to thick-bedded, commonly light-gray to dark-gray, rarely pink-weathering (light-gray fresh) lime mudstone that has locally abundant, well developed wavy styolites. Minor green-gray shale intervals present locally. Trilobites are locally abundant and diverse in this subunit and are indicative of a late Middle Cambrian age (Palmer and others, 1985; Babcock and Blodgett, 1992; Babcock and others, 1993; St. John, 1994; St. John and Babcock, 1994, 1997). The lower limestone subunit is poorly exposed and consists only of scattered rubble-crop of coquinoid limestone (lime wackestone to packstone) that has an abundant and diverse trilobite fauna (agnostids notably common) and ancillary acrotretid brachiopods, hyoliths, and cap-shaped fossils of early Middle Cambrian age. Thickness of this subunit is uncertain, but probably at least 5 m. Faunas from both subunits are most closely allied biogeographically with coeval faunas from the Siberian Platform. Stratigraphically below these are medium-bedded, medium-gray, orange-weathering dolostone, limestone, orthoquartzite, and minor chert in the Sleetmute quadrangle. Dolostone has locally abundant floating quartz grains, is locally trough cross stratified, but also has well developed parallel laminations, low domal stromatolites, and local paleokarst intervals. Total thickness of unit uncertain, but is at least 300 to 400 m in thickness. Several repeated sedimentary cycles observed in unit. The Khuchaynik Dolomite is medium-gray, light- to medium-gray-weathering dolostone at least 228 m thick that contains numerous packstone or grain-stone beds and locally numerous discontinuous bands of gossan are present. Lone Formation is dominantly thin- to medium-bedded siltstone and fine- to coarse-grained sandstone at least 107 m thick. Contains interbeds of lime mudstone or dolomudstone as much as 12 m thick. Usually weathering maroon, it locally weathers earthy yellow, tan, white, gray, gray-green, or reddish-brown. “Sedimentary features in sandstone include planar crossbeds, symmetrical ripple marks, load casts, and siltstone intraclasts” (Babcock and others, 1994). Contact with Big River Dolostone is conformable and sharp; the Big River Dolostone is a distinct bed of earthy yellow-weathering dolomitic lime mudstone that lacks coated grains. Distinguished from Windy Fork Formation by presence of much more sandstone and dolostone and much less siltstone. Big River Dolostone is light- to medium-gray-weathering dolomudstone that has a fenestral fabric and numerous packstone to grainstone beds composed of coated grains. Unit contains two distinctive white-weathering dolostone bands in the upper part of unit. Distinguished from the overlying Khuchaynik Dolostone by these distinctive white bands, the presence of poorly sorted, large, irregular grains, and the lack of major sulfide deposits. Windy Fork Formation is “dominantly thin- to medium-bedded siltstone and fine- to coarse-grained sandstone that weather earthy yellow or orange-brown, at least 84 m thick. Some sandstone shows planar crossbeds. Interbeds of lime mudstone or dolomudstone are a minor part of unit” (Babcock and others, 1994). Each of these units contains finely disseminated pyrite throughout. Age of unit in the Sleetmute quadrangle is thought to be upper Proterozoic based on distinctive and very similar or identical lithologies shared with units in the McGrath quadrangle of presumed late Proterozoic age (Babcock and others, 1994; R.B. Blodgett, written commun., 2000). On generalized map, included as part of unit DZwp

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DSld **Shallow-marine, carbonate-dominated rocks (Devonian and Silurian?)**—Limestone, dolostone, and lime mudstone of Late Devonian and possibly as old as Silurian age in central Alaska. These limestone bodies occur between strands of the Tintina Fault System in the so-called Preacher Block in the Circle quadrangle (Foster and others, 1983) as well in the eastern Eagle quadrangle (Foster, 1976). These generally appear to be shallow-marine, carbonate-dominated rocks. In the Circle quadrangle, medium-gray, generally massive, locally recrystallized limestone is found in scattered outcrop belts between strands of the Tintina Fault System (Foster and others, 1983). It has yielded Early Devonian conodonts from several localities (Foster and others, 1983) and is thought to possibly correlate with the Tolovana Limestone (unit DSt). In the Tanana quadrangle, includes a number of units mapped by J.N. Dover (unpub. data, 1997) that consist of light- to medium-gray or tan, sandy, platy limestone, gray bioclastic limestone, and massively bedded silicified limestone and dolostone of Late Devonian

(Famennian) age and the informally named limestone of Raven Ridge, which consists of gray micritic and brecciated limestone, also of Late Devonian(?) age. In the Kantishna River quadrangle, medium- to dark-gray limestone, in part dolomitic, and medium-gray shaly to phyllitic siltstone has yielded Late Devonian (Frasnian) corals from one locality (Chapman and others, 1975). On generalized map, included as part of unit DSsm

Dlse **Carbonate rocks of southeast Alaska (Devonian)**—Consists of thin-bedded to massive gray limestone of the Wadleigh and Black Cap Limestones; which locally contain minor shale and argillite interbeds, as well as the limestone members of the Cedar Cove and Karheen Formations, and the informal limestone of Kasaan Island. The Wadleigh Limestone on Prince of Wales Island is generally thick- to medium-bedded or massive limestone about 300 m thick composed of fragmented shelly fossils in a dark, lime mudstone matrix and minor argillaceous and calcareous shale. Massive stromatoporoids may form reefs and reef breccia; brachiopods, gastropods, ostracodes, pelecypods, and crinoids make up substantial quantities of the coarse fossil detritus (Eberlein and others, 1983) and indicate an age range of Emsian (late Early Devonian) to Famennian (Late Devonian) (Eberlein and Churkin, 1970; Eberlein and others, 1983; Savage and Funai, 1980; Soja, 1988a). The significantly thicker Black Cap Limestone, in the Glacier Bay area (Rossman, 1963), is a structurally complex thin-bedded black limestone about 210 m thick that grades upward to a lighter colored, thicker-bedded to massive limestone about 1,160 m thick. Numerous fossils including rugose and tabulate corals, brachiopods, gastropods, ostracodes, stromatoporoids, and conodonts suggest an Early to Middle Devonian age for the unit (Blodgett and others, 2012). Limestone member of the Cedar Cove Formation is as thick as 350 m and consists of massive to thin-bedded fossiliferous limestone that contains interbeds of argillite and tuff and is locally metamorphosed to marble (Loney and others, 1963). Rugose and tabulate corals, stromatoporoids, brachiopods, mollusks, and trilobites provide a Middle Devonian to lower Upper Devonian (Frasnian) age for this unit (Loney and others, 1975). Additional collections indicate an age no younger than early Middle Devonian (Eifelian) for the limestone member of the Cedar Cove Formation (R.B. Blodgett, written commun., 2014). The limestone of Kasaan Island (Eberlein and others, 1983) is part of the Karheen Formation near Prince of Wales Island and similar limestone along Duncan Canal on Kupreanof Island are thin-bedded to massive fossiliferous limestone a couple hundred meters thick (Eberlein and others, 1983; Karl and others, 1999). As with the other limestone units in this map unit, this limestone contains abundant fossil fragments of corals, stromatoporoids, brachiopods, conodonts, and crinoids, which here are of Emsian (late Early Devonian) to lower Eifelian (early Middle Devonian) age (Eberlein and others, 1983; Soja, 1988b; McClelland and Gehrels, 1990; Karl and others, 1999). Along Duncan Canal, the limestone also contains interbeds of argillite, sandstone, and volcanic rocks (Karl and others, 1999). Marble of the Gambier Bay Formation on Admiralty Island (Lathram and others, 1965), which may be age correlative, is included in map unit Dgbm here. On generalized map, unit Dlse is included as part of unit DSsm

Dcc **Karheen and Cedar Cove Formations (Devonian)**—Karheen Formation has two facies: an upper shallow-water sandstone, shale and conglomerate facies, and a lower deep-water facies. According to R.B. Blodgett (written commun., 2014), the Karheen Formation, as used here, is much more complex than generally described. Much of it is Silurian in age and there is another unnamed unit likely included here. The shallow-water facies, about 1,800 m thick, contains minor well-bedded and penecontemporaneously deformed platy limestone in addition to its clastic components and is characterized by red beds, calcareous cement, festoon crossbedding, ripple marks, and mud cracks. Clasts are mainly volcanic rocks and chert, but pebbles to boulders of sedimentary rocks and felsic to mafic plutonic rocks are also present (Eberlein and others, 1983). Locally the limestone contains abundant brachiopods. Unconformably overlies Staney Creek unit of Eberlein and others (1983) and the Descon Formation. Eberlein and others (1983) reported that abundant detrital K-feldspar and bronze-colored biotite in the sandstone distinguishes the Karheen from older sandstone, but S.M. Karl (unpub. data, 2013) noted that, upon thin-section examination, detrital K-feldspar is not abundant in this facies. The deep water facies consists of matrix-supported debris-flow deposits, which were described by Gehrels (1992) as a sedimentary breccia composed of unsorted clasts of plutonic rocks and highly deformed volcanic, sedimentary and intrusive rocks that are as large as 50 cm in diameter. The clasts are moderately flattened, tectonically brecciated, and locally semischistose (Gehrels, 1992). Eberlein and Churkin (1970) described the deep-water facies as green-gray, gray, and reddish-brown lithic wacke and graywacke and minor siltstone; red, red-brown, and green shale; thin-bedded sandy limestone; contorted platy limestone; pebble-to-cobble polymictic conglomerate; and biostromal limestone and reef breccia. Sandstone and shale is commonly graded and contains festoon cross bedding, ripple marks, and mud cracks (Eberlein and Churkin, 1970). Latest Lower Devonian or earliest Middle Devonian (Pragian or younger) graptolites *Monograptus pacificus* are reported (Churkin and others, 1970). Eberlein and others (1983) also describe “graptolite and plant-bearing shale interbedded with graywacke, sandstone, and conglomerate.” The vascular plants preserved in this unit are the oldest plant fossils known in North America (Churkin and others, 1969). Eberlein and others (1983) also report subordinate andesitic volcanic rocks and that "the youngest beds of the sequence appear to be a 200 m thick section of interbedded andesitic flows, broken pillow breccia, and tuff." These volcanic rocks are included in unit Dmv here. The Cedar Cove Formation, on Chichagof Island, consists of up to 900 m of thin-bedded argillite and minor limestone, turbiditic graywacke, and conglomerate. Conglomerate clasts include "volcanic rock, granite, alaskite, syenite, graywacke, quartz, chert, and limestone" (Loney and others, 1975, p. 10). Graywacke contains large pink K-feldspar, plagioclase, quartz, pyrite grains, and volcanic rock fragments (Loney and others, 1975; Karl and others, 1999). Locally, includes the limestone member of the Cedar Cove Formation (unit Dlse). Loney and others (1975) reported Middle Devonian to Frasnian (lower Upper Devonian) corals, stromatoporoids, brachiopods, and a trilobite. Karl (1999) reported Emsian (upper Lower Devonian) conodonts from the lower member of the Cedar Cove Formation

DSt **Tolovana Limestone (Middle Devonian to Silurian, Llandovery?)**—"Lower part consists of alternating green and maroon lime mudstone, succeeded by yellowish-brown weathering, silty, shaly lime mudstone and wackestone having brachiopods; its upper and greater part consists of light-gray weathering peloid- and ooid-rich lime packstone and grainstone and rare dolomite" (Weber and others, 1992). As exposed in the White Mountains of the Livengood quadrangle, "appears to be more than 1,200 m thick and of Silurian age based on conodonts and brachiopods, as well as corals." The depositional environment is interpreted as shallow marine (Weber and others, 1992). In the same strike belt in southeastern Livengood quadrangle, a somewhat younger (Middle Devonian) unit of lime mudstone and wackestone has also been assigned to the Tolovana Limestone; this subunit continues into the Fairbanks and Kantishna River quadrangles (Wilson and others, 1998). Rocks formerly correlated with the Tolovana Limestone in the northwesternmost Circle quadrangle (Foster and others, 1983) were reassigned to the Schwatka unit of Weber and others (1992) (Wilson and others, 1998), which is here assigned to the Ogilvie Formation (unit Dof); rocks formerly assigned to the Tolovana Limestone in the north-central and northeastern Circle quadrangle (Foster and others, 1983) are here assigned to unit DSld, shallow-marine carbonate-dominated rocks. On generalized map, included as part of unit DSsm

Dof **Ogilvie Formation (Middle to Lower Devonian)**—Massive, medium-gray, bioclastic limestone contains coral-stromatoporoid buildups. Thickness ranges from 60 to 1,100 m (Clough and Blodgett, 1984, cited by Dover, 1992; see also Clough and Blodgett, 1987). Unit has a similar distribution to the shallow-marine carbonate rocks of unit DSld above, but its upper limit may be slightly older than DSld. Unit was originally defined in Yukon of Canada by Norris (1967) and "Consists of medium-brown to grey, fine-grained, in part skeletal and reefal, thin-bedded to massive, resistant, cliff-forming limestones generally weathering light grey. Scattered argillaceous material and silt and chert are present in some beds. Dolomite is present in the lower part of the formation in the Nahoni Range area and in some sections east of the Blackstone River." It contains a "moderately abundant fauna [that] includes sponges, stromatoporoids, tabulate corals, brachiopods, cephalopods, gastropods, pelecypods, goniatites, cricoconarids, ostracodes, trilobites, echinoderm fragments and conodonts" (Norris, 1967). Also included here is the Schwatka unit of Weber and others (1992), which consists of slightly recrystallized, dark-gray, sparsely fossiliferous, medium-bedded to massive lime mudstone or wackestone. Conodonts and two-holed crinoid ossicles constrain age to Emsian to Eifelian (Weber and others, 1992). Interfingers with volcanic rocks of unit Dvec. Weber and others (1992) interpreted the depositional environment as shallow marine. North of the Tintina Fault, the unit crops out in the Charley River quadrangle and in the Yukon; south of the Tintina Fault, it occurs in the Circle and Livengood quadrangles. On generalized map, included as part of unit DSsm

D€bg **Baird Group and similar rocks (Middle Devonian to upper Cambrian)**—Originally defined as three distinct formations (the Kugururok Formation, Eli Limestone, and Skajit Limestone), the Baird Group consists of "beige- to orange-weathering, laminated, partly argillaceous to silty metalimestone and light- to dark-gray, flaggy-bedded to massive metalimestone, marble, and dolostone. The Baird Group was established by Tailleur and others (1967), but was restricted by Dumoulin and Harris (1994) to the carbonate succession of the west-central Baird Mountains quadrangle; broadly coeval carbonate strata of the eastern Baird Mountains quadrangle and Middle and Late Devonian carbonate rocks of the Maiyumerak Mountains were excluded" (Till and others, 2008a). As shown here, the Baird Group is restricted to the western part of Alaska north of Kotzebue Sound, primarily in the Baird Mountains quadrangle, and a small area in the Chandalar quadrangle to the east. The Eli Limestone and Kugururok Formation are mapped together here as unit Dke, and the Skajit Limestone is not used here. Rocks commonly assigned to the Skajit Limestone are excluded from the Baird Group and instead included in unit Pzm here. As shown, parts of two units of Till and others (2008a), DOb (the Baird Group, proper) and DOc (Younger carbonate rocks of the Nanielik antiform) are included in this map unit. As used by Till and others (2008a), the oldest strata of the Baird Group "* * * are Early and Middle Ordovician, locally contain reworked Late Cambrian conodonts, and comprise two roughly coeval lithofacies: dolostone with fenestral fabric and evaporite molds that formed in locally restricted, shallow to very shallow water, and bioturbated to laminated, argillaceous to silty metacarbonate rocks with local cross-bedding, ripples, and flame structures that accumulated in somewhat deeper platform settings. * * * Younger strata include Upper Ordovician and middle Silurian (Wenlock) metalimestone deposited in middle to outer platform settings and upper Silurian and Lower and Middle Devonian (Emsian, Eifelian, and possibly Givetian?) shallow-water dolostone and metalimestone with corals and stromatoporoids; the Emsian section includes an interval of calcareous, chloritic metasandstone. DOb [of Till and others, 2008a] includes local occurrences of metabasalt of unknown age that are especially abundant in western exposures. These rocks contain fine-grained blue amphibole (crossite) at multiple localities, indicating that the Baird Group has experienced blueschist facies metamorphism. The unit has similarities in lithofacies and biofacies to * * * coeval strata of the York Mountains on Seward Peninsula. Conodont assemblages have both Laurentian and Siberian affinities (Dumoulin and Harris, 1994; Dumoulin and others, 2002)" (Till and others, 2008a). The Younger carbonate rocks of the Nanielik antiform (unit DOc of Till and others, 2008a) are "very light- to dark-gray (locally orange-) weathering, gray to black, commonly massive dolostone and lesser metalimestone and marble exposed in the Nanielik antiform (northeastern Baird Mountains and northwestern Ambler River quadrangles) and in the northwestern Chandalar quadrangle. DOc was first described in the Nanielik antiform (Sheep Creek section of Dumoulin and Harris, 1987) and later recognized to the east (Dumoulin and Harris, 1994). Meter- to decimeter-scale color banding is characteristic of this unit and reflects shallowing-upward peritidal cycles of darker colored, bioturbated, bioclastic and (or) peloidal carbonate strata overlain by light-colored cryptalgal laminite. Recognizable fossils include corals, stromatoporoids, brachiopods, gastropods, bryozoans, pelmatozoan debris, ostracodes, and dasycladacean algae. Corals and conodonts indicate an age of Upper Ordovician through Silurian for most of the unit. Definitively Devonian rocks have not been found in the eastern Baird Mountains quadrangle, but stromatoporoid wacke-packstone of late Early to early Middle Devonian (Emsian-Eifelian) age occurs locally in the Chandalar quadrangle. The unit is generally fault-bounded but a gradational and apparently conformable contact above OƐc [Older carbonate rocks of the Nanielik antiform of Till and others (2008a), shown here as unit OƐls] is locally preserved. Sedimentary structures and fossils indicate warm, shallow-water depositional settings that were shallowest and most restricted during Late Ordovician (Richmondian or Katian) time. DOc has similarities in lithofacies and biofacies to the younger part of DOb, as well as coeval strata of the York Mountains on Seward Peninsula. Ordovician biotas include some megafossils and microfossils with Siberian affinities and others with Laurentian affinities; Silurian and younger fossil assemblages are chiefly cosmopolitan (Dumoulin and Harris, 1994; Dumoulin and others, 2002)" (Till and others, 2008a). Locally subdivided into unit Dke:

Dke **Kugururok Formation and Eli Limestone (Devonian)**—Kugururok Formation consists of three informal lithologic members: (1) a lower, dominantly clastic unit of shale that has interbedded sandstone, granule conglomerate, siltstone and limestone; (2) a middle calcarenite unit containing some conglomeratic limestone, sparse chert lenses and dolomitic(?) sandstone; and (3) an upper, light-colored, laminated to cross-bedded dolomite unit. Thickness at the type section in the Misheguk Mountain quadrangle is 1,370 ft (417 m) and elsewhere over 2,000 ft (610 m). Age is Late Devonian (Frasnian and Famennian) based on paleontological evidence (Sable and Dutro, 1961). "Eli Limestone is yellow-brown to orange weathering, medium- to dark-gray, fine- to coarse-grained, commonly argillaceous limestone and lesser dolostone; beds are planar to irregular and bioturbated and rock types range from lime mudstone to bioclastic packstone. Conodonts denote an age of late Middle or early Late to late Late Devonian (late Givetian or Frasnian to Famennian); it also contains brachiopods of Late Devonian (possibly mid-Famennian) age" (Till and others, 2008a). These units were "deposited in a range of shallow-water, inner to middle shelf environments; the shallowest and most restricted depositional regimes prevailed during the late Middle Devonian. * * * Middle Devonian carbonate rocks correlate at least in part with youngest part of Baird Group * * *" (Till and others, 2008a). As originally defined, these units were part of the Baird Group; however, as they are younger than any part of the Baird Group type section and, unlike the Baird Group; are not metamorphosed, they were excluded from the Baird Group by Till and others (2008a) and are part of the Eli River sequence of Till and others (2008a). Unit also includes Devonian limestone mapped in the Arctic (Brosgé and others, 2000), Table Mountain (C.G. Mull and H.S. Sonneman, Exxon, unpub. report, 1968–1974), and Coleen (Brosgé and Reiser, 1969) quadrangles, and dolostone and dolomitic limestone on Saint Lawrence Island (Patton and others, 2011). On generalized map, included as part of unit DƐbg

DZnl **Mount Copleston Limestone and Nanook Limestone (Lower Devonian to Ediacaran)**—Thin- to thick-bedded limy mudstone, dolostone, and silicified limestone that contains minor amounts of siltstone and shale. Divided into eight units by Dutro (1970); the units range from white and very light-gray to less common dark-gray in color, are fine- to medium-grained, and mainly consist of limy mudstone and dolostone, lesser silicified limestone, and, in the lowest unit, dark-maroon very fine-grained thinly laminated shale. Total thickness of the combined units is as much as 1,300 m. Fossils include corals, brachiopods, gastropods, trilobites, and conodonts, which indicate the presence of Upper Cambrian, Ordovician, and Lower Devonian (Emsian) strata. The lowest parts of the Nanook Limestone are inferred to be Late Proterozoic (Ediacaran) in age. The Mount Copleston Limestone (Blodgett and others, 1992), originally the uppermost part of Dutro's unit 8, was separated from the Nanook Limestone on the basis of its distinct lithology and fossil assemblages that indicate that Silurian strata was not present and therefore a significant time gap was present between it and lower parts of the Nanook Limestone. The Mount Copleston Limestone consists of thin- to medium-bedded, dark-gray lime mudstone and bioclastic wackestone and packstone. It is about 72 m thick at its type section—approximately the upper third of Dutro's (1970) unit 8. It unconformably overlies Upper Ordovician strata at its type section in its eastern exposure belt and Middle Ordovician strata in its western belt. The type section contains crinoid ossicles of Emsian and Eifelian age and appears to be restricted to Emsian (late Early Devonian) on the basis of conodonts (*gronbergi* to *serotinus* zones) (Blodgett and others, 1992). The redefined Nanook Limestone is therefore Ordovician to Ediacaran in age. The Mount Copleston Limestone is not shown separately here because of its extremely small outcrop area. On generalized map, included as part of unit DPnl

DOls **Thin-bedded limestone (Lower Devonian to Ordovician)**—"Thin-bedded to massive, fine-grained gray limestone, highly fractured and veined with white calcite, contains algal reefs and reef breccia. Locally contains interbedded tuffs and mafic volcanic rocks. Recrystallized to marble with interbedded quartzite and quartz-chlorite schist * * *" Hoare and Coonrad (1978). Algal mounds indicate shallow-water deposition (Decker and others, 1994). Unit is in scattered outcrops along a north-northeasterly trend from Goodnews Bay to the northern edge of the Goodnews Bay quadrangle. Unit thrust over Permian limestone (unit Ptls) and calcareous schist unit (unit JPs) and intruded by gabbro of Jurassic or Triassic age (included in unit JTRos). Hoare and Coonrad (1978) reported sparse fossils of Middle Devonian to Early(?) Ordovician age. One sample collected by Stephen Box in northern part of the Goodnews Bay quadrangle boundary contained conodonts of Early Ordovician age (sample 89AJM60A, www.alaskafossil.org). A sample collected by J.M. Hoare contained ostracodes, echinoderms, fragments of brachiopods, algae, and small colonies of tabulate coral, possibly the genus *Dania* of Silurian age (A.K. Armstrong, written commun., 1975) Unit was included in the Goodnews terrane by Box (1985)

DOka **McCann Hill Chert, Road River Formation, and Troublesome unit of Weber and others (1992) (Lower Devonian to Ordovician)**—McCann Hill Chert consists of "thin-bedded and laminated dark- to light-gray chert, siliceous shale, and minor chert gritstone. Contains plant fragments, poorly preserved spores, and rare conodonts, gastropods, and cephalopods. Basal part of formation has beds of dark-gray bioclastic limestone with remarkable varied fauna including corals, brachiopods, trilobites, tentaculitids, fish, and ostracodes of Early Devonian (Emsian) age" (Brabb and Churkin, 1969). Thickness 200 to 800 feet except near Jones Ridge in the Charley River quadrangle, where the basal part of the McCann Hill Chert was placed in the Ogilvie Formation (Blodgett, 1978; Clough and Blodgett, 1984, 1987). Road River Formation consists of "dark-gray graptolitic shale with lesser amounts of grayish-black laminated chert and very minor dark-gray limestone, greenish-gray dolomite, chert arenite, and conglomerate. Chert, chert arenite, and chert conglomerate occur mainly in basal part of formation. Graptolites indicate that most series of Ordovician and Silurian are represented, and that the youngest rocks are Early Devonian (pre-Emsian). Thickness 400 to 900 feet" (Brabb and Churkin, 1969). The Troublesome unit of Weber and others (1992) consists of rhythmically interbedded dark-gray to black cherty argillite to chert, and thin beds of black to gray siliceous slate in the Livengood quadrangle. Associated with extensive mafic intrusive and extrusive rocks. Unidentified Radiolaria are the only reported fossils (Weber and others, 1992). Depositionally overlain by Frasnian carbonate buildups at base of Quail unit of Weber and others (1992), unit Dq here, hence Middle Devonian or older. As mapped here, also includes Pzc unit of Foster and others (1983) in the Circle quadrangle, which consists of chert interlayered with argillite, and rare marble and quartzite, intruded by diorite and gabbro (Foster and others, 1983). Radiolaria from unit Pzc are not age-diagnostic but are reported as "possibly of Mississippian age" (Foster and others, 1983); this constraint is, however, less compelling than the pre-Frasnian age for the Troublesome unit in its type area. On generalized map, included as part of unit DOsc

DOhb **Hood Bay Formation (Lower? Devonian to Ordovician)**—Black argillite, thin-bedded black chert, thin-bedded black limestone, brown calcareous and carbonaceous wacke sandstone, graywacke, and dull green pillow basalt. The chert, argillite, and limestone contain radiolarians. Graywacke clasts include mainly chert, with subordinate limestone, sandstone, argillite, and volcanic rock fragments. Pillow basalts have interbeds of argillite and gray green tuffaceous siltstone. Karl and others (2010, p. 2) indicated that deformed, quartz-veined black chert and argillite containing Ordovician graptolites (Carter, 1977) grade upward to carbonaceous argillite, chert, chert sandstone grit, meter-scale lenses of pillow basalt, and thinly laminated black limestone containing Silurian-Devonian conodonts (A.G. Harris, written commun., 1995). Crisscrossing quartz veinlets in the Hood Bay Formation, which are absent in the Cannery Formation (unit PDcf), are inferred to represent a pre-Cannery deformation event. On generalized map, included as part of unit DOsc

**Sedimentary and metasedimentary rocks of York terrane and Grantley Harbor Fault Zone (Devonian to Proterozoic)**—Lower Paleozoic and possibly older carbonate and siliciclastic rocks of western Seward Peninsula retain primary sedimentary features and are divided by Till and others (2011) into three components: a relatively well-studied stratigraphic sequence found mainly in the central York Mountains, the "York Mountains succession"; a group of relatively poorly understood rocks, "units of uncertain affinities"; and a third component of low-grade metasedimentary rocks of the Grantley Harbor Fault Zone. The York Mountains secession is not metamorphosed; the units of uncertain affinities may reflect low greenschist facies mineral assemblages. The rocks of the Grantley Harbor Fault Zone are more penetratively deformed than similar rocks of the other two components and are less deformed than similar rocks in the Nome Complex (see unit PzPnc below). "Carbonate strata of the York terrane correlate well with carbonate successions in three regions: the Brooks Range (northeast of the Seward Peninsula), the Farewell terrane of interior Alaska (southeast of Seward Peninsula), and the peri-Siberian terranes of northeastern Russia (Dumoulin and Harris, 1994; Dumoulin and others, 2002). Lithofacies and biofacies of York terrane carbonate rocks are especially similar to those of coeval strata in the western Brooks Range (Baird Mountains) and the Farewell terrane. Rocks in all three regions contain a distinctive biota characterized by both Siberian and Laurentian (North American) endemic forms, including many identical species. Detailed lithologic similarities between the three successions are also numerous (Dumoulin and others, 2002)" (Till and others, 2011)

Pzgp **Phyllite and argillite, Grantley Harbor Fault Zone (lower Paleozoic)**—"Phyllite, argillite, and lesser metasiltstone and fine-grained metacarbonate rocks exposed south and north of Grantley Harbor in the central Teller quadrangle. Outcrops consist of brownish-orange- to black-weathering, silvery-gray to black, locally carbonaceous phyllite to argillite, with interlayers and lenses of tan to green metasiltstone to semischist and dark gray to black, locally tannish-orange metacarbonate. Lithologies are interlayered on a scale of centimeters, with metacarbonate layers as thick as 1.5 meters. These rocks have yielded sparse conodont fragments of indeterminate Ordovician to Triassic age (T. Carr and T. Hudson, written commun., 1982, 1984) and contain rare relict bioclasts, including probable recrystallized radiolarians and siliceous sponge spicules, observed in thin section" (unit Pzp, Till and others, 2011). On generalized map, included as part of unit DZyk

DSyl **Limestone of the Seward Peninsula (Lower Devonian and (or) Silurian)**—Map unit DSl of Till and others (2011), part of their York terrane, York Mountains succession, which consists of "light-gray-weathering, medium-dark-gray limestone exposed in a small, fault-bounded area in the central Teller quadrangle. Lithofacies include cherty lime mudstone, peloidal wackestone, and lesser coralline packstone. Lower beds in this unit produced relatively long-ranging conodonts but upper beds yielded conodonts of middle Silurian (middle Wenlock) age and Silurian (probably middle to late Silurian) corals; the fauna indicates a warm, relatively shallow water, normal-marine depositional setting * * *. [Unit] has also yielded corals thought to be of probable Middle or Late Devonian age by Oliver and others (1975); the age of this collection was later revised to late Silurian (late Ludlow)-early Late Devonian (Frasnian), probably late Silurian to Early Devonian, by A. Pedder (Dumoulin and Harris, 1994; Till and Dumoulin, 1994)" Till and others (2011). On generalized map, included as part of unit DZyk

SOyl **Dark limestone (Silurian and Upper Ordovician)**—Map unit SOdl of Till and others (2011), part of their York terrane, York Mountains succession. Primarily consists of medium- to dark-gray limestone, dolomitic limestone, and dolostone, locally cherty; contains numerous silicified fossils (Sainsbury, 1972; Till and others, 2011). A section of rock at least 220 m thick contains fossils of early to late Silurian age and consists "mainly of mudstone and bioclastic wackestone and packstone and contains more dolostone than the Ordovician part of the unit" (Till and others, 2011). "Ordovician rocks, at least 120 m thick, are wackestones and packstones, with peloids and skeletal grains in a micritic matrix" (Till and others, 2011) and contain fossils of Late Ordovician age. "Features such as fenestral fabric, micritized bioclasts, algal lamination, conodont biofacies, and the abundance and diversity of corals and stromatoporoids all indicate that [Till and others' (2011) unit] SOdl was deposited in warm, shallow to very shallow water in a locally restricted platform setting. Ordovician conodonts and megafossils from this unit include both Siberian and Laurentian (North American) endemic forms (Dumoulin and Harris, 1994; Blodgett and others, 2002; Dumoulin and others, 2002). Silurian fossils are mainly cosmopolitan. * * * Faunas and lithofacies of SOdl correlate well with those from age-equivalent strata in the Baird Group (Tailleur and others, 1967; Dumoulin and Harris, 1994) and related units in the western and central Brooks Range * * * and of [with] the Telsitna Formation and related rocks in the Farewell terrane of interior Alaska (Dumoulin and Harris, 1994; Dumoulin and others, 2002)" (Till and others, 2011). On generalized map, included as part of unit DZyk

SOyld **Limestone, dolostone, and shale (Silurian and Ordovician)**—Unit combines three units described by Till and others (2011) on the Seward Peninsula: Ols, SOul, and Ol—all largely carbonate rocks. Till and others' (2011) unit Ols is thin- to medium-bedded, pale-orange- to pale-yellow-brown-weathering, medium-gray to dark-gray limestone, dolomitic limestone, and dolostone that contains local shale and chert nodules. Ols forms subdued slopes in the vicinity of the York Mountains, and is generally fault-bounded, although locally, it depositionally overlies Till and others' (2011) unit Ol. Till and others' (2011) unit Ols is at least 300 m thick and consists of a relatively thin unit of fissile black shale and lesser interbedded black limestone and dolomitic limestone that contains calcified and pyritized radiolarians and sponge spicules. These limestones grade upward into flaggy, thin-bedded black limestone containing shaly partings and soft-sediment deformational features, which then grades into thin-bedded, graded, cross-bedded, and bioturbated sparsely bioclastic limestone and dolostone. Unit SOul of Till and others (2011) consists either of dolostone that contains corals of Late Ordovician age (Sainsbury, 1969; Sainsbury and others, 1971) or late Middle to early Late Ordovician (Oliver and others, 1975) age or, alternatively, very fine-grained, locally cherty, gray dolostone that contains long-ranging conodonts, domal to laminar stromatoporoids, and diverse tabulate and rugose corals of Silurian age. Till and others' (2011) unit Ol is massive to thick-bedded, light-brownish-gray to medium-gray, fine-grained limestone with local chert nodules and lesser interbeds of argillaceous limestone and shale, widely exposed in and adjacent to the York Mountains. Parts of this unit correlate well in age and lithology with Early and Middle Ordovician rocks of the Baird Group in the western Brooks Range (unit DOb of Till and others, 2008a). On generalized map, included as part of unit DZyk

Oyl **Argillaceous limestone and limestone (Middle and Lower Ordovician)**—Sainsbury (1972) described this unit as "thin-bedded ruditic argillaceous and silty limestone and dolomite limestone, carbonaceous limestone, and subordinate massive micritic limestone which locally contains chert; abundant ripple marks, swash marks, casts of worm tubes, crossbedding, and limestone clasts. Local stromatolites in massive beds." Till and others (2011) reported that the unit is at least 350 m thick (Dumoulin and Harris, 1994) and contains 8- to 15-m-thick shallowing-upward cycles (Vandervoort, 1985) and locally abundant trace fossils, but is less fossiliferous than unit SOyld and includes quartzose grainstone and ripple marks not seen in SOyld. "Common rock types * * * are dolomitic, locally argillaceous lime mudstone and grainstone made up mainly of peloids and intraclasts with lesser bioclasts and ooids. Mud-supported strata are bioturbated, with bedding-plane feeding trails and sub-vertical burrows. Grain-supported rocks are planar- to cross-bedded with locally well-developed oscillation and current ripples. Some grainstones contain 10 to 40 percent fine-sand- to silt-size non-carbonate grains, mainly quartz and lesser feldspar, with trace amounts of pyroxene, zircon, and leucoxene (Sainsbury, 1969). Most exposures * * * are fault-bounded, and its original depositional relations with other units in the York Mountains are uncertain. * * * Lithologic and fossil data indicate that [the unit] * * * was deposited in a range of subtidal to supratidal settings within a deepening-upward regime (Dumoulin and Harris, 1994); overall, * * * appears to have formed in somewhat shallower and more agitated water than Ol [unit SOyld here]. * * * Conodont assemblages * * * are mainly cosmopolitan but include a few Laurentian (North American) and Siberian endemic forms (Dumoulin and Harris, 1994; Dumoulin and others, 2002; J.E. Repetski, written commun., 2008)" (Till and others, 2011). According to Till and others (2011), rocks of similar lithofacies, biofacies, and age are found in unit OPpt of this map. Oyl also correlates well with parts of unit Od in the Nome Complex, the Baird Group (Tailleur and others, 1967; Dumoulin and Harris, 1994) in the western Brooks Range (map unit DOb of Till and others, 2008a), the Novi Mountain Formation, lower Telsitna Formation, and related rocks in the Farewell terrane of interior Alaska (Dumoulin and Harris, 1994; Dumoulin and others, 2002) [see unit DZwp here]. On generalized map, included as part of unit DZyk

OPpt **Older rocks of York terrane and Grantley Harbor Fault Zone (Middle Ordovician to Proterozoic)**—Limestone and dolomitic limestone, sandstone, siltstone, and phyllite and low-grade metasiltstone and metalimestone that were collectively called "units of uncertain affinities" by Till and others (2011). The older rocks of the Grantley Harbor Fault Zone of Till and others (2011) are also included here. Limestone, which forms the majority of the exposed area of the unit, is light-gray- to grayish-orange-weathering, medium-light-gray to medium-dark-gray limestone and dolomitic limestone widely exposed in the Teller quadrangle. "Beds are even to irregular and mostly 2 to 30 cm thick. Much of the unit is parallel laminated, but crossbedding occurs locally and some intervals are bioturbated. Other sedimentary features include fenestral fabric and intraclast conglomerate with clasts as much as 5 cm long. Lime mudstone, in part dolomitic and (or) argillaceous, is the main lithology" (Till and others, 2011). Silt to very fine sand-sized quartz grains are a minor component locally. Metamorphic grade and degree of deformation vary from apparently nonmetamorphosed and undeformed to recrystallized areas that are rich in metamorphic white mica, and are phyllitic or schistose. Till and others (2011) also report CAI values for conodonts that are mostly 4–4.5, but are locally 5 and 6, indicating that temperatures of 190 °C to more than 360 °C were reached. Most exposures of the carbonate rocks are fault-bounded, but Sainsbury (1972) reported that the carbonate rocks transitionally overlie sandstone, siltstone, and phyllite. The underlying clastic unit consists of gray- to orange-weathering, gray to brown, very fine- to coarse-grained, locally calcareous sandstone to siltstone, interbedded with gray to black mudstone and, locally, limestone. Beds are typically less than about 5 cm thick but may be as thick as 20 cm. Climbing ripples, cross beds, parallel and convolute laminae, and graded bedding suggest a turbidite origin (Till and others, 2011). Gray-weathering, sericite-rich pelitic phyllite and brown-weathering calcareous phyllite is nonfossiliferous (Till and others, 2011) and is intruded by gabbro (unit Ꝑgb) that crystallized at about 540 Ma (Amato and others, 2009). Rocks of the Grantley Harbor Fault Zone consist of metasiltstone, metasandstone, and phyllite that may be a more deformed and metamorphosed equivalent of the clastic part of this unit (Till and others, 2011). Additionally, thinly layered to laminated, orange- and gray-weathering, color-banded, white to dark-gray metalimestone may be a more metamorphosed equivalent of the carbonate rocks part of this unit. Fossil collections, mostly conodonts, indicate that multiple ages are present (Till and others, 2011). The best controlled conodont assemblages are tightly dated as early-middle Early Ordovician and other collections are early Middle Ordovician (Till and others, 2011). The intruding gabbro (Ꝑgb) is earliest Cambrian, which constrains the age of at least part of the unit to Proterozoic. The clastic rocks, also intruded by gabbro in northeastern exposures, have also produced a single conodont of middle Early to Late Ordovician age at one site and conodont fragments of indeterminate Cambrian-Triassic age at two other sites at southern exposures (Till and others, 2011). A detrital zircon sample of sandstone has a major peak in its cumulative probability distribution that is similar to the age of the gabbro at 550 Ma; there are also a large number of zircons of varying Proterozoic age and a few Archean grains (Amato and others, 2009)

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Silurian to Cambrian

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**Rock units associated with the Doonerak Window**—The Doonerak antiform of Till and others (2008a) is cored by lower Paleozoic rocks and a thin sequence of Carboniferous through Triassic sedimentary rocks (younger rocks included in unit JPzs here) considered correlative to pre-Mississippian basement that underlies the North Slope. Till and others (2008a) report that the structural antiform formed during the Tertiary and deforms lower Paleozoic rocks. “Thrust surfaces within the antiform are characterized by truncation of bedding and cleavage and abrupt lithologic transitions, suggesting that they formed under brittle conditions, in contrast to deformational features in the Central belt [of Till and others (2008a)]. Conodont CAIs from rocks within the antiform are variable and include values significantly lower than those typical of the Central belt” (Till and others, 2008a)

S€s **Sedimentary rocks of Doonerak Window (Silurian to Cambrian)**—Black phyllite and metasiltstone; minor quartzite; graywacke; red, green, and purple phyllite; green chert; siliceous metatuff; lenses of brown dolomite and thin limestone beds cut by abundant mafic sills. Middle Cambrian microfossils, brachiopods and trilobites, Ordovician conodonts, and Silurian graptolites and conodonts have all been recovered from the sedimentary rocks (Dutro and others, 1984; Repetski and others, 1987). Unit is metamorphosed to lower greenschist and prehnite-pumpellyite facies (Dillon and others, 1986). Mafic dikes cutting unit have yielded K/Ar ages on hornblende of 380.5±17 and 395±12 Ma (Dutro and others, 1976; ages recalculated using constants of Steiger and Jager, 1977), approximately Middle Devonian. On generalized map, included as part of unit S€da

O€dv **Oldest volcanic rocks (Ordovician and Cambrian?)**—Andesitic to basaltic volcaniclastic rocks and local tuffaceous phyllite, gabbro, and diabase, and black phyllite, metamorphosed to lower greenschist and prehnite-pumpellyite facies (Dillon and others, 1986) and exposed as part of the basement assemblage of the Doonerak Window (Till and others, 2008a) in the Wiseman quadrangle. These rocks, called the Apoon assemblage by Julian and Oldow (1998), include flows and pyroclastic rocks that have island-arc chemical affinities. $^{40}Ar/^{39}Ar$ ages on hornblende from mafic dikes were 392±12, 474±14, 487±20, and 529±17 Ma (Dutro and others, 1976; Till and others, 2008a). On generalized map, included as part of unit S€da

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St **Turbidite deposits of southeast Alaska (Silurian)**—Thin- to thick-bedded lithic graywacke, siltstone, and argillite turbidites, and interbedded conglomerate, limestone, and volcanic rocks (Rossman, 1963; Muffler, 1967; Loney and others, 1975; Eberlein and others, 1983; Brew, 1996). Turbidite beds commonly have laminar, cross-bedded, graded, and load cast structures typical of full and partial Bouma sequences (Muffler, 1967; Karl and Giffen, 1992). The olistostromal conglomerate is commonly polymictic and contains clasts of granitic and gabbroic rocks, greenstone, graywacke, chert, and limestone blocks thought to have been derived from local sources, but is locally monomictic (Muffler, 1967; Brew and others, 1984; Karl and Giffen, 1992; Brew, 1996; Karl and others, 1999). Sandstone grains consist of volcanic rock fragments, mudstone, slate, chert fragments, and grains of plagioclase, calcite, and quartz (Muffler, 1967; Karl and Giffen, 1992). Mafic to intermediate flows, breccia, and tuff are reported by several sources (Brew and others, 1984; Brew, 1996; Karl and others, 1999); where separately mapped, they are included in unit Sv here. Includes clastic rocks of the Rendu and Tidal Formations in Glacier Bay (Rossman, 1963), the Point Augusta Formation on Chichagof

Island (Loney and others, 1975), Bay of Pillars Formation on Kupreanof Island (Muffler, 1967; Brew, 1996), and polymictic olistostromal conglomerate interbedded within the Heceta Limestone (unit DSl) in the Prince of Wales Island area (Brew, 1996; Karl and others, 1999). Also includes shallow water carbonaceous sedimentary rocks of the Staney Creek area on Prince of Wales Island, which consists of limestone, siltstone, calcareous mudstone, and polymictic conglomerate (Eberlein and others, 1983). Age is primarily derived from Silurian graptolites in the Bay of Pillars and Point Augusta Formations (Muffler, 1967; Loney and others, 1975) and the sedimentary rocks of the Staney Creek area (Eberlein and others, 1983), but the unit is also locally interbedded with fossiliferous Silurian limestone (Shpa). Poorly preserved Early Jurassic radiolarians (C.D. Blome, written commun., 1996, reported by D.A. Brew, written commun., 2004), in an argillite and chert section of rocks unconformably overlying this unit in the northwestern Juneau quadrangle, are unique to southeast Alaska. As the outcrop area is extremely small, and documentation of this occurrence is lacking or conflicting, it is not shown separately here. On generalized map, included as part of unit DOsc

Sl **Limestone, southeast Alaska (Silurian)**—Primarily very thick sequences (up to 3,000 m) of cliff-forming, dominantly reefoid limestone, which is locally fossiliferous, commonly massive, but is also thin- to thick-bedded. It locally contains minor interbeds of sandstone and argillite, conglomerate, and limestone breccia (Rossman, 1963; Eberlein and Churkin, 1970; Brew and Ford, 1985; Karl, 1999). "Conglomerates are typically polymictic, with a variety of plutonic, supracrustal volcanic, and sedimentary lithologies represented among the clasts. Locally, however, the clasts are almost entirely of a single rock type (oligomictic), as exemplified by beds of chert pebble or limestone pebble conglomerate and by beds of limestone breccia * * *" (Eberlein and Churkin, 1970, p. 16). Locally present are limestone turbidites that are probably interchannel and overbank deposits (Brew and Ford, 1985). Where clastic rocks are mapped separately from the calcareous units, they are included in unit St. Unit also includes thin-bedded calcareous argillite (Rossman, 1963), which locally has ripple marks and mud cracks that indicate shallow-water deposition (Eberlein and others, 1983). Rocks of unit are thought to have formed fringing reefs or shallow carbonate banks surrounding islands and are coeval with the deeper water turbidites (unit St) (Brew and Ford, 1985; Karl and others, 1999). Includes the Willoughby, Kennel Creek, and Heceta Limestones, carbonate rocks of the Rendu Formation, and those associated with the Point Augusta and Tidal Formations in the Glacier Bay and Chichagof Island areas (Rossman, 1963; Eberlein and Churkin, 1970; Brew and Ford, 1985), and limestone on Kuiu Island (Brew and others, 1984). The Willoughby, Kennel Creek, and Heceta Limestones contain abundant tabulate and rugose coral fossils and the distinctive bivalve fossil *Pycinodesma* (Seitz, 1959; Rossman, 1963; Eberlein and Churkin, 1970; Loney and others, 1975; Rohr and Blodgett, 2013), which is considered endemic to late Silurian strata of southeast Alaska (Blodgett and others, 2010). These units and the Kuiu Limestone also contain less abundant cephalopod, brachiopod, conodont, and stromatoporoid fossils. Neither the Rendu Formation nor the underlying Pyramid Peak Formation contain fossils, but, based on their stratigraphic position underlying the Black Cap Limestone (unit Dl) and possibly unconformably overlying the Tidal Formation (included in unit St), they are thought to be Silurian or possibly Early Devonian (Rossman, 1963). The Kennel Creek Limestone grades upward into the Cedar Cove Formation (included in unit DSl), but the lower contact is faulted (Loney and others, 1963). Karst topography and features are commonly developed in the rocks of this unit. On generalized map, included as part of unit DSsm

Slc **Lost Creek unit (Silurian)**—Light- to medium-gray lime mudstone or wackestone in the Livengood and Tanana quadrangles (Blodgett and others, 1988; Weber and others, 1992; J.N. Dover, written commun., 1997). Limestone occurs as debris-flow deposits that pinch out laterally and contain rip-up clasts of shale, chert, and other sedimentary rocks. Basal part of unit contains channels of graywacke and chert pebble and cobble conglomerate incised into the underlying Livengood Dome Chert (unit Oc). Channels and debris flows together indicate a deep-water depositional setting. A separate band of micritic limestone, flanked by chert and assigned a possibly Silurian or Devonian age, was included in this unit by Weber and others (1992). Brachiopods, corals, and trilobites indicate a late to middle Silurian age (Wenlock to Ludlow). On generalized map, included as part of unit DOsc

SOig **Iviagik group of Martin (1970) (Silurian, Llandovery, to Ordovician)**—Consists of two informal units: a lower, finer grained unit of slaty black argillite and siliceous shale that contains minor siltstone and chert; and an upper, coarser grained unit of lithic, sand-rich turbidite deposits (Moore and others, 2002). According to Moore and others (2002), the fine-grained unit is a thin- to medium-bedded basinal succession, more than 50 m thick, that contains sparse yellow-orange beds that may be bentonite. A diverse Early and Middle Ordovician graptolite fauna is present in the unit. The coarser unit consists of "channelized, thick-bedded, medium-grained sandstone, local pebbly sandstone, and minor siltstone" (Moore and others, 2002). It is at least 300 m thick and contains intercalated calcareous mudstone that yield early Silurian conodonts and graptolites

SOd **Descon Formation and other sedimentary and volcanic rocks of Prince of Wales Island (Silurian, Llandovery, and Ordovician)**—Unit includes the sedimentary and volcanic rocks of the Descon Formation of Eberlein and Churkin (1970) and coeval metamorphic rocks of the informally named Moira Sound unit (Slack and others, 2007; Ayuso and others, 2007). The Descon Formation consists of volcaniclastic mudstone and graywacke turbidites, subordinate conglomerate, sandstone, and shale, and minor limestone, chert, and basalt flows and breccia at least 2,600 m thick (Eberlein and Churkin, 1970; Herreid and others, 1978; Gehrels, 1992; Brew, 1996). Graywacke is largely basaltic detritus in a noncalcareous chlorite-rich matrix and commonly shows graded bedding. Conglomerate and sedimentary breccia includes crudely layered porphyritic-andesite breccia and polymictic conglomerate that has clasts of chert, felsic volcanic rock, graywacke, and gabbro (Brew, 1996); metamorphic rock clasts are conspicuously absent. The Moira Sound unit is dominantly siltstone, mudstone, graywacke turbidite, and carbonaceous argillite, alternating with thick sections of mafic, intermediate-composition and silicic volcanic rocks with minor conglomerate and limestone, all metamorphosed to greenschist faces (Slack and others, 2007; Ayuso and others, 2007). Conglomerate in the Moira Sound unit contains metamorphic rock clasts thought to be derived from the underlying Wales Group (unit €Ꝑwg), which is a distinct difference from the conglomerate of the Descon Formation. Both units are dated by graptolites of Ordovician and early Silurian (Llandovery) age (Churkin and others, 1970). The Descon Formation is conformably overlain by the late Silurian (Llandovery to Ludlow) Heceta Limestone (unit Shpa of Eberlein and Churkin, 1970). The Descon Formation contains Middle to Late Ordovician detrital zircons (Gehrels and others, 1996), whereas the Moira Sound unit contains detrital zircons reflective of the underlying Wales Group (S.M. Karl, unpub. data). Although the base of the Descon Formation has not been observed, Gehrels and Saleeby (1987) suggested that it may unconformably overlie the Wales Group (unit €Ꝑwg) because the Wales metamorphic suite has been deformed and metamorphosed more than the Descon Formation. While this inference might be true for the Moira Sound unit on southern Prince of Wales Island (mapped as Descon by Gehrels and Saleeby, 1987), this is probably not true for the Descon Formation proper. Locally subdivided into units SOdc and SOv; on generalized map, all are included as part of unit SOpw

SOdc **Associated carbonate rock**—Light- to dark-gray beds of limestone up to 1 m in thickness, massive dark gray limestone interbedded with siliceous black argillite, and cross-laminated sandy limestone interbedded with shale, argillite, mudstone, and siltstone of the Descon Formation (Eberlein and Churkin, 1970). Sedimentary structures indicate deposition by turbidity flows (Gehrels, 1992). Locally includes patch reefs, associated with Luck Creek volcanic unit (unit SOv here), that consist of algal, micritic, massive gray limestone that contain stromatolites, corals, crinoids, pentacrinites, and bivalves (Karl and others, 1999). Also includes thin dark-gray metalimestone lenses associated with black graptolitic argillite associated with the Moira Sound unit of Slack and others (2007). Locally includes thin-bedded, wavy-bedded, crossbedded, or rhythmically bedded metalimestone turbidites with interbedded calcareous metamudstone. In Ketchikan area, consists of tan-weathering, sugary, white calcite and dolomite, intercalated with subordinate green metavolcanic and gray metasedimentary phyllite and schist (S.M. Karl, unpub. data). East of Peril Strait in the Sitka quadrangle, unit generally also includes massive blocks and layers of dark-gray to white, fine- to medium-grained, and gray-weathering Paleozoic(?) marble in layers that range from less than 1 cm to several meters in thickness

SOv **Associated volcanic rocks**—Felsic to mafic volcanic rocks and minor interbedded argillite and volcaniclastic conglomerate. Includes basaltic to andesitic pillow flows, porphyritic andesite, andesitic to rhyolitic breccia and tuff, and agglomerate (Eberlein and others, 1983; Brew and others, 1984; Gehrels, 1992; Brew, 1996). Unit is locally metamorphosed to subgreenschist or lower greenschist facies (Gehrels, 1992). Ordovician plutons (predominately Middle Ordovician) of unit Ogi are coeval and were probably the magma source of the volcanic rocks (Gehrels and Saleeby, 1987). On Prince of Wales Island, includes pale-colored dacitic and rhyolitic breccia, tuff-breccia, tuff, and extrusive domes (Brew, 1996) and andesitic and basaltic flows and breccia (Herreid and others, 1978; Rubin and Saleeby, 1992). Age constrained by stratigraphic relations with sedimentary rocks of the Descon Formation (included in unit SOd), intrusive relations with plutons of Late and Middle Ordovician age (unit Ogi), and K/Ar ages of volcanic rocks that indicate early Silurian and Late Ordovician emplacement (Eberlein and others, 1983; Gehrels and Saleeby, 1987)

Ordovician to Proterozoic

Oc **Chert of Interior Alaska (Ordovician)**—Dark-gray and black banded chert, siliceous slate, argillite, and less abundant greenstone, and fine-grained, thin-bedded, impure limestone and dolostone. Beds separated by carbonaceous partings. Unit interpreted to be a deep-water sequence composed of turbiditic and hemipelagic deposits (Patton and others, 2009). Unit locally contains conodonts and graptolites of Early and Middle Ordovician age in the Medfra quadrangle (Patton and others, 2009) and in adjoining parts of the Denali quadrangle and has graptolites in the Livengood quadrangle occurrences (Weber and others, 1992). Includes the Livengood Dome Chert in the Livengood, Circle, and Tanana quadrangles (Foster and others, 1983; Weber and others, 1992; J.N. Dover, written commun., 1997), the Nilkoka Group in Fairbanks quadrangle (Péwé and others, 1966), and chert and slate in the Denali and Kantishna River quadrangles (unit Doc of Bela Csejtey, Jr., written commun., 1993; Chapman and others, 1975). Locally, also included is a distinctive marker bed of lime mudstone within the chert unit, locally characterized by coated ooids in the Tanana and Circle quadrangles (J.N. Dover, written commun., 1997). Thickness varies from 10 to several tens of meters, probably in part due to structural thickening and repetition. Unit exposed in two areas and assigned to three different terranes. The northern exposures of this unit are in the Circle, Livengood, and Tanana quadrangles between thrust splays associated with the Tintina Fault System and are typically considered part of the Livengood terrane (Dover, 1994). The southern exposures are in the Medfra, Ruby, Denali, and Kantishna quadrangles and are considered part of the Minchumina and Farewell terranes (Patton and others, 2009). Unit may correlate with part of the Road River Formation of eastern Alaska and Yukon. Unit is exposed near the Amy Creek unit of Weber and others (1992), included here in unit DⱣkb

OⱣls **Limestone, northern Alaska (Ordovician through Proterozoic?)**—Unit largely corresponds to unit OⱣc, Older carbonate rocks of the Nanielik antiform of Till and others (2008a) and, in the central Brooks Range, the lower part of the Skajit Limestone. Description here derived from Till and others (2008a). Unit consists of "dolostone, metalimestone, marble and subordinate quartzose metasedimentary rocks, carbonate conglomerate, and metabasite exposed in the Nanielik antiform (northeastern Baird Mountains and northwestern Ambler River quadrangles), central Survey Pass quadrangle, and along the Dalton Highway in the Wiseman and Chandalar quadrangles." Lower part of unit is primarily orange- to light-gray-weathering, dark- to light-gray dolostone, metalimestone, and marble and subordinate quartzose metasedimentary rocks, carbonate-cobble conglomerate, and metabasite. Well-preserved tabular to club-shaped stromatolites and coated grains occur locally in dolostone and suggest an intertidal to shallow subtidal depositional setting. Matrix-supported conglomerate may represent debris flows (Till and others, 2008a). Metabasite, known only in the Baird Mountains quadrangle, consists of metamorphosed pillow breccia, pillow lava, and mafic pyroclastic rocks that contain blue amphibole. Three subunits overlie this lower unit: (1) impure metalimestone, marble, dolostone, and subordinate phyllite and calcareous and chloritic schist that display preserved sedimentary structures including grading, parallel and cross-laminae, which suggest deposition by turbidity currents; (2) massive marble that grades upward into thin couplets of bioturbated metalimestone and laminated dolostone, which is interpreted as shallowing-upward peritidal cycles. This subunit contains protoconodonts, chancellorid sclerites, hyolithids, and steinkerns of monoplacophoran mollusks that indicate a maximum age of Early Cambrian for the marble; presence of acrotretid brachiopods and agnostid arthropods demonstrate Middle and Late Cambrian ages for the middle and upper parts of the subunit; (3) condensed Lower and Middle Ordovician section, deposited in a shallowing-upward regime, consists of carbonaceous phyllite with subordinate layers of radiolarian chert and fine-grained metalimestone. Subunit grades upward into platform-margin carbonate turbidites and then into middle- to inner-platform bioclastic support stones; graptolites and conodonts indicate an age of Arenig (Lower Ordovician) to Caradoc (approximately Upper Ordovician) for this subunit. The stratigraphic succession of OⱣc is most complete and lithologies are most diverse in the Baird Mountains and western Ambler River quadrangles. There, the close spatial relationship of the unit with Proterozoic metamorphic rocks (unit Ɀam of Till and others, 2008a) is thought to reflect an original depositional relationship (Till and others, 2008a). On generalized map, included as part of unit DⱣnl

O€jr **Jones Ridge Limestone and related units (Ordovician to Cambrian)**—Map unit includes three formally defined formations in the Charley River and Black River quadrangles of eastern Alaska: the Jones Ridge Limestone, the Hillard Limestone, and the Funnel Creek Limestone. The Jones Ridge Limestone is about 915 m thick and is divided into two members; lower 610 m of the lower member is mainly very light-gray, massive, extensively silicified and commonly oolitic, pisolitic, or laminated limestone and dolostone. Upper 285 m of lower member is pale-yellowish-brown, very fine-grained, thin- to thick-bedded limestone. Upper member, about 18 m thick, is pale-yellowish-brown, thick-bedded, bioclastic limestone (Dover, 1992; Van Kooten and others, 1996). Hillard Limestone is very fine- to medium-grained, thick-bedded, pale-yellowish-brown, laminated limestone interbedded with limestone conglomerate and oolitic and sandy limestone (Dover, 1992). Funnel Creek Limestone consists of light-gray, fine- to medium-grained, extensively silicified and commonly oolitic, cliff-forming, laminated limestone and dolostone approximately 1,300 ft (400 m) thick (Brabb and Churkin, 1969). Unit is not fossiliferous, but age is considered Early Cambrian on the basis of stratigraphic position. Also included in map unit is dark-gray, fine-grained, medium- to thick-bedded, partly silicified limestone in the Demarcation Point quadrangle (Reiser and others, 1980). It contains minor dolostone, conglomeratic sandstone, and fossiliferous orange-weathering shaly limestone that has interlaminated calcareous sandstone as well as minor tuffaceous limestone and black bedded, locally conglomeratic chert (Reiser and others, 1980). Late Cambrian brachiopods and trilobites are reported from the unit (Reiser and others, 1980). This unit is associated with an argillite unit in eastern Alaska that is herein correlated with the Adams Argillite (unit €a). In northeast

Alaska, the limestone is also associated with much more extensive volcanic rock unit (unit Ꞓv). No similar volcanic rock unit is known from east-central Alaska

Cambrian to Proterozoic

Ꞓa **Adams Argillite (Cambrian)**—Light-gray argillite, siltstone, and cross-laminated quartzite with an oolitic and sandy limestone near base of unit (Brabb and Churkin, 1969). Age control derives from worm(?) burrows in the quartzite, Oldhamia in the argillite and, in the limestone near the base of the unit, archaeocyathids and trilobites of Early Cambrian age (Brabb and Churkin, 1969). Unit thickness is 90 to 180 m. In Eagle quadrangle, correlative units (included in this map unit) include greenish-gray laminated quartzite that has interbeds of greenish-gray and dark-gray argillite and minor grayish-red argillite, siliceous shale, chert, and dark-gray sandy limestone (Foster, 1976). Unit includes type area of the Adams Argillite in the Charley River quadrangle of east-central Alaska (Brabb and Churkin, 1969) as well as rocks that are apparently correlative in the Demarcation Point quadrangle of northeast Alaska (Reiser and others, 1980)

ꞒⱣwn **Wickersham and Neruokpuk units (Cambrian and Proterozoic)**—Three widely distributed and similar units in east-central and northeast Alaska and Yukon are included here. Known locally as the Hyland Group in Yukon (see Gordey and Makepeace, 2003), the Neruokpuk Schist of Leffingwell (1919) (see, for example, Reiser and others 1980; Lane, 1991) or, in some sources, Neruokpuk Formation or Neruokpuk Quartzite in Alaska and Yukon, the Nilkoka Group (Péwé and others, 1966) in central Alaska, and the informal Wickersham unit in Alaska (Weber and others, 1992). The unit is distinctly characterized by the presence of maroon and green slate and grit; however, it is quite variable in lithology and metamorphic grade. It is a dominantly clastic sequence of poorly sorted quartzite, feldspathic quartzite, grit, calcareous siltstone and fine-grained sandstone, and subordinate dark limestone and chert, locally, that contains maroon and green (Cambrian) *Oldhamia*-bearing slate in its upper part. The lower part of the Wickersham has been described as a dominantly poorly sorted to bimodal quartzite, gritty quartzite, and granule conglomerate that characteristically contains sparse, single-crystal milky white to blue quartz granules (“eyes”) in a slightly cherty quartzofeldspathic-wacke matrix (Weber and others, 1992). In central Alaska, unit typically consists of gray, maroon, and green slaty argillite interlayered with gray and greenish-gray grit and quartzite, phyllite, slate, minor limestone, and chert. Potassium or sodium feldspar grains are locally abundant, and rare argillite rip-up clasts have been reported (Foster and others, 1983; Weber and others, 1992). In northeast Alaska, the Neruokpuk Schist of Leffingwell (1919) (Reiser and others, 1980) can be described as undergoing a lithologic transition from south to north. Southern exposures consist of interbedded thin- to thick-bedded, resistant massive quartz wacke and semischist, subordinate phyllite and argillite, and rare calcareous sandstone. In northern exposures, unit is generally less metamorphosed and consists of mostly greenish to brownish gray and grayish black, fine- to coarse-grained quartz wacke that locally grades to sublitharenite and lithic graywacke and local granule grit conglomerate. Unit also includes siltstone of similar composition, as well as red, green, and black phyllitic slate and rare limy beds (Reiser and others, 1980). In both central and northeastern Alaska, Cambrian limestone and dolostone of similar description is present. In the Livengood quadrangle, the limestone is dense to very finely crystalline, nonfossiliferous, micaceous, sandy, or sparsely sandy. It contains monocrystalline, rounded to subrounded, matrix-supported quartz grains and is discontinuously thinly and horizontally bedded or platy to shaly (Weber and others, 1992). In the Demarcation Point quadrangle, the limestone is dark-gray to grayish-black, thick- to medium-bedded, and medium- to light-gray-weathering. It is, in part, pelletoidal, pisolitc, and recrystallized, and it commonly contains abundant floated rounded quartz grains. Locally it grades to coarse-grained calcareous sandstone and calcareous grit conglomerate that has a distinctive intricate net of white calcite veins (Reiser and others, 1980). Unit also includes red, green, and orange partly calcareous slate and argillite, quartzite, and greenstone of the Strangle Woman Creek sequence of Brosgé and Reiser (1969) in the Coleen quadrangle. The Strangle Woman Creek sequence also includes minor greenstone, which is included here. Rocks adjacent to the Coleen quadrangle outcrops, in Yukon, are the country rock to the Old Crow batholith (unit MDgi) and are described as “red, green and grey slaty argillite; fine grained, light grey quartzite; dolomite”; they have been tentatively assigned to the Pinguicula or Fifteen Mile units of Mesoproterozoic age (Gordey and Makepeace, 2003), which here is considered equivalent to the Wickersham or Neruokpuk units. In east-central Alaska, the Wickersham is exposed south of or within strands of the Tintina Fault System; north of the fault system in Yukon the Wickersham equivalent unit is the Hyland Group (Gordey and Makepeace, 2003). Unit also includes a very small area of mafic intrusive rocks in the Black River quadrangle that are possibly equivalent to Hart River Volcanics of the Yukon. On generalized map, included as part of unit ꞒⱣwn

ꞒⱣt **Tindir Group (Cambrian? and Proterozoic)**—The Tindir Group is commonly divided into upper and lower parts (see Young, 1982; MacDonald and others, 2010). The lower Tindir Group is as much as 2 km thick and divided into several informal units. As the base of the lowest unit is nowhere exposed, true thickness is unknown. The lower shale unit is gray to black mudstone overlain by light-gray quartzite that contains discontinuous stromatolite bioherms. The lower shale is unconformably overlain by a lower dolostone unit (Van Kooten and others, 1996), which is less than 350 m thick and is dominated by branching to massive domal stromatolites. An upper shale unit consists of less than 500 m of fissile black shale with interbedded quartzite and carbonate beds. The uppermost unit of the lower Tindir Group, an upper dolostone, consists of yellow-weathering dolostone that has intraclast breccia, black chert nodules, shale interbeds, and molar tooth structures (Young, 1982). All units in the lower Tindir Group are intruded by north-northwest-trending mafic dikes. Young (1982) separated the upper Tindir Group into five informal units. Unit 1 is “as much as 200 m of green and gray, commonly amygdaloidal pillow basalts and locally cupriferous tuffs and volcanic breccias” (Young, 1982) and minor tuff, shale, sandstone, and conglomerate. Young (1982) described unit 2 as purple mudstone and minor gray and green mudstone and siltstone, as well as thin beds (less than 50 cm) of purple diamictite and graded purple and gray sandstone in a generally coarsening-upward sequence that varies from less than 200 m to more than 700 m thick. Iron formation is locally present near the top of unit 2; elsewhere unit is capped by an orange-weathering diamictite that has a dolomite-rich matrix. Unit 3 of Young (1982) “is composed mainly of crudely stratified purple and red diamictite with much thinner interbeds of purple mudstone and red and orange beds and lenses of chert,” which MacDonald and others (2010) divided into two parts: a lower planar-laminated siltstone and sandstone more 100 m thick that contains minor dolomite marl, and an upper massive diamictite that has clasts as large as boulders. Young’s (1982) unit 4, as thick as 600 m, is highly lithologically variable, generally it consists primarily (about 70 percent of unit) of gray and green shale, which is interbedded with turbiditic dolomitic sandstone, siltstone, and incidental amounts of gray diamictite and volcanic breccia. Locally, a fine-grained buff to gray, locally cherty dolostone constitutes the bulk of unit 4. Young’s (1982) unit 5, the uppermost unit of the upper Tindir Group, is also highly lithologically laterally variable and is primarily described as gray wavy-bedded limestone and calcareous siltstone that has channels filled with granule to pebble conglomerate of largely limestone clasts. Structures indicating deposition by turbidites are common. Elsewhere, parts of the unit stratigraphically above the conglomeratic layers suggest deposition in a shallow-marine, tidally influenced(?) environment (Young, 1982). Locally, the unit is composed largely of dark-gray to black carbonaceous shale that contains minor quartz sandstone and slumped dolostone beds. In contrast to the lower Tindir Group, none of the upper Tindir Group exposures above unit 1 contain mafic intrusions (MacDonald and others, 2010). Age control is limited and open to interpretation. Allison (1981) thought the microfossils she examined from the upper Tindir Group to be of Cambrian age; Young (1982) seems to imply that a hiatus in deposition is likely present between the upper Tindir Group and overlying well dated late Early Cambrian units, making the Tindir Group entirely Proterozoic. Kaufman and others (1992), on the basis of geochemical evidence, interpreted the microbiota of the upper Tindir Group to be of late Riphean age (780 to 620 Ma, middle Neoproterozoic) and therefore also suggested that the Tindir Group is entirely of Proterozoic age. MacDonald and Cohen (2011) suggested abandoning the Tindir nomenclature and placing parts of the lower Tindir Group into the Pinguicula and Fifteen Mile groups, which form the Mackenzie Mountains Supergroup of Turner (2011), putting the uppermost part of the lower Tindir Group and lowermost unit of the upper Tindir Group into the Coates Lake Group of Eisbacher (1981) and placing the remaining parts of the upper Tindir Group into the Windermere Supergroup of Ross (1991). [For a proposal regarding the Canadian stratigraphic nomenclature relative to these units, see MacDonald and others (2011)]

## PROTEROZOIC

Ƥkd **Katakturuk Dolomite (Proterozoic)**—Defined by Dutro (1970), unit in northeastern Alaska is entirely dolostone except for about 75 m of shaly, dolomitic silty beds near its base. It is locally stromatolitic, sometimes with chert nodules and sparry karst infillings, and may be interbedded with lesser black siltstone and shale, laminated mudstone, and quartzose sandstone; unit also locally contains dolostone boulder conglomerate (Bader and Bird, 1986; Robinson and others, 1989). Dutro (1970) informally divided unit into nine lithologic units and assigned an age of Middle Devonian or older. Blodgett and others (1986) reassigned age to the Proterozoic on basis of the stratigraphic relation with overlying Nanook Limestone (of Devonian to Ediacaran age; included in unit DZnl here). Clough and Goldhammer (2000) describe the Katakturuk Dolomite as a south-dipping, low-angle, distally steepened carbonate ramp complex that has a complete spectrum of facies types, from proximal, updip tidal-flat complexes to distal, downdip, turbidites and debris-flow deposits. They believe it represents passive-margin cyclic sedimentation and provides insight into the evolution of Precambrian carbonate platforms in response to eustatic sea-level changes. Macdonald (2011) advocates separating a unit at the base of the Katakturuk Dolomite into his informally named Hula Hula diamictite, an orange-weathering conglomerate that has clasts of volcanic rocks (presumably from unit Ƥv, described below). He suggests that this proposed subunit was deposited under glacial influence, but this interpretation is not yet universally accepted

## VOLCANIC ROCKS

### CENOZOIC TO MESOZOIC

#### Quaternary to Tertiary

Qv **Youngest volcanic rocks (Quaternary and latest Tertiary?)**—Volcanic rocks ranging in composition from rhyolite to basalt. Along the Aleutian magmatic arc and the Wrangell Mountains, the rocks are predominantly andesite and lesser dacite and basalt of calc-alkaline and tholeiitic affinity in lava flows, volcanic breccia, lahar deposits, and debris-flow deposits. Lava flows and clasts in other volcanic deposits of unit are porphyritic, typically glassy, gray to black, and commonly vesicular. Unit also includes basaltic, basaltic andesite, and dacite parasitic cinder and spatter cones. Unit typically forms volcanic edifices; it also forms isolated outcrops that cap ridges, providing a good example of topography reversal, which results from erosion of surrounding country rocks, leaving exposed more erosion-resistant flows that formerly had occupied valleys. Individual flows are locally as thick as 30 m and are laterally continuous over large areas. Includes Edgecumbe Volcanics (basalt, andesite, and dacite) on Kruzof Island (Loney and others, 1975; Riehle and others, 1989) and unnamed basaltic to rhyolitic rocks on islands west of Prince Wales Island (Eberlein and others, 1983), and on Zarembo, Kuiu, and Kupreanof Islands (Brew and others, 1984). Rocks of Holocene age were recognized east of Wrangell Island (Elliott and others, 1981) and on Kruzof Island (Loney and others, 1975), and basaltic rocks of Holocene and (or) Pleistocene age are found on southern Kupreanof Island (Brew and others, 1985). On Revillagigedo Island and mainland to the east in the Ketchikan quadrangle (Berg and others, 1978, 1988) and at many other localities in southeast Alaska (Karl and others, 2012), this extrusive unit consists of alkaline-olivine basalt that forms volcanic cones, columnar jointed lava flows, and rubble flows that contain pumice and scoria; it also includes lenses of ash and lapilli a few centimeters to a few meters thick—too small to show on the map. Includes post-glacial flows and pyroclastic deposits that overlie glacial deposits and landforms. On generalized map, included as part of unit QTvi

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

QTvs **Kiska Harbor and Milky River Formations (Quaternary? and late Tertiary)**—Kiska Harbor Formation, exposed in the Kiska quadrangle, is composed of subaerial lava flows, autoclastic breccia, pyroclastic rocks, water-laid pumiceous sand, and conglomerate (Coats and others, 1961). Flows are predominant in northern exposures and sedimentary (water-laid) beds to the south. The flows and sedimentary rocks interfinger; the flows thin southward and grade into autoclastic breccia, whereas sedimentary layers thin northward (Coats and others, 1961). The sedimentary rocks are composed entirely of volcanic debris, and generally are crossbedded. Depending on location, crossbeds are inclined to the east and southeast or south and southwest (Coats and others, 1961). On Little Kiska Island, the Kiska Harbor Formation unconformably overlies steeply dipping beds of the Vega Bay Formation (unit Tvu here). Coats and others (1961, p. 573) noted that the Kiska Harbor Formation resembles the rocks of dissected composite volcanoes on the north end of Tanaga and Kanaga Islands that contain fossils of Pliocene age. Panuska (1981) reported K/Ar whole rock ages between 3.30±0.10 and 5.50±0.7 Ma. The Milky River Formation of the Alaska Peninsula is of variable thickness (but about 600 m at thickest) and consists of volcanogenic, nonmarine sedimentary rocks and interlayered flows and sills; volcanic rocks are thicker and more abundant stratigraphically upward in unit. Lower part of unit consists nearly entirely of coarse, highly crossbedded and channeled, fluvial volcaniclastic sandstone and cobble-boulder conglomerate. Rocks are poorly indurated, dark-brown to gray, and have clasts composed almost entirely of volcanic lithologies. Upper part of unit contains numerous porphyritic andesite flows, lahar deposits, and tuff beds interlayered with sedimentary rocks. Volcanic rock clasts in lahar deposits are as large as 2 m. A flow unit near top of the stratigraphic section in type locality of the Milky River Formation was dated at 3.53±0.27 Ma (K/Ar, whole rock, Wilson and others, 1981). Another flow unit in lower part of the section exposed in the Port Moller D-1 1:63,360-scale quadrangle has been dated at 3.87±0.06 Ma (K/Ar, plagioclase, Wilson, 1989). Unit unconformably overlies the Bear Lake Formation (unit Tms) and conformably underlies Pliocene(?) and Quaternary volcanic flows (unit QTv). Included in unit in area northwest of Pavlof group of volcanoes are rocks mapped as agglomerate of Cathedral Valley by Kennedy and Waldron (1955), which they describe as a thick sequence of agglomerate beds and subordinate tuff beds and lava flows that are well exposed. These volcanic rocks crop out northwest of Mount Dutton and Pavlof volcanoes. According to Kennedy and Waldron (1955), the unit in that area is predominantly basalt and basaltic andesite and dips north toward the Bering Sea. Kennedy and Waldron (1955) suggested that the agglomerate of Cathedral Valley flows are probably comparable in age to the Belkofski Tuff, later renamed the Belkofski Formation by Burk (1965), which is included in unit Tuu here; we suggest here that a better lithologic and stratigraphic correlation is with Milky River Formation and, thus, map these rocks as such

## Tertiary to Cretaceous

Tvu **Volcanic rocks of southern Alaska (Tertiary, Pliocene? and older)**—Widely distributed throughout southern Alaska, unit is composed of andesite, basalt, and dacite lava flows, tuff, lahar deposits, volcanic breccia, and hypabyssal intrusions, typically poorly age constrained, and all locally hydrothermally altered or hornfelsed. Rocks of this unit tend to fall within two groups on the basis of age, where it has been determined. In south central Alaska, unit includes subaerial flows and associated pyroclastic rocks that range in composition from rhyolite to basalt. These rocks tend to be dominantly moderately altered rhyolite and basalt, but andesite, dacite, and latite also occur. Similar volcanic rocks are mapped in the Anchorage and Talkeetna Mountains quadrangles (unit Tv, Winkler, 1992; Csejtey and others, 1978, respectively), where they also include small lenses of fluvial conglomerate. Flows possibly correlative with this unit occur within the Arkose Ridge Formation (included in unit Ttk here) and yield K/Ar ages that range from 56.2±1.7 to 39.2±2.4 Ma (Csejtey and others, 1992; Winkler, 1992). A crude stratification is described (Csejtey and others 1978; Winkler, 1992), where felsic rocks and pyroclastic rocks occur stratigraphically lower and basaltic and andesitic flows occur in the upper part of the section. Unit includes rhyolitic breccia, ash-flow tuff, flows, and intrusive rocks and subordinate mafic and intermediate flows in the Lake Clark quadrangle and is thought to encompass entire Tertiary and may include Jurassic rocks of the Talkeetna Formation. Much of this unit was included in map unit Tv of Nelson and others (1983), but those rocks that we believe correspond in age with the Oligocene to Eocene Meshik Arc (Wilson, 1985) were placed within map unit Tmv here. In the Sleetmute quadrangle, brownish black olivine basalt that locally displays columnar jointing and possibly pillow structures (Miller and others, 1989) is included here, as well as olivine basalt in the Livengood, Fairbanks, and Lime Hills quadrangles. On Kavalga, Ogliuga, Ulak, and Skagul Islands (Fraser and Barnett, 1959), basaltic or andesitic lava and pyroclastic deposits were undivided in mapping; however, K/Ar age determinations suggest a bimodal age distribution of these rocks. Dates on altered rock samples from Ulak Island were 33.9±1.1 Ma and 43.4±4.6 Ma (DeLong and others, 1978; Marvin and Cole, 1978), whereas samples from Skagul and Kavalga Islands yielded 5.2±0.9 Ma and

6.2±0.4 Ma on andesite (Marvin and Cole, 1978). Marine deposits of volcanic breccia, tuff, and a few pillow lava flows, all of basaltic composition, with a few interbeds of conglomerate and sandstone of similar material are found on Kiska Island (Coats and others, 1961). Samples from flows, a dike, and a basalt boulder within the Vega Bay Formation yielded K/Ar ages that range from 55.3 to 14.7 Ma (DeLong and others, 1978; Marvin and Cole, 1978); the oldest age is inconsistent with the presumed stratigraphic position of the Vega Bay Formation and is therefore viewed as incorrect. The next oldest age of 29.2±4.4 Ma is on an olivine-basalt boulder within the sedimentary rocks of the unit and clearly indicates a protolith age. An age of 17.8±1.1 Ma was determined on a dike cutting the unit, presumably suggesting a minimum age for the unit; however, a flow within the unit yielded an age of 14.7±1.2 Ma, resulting in some doubt as to the age of the unit. Scattered outcrops of felsic to mafic volcanic rocks and related shallow intrusive bodies in the northwest part of the Talkeetna Mountains quadrangle (unit Tv of Csejtey and others, 1978) are also included here; other parts of Csejtey and others' (1978) unit Tv have been assigned to unit Tepv. Finally, includes "basaltic pyroclastic and flow rocks, including minor pillowed lava flows; locally interbedded with marine sedimentary rocks, including tuffaceous or glauconitic strata, probably related genetically to mafic dikes, sills, and plugs on Middleton Island" (Winkler and Plafker, 1993). On generalized map, included as part of unit Tv; locally subdivided into the following seven units Twv, Tpv, Tvm, Tob, Tca, Tmv, and Tev:

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

Tpv **Basalt and tuff (Tertiary, Pliocene)**—Olivine basalt lava flows as thick as 10 m and locally diabasic intrusive rocks are found in the northwest corner of the Taylor Mountains quadrangle. These columnar-jointed flows, which form a large tilted plateau, yielded K/Ar ages of 4.62±0.14 Ma (from plagioclase) and 4.72±0.1 Ma (whole rock) (Reifenstuhl and others, 1985); D.C. Bradley (written commun., 2010) reported a whole rock $^{40}Ar/^{39}Ar$ plateau age of 4.63±0.07 Ma. An outcrop of olivine basalt at Kazik Hill in the northeast Taylor Mountains quadrangle is undated, but also included here. Map unit also includes the Intricate Basalt of Detterman and Reed (1980) in the Iliamna quadrangle, a glassy to porphyritic black to dark-green olivine-augite basalt, which occurs largely in the vicinity of Intricate Bay, but also occurs south of Gibraltar Lake and includes mafic dikes not shown here. Detterman and Reed (1980) reported K/Ar whole rock dates of 4.4±0.5 and 5.1±1.0 Ma on an olivine basalt dike that cuts the Naknek Formation. Unit also includes Gibraltar Lake Tuff, which has an upper nonwelded member of light-gray to white crystal ash-flow tuff that has a maximum thickness of 152 to 182 m; locally capped by basalt flows of Intricate Basalt. Lower member is at least 300 m thick, consists of light- to medium-gray and tan rhyolitic crystal and lithic welded tuff; locally, interbedded porphyritic rhyolite flows. Detterman and Reed (1980) had little age control; however, based on geomorphic character and comparison with other Tertiary age units, they suggested that the age was more likely Pliocene than Oligocene. On generalized map, included as part of unit Tvpm

Tvm **Volcanic rocks of the Aleutian Islands and Alaska Peninsula (Tertiary, Miocene)**—Consists of subaerial hornblende- and pyroxene-andesite and basalt flows, sills, and plugs largely restricted to the Aleutian Islands and the Pacific coast of the Alaska Peninsula. Extrusive rocks of unit typically cap ridges and consist of massive lava flows, agglomerate, and lahar deposits; unit also includes minor small intrusive bodies. Minor propylitic alteration is characteristic of these rocks. Locally, these rocks are the extrusive rocks associated with the plutons of map unit Tmi. In the Aleutian Islands, also includes breccia, tuff, and marine conglomerate on Amchitka Island that exceeds 1,000 ft (305 m) in thickness (Powers and others, 1960). Includes the Chitka Point Formation as redefined by Carr and others (1970), who extended the outcrop area of the Chitka Point by including andesitic rocks originally defined as part of the Amchitka and Banjo Point Formations (Powers and others, 1960) and excluded basaltic rocks that they considered to be part of the Banjo Point Formation. The conglomerate of the Chitka Point Formation on Amchitka Island consists primarily of well-rounded to subrounded cobbles of porphyritic andesite; also less abundant, but common, are clasts derived from the Amchitka Formation (Powers and others, 1960). At the type locality of the Chitka Point Formation, the conglomerate contains abundant carbonized fragments of woody material, which suggests proximity to land. A coal sample from the conglomerate yielded numerous pollen and spores, probably of middle to late Miocene age (E. Leopold, cited in Carr and others, 1970). In addition, Carr and others (1970) reported late Miocene K/Ar ages (minimum age of 14.6±1.1 to 12.8±1.1 Ma) from flows within the Chitka Point Formation and therefore assigned a Miocene age, revising the Quaternary or Tertiary age assignment by Powers and others (1960). Unit also includes dikes and small intrusive bodies largely of basalt and andesite on southern Adak and Kagalaska Islands (Coats, 1956b, c). In the Russian Mission, Dillingham, and Iditarod quadrangles of southwest Alaska, rocks assigned to this unit generally consist of very fine-grained to aphanitic, dark- to medium-gray, locally vesicular basalt and basaltic andesite; K/Ar ages are between 19.35±0.58 and 6.19±0.19 Ma (Patton and others, 2006; Wilson and others, 2006a, in press [a]; Miller and Bundtzen, 1994). On generalized map, included as part of unit Tvpm

Tob **Olivine basalt flows (Tertiary, Miocene)**—Vesicular, massive olivine basalt flows exposed in the Coleen and Black River quadrangles, plus an outlier in the southeast Chandalar quadrangle. In the Coleen and Black River quadrangles, the flows may be as much as 100 m thick and are interbedded with lacustrine sedimentary rocks (Fouch and others, 1994). Kunk and others (1994) reported $^{40}Ar/^{39}Ar$ ages that range from 15.7±0.1 to 14.4±0.1 Ma. In the Chandalar quadrangle, the flows are as much 300 m thick and not dated. On generalized map, included as part of unit Tvpm

Tca **Admiralty Island and Cenotaph Volcanics (Tertiary, Miocene to Oligocene)**—Admiralty Island Volcanics consist of a wide range of volcanic and volcaniclastic rocks primarily exposed on Admiralty, Kupreanof, and Kuiu Islands in southeast Alaska and range from rhyolite to basalt, although rhyolite is uncommon. Rhyolite is quartz and feldspar porphyritic, light-gray or light-brown when fresh and buff, white, green, lavender, maroon, or pink where altered; occurs in domes, as dikes up to several meters thick in swarms, or as breccia (Brew and others, 1984; Karl and others, 1999). Dacite found in flows that have large amygdules lined with silicate minerals and abundant inclusions of igneous rock types (Brew and others, 1984). Basalt or andesite flows are dark-gray and less commonly light-gray, grayish-green or red, commonly sparsely porphyritic and often contain phenocrysts of labradorite-bytownite feldspar, augite, and uncommon olivine and hypersthene. Tuff and breccia beds are interlayered with flows in lower part of the sequence. Locally the flows are altered and sheared along major linear features believed to be faults of considerable displacement. In several places sandstone and conglomerate are interbedded with flows and tuff beds at the base (Lathram and others, 1965). Cenotaph Volcanics are found in the Mount Fairweather quadrangle and are andesitic volcanic rocks, volcanic breccia and tuff, siltstone, sandstone, and conglomerate (D.A. Brew, written commun., 1997). On generalized map, included as part of unit Tvme

Tmv **Meshik Volcanics and similar rock units (Tertiary, Oligocene to Eocene)**—Typically consists of coarse andesitic and basaltic volcanic rubble, lahar deposits, andesite and basalt lava flows, tuff, hypabyssal basalt and andesite plugs, lesser dacite and rare rhyolite, and minor amounts of volcaniclastic sedimentary rocks. Includes the Meshik Volcanics of the Alaska Peninsula, the Mount Galen Volcanics of central Alaska (Decker and Gilbert, 1978), the Ship Creek, Windy Fork, and Terra Cotta volcanic fields of the McGrath quadrangle (Bundtzen and others, 1997a), and the Finger Bay Volcanics of the Aleutian Islands (Coats, 1956b). Also includes the Rat Formation (Lewis and others, 1960), Amchitka Formation (Powers and others, 1960; Carr and others, 1970), and other rocks included in the “Lower Series” (Vallier and others, 1994) of the Aleutian Islands, as well as other unnamed volcanic rocks. The Meshik Volcanics represent the early phase of the Aleutian magmatic arc, named the Meshik Arc, and correspond to the “Lower Series” rocks in the Aleutian Islands. Unnamed equivalent rocks extend as far north as the Lake Clark quadrangle. The sedimentary rocks are equivalent in age and lithology to the Stepovak and Andrew Lake Formations (unit Tarcs). As described by Detterman and Reed (1980), in many cases eruptive centers can be identified, either as volcanic necks of eroded volcanoes or as caldera complexes. Potassium-argon ages on multiple samples of the Meshik Volcanics and rocks in the Aleutian Islands range from about 42 Ma to about 25 Ma (Wilson and others, 1999, 2006b, 2015); the vast majority of age determinations are between 40 and 30 Ma. Megafauna fossil collections from the Meshik Volcanics are rare, but existing collections are Eocene and Oligocene in age. The Mount Galen Volcanics, originally considered part of the Cantwell Formation (Decker and Gilbert, 1978), can be considered the northernmost part of this magmatic arc. They consist of andesite and basalt flows, tuff, and breccia of calc-alkaline affinity. The Finger Bay Volcanics of Adak and Kagalaska Islands and most of the Andreanof Islands east of Adak Island (Coats, 1956a; 1956b; Fraser and Snyder, 1959), and similar rocks on southeastern Great Sitkin Island (Simons and Mathewson, 1955; Waythomas and others, 2003) are basalt flows, hornblende-basalt tuff, flow breccia, agglomerate, basalt dikes, and subordinate rhyolite tuff and quartz porphyry dikes, intruded by large masses of gabbro and small masses of rhyolite (Coats, 1956b). The Rat Formation of Hawadax (formerly “Rat”) Island (Lewis and others, 1960) consists of flows and flow breccia of porphyritic andesite and minor conglomerate composed of andesitic debris. Altered pyroclastic deposits, pillow lavas, and minor sedimentary rocks on Ulak Island (Coats, 1956a) are included here as well. Also included is the Amchitka Formation (Powers and others, 1960; Carr and others, 1970), which is mainly volcanic agglomerate, tuff-breccia, tuff, and pillow lava flows of andesitic to latitic composition. In the McGrath quadrangle, the Ship Creek, Windy Fork, and Terra Cotta volcanic fields of Bundtzen and others (1997a) include gray-green andesite flows, light- to medium-gray, porphyritic, hornblende-bearing massive dacite and potassium-feldspar porphyritic rhyodacite flows, and a similar chemical range of tuff and lahar deposits. Rocks in these volcanic fields have yielded K/Ar ages ranging between 45.5±1.4 and 37.2±2.9 Ma (Solie and others, 1991a). On generalized map, included as part of unit Tvme

Tev **Felsic volcanic rocks of southwest Alaska (Tertiary, Oligocene? and Eocene)**—Primarily felsic tuff and subordinate flows and hypabyssal intrusive rocks exposed across southwest Alaska. In the Iliamna quadrangle, unit consists of cream, light-gray, green, and purple bedded lithic, crystal, and vitric tuff (Detterman and Reed, 1980). Also includes distinctive light-colored horizons of felsic tuff interlayered with olivine basalt in the northeast Dillingham quadrangle (Wilson and others, 2003). A sample from the northeast Dillingham quadrangle yielded a $^{40}Ar/^{39}Ar$ age determination of 45.1±0.19 Ma, whereas a sample from the southern Dillingham quadrangle yielded a $^{40}Ar/^{39}Ar$ age of 41.62±0.18 Ma, consistent with the age of the Meshik Volcanics (unit Tmv). Includes two areas of massive columnar-jointed olivine basalt flows in the northeast Dillingham quadrangle (Wilson and others, 2003). The younger of these flows ranges from 3 to 10 m thick, are interbedded with felsic tuff, and yielded a $^{40}Ar/^{39}Ar$ age of 44.47±0.41 Ma. The older olivine basalt may, in part, be a sill—locally it is overlain by contact-metamorphosed rocks of unit KŦs, marine volcaniclastic sandstone, conglomerate, and argillite; it yields a $^{40}Ar/^{39}Ar$ isochron age of 53.71±0.61 Ma. Similar tuff and subordinate flows and hypabyssal intrusive rocks of apparently felsic composition occur in small exposures in the eastern Lime Hills and the Melozitna quadrangles, as well as in local accumulations of volcaniclastic sedimentary rocks. In some areas of the Lime Hills quadrangle, rocks range from andesite to dacite in composition, but in general the composition was not reported (Gamble and others, 2013). Farther west in the Bethel quadrangle, Box and others (1993) mapped moderately altered rhyolite flows, domes, and ash-flow tuff. Rhyolite of the main volcanic field contains phenocrysts of sanidine, riebeckitic amphibole, and rare quartz. An $^{40}Ar/^{39}Ar$ total-fusion age on riebeckite was 54.7±1.6 Ma. Also includes andesite to basalt plugs, volcanic rubble and breccia, including some agglomerate; may include deposits of lahars (Detterman and Reed, 1980). Many of the rocks of this map unit are associated with eruptive centers. An isolated andesitic plug in northeast Dillingham quadrangle yielded a $^{40}Ar/^{39}Ar$ isochron age of 47.95±1.39 Ma. Overall, dates on rocks of this map unit range from the 54.7±1.6 Ma age mentioned above to 33.6±3.4 Ma. On generalized map, included as part of unit Tvme

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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 $^{40}Ar/^{39}Ar$ hornblende plateau age of 115±2 Ma, but either the age or the sample setting must be considered suspect because this is significantly older that the unit it intrudes; an intermediate-composition dike yielded an $^{40}Ar/^{39}Ar$ 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 $^{40}Ar/^{39}Ar$ 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 $^{40}Ar/^{39}Ar$ plateau age on amphibole from an andesite dike yielded an age of 58.64±0.52 Ma. Unit also includes unit TJds of Winkler (1992), which yielded widely different whole-rock K/Ar ages of 130±6 Ma and 38±2 Ma. The subvolcanic hornblende dacite of Jumbo Dome in the Healy quadrangle yielded a K/Ar age as young as 2.79±0.25 Ma (Csejtey and others, 1992). Other determinations yielded ages throughout the Tertiary

Tbk **Basalt and keratophyre (Tertiary, Paleogene, or older)**—Largely tuff and tuff agglomerate of generally basaltic composition and interbedded pillow lava flows on Attu and Agattu Islands, called the "Basement Rocks" by

Gates and others (1971). Pyroclastic rocks range from coarse, bomb-filled lapilli tuff to fine-grained, silt-sized tuff, agglomerate, and breccia. Beds, up to 30 m thick, range from massive and poorly sorted to well bedded and graded (Gates and others, 1971). Agglomerate consists of angular to subrounded blocks up to 1 ft (30 cm) in diameter of basalt, keratophyre, and, rarely, albite granite in a mottled pale-green and white tuffaceous matrix (Gates and others, 1971, p. 718–719). Pillow lava flows form an important part of the basement series. Individual flows range in thickness from 1 ft (30 cm) to several tens of feet and contain pillows typically 3 to 6 ft (1 to 2 m) in horizontal dimension. Columnar jointing is locally present. Pillows have glassy-appearing selvages on their outer surfaces; in cross section, some display concentric layering of amygdules. Basaltic rocks are commonly altered to spilite; more siliceous volcanic rocks are altered to keratophyre and quartz keratophyre (Gates and others, 1971). Interstices between pillows are filled with varicolored chert, chalcedony, red jasper, or calcareous mud, and, locally, red limestone (Gates and others, 1971). DeLong and McDowell (1975) report two K/Ar ages from this unit, interpreted as minimum ages: 29.0 Ma on a pillow basalt flow and 30.7 Ma on amphibolite

Tepv **Andesite and basalt flows (Tertiary, Eocene and Paleocene)**—Composed of columnar-jointed andesite and basalt lavas that locally contain interbedded tuff, breccia, and agglomerate, this unit is exposed in two general areas, the largest of which is a belt in west-central Alaska. In the Takhakhdona Hills of the Melozitna quadrangle, dark-green to black vesicular basalt flows formerly mapped by Patton and others (1978) in their unit TKv are now known to be of Tertiary age. Isolated exposures include the Roundabout Mountain volcanic field in the Kateel River quadrangle and olivine basalt flows on the eastern part of the boundary between the Bettles and Tanana quadrangles. The second area of exposure is in the Talkeetna Mountains quadrangle, where there are outcrops of predominantly reddish-brown-weathering, aphanitic to porphyritic basaltic andesite and basalt lavas, often columnar-jointed, and including lesser tuff, and local cinder deposits (Csejtey, 1974; Anderson, 1969; Oswald, 2006). Individual flows and tuff beds are tens of meters thick; as a whole, unit may be several hundred meters thick. A small area of basalt flows is also mapped in the western Lime Hills quadrangle (Wilson and others, 1998). K/Ar isotopic cooling ages range from 65.2±3.9 to 38.6±2.4 Ma. On generalized map, included as part of unit Tv

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

TKv **Volcanic rocks in southern Alaska (early Tertiary to Late Cretaceous)**—Primarily consists of basalt and andesite, but ranges from basalt to rhyolite, largely exposed in southwest Alaska. A common association is with rocks of the Kuskokwim Group (unit Kk), however, this volcanic rock unit is somewhat more widespread in southwest Alaska. Unit varies compositionally across exposure area and incorporates the full lithologic range of flows, tuff, and breccia and minor interbedded sandstone and shale in the Ruby, Iditarod, and Ophir quadrangles (Cass, 1959; Chapman and Patton, 1979; Chapman and others, 1985; Miller and Bundtzen, 1994). In the Iditarod quadrangle, includes that part of the Iditarod Volcanics that overlies the Kuskokwim Group. Andesite and basalt flows and volcaniclastic rocks are widely exposed in the central part of the Holy Cross quadrangle and in a small area in the north-central part of the Russian Mission quadrangle between the Yukon and Kuskokwim Rivers. Flows are generally porphyritic and are composed of phenocrysts of plagioclase and pyroxene in a groundmass of plagioclase microlites. Some of the flows are columnar jointed and locally vesicular. Volcaniclastic rocks in this unit include breccia, tuff, and agglomerate. The andesitic and basaltic rocks commonly are interlayered with or intruded by small bodies of dacite and rhyolite (Patton and others, 2006). In the southwest part of Talkeetna quadrangle, Reed and Nelson (1980) mapped interbedded medium- to coarse-grained greenish-gray crystal-lithic lapilli tuff and mafic volcanic rubble flows in units as much as 150 m thick, as well as associated sandstone, shale, and minor calcareous mudstone. In the McGrath, Melozitna, Unalakleet, Tanana, and Medfra quadrangles (Patton and others, 1978; Patton and others, 1980; Bundtzen and others, 1997a), unit consists of dacite, rhyolite, and trachyandesite lava flows, domes, sills, dikes, and interlayered breccia and tuff. In the Bethel quadrangle, unit includes felsic rocks of the Swift Creek, Tulip, and Eek volcanic fields of Box and others (1993) as well as rhyolitic rocks in the Ruby (Cass, 1959), Denali (Bela Csejtey, Jr., written commun., 1993), Tanana (Chapman and others, 1982), and Kantishna River quadrangles (Chapman and others, 1975); unit also includes felsic tuff in the Tyonek quadrangle (Solie and others, 1991a). Locally, in Unalakleet and Medfra quadrangles, tuff at the base of unit TKv contains interbeds of quartz-chert-pebble conglomerate, sandstone, siltstone, and thin coaly layers that contain abundant plant fossils. Palynflora collected from coaly layers at the base of the unit in the Medfra quadrangle are latest Cretaceous in age. Unit overlaps compositionally and spatially with units Tpt and TKwt, described below. Where known, age determinations generally range between approximately 70 and 50 Ma. On generalized map, included as part of unit TKpr

Tpt **Pyroclastic rocks (Tertiary, early Eocene or Paleocene)**—Tuffaceous rocks distributed in several areas of Alaska. The largest area of exposure is a belt in the Bettles, Tanana, and Melozitna quadrangles where light-gray to pink rhyolite tuff, welded(?) tuff, flows, and breccia and subordinate pumice, dark vitrophyre, and obsidian constitute the unit (Patton and others, 2009). Obsidian chips and artifacts found in archeological sites in northwest Alaska may have originated from this unit. In southwest Alaska in the northeast Dillingham quadrangle, unit includes crystal tuff that contains variable amounts of biotite and feldspar crystals and varies in general appearance from crystal tuff to porphyritic plutonic rock (Wilson and others, 2003), but in all cases the groundmass is tuffaceous. The proportion of tuff appears to increase from east to west. Wallace and others (1989) report K/Ar ages of 58.6±1.8 Ma (biotite) and 57.9±1.7 Ma (hornblende) for this unit, whereas multiple $^{40}Ar/^{39}Ar$ age determinations on biotite yield a tight age range between 59.69±0.05 and 59.25±0.05 Ma (Iriondo and others, 2003). On the northern part of Saint Matthew Island in the Bering Sea, unit is chiefly rhyolite and dacite welded tuff, tuff breccia, and dark rhyolite vitrophyre (Patton and others, 1975) and also includes minor intercalated andesite and basalt flows and dikes. On southwestern part of island, unit is chiefly light-colored rhyolite and dacite hypabyssal rocks (Patton and others, 1975). These felsic rocks appear to overlie mafic flows and volcaniclastic rocks and may be extrusive and hypabyssal cogenetic equivalent of granodiorite on the island (Patton and others, 1975). Age thought to be Eocene or Paleocene (see Wittbrodt and others, 1989). Tuffaceous rocks of similar age are known from the interior of Alaska in the Tanana (Reifenstuhl and others, 1997) and Big Delta quadrangles (Weber and others, 1978; Day and others, 2007); described by Reifenstuhl and others (1997) as "white and pink, purple and white, light-orange and pink, glassy-aphanitic to very fine-grained, flow-banded rhyolite, rhyolite tuff breccia, ignimbrite, and potassium feldspar-porphyritic rhyolite. The rock types present suggest that the rhyolite was emplaced as flows, domes, tuffs, breccia, and rare obsidian, and suggest extrusion over a significant period of time." Bacon and others (1990) described areas of tuffaceous rocks in east-central Alaska that they interpreted as caldera complexes. In the easternmost Big Delta quadrangle, a complex that they called "Slate Creek," another complex they called "EC" in the easternmost Tanacross quadrangle, and additional exposures along Taylor Highway in the Eagle quadrangle have yielded a range of K/Ar and U/Pb ages that date these rocks to the Paleocene and Eocene, between 61.6±2.0 and 54.6±1.6 Ma (Foster and others, 1979; Bacon and others, 1990). In the northern Tyonek quadrangle, more mafic andesite to dacite welded tuff occurs, where it consists of massive welded tuff in beds thicker than several meters (P.J. Haeussler, written commun., 2007). Unit also includes the Porcupine Butte andesite of Solie and Layer (1993), which consists of columnar jointed andesite forming the neck of a Paleocene volcanic center (Solie and others, 1991a). Pyroclastic volcanic rocks are also found in southeast Alaska in the Juneau and Taku River quadrangles and range from tuff to coarse block-and-ash-fall breccia, which are recognized as part of the Sloko Group of Canada. They include minor sedimentary rocks, andesite, trachyte, dacite, rhyolite, and minor andesite and basalt flows. Age in inferred from the intimate association of the volcanic rocks with granodiorite of the Coast plutonic complex of Brew and Morrell (1979b). On generalized map, included as part of unit Tkpr

TKwt **Welded tuff and other felsic volcanic rocks (early Tertiary? and early Late Cretaceous)**—Unit consists of at least two ages of tuff, welded tuff, volcanic breccia, rhyolitic volcanic rocks, and shallow intrusive rocks in the Big Delta, Eagle, and Tanacross quadrangles of east-central Alaska. Existing mapping is not adequate to reliably distinguish the Paleocene tuffaceous units that properly belong in unit Tpt from the older Cretaceous rocks. The older part of the unit is represented by the West Fork and Sixtymile Butte calderas (Bacon and others, 1990), which yield K/Ar ages of approximately 93 Ma. U/Pb zircon dating (LA-ICPMS) by Mortensen (2008), however, yielded ages of 107.8±0.5 and 108.6±1.5 Ma for the Sixtymile Butte and the Dennison Fork calderas, respectively (note that Mortensen [2008] suggested that the West Fork and Dennison Fork exposures may represent a single caldera complex). Unit also includes the South Fork Volcanics of Yukon, which yield K/Ar and U/Pb ages between about 108 and 90 Ma; most ages were between 95 and 90 Ma (Gordey and Makepeace, 2003). Bacon and Lanphere (1996) reported an $^{40}Ar/^{39}Ar$ biotite age from tuff on the Middle Fork complex of 69.10 Ma and obtained zircon ages from rhyolitic tuff and a granite porphyry intrusion of 71.1±0.5 to 69.7±1.2 Ma and a revised age of 69.94±0.52 Ma for the previously dated biotite (Bacon and others, 2014). Most rocks of unit are highly altered (Bacon and others, 1990). Age of both parts of this unit, as well as unit Tpt, correspond to times of extensive plutonic intrusions in the Yukon-Tanana Upland and mostly likely represent the extrusive equivalent of these plutons. On generalized map, included as part of unit Tkpr

Tpcv **Cantwell Formation, volcanic rocks subunit (Tertiary, Paleocene)**—Intercalated, moderately deformed sequence of andesite, altered basalt, rhyolite, and dacite flows, felsic pyroclastic rocks, and minor sandstone and carbonaceous mudstone largely in the Healy quadrangle (Csejtey and others, 1992). K/Ar ages are typically Paleocene, although some are as young as Eocene. The Teklanika formation of Gilbert and others (1976) is sometimes used in the literature as a synonym for this unit. Gilbert and others (1976) pointed out the significant difference in age of the volcanic rocks of this unit relative to the underlying sedimentary rocks of the Cantwell Formation. Also includes unit Tv of Nokleberg and others (1992a) in the Mount Hayes quadrangle, which consists chiefly of ash-flow tuff, breccia, agglomerate, flows, dikes, sills, and minor volcanic sandstone, conglomerate, and fossiliferous limestone. Nokleberg and others (1992a, b) assigned their unit Tv an Eocene age on the basis of a K/Ar whole-rock age determination of 49.0 Ma (age has been recalculated using constants of Steiger and Jager (1977) as 50.3±1.6 Ma) on a rhyodacite tuff. In the Healy quadrangle, ages range between 64.6±3.4 and 44.0 Ma, with the majority of the ages greater than 55 Ma. On generalized map, included as part of unit Tv

Tsr **Soda rhyolite and basalt (Tertiary, Paleocene)**—Soda rhyolite flows composed of large phenocrysts of twinned sanidine and reddish-brown hornblende in a fine-grained trachytic groundmass on Saint Lawrence Island. Unit locally includes basalt, trachyandesite, andesite lava flows, small hypabyssal bodies of rhyolite, and felsic crystal tuff. Unit is poorly exposed but is believed to be only slightly or moderately deformed. Assigned an early Tertiary age on the basis of K/Ar and $^{40}Ar/^{39}Ar$ age determinations of 65.5±1.3 to 62.1±1.8 Ma (Patton and Csejtey, 1980). Unit crops out at scattered localities in the western half of the island (Patton and others, 2011). On generalized map, included as part of unit Tv

## MESOZOIC

### Cretaceous to Jurassic

Kvu **Volcanic rocks, undivided (Cretaceous)**—Volcanic rocks that range in composition from rhyolite to olivine basalt flows, from dacitic to andesitic tuff and tuffaceous sandstone, and rhyolitic domes (Hoare and Coonrad, 1978; Patton and others, 1968, 1975; Box 1985; Box and others, 1993). Includes Tulip volcanic field rhyolite domes and flows; Swift Creek volcanic field lithic air-fall tuff; Kipchuk volcanic field andesite and basalt flows, tuff, tuffaceous sandstone; and rhyolite domes and flows in the Bethel quadrangle (Box and others, 1993). In Shungnak and Kateel River quadrangles, unit varies locally but generally consists of latite, quartz latite, and trachyte flows, crystal-lithic tuff, rhyolitic and rhyodacitic welded tuff and flows(?), and hypabyssal intrusive rocks (Patton and others, 1968). In the Tyonek quadrangle, unit is andesite, dacite, and rhyolite flows and tuff. Includes massive and crystal-rich tuff that contains either hornblende or plagioclase as phenocryst phases, as well as flow-banded rhyolite (Solie and others, 1991; Wilson and others, 2009, 2012). In the Healy quadrangle, small exposures of andesitic and basaltic subvolcanic rocks (Csejtey and others, 1992) have yielded late Cretaceous radiometric ages of 97.3±2.9 Ma and 79.1±6.0 Ma, respectively. In the Tyonek and Nabesna quadrangles, unit consists of dominantly andesitic composition metamorphosed and altered volcanic tuff, breccia, or agglomerate. More mafic compositions are suggested by one outcrop of pillow lavas (small pillows, up to 30 cm in diameter) and lesser metasedimentary volcaniclastic turbidites and rare nonvolcaniclastic turbidites.

Rocks are generally light green, indicative of alteration or low-grade metamorphism, but others are light-gray and fresh. Age best constrained at a locality near Hayes River Pass in the Tyonek quadrangle where the youngest detrital zircons in volcaniclastic sedimentary rocks were dated between 151 and 136 Ma, Late Jurassic to Early Cretaceous, indicating the sedimentary rocks are Hauterivian or younger (D.C. Bradley, written commun., 2008). Magoon and others (1976) included these rocks in their undivided metasedimentary rocks unit of Jurassic and (or) Cretaceous age. Other authors have included these rocks in the informally named Kahiltna assemblage (see, for example, Jones and others, 1981). In many other parts of western Alaska, unit consists of felsic dikes, sills, and hypabyssal rocks. In southeast Alaska, andesitic shallow intrusive rocks are found in the Juneau and Petersburg quadrangles thought to be Cretaceous in age (Brew and others, 1984; Brew and Ford, 1985). Locally subdivided into unit Kmvi

Kmvi **Mafic to intermediate volcano-plutonic complexes (Late Cretaceous)**—Complexes composed primarily of altered basalt, andesite, and trachyandesite porphyritic lava flows, hypabyssal intrusive bodies, altered mafic and intermediate crystal and lithic tuffs, and subordinate olivine basalt and dacite flows that occur in a belt in southwest Alaska from the Medfra quadrangle to the Hagemeister Island quadrangle. In the Iditarod, Sleetmute, and Medfra quadrangles, unit consists chiefly of altered basaltic andesite and trachyandesite porphyry flows and hypabyssal intrusive bodies. Elsewhere includes volcanic rocks that include rhyolite to olivine basalt flows, dacitic to andesitic tuff and tuffaceous sandstone, and rhyolitic domes (Hoare and Coonrad, 1978; Patton and others, 1975; Box 1985; Box and others, 1993). Also includes moderately to steeply dipping, fresh to weakly altered porphyritic basaltic andesite flows of calc-alkaline affinity and interbedded sandy to boulder-rich volcaniclastic rocks mapped by Globerman (1985) and Box (1985) in the Hagemeister Island quadrangle, which were originally mapped as unit Tv by Hoare and Coonrad (1978). In the Hagemeister Island and southern Goodnews Bay quadrangles, unit overlies Upper Cretaceous Summit Island Formation on Summit Island and adjacent mainland. On Saint Matthew Island, unit consists of flat-lying to gently dipping mafic flows of andesite and basalt, and volcaniclastic rocks that consist of andesitic and basaltic tuff and conglomerate. K/Ar and $^{40}Ar/^{39}Ar$ ages range from 79.2±2.4 Ma to 64.5±2.0 Ma. A basalt sill from Saint Matthew Island yielded a whole-rock K/Ar age of 52.2±1.6 Ma (Wittbrodt and others, 1989), however, as this age is significantly younger than other dated rocks from Saint Matthew Island, Wittbrodt and others (1989) suggested that the basalt sill was derived from a significantly younger event, which intruded this map unit. Overall, the most reliable age determinations range between approximately 79 and 64 Ma. On generalized map, included as part of unit KJvp

KJv **Highly altered volcanic rocks in southwest Alaska (Cretaceous or Jurassic)**—Highly altered volcanic and hypabyssal rocks in the west central part of the Bethel and southeastern Russian Mission quadrangle (Box and others, 1993). Unit contains poorly to moderately exposed basalt and andesite lava flows and subordinate altered andesite, dacite, rhyolite, and gabbro. Rhyolitic rocks are orange-weathering, porphyritic, and have as much as 10 percent phenocrysts in an altered groundmass of quartz, potassium feldspar, and plagioclase, which locally are in graphic intergrowths. Dacite has phenocrysts of as much as 5 percent each of plagioclase and biotite in a groundmass of plagioclase, quartz, and opaque oxides (Box and others, 1993). Some of these rocks have trace element signatures similar to the Slate Creek pluton (unit TJis) of Box and others (1993). Age is uncertain, though rocks are generally spatially associated with rocks of map units Jab and Jvc of Late Jurassic age; although it is unlikely, some rocks of this unit may be as young as Tertiary. Unit is contact metamorphosed by nearby Late Cretaceous and early Tertiary plutons. Corresponds to the Whitefish Lake volcanic field of Box and others (1993). On generalized map, included as part of unit KJvp

Ksbd **Spilitic pillow basalt and diabase (Early Cretaceous?)**—Dark-greenish- to reddish-brown, fine-grained, spilitic amygdaloidal pillow basalt flows and dark-greenish-gray, medium- to coarse-grained, spilitic diabase intrusive rocks (Patton and others, 1968; Patton and others, 2009), primarily in the Shungnak quadrangle. Unit inferred to overlie unit KJiv and in turn be overlain by unit Kvu. Unit most likely extends southwestward into the Candle quadrangle, where it has not been distinguished from the large area of Quaternary or Tertiary alkalic basalt (unit QTv, herein) there and in the Kateel River quadrangle. On generalized map, included as part of unit Kms

KJiv **Andesitic volcanic rocks (Early Cretaceous and Late Jurassic?)**—Widely distributed in western Alaska and on Saint Lawrence Island, unit consists of flows of andesite and basalt, interbedded with tuff, tuff breccia, agglomerate, volcanic conglomerate, and volcanic graywacke. Flows typically have phenocrysts of plagioclase and pyroxene set in a matrix of devitrified glass, altered plagioclase microlites, pyroxene, chlorite, and opaque oxides. Rhyolite and dacite flows are present locally. Tuff is composed chiefly of fine-grained basalt and andesite clasts, plagioclase crystals, and mafic minerals in an altered matrix of devitrified glass. In upper part of the unit, the tuff is highly calcareous and contains abundant shelly debris, including earliest Cretaceous *Buchia sublaevis*, *Buchia subokensis*, and *Buchia crassicollis* (Patton, 1966; Patton and others, 1968) and *Simbirskites* (Patton, 1967). Tuff commonly occurs in cyclical sequences that grade upward from coarse tuff breccia and lapilli tuff to very fine-grained cherty tuff and blue-green radiolarian chert. Massive agglomerate, breccia, and volcanic conglomerate are present locally. Locally, unit is highly disrupted or intruded by sills and dikes of diabase, diorite, and gabbro. Some of the conglomerate beds east of the Yukon River in the Holy Cross quadrangle contain clasts of altered granitic rocks. Unit is well exposed in the Hughes, Shungnak, Selawik, and Candle quadrangles. Unit also crops out in scattered localities in the Holy Cross quadrangle and northern Russian Mission quadrangle and in several small exposures along the faulted western boundary of the Yukon-Koyukuk Basin in the Kwiguk quadrangle and adjoining Saint Michael quadrangle. Unit is assigned an age of Jurassic to Early Cretaceous based on sparse isotopic and fossil data and on its stratigraphic position below the late Early Cretaceous sedimentary rocks of the Yukon-Koyukuk Basin and above the Triassic rocks of the Angayucham-Tozitna terrane. In the area east of the Yukon River a diorite intrusive body, included in this unit, yielded a K/Ar amphibole cooling age of 128±4.5 Ma (Early Cretaceous) and an andesite porphyry clast from a volcanic conglomerate gave a K/Ar amphibole age of 164.19±4.93 Ma (Middle Jurassic) (Patton and others, 2006). On generalized map, included as part of unit KJab

Ksv **Shoshonitic flows and tuff (Early Cretaceous)**—Lithic tuff, pillowed andesite flows, diabase, and volcanic conglomerate of shoshonitic composition, characterized chemically by very high $K_2O$, Rb, and Ba contents and low $TiO_2$ content in the Unalakleet quadrangle (Patton and Moll-Stalcup, 1996). Tuff consists of coarse-grained volcanic rock fragments, crystals of plagioclase and clinopyroxene, and pumice. Flows consist of plagioclase and clinopyroxene phenocrysts in a groundmass of plagioclase laths and devitrified glass. The diabase is compositionally similar to the shoshonitic flows but has a diabasic texture. The conglomerate consists of well-rounded cobbles of shoshonitic andesite porphyry in a tuffaceous matrix. Unit also locally includes fine-grained syenite composed of 5 to 15 percent coarse-grained phenocrysts of twinned potassium feldspar in a groundmass of potassium feldspar laths and interstitial quartz. K/Ar ages of 118±3.5 and 117±3.5 Ma on samples from this unit were reported by Patton and Moll-Stalcup (1996). These volcanic rocks yield ages slightly older than the syenite and nepheline syenite of map unit Ksy, which is exposed to the north, largely in the Candle and Selawik quadrangles. On generalized map, included as part of unit Kms

## Jurassic to Triassic

Jab **Andesite and basalt (Jurassic)**—Massive andesitic and basaltic flows; minor trachyte, trachyandesite, and dacite; some interbedded tuffaceous sedimentary rocks, and, locally, several hundred feet of volcanic breccia at or near base (Box and others, 1993) are primarily exposed in the Bethel and Russian Mission quadrangles of southwest Alaska. An estimated 25 percent of the unit is interbedded graywacke, siltstone, impure limestone, and pebble conglomerate (Hoare and Coonrad, 1959a, b). The rock unit forms a belt in low rolling hills on the west flank of the Kuskokwim Mountains from the Kwethluk River northward (Hoare and Coonrad, 1959a). Marine pelecypods of Bajocian age (Middle Jurassic) occur in sedimentary strata of this unit (Hoare and Coonrad, 1959a; Box and others, 1993). Unit provisionally also includes an isolated outcrop in the north-central Dillingham quadrangle that is predominantly diabase, which may intrude rocks provisionally assigned to map unit KŦs, thus suggesting that its age may be Triassic or younger. Volcanic rock outcrops to the northeast within the Dillingham quadrangle were inferred to be Triassic by Wallace and others (1989); in neither case does true age control exist. On generalized map, included as part of unit KJab

Jtk **Talkeetna Formation (Early Jurassic)**—Volcanic flows, breccia, tuff, and agglomerate that is locally interbedded with minor sandstone and shale, all typically somewhat altered or metamorphosed (Detterman and Hartsock, 1966; Detterman and Reed, 1980), widely distributed in the Talkeetna Mountains and west of Cook Inlet. First described in Talkeetna Mountains of south-central Alaska by Paige and Knopf (1907); the name Talkeetna Formation was introduced by Martin (1926) and now is recognized as a widespread and important marker horizon in southern Alaska. The unit consists of andesitic flows, flow breccia, tuff, and agglomerate, and includes subordinate interbeds of sandstone, siltstone, and limestone in a dominantly shallow marine sequence 1,000 to 2,000 m thick (Csejtey and others, 1978). Detterman and Hartsock (1966) geographically extended unit into Cook Inlet area and formally divided unit into three members: Horn Mountain Tuff, Marsh Creek Breccia, and Portage Creek Agglomerate. Detterman and others (1987a, 1996) further geographically extended unit to include a section composed primarily of gray-green, coarse-grained tuffaceous sandstone with lesser amounts of green to red, massive coarse-grained tuff and minor brownish-gray siltstone and gray to gray-brown limestone. This section is 405 m thick and is exposed on the northeast shore of Puale Bay; it was originally considered part of the Bidarka Formation (Kellum, 1945). At Puale Bay, rocks of the formation record an inner-neritic to sublittorial environment; to the northeast, the formation is primarily volcanic rocks (Detterman and Hartsock, 1966). Stratigraphically and lithologically equivalent rocks have been encountered in drillholes as far southwest as the Cathedral River on the southwest part of Alaska Peninsula. An Early Jurassic age (Hettangian and early Sinemurian) is based on an abundant megafauna; this megafauna is present in great abundance in only a few horizons and may represent mass kills as a result of volcanic eruptions (Detterman and others, 1996). At Puale Bay, contact of Talkeetna with underlying calcareous Kamishak Formation (unit Ŧcnk) 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

JŦpf **Pogibshi formation of Kelley (1980) (Early Jurassic and Late Triassic?)**—Volcaniclastic rocks interbedded with small amounts of limestone, coal, and tuffaceous argillite constitute the informally named Pogibshi formation of Kelley (1980) exposed on east side of Cook Inlet. Kelley (1980) divided the unit into three members on the basis of rock type, modal composition, and depositional texture. Stratigraphically lowest member, the Dangerous member, consists of volcaniclastic breccia, conglomerate, and sandstone and is in depositional contact with informal Port Graham formation of Kelley (1980) (unit Ŧpg herein). Locally tuffaceous dark-gray sedimentary rocks in the Dangerous member make it difficult to distinguish the Dangerous member from the Port Graham formation. July member consists of dacitic pyroclastic rocks, tuffaceous sandstone, granule conglomerate, and mudstone. Kelley (1980) indicated that the high quartz content and abundance of glassy debris help to distinguish this unit from other parts of his Pogibshi formation. The uppermost member, the Naskowhak member, consists of greenish-gray tuffaceous mudstone, siltstone, and tuff. Locally, the basal part of the Naskowhak member includes laterally extensive coal-bearing units that help to distinguish the Pogibshi formation of Kelley (1980) from the otherwise lithologically similar Talkeetna Formation on the west side of Cook Inlet. Unit is reportedly intruded by the tonalite of Dogfish (Koyuktolik) Bay (unit Ŧqd) and possibly by the diorite of Point Bede, both in the southern Seldovia quadrangle (Bradley and others, 1999); if so, a Late Triassic U/Pb age (227.7±0.6 Ma) on the diorite (D.C. Bradley, USGS, oral commun., 2007) may indicate that the Pogibshi is, in part, significantly older than the Talkeetna Formation. Martin (1915, 1926) and Blodgett (2009) reported a diverse Lower Jurassic fauna along the coast southwest of Seldovia. Bradley and others (1999) erroneously attributed these Jurassic collections by Martin (1915) to the Port Graham formation of Kelley (1980), but those collections were from localities within the outcrop area Bradley and others (1999) assigned to the Talkeetna Formation, which we reassign back to the Pogibshi formation of Kelley (1980). Fossils noted in the two Martin reports (1915, 1926) included several species of scleractinian corals, numerous bivalves (mostly pectinaceans), gastropods, and ammonites. R.B. Blodgett (2009) briefly visited a section of early Sinemurian age, exposed about 3 km west of Seldovia, and found numerous pectinacean bivalves of the genus *Weyla*, gastropods, and several species of scleractinian corals. Bivalves, both articulated and disarticulated specimens, appear to belong to the genus *Weyla*, an Early Jurassic index fossil found primarily along western coast of North and South America. Early Jurassic ammonites from these same rocks were discussed and, in part, illustrated in Imlay (1981), who recognized both Sinemurian and Hettangian fossil assemblages. Fossils in a collection made by J.S. Kelley were examined by A.K. Armstrong (USGS), who identified poorly preserved Permian corals (sample 75JK-151B, www.alaskafossil.org). Because of the poor state of preservation of the coral material, we tentatively discount this collection until further material can be collected and identified from this locality. Connelly (1978) and Connelly and Moore (1979) suggested correlation of these rocks with the Upper Triassic Shuyak Formation of the Afognak Island, which is intruded by the Afognak pluton of Triassic age (also see Wilson and others, 2005; Wilson, 2013). Rioux and others (2007) reported an age on a metamorphosed volcaniclastic rock within the Border Ranges Fault System in the Anchorage quadrangle that may be equivalent to the informally defined Pogibshi Formation of Kelley (1980). The sample yielded two distinct populations of zircons, reported as 202.1±1.2 and 205.8±0.4 Ma. On generalized map, included as part of unit JŦkp

## Triassic

Ŧvs **Volcanic and sedimentary rocks of Nakwasina Sound (Triassic)**—Consists of intensely folded massive and schistose greenstone, graphitic schist, phyllite, and graywacke. Unit is dominantly greenstone with interlayered graphitic schist or phyllite. Massive greenstone, greenschist, phyllite, limestone, graywacke, and chert are subordinate. Contains lenticular beds of metalimestone similar in color and composition to the Whitestripe Marble (unit Ŧwm here) (Loney and others, 1975). Intruded by Early Jurassic diorite on Halleck Island (included in unit KJdg) (S.M. Karl, unpublished data). On generalized map, included as part of unit Ŧmb

Ŧb **Mafic volcanic rocks of Chilkat Peninsula (Late Triassic)**—Dark green, massive to pillowed and amygdaloidal mafic volcanic flows and minor tuff. Amygdules are undeformed and contain calcite and epidote. Massive, flow-banded, and locally pillowed or amygdaloidal metabasalt (Plafker and Hudson, 1980). Up to 3.4 km thick, unit also contains magnetite, traces of malachite, pods and veins of epidote and has associated tuffaceous metasediment. Metamorphosed to low greenschist facies and intruded by the Mount Kashagnak pluton of inferred mid-Cretaceous age (included in unit Kmqm here) (Redman and others, 1984). On generalized map, included as part of unit ₹mb

₹n **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 volcaniclastic 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 Chilikradrotna Greenstones of the Alaska Peninsula, are described below as unit ₹cb. On generalized map, included as part of unit ₹mb

₹cb **Cottonwood Bay and Chilikradrotna Greenstones (Late Triassic, Norian?)**—Cottonwood Bay Greenstone is largely dark-gray to dark-green, porphyritic to amygdaloidal basaltic flows altered to greenstone (Detterman and Reed, 1980). Unit occurs either as roof pendants of, or east of, Alaska-Aleutian Range batholith in Iliamna and Mount Katmai quadrangles and, as a result, is commonly contact metamorphosed. Unit is associated with the Kamishak Formation (unit ₹cnk here); the basal beds of Bruin Limestone Member of Kamishak Formation contain volcanic rocks similar to Cottonwood Bay Greenstone; using this evidence, Detterman and Reed (1980) assigned a Late Triassic age to unit. Because the Kamishak Formation is Norian age, Detterman and Reed (1980) stated that the Cottonwood Bay Greenstone is probably older than Norian. Together, the Cottonwood Bay Greenstone and Kamishak Formation constitute a package very similar to that defined for the Wrangellia terrane. Because of metamorphism, it can be difficult to distinguish the Cottonwood Bay Greenstone from the Talkeetna Formation (Detterman and Reed, 1980). Chilikradrotna Greenstone (Bundtzen and others,1979), largely metabasalt, locally includes andesite, chert, limestone, and tuffaceous sedimentary rock, all weakly metamorphosed and exposed to the west of Alaska-Aleutian Range batholith in the Lake Clark quadrangle. Also associated with this unit is highly fractured dark-gray limestone and chert (Eakins and others, 1978), here assigned to the Kamishak Formation. Eakins and others (1978) also mapped gray shale and gray volcaniclastic sandstone in close proximity to outcrops of the Chilikadrotna Greenstone. These units were originally thought to be of Silurian age on the basis of an erroneous fossil determination in the associated limestone; it has since been revised (R.B. Blodgett, 2004, written commun.). On generalized map, included as part of unit ₹mb

₹vsw **Older volcanic rocks of southwest Alaska (Triassic)**—Massive pillow basalt and basaltic breccia interbedded with thin-bedded tuffaceous chert and shale in the Bethel quadrangle (Box and others, 1993) and inferred to extend into the Taylor Mountains quadrangle. Also included here are volcanic rocks as thick as 60 m interbedded with cherty siltstone in the northwestern Taylor Mountains quadrangle (Sainsbury and MacKevett, 1965) between splays of the Holitna Fault. These volcanic rocks are associated with sparsely distributed limestone that yields *Monotis* and *Halobia* fossils of Late Triassic (Norian) age (Miller and others, 2007). On generalized map, included as part of unit ₹mb

## PALEOZOIC

### Permian

Pv **Volcanic rocks of Puale Bay (early Permian)**—Massive, dark-green to black volcanic breccia, agglomerate, and andesitic flows (Hanson, 1957; Hill, 1979). These rocks are only exposed on offshore islets east of Puale Bay. Well-developed joint system has obscured original structure, and because of this, in part, thickness is unknown. No definite age control exists, but these rocks appear to structurally underlie mid-Permian limestone (unit Pls). Hill (1979) briefly examined exposures and sampled rocks. Limited chemical data from Hill (1979) suggest these volcanic rocks are of calc-alkaline affinity, in contrast to Late Triassic tholeiitic volcanic rocks of nearby mainland (unit ₹cb)

Phb **Volcanic rocks of the Halleck Formation and related rocks of southeast Alaska (early Permian)**—Olivine-rich basalt, pillow flows, pillow breccia, and angular breccia, intercalated with the clastic sedimentary rocks of the

Halleck Formation (unit Ph), which constrains age (Brew and others, 1984). Unit also includes informally named Permian Sitth-gha-ee Peak formation, which consists of basaltic(?) greenstone, greenschist, phyllite, and slate northeast of Glacier Bay (D.A. Brew, written commun., 1999). On generalized map, included as part of unit Pv

Carboniferous

Clgv **Volcanic rocks and sills associated with Lisburne Group (Pennsylvanian? and Mississippian)**—Typically, consists predominantly of light-gray to green-gray, light-brown to rusty-weathering felsic tuff that has abundant feldspar and sparse biotite phenocrysts; typically has calcareous cement and disseminated sulfide minerals. Tuff is associated with tuffaceous sandstone, coarse-grained limestone that contains disseminated light-green chloritic minerals, and thick-bedded to massive calcareous rocks that contain volcanic fragments (Dover and others, 2004). In the Baird Mountains quadrangle, unit is orange-, tan-, or light-brown-weathering, thinly laminated limestone, tuff, and volcaniclastic rocks with subordinate sills and plugs of intermediate to mafic composition; unit contains conodonts of early Early Mississippian age (Karl and others, 1989a). Elsewhere unit has been shown to contain conodonts of latest Late Mississippian age (Brosgé and others, 2001). Where unit is known as sills, the sills are generally chloritized andesite. Most typically associated with the Lisburne Group, similar volcaniclastic rocks range from agglomerate to tuff of felsic to intermediate composition and are associated with the Kayak Shale in the Howard Pass quadrangle. Like the exposures in the Baird Mountains quadrangle, these volcaniclastic rocks contain conodonts of early Early Mississippian age. In the Table Mountains quadrangle, rhyolitic volcanic rocks are interbedded with the Kekiktuk Conglomerate of Early Mississippian age. Typically associated with the Endicott Mountains allochthon, these volcanic rocks are also known from rocks of the autochthonous North Slope of Alaska. On generalized map, included as part of unit CDbrv

Devonian

Dfr **Freshwater Bay and Port Refugio Formations (Late Devonian)**—Freshwater Bay Formation on Chichagof Island is composed of green and red andesite and basalt flows, breccia, and tuff, pyroclastic rhyolite deposits, minor amounts of interbedded conglomeratic volcanic graywacke, grayish-black argillite, and dark-gray limestone (Loney and others, 1963). The correlative but more sedimentary-rock-rich Port Refugio Formation on Prince of Wales Island consists of km-thick sections of siltstone, shale, volcanogenic graywacke, conglomerate, and minor limestone that alternate with km-thick sections of pillow basalt intercalated with minor chert, shale, limestone and aquagene tuff (Eberlein and others, 1983). Unit also includes the Coronados Volcanics and the Saint Joseph Island Volcanics found on western Prince of Wales Island and adjacent islands (Eberlein and others, 1983). The Port Refugio Formation may be a distal facies of the Freshwater Bay Formation. Eberlein and Churkin (1970, p. 43) stated that “many of the graywackes are largely reworked basaltic lavas that contain euhedral crystals of plagioclase and pyroxene that resemble the phenocrysts in the basaltic flows of the formation,” and that many of the conglomerate clasts are andesitic or basaltic rocks. Volcanic flows are found throughout the unit and are up to a hundred meters thick (Eberlein and Churkin, 1970). Age control from the Freshwater Bay is derived from brachiopods, including *Cyrtospirifer*, mollusks, and corals of Frasnian (Late Devonian) age (Loney and others, 1975) and conodonts of Famennian (Late Devonian) age (Karl, 1999). Eberlein and Churkin (1970) reported Late Devonian “beautifully preserved” brachiopods that Savage and others (1978) assigned a middle to late Famennian age and that are associated with vascular plant fossils. On generalized map, included as part of unit Dsv

Dvec **Woodchopper Volcanics and Schwatka unit of Weber and others (1992) (Devonian)**—Woodchopper Volcanics are described as amygdaloidal basalt, pillow basalt, and aquagene tuff, subordinate interbedded chert, argillite, quartzite, and limestone of Late(?) to Early Devonian age in the Charley River quadrangle (Brabb and Churkin, 1969). Brabb and Churkin (1969) also mapped several hundred feet of dark-gray laminated shale that contains minor interbeds of limestone associated with the Woodchopper Volcanics, which we have included here; Dover and Miyaoka (1988) included these sedimentary rocks in their redefined Nation River Formation, which we do not believe is an appropriate assignment, as the Nation River Formation is a plant- and coal-bearing clastic unit. Schwatka unit of Weber and others (1992) is included here; it is mapped in Livengood and Circle quadrangles, offset from the Woodchopper Volcanics by the Tintina Fault System. The Schwatka consists of massive basalt flows, agglomerate, tuff, fine-grained volcaniclastic rocks, minor thin lenses of laminated platy impure limestone, and local lenticular bodies of calcite-cemented conglomerate interbedded with Devonian limestone (Weber and others, 1992). The Schwatka unit is metamorphosed to greenschist facies

Dmv **Mixed volcanic rocks of southeast Alaska (Middle to Early Devonian)**—Consists of mafic to felsic amygdaloidal pillows, agglomerate, tuff, and breccia, which are locally metamorphosed to greenstone, and contains minor associated volcanic conglomerate, sandstone, siltstone, argillite, limestone, and small plugs and dikes (Muffler, 1967; Brew and others, 1984; Brew and Ford, 1985; D.A. Brew, written commun., 1997) which are primarily exposed in two areas of southeast Alaska. In the Glacier Bay area, unit is associated with the Black Cap Limestone (unit DIse here) (D.A. Brew, written commun., 1997). In the Craig quadrangle, the unit includes the St. Joseph Island and Coronados Volcanics, rhyolite of Kasaan Island, as well as volcanic rocks of the Karheen Formation. The St. Joseph Island Volcanics are as much as 3,000 m thick and although no fossils have been reported from included sedimentary rocks, a lamprophyre dike cutting the unit has been dated at 335±10 Ma (K/Ar, biotite) and provides a minimum age for the unit (Eberlein and others, 1983). Compositionally similar to the Glacier Bay region, these are also basaltic and subordinate andesitic pillow flows, breccia, aquagene tuff, and minor sedimentary interbeds (Gehrels, 1992). Early Devonian rhyolite and dacite is found in tuffs, flows, and dikes on east-central Prince of Wales Island (Eberlein and others, 1983) and in the Ketchikan and Prince Rupert quadrangles (S.M. Karl, unpublished data). On generalized map, included as part of unit DSv

Silurian

Sv **Volcanic rocks in southeast Alaska (Silurian)**—Includes volcanic rocks associated with the Bay of Pillars and Point Augusta Formations and the informal Berg Mountain formation of Brew (1997) in southern and northern southeast Alaska, respectively. The northern exposures of this unit consist of dark green, weakly metamorphosed basalt and subordinate white, green, and lavender chert and minor basaltic agglomerate, chert breccia, graywacke, argillite, and limestone (Gilbert, 1988). Basalt commonly displays pillow structures. The southern exposures of this unit consist of mafic to intermediate volcanic breccia, agglomerate, and flows, as well as greenschist and greenstone derived from these rocks (Brew and others, 1984). It also locally includes massive, dark-green to dark-red, dominantly matrix-supported conglomerate that has a matrix of massive volcanic sandstone and is associated with subordinate volcaniclastic turbidites. Conglomerate contains both rounded and angular clasts, as well as angular olistostromal blocks of contemporaneous, plastically deformed sandstone turbidites and limestone. Gradationally overlies volcanic flows and mudstone turbidites of the Bay of Pillars Formations (S.M. Karl, USGS, and James Baichtal, U.S. Forest Service, unpub. data). Rocks of the northern part of unit have been variously assigned to or associated with the Berg Mountain, Point Augusta, Rendu, and Tidal Formations, whereas rocks of the southern exposures of this unit are typically associated with the Bay of Pillars Formation. On generalized map, included as part of unit DSv

Ordovician and Cambrian

O€v **Fossil Creek Volcanics and similar rocks (Ordovician and Cambrian)**—Unit includes the Fossil Creek Volcanics of east-central Alaska, which is divided into two members: one largely volcanic, one largely sedimentary. The volcanic member consists of alkali basalt, agglomerate, and volcaniclastic conglomerate. Agglomerate and conglomerate contain well-rounded clasts of basalt, granite, quartzite, limestone, chert, and phyllite. Sedimentary member consists of shale, chert, and limestone and is intruded by gabbro. Late Ordovician brachiopods, trilobites, gastropods, and conodonts have been recovered from sedimentary rocks in the volcanic member (Blodgett and others, 1987); Early Ordovician conodonts and trilobites have been recovered from the sedimentary member (Weber and others, 1992). Unit occurs in the White Mountains stratigraphic belt of the Livengood, Circle, and Tanana quadrangles (Dover, 1994) and is laterally equivalent to the Livengood Dome Chert. In northeast Alaska, unit includes dark-grayish-green to greenish-black and brown mafic vesicular flows, basaltic tuffs, agglomerate(?), pebble- to cobble-sized volcanic conglomerate, calcareous volcanic wacke, tuffaceous limestone, and tuffaceous dolostone of Cambrian age (Reiser and others, 1980). Weathers dark-olive-brown and dark-gray, except the dolomitic facies, which weathers yellowish brown. Minor gray, dark-gray-weathering chert, chert conglomerate, and silicified chert breccia. Locally includes basaltic tuff and mafic intrusive rocks. Probably correlates with the upper part of the Marmot Formation and Dempster Volcanics of Yukon (Gordey and Makepeace, 2003). May be age and lithologically correlative with unit O€dv, which is found in the Doonerak Window of the Brooks Range

PROTEROZOIC

Ptnm **Basalt and red beds member (Tindir Group) (Proterozoi**c)—Dark-greenish-gray basalt, commonly amygdaloidal and displaying pillow structures; unit ranges from 90 m to at least 750 m thick in the Charley River and Eagle quadrangles. Feldspar and pyroxene are mainly unaltered but, at a few localities, are chloritized and rock is greenstone. Minor basaltic tuff contains pebbles and cobbles of basalt. Red beds mostly grayish-red shale and siliceous shale. Minor greenish-gray shale and siliceous shale, jasper, greenstone-dolostone conglomerate, hematitic doloarenite, vitric tuff, and some occurrences of basalt have been largely replaced by hematite and carbonate (Brabb and Churkin, 1969). Similar rocks are also found in the Mount Michelson (Robinson and others, 1989) and Demarcation Point quadrangles (Reiser and others, 1980). On generalized map, included as part of unit Ꝑv

Ꝑv **Mount Copleston volcanic rocks of Moore (1987) (Proterozoic)**—Metabasalt flows associated with and underlying the Katakturuk Dolomite (unit Ꝑls). Unit is exposed in the east-central Mount Michelson quadrangle; its best exposed section is about 100 m thick and divided into 3 sections. The lowest part of the unit consists of about 25 m of "poorly vesiculated and probably pillowed metabasalt * * * in turn, overlain by a 10-m section of thin-bedded, very fine-grained quartzitic sandstone that displays starved ripple marks and near isoclinal folds" (Moore, 1987). The upper 80 m of the section consists of 1- to 3-m-thick mostly pillowed to massive metabasalt flows. However, the flows locally display pahoehoe texture and flow tops marked by red-weathering zones. Macdonald (2011) reports that the volcanic rocks can be as much as 450 m thick in the eastern part of their exposure area and that the upper 100 m is dominantly volcaniclastic. As shown here, also includes the volcaniclastic rocks of Redwacke Creek in the Demarcation Point quadrangle (Reiser and others, 1980)

## INTRUSIVE ROCKS

### CENOZOIC TO MESOZOIC

#### Quaternary or Tertiary

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

#### Tertiary to Cretaceous

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, Mitrofania 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)

Tgb **Gabbroic rocks in southern Alaska (Tertiary)**—Small, gabbroic to dioritic intrusive bodies of probable Tertiary age are widely distributed in southern Alaska. Most of these have poor age control and are poorly studied. Subdivided here into the following three regional groups:

Tgbe **Younger gabbro of southeast Alaska (Tertiary, Miocene to Eocene)**—Map unit includes two belts of mafic intrusive rocks. The younger belt, earliest Miocene to late Oligocene, consists of "layered and locally zoned bodies of two-pyroxene ± olivine ± biotite ± hornblende ± quartz gabbro and subordinate troctolite, peridotite, leucogabbro, diorite, and tonalite" (Gehrels and Berg, 1992). This younger belt consists of stocks on northern Kupreanof and Kuiu Islands (Brew and others, 1984), Chichagof Island (Johnson and Karl, 1985; Loney and others, 1975), and north of Cross Sound in the Fairweather Range (Brew and others, 1978). Stocks on Revillagigedo Island and adjacent area of mainland yield K/Ar ages between 24.9±0.75 and 23.2±0.7 Ma, early Miocene and late Oligocene (Smith and Diggles, 1981). A large body (La Perouse gabbro) northwest of

Cross Sound yielded an $^{40}Ar/^{39}Ar$ apparent age of 28.0±8.0 Ma, Oligocene (Loney and Himmelberg, 1983). The second (older belt) plutonic suite yields bimodal Eocene (early and latest) radiometric ages and is found on Yakobi and Chichagof Islands. Found west of the Border Ranges Fault in the Sitka quadrangle, these rocks are dominantly composed of medium- to dark-gray, locally brown-gray, medium- to coarse-grained gabbronorite and norite (Johnson and Karl, 1985). They contain abundant sulfides and form the host rock for nickel-sulfide ore bodies (Johnson and Karl, 1985) and yield discordant K/Ar ages of 34.0±1.0 and 39.6±1.2 Ma from biotite and hornblende (Karl and others, 1988) and $^{40}Ar/^{39}Ar$ ages of 50.5±.1 and 50.3±.1 Ma on biotite (Bradley and others, 2003). On generalized map, included as part of unit Tgb

Tgba **Diabase and gabbro, Aleutian Islands (Tertiary, Miocene to Paleocene?)**—Diabase and gabbro dikes, sills, and small plutons are widespread and form two-thirds of the intrusive rocks on Attu Island and are very common on Agattu Island (Gates and others, 1971). These dikes and sills intrude all Attu Island units as old as the Chuniksak and Chirikof formations, but do not cut the Massacre Bay (included in unit QTv, here) and Faneto Formations (included in unit QTs, here). Hence, they are considered Miocene in age, although some of these rocks may be older (Gates and others, 1971, p. 746). Placed in the Attu Basement Series by Yogodzinski and others (1993). Similar gabbroic bodies in two large intrusions also occur on Kiska Island (Coats and others, 1961) and in a large mass of gabbro that locally includes hornblende gabbro, as well as augite-quartz syenite that intrudes the Finger Bay Volcanics on Adak Island (Coats, 1956a). On Attu Island, diabase and gabbro that intrude map unit Tba have yielded K/Ar whole-rock ages of 27.2±1.4 and 32.7±1.4 Ma (DeLong and McDowell, 1975). On Amlia Island, gabbro has yielded a K/Ar age of 39.8±1.2 Ma (McLean and others, 1983). Drewes and others (1961) mapped a gabbro body they inferred was a border facies of the granitic Shaler batholith on Unalaska and Sedanka Island; however, the gabbro is spatially distinct from the Shaler batholith and radiometric dates indicate that the gabbro is significantly older—about 30 Ma—whereas the other parts of the Shaler batholith are about 12 Ma. Unit also includes the Sled Pass gabbro of the eastern Lime Hills quadrangle (Gamble and others, 2013) for which Jones and others (2014) have reported a U/Pb zircon age of 28.5 Ma, which is unique for gabbro in that part of Alaska. On generalized map, included as part of unit Tgb

Tgbw **Gabbro, southwest Alaska (Tertiary, Paleogene?)**—Unit occurs as small plutons in the McGrath, Lime Hills, Lake Clark, and Tyonek quadrangles. Dark-colored hornblende and pyroxene-hornblende fine- to medium-grained gabbro (McGrath quadrangle: Bundtzen and others, 1997a; Lime Hills quadrangle: Gamble and others, 2013) or hornblende and biotite-bearing olivine gabbronorite (Lake Clark quadrangle: Nelson and others, 1983). On generalized map, included as part of unit Tgb

Tgw **Granite, southwest Alaska and Aleutian Islands (Tertiary, Oligocene, or older)**—Consists of several distinct plutons. The Windy Fork pluton (Bundtzen and others, 1997a; Gamble and others, 2013) in the McGarth and Lime Hills quadrangles consists of light-gray or grayish-pink biotite granite or aplite and peralkaline granite. The Windy Fork pluton yields K/Ar ages of 30.9±0.9 Ma (biotite), 29.7±0.9 Ma (hornblende) (Reed and Lanphere, 1972) and 23.5±0.7 Ma (pyroxene) (Gilbert and others, 1988a) and U/Pb ages on zircon are 31.8±0.6 and 30.9±0.4 Ma (D.C. Bradley, written commun., 2014); granite in the Lake Clark quadrangle (Nelson and others, 1983) is undated. Zircon dates on the Big River pluton of the Lime Hills quadrangle (Gamble and others, 2013) indicate an age of about 31 Ma (Jones and others, 2014). These plutons are included in the Tertiary phase of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). The second part of this map unit consists of albite granite found on Attu Island (Gates and others, 1971). The granite is gray, pale-pink, or purplish, has widely variable grain size, and locally contains euhedral gray-green feldspar (albite) phenocrysts up to 5 mm long. Quartz makes up about 20 percent of rock and, locally, granite may have as much as 5 percent green amphibole (Gates and others, 1971). The albite granite is surrounded by a halo of albitized and silicified basement rocks (unit TMzzu, here) that is as much as 2 miles wide. Age control is limited; albite granite blocks occur within keratophyric tuff in the basement rocks although the main intrusions cut through the basement rocks. Diabase dikes cut the granite, and boulders of the granite occur in the conglomeratic Chirikof Formation (unit Tms) on Attu Island, suggesting that the granite may be largely pre-Miocene. The granite on Attu Island was placed in the Attu Basement Series by Yogodzinski and others (1993). On generalized map, included as part of unit Toeg

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

Tod **Granodiorite, quartz diorite, and diorite (Tertiary, Oligocene and late Eocene)**—Compositionally variable suite of medium- to coarse-grained, grayish-white, mafic granitic rocks exposed along the southern coastal region of the state. Unit occurs as far west as the Seguam quadrangle to as far east as the Ketchikan quadrangle and as far north as the McCarthy quadrangle. Commonly granodiorite and quartz diorite; also includes diorite and tonalite. Along the west side of Cook Inlet, the plutons are considered part of the Tertiary phase of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972) and tend to be exposed along its western margin. On the Alaska Peninsula, these plutons are associated with the Meshik magmatic arc and, in the Aleutian Islands, with the "Lower Series" magmatic rocks of Vallier and others (1994). In the eastern Gulf of Alaska area and northern southeast Alaska, associations are not as readily apparent; plutons of this age and composition intrude a variety of terranes. Potassium-argon ages for these plutons range from about 39 to 25 Ma. Hornblende diorite in the Skagway quadrangle is undated but may be Oligocene in age (Gilbert and others, 1987). On generalized map, included as part of unit Toeg

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 $^{40}Ar/^{39}Ar$ 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 $^{40}Ar/^{39}Ar$ 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

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**Granitic rocks of the Coast plutonic complex of Brew and Morrell (1979b) (Tertiary, Eocene and older)**—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). These plutons are found in a belt along the east side of southeast Alaska and parallel the belt described above (unit Toegr). Radiometric ages range from 55 to 42 Ma and are typically discordant. Concordant K/Ar ages are about 52 to 50 Ma (Smith, 1977; Smith and Diggles, 1981; Drinkwater and others, 1989) and U/Pb zircon apparent ages (Gehrels and others, 1991) vary as well, but appear to indicate emplacement during Eocene time. Along the western margin of the unit, hornblende-dominant, biotite-bearing tonalite and subordinate quartz diorite are found as steeply dipping, foliated, and locally lineated sills (Barker and others, 1986; Berg and others, 1978, 1988; Brew and Ford, 1985; Brew and others, 1984; Brew and Grybeck, 1984; Brew and Ford, 1977; Elliott and Koch, 1981; MacKevett and others, 1974; Redman and others, 1984). Field and U/Pb zircon data indicate emplacement in Paleocene and Late Cretaceous time, during waning stages of deformation and metamorphism in Coast Mountains (Gehrels and others, 1991; Brew and Ford, 1981)

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; Alldrick 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

Tcpp **Porphyritic granodiorite phase, Coast plutonic complex of Brew and Morrell (1979b) (Tertiary, Eocene)**—Consists mainly of weakly foliated to massive, medium-grained, hornblende-biotite granodiorite, and locally of foliated and gneissic granodiorite as well as distinctive porphyritic, coarse-grained, homogeneous, biotite-hornblende granodiorite that locally grades into quartz diorite and quartz monzonite; typically contains about 5 percent euhedral phenocrysts of potassium feldspar that are as large as 5 cm. Mafic minerals generally make up as much as 25 percent of this pluton. Intrudes foliated tonalite (unit TKts) and is intruded by leucocratic granodiorite (unit Tcp) (Berg and others, 1988; S.M. Karl, unpublished data). Includes associated pervasively intruded migmatite that consists of tonalitic to granodioritic gneiss and orthogneiss of diverse migmatitic fabrics; agmatitic metabasite and ultramafic rocks; quartzite; quartz-biotite schist and gneiss; and marble and irregularly banded calc-silicate rocks. The age of the migmatite primarily reflects timing of intrusions, and original country rock many have been significantly older. In the western part of the unit, in the Ketchikan and Prince Rupert quadrangles, part of this unit may more properly be associated with the tonalite sill (unit TKts). Radiometric ages vary; K/Ar ages on biotite and hornblende are early Eocene and commonly discordant (Smith and Diggles, 1981; Berg and others, 1988; Douglass and others, 1989), whereas U/Pb analyses (Berg and others, 1988; Gehrels and others, 1991), largely multigrain analyses, yielded Eocene and latest Cretaceous discordant ages

TKts **Foliated tonalite sill of Coast plutonic complex of Brew and Morrell (1979b) (Tertiary, Paleocene, and latest Cretaceous)**—Homogeneous, well foliated, non-layered; locally lineated; medium- to coarse-grained, hornblende-dominant, biotite-bearing tonalite and subordinate quartz diorite found as steeply dipping, foliated, and locally lineated sills along the west side of the Coast plutonic complex of Brew and Morrell (1979b). Commonly referred to as "The Great Tonalite Sill" (see, for example, Brew and Grybeck, 1984 or Brew and Friedman, 2002). Gray on fresh surfaces and weathering darker gray, it has an average color index of 25, has equigranular to seriate texture, and locally contains hornblende phenocrysts up to 2 cm in length; some bodies have distinctive skeletal garnet. Inclusions and schlieren of dioritic composition are common; gneiss inclusions occur locally (Brew and Ford, 1985). Associated migmatite consists of intimately intermixed paragneiss and orthogneiss and has widespread lit-par-lit injection gneiss (Redman and others, 1984). Paleosomes include amphibolite, metamorphic grade hornblende and biotite schist and gneiss, calc-silicate gneiss, and granodioritic to dioritic meta-intrusive rocks (Karl and others, 1999). Field and U/Pb zircon data indicate emplacement in Late Cretaceous and Paleocene time, during waning stages of deformation and metamorphism in Coast Mountains (Gehrels and others, 1991; Brew and Ford, 1985). Radiometric ages vary; K/Ar ages on biotite and hornblende tend to be early Eocene and Paleocene and significantly discordant, whereas U/Pb analyses (Barker and others, 1986; Berg and others, 1988; Saleeby, 2000; Rubin and Saleeby, 2000), largely multigrain analyses, yielded Paleocene and latest Cretaceous discordant ages. On generalized map, included as part of unit TKtsp

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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

Tephi **Felsic hypabyssal intrusions (Tertiary, Eocene)**—Predominantly subaerial rhyolite, rhyodacite, and dacite lava and tuff, and lesser domes and other hypabyssal intrusions found in Anchorage and Talkeetna Mountains quadrangles; includes minor quartz-feldspar/sericite tuffaceous sandstone of Anderson (1969). Rhyolite flows are aphanitic to sparsely porphyritic with plagioclase and (or) hornblende phenocrysts and are locally flow-banded; dacitic tuff and subvolcanic intrusions contain oscillatory-zoned plagioclase, quartz, and amphibole (Oswald, 2006; L.E. Burns, Alaska Division of Geological and Geophysical Surveys, written commun., 2010). Individual flows and tuffs are meters to tens of meters thick; overall unit may be as much as several hundred meters thick. Includes plagioclase-quartz-hornblende dacite porphyry of Csejtey (1974); porphyritic rhyolite of Anderson (1969); rhyolite, dacite, and ash flow tuff; rhyolite, rhyodacite, and dacite; vitric and dacite flows (L.E. Burns, Alaska Division of Geological and Geophysical Surveys, written commun., 2010); and dacite porphyry, rhyolite tuff, felsic tuff, and extrusive rhyolite of Oswald (2006). K/Ar and $^{40}$Ar/$^{39}$Ar ages range from 45.2±0.5 to 33.7±0.4 Ma (Amos and Cole, 2003; Cole and others, 2006; J.M. Schmidt, written commun., 2008). On generalized map, included as part of unit Tehi

Tehi **Felsic dikes, sills, and small stocks in southern Alaska (Tertiary and older?)**—Dikes, sills, and small intrusive bodies of mafic to felsic composition in the Anchorage and Seward quadrangles. These bodies yield a wide range of ages, representing multiple intrusive events throughout the region. Hypabyssal rocks of felsic and intermediate composition from the Anchorage quadrangle yielded six whole-rock K/Ar ages, from 54.8±2.7 to 40.0±1.6 Ma, and three zircon fission track ages, from 41.3±6.0 to 36.8±4.8 Ma (Winkler, 1992). Also in the Anchorage quadrangle, a basalt sill yielded a whole-rock K/Ar age of 40.9±1.6 Ma (Silberman and Grantz, 1984). An $^{40}$Ar/$^{39}$Ar plateau age on amphibole from an andesite dike yielded an age of 58.64±0.52 Ma. Unit also includes unit TJds of Winkler (1992) that yielded widely different whole-rock K/Ar ages of 130±6 and 38±2 Ma. A basaltic-andesite dike intruding McHugh Complex yielded an $^{40}$Ar/$^{39}$Ar hornblende plateau age of 115±2 Ma, whereas an intermediate composition dike yielded an $^{40}$Ar/$^{39}$Ar isochron(?) age of 57.0±0.22 Ma (W. Clendenin, South Carolina Department of Natural Resources, Geological Survey, written commun., cited in Bradley and others, 1999). Lytwyn and others (2000) described a suite of dikes that range in composition from basalt to rhyolite that they associated with near/trench intrusions commonly related to the subduction of Kula-Farallon spreading center

Tpgi **Granitic intrusive rocks of the Chugach accretionary complex (Tertiary, Paleocene)**—Medium-grained biotite granodiorite, quartz monzonite, and granite plutons that generally exhibit hypidiomorphic-granular texture and locally contain potassium feldspar phenocrysts as long as 1 cm. Rare muscovite is found in limited areas near contacts in the Shumagin Islands and on Kodiak Island. A minor hornfels zone as wide as 500 m is mapped at contact with Shumagin Formation (included in unit Kaf, here) (Moore, 1974a). Plutons of this unit form a belt from Sanak Island in the False Pass quadrangle at the southwest end of the Alaska Peninsula, through the outer Shumagin Islands, Semidi Islands, and Kodiak Island to the Kenai Peninsula. These plutons form an erosion-resistant core of the islands offshore of the Alaska Peninsula and form an extensive batholith on Kodiak Island, as well as many satellite plutons on Kodiak and adjacent islands. On the Kenai Peninsula, unit is primarily "medium- to dark-gray foliated medium- to coarse-grained biotite-muscovite-(hornblende) granite and granodiorite; marginal phases are locally biotite-muscovite-(hornblende) tonalite" (Tysdal and Case, 1979). Consists of a large batholith that extends from Nuka and Aialik Bays and offshore islands northward more than 60 km into the Harding Icefield, where it is exposed in many nunataks, and westward into the Seldovia quadrangle around Harris Bay. Potassium-argon and $^{40}$Ar/$^{39}$Ar ages reported by Burk (1965), Moore (1974a, b), Kienle and Turner (1976), Wilson (1980), Hill and others (1981), Shew and Wilson (1981), Moore and others (1983), Haeussler and others (1995), Bradley and others (1999, 2000), and (Lytwyn and others, 2000) range from 65.6±3.3 to 49.6±1.7 Ma and U/Pb age determinations range from 61.1±0.5 to 56.0±0.5 Ma (Bradley and others, 2000; Farris and others, 2006). The most reliable of both types of age determinations show a trend of slight younging to the northeast from Sanak to Kodiak Island (750 km) and then a more significant decrease in age on the Kenai Peninsula (250 km more). These plutons, as well as some of the plutons in map unit Toegr, are thought to represent a belt of near-trench, "slab-window" intrusions related to the subduction of a spreading center as the spreading center passed along the continental margin (Marshak and Karig, 1977; Bradley and others, 1992, 2000; Farris and others, 2006). Lytwyn and others (2000) described a suite of dikes (part of map unit Tehi, here) that they associated with the same ridge-subduction-related system thought responsible for these plutons

TKpeg **Trondhjemitic pegmatite (Tertiary, Eocene? or older)**—Restricted to southern southeast Alaska, unit is a pegmatite dike swarm that consists of about 70 percent sodic plagioclase, 25 percent quartz, and accessory to minor biotite, hornblende, and potassium feldspar (Berg and others, 1988). Outcrops typically show layers of coarse- and fine-grained pegmatite that alternate with schlieren and screens of amphibolite. The unit is always adjacent to or included within amphibolite (unit MzPzgn). Absence of foliation or other evidence of significant penetrative deformation in the pegmatite indicates that it was emplaced during or after the waning stages of the mid- or Late Cretaceous regional metamorphism that apparently affected most of the rocks in the Ketchikan and Prince Rupert quadrangles (Berg and others, 1988). Unit has yielded a K/Ar biotite age of 45.7 Ma (Smith and Diggles, 1981; Berg and others, 1988) and U/Pb analyses of zircons from this body yielded discordant results with lower intercept ages of 73, 61, 53, and 50 Ma and upper intercept ages of 574, 1,368, 542, and 594 Ma, respectively. The lower intercepts were interpreted as crystallization ages and the upper intercepts were thought to reflect entrained or inherited zircons (Saleeby, 2000). On generalized map, included as part of unit TKtsp

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**Granitic rocks of interior Alaska (Tertiary, Paleocene, to Cretaceous, Maastrichtian)**—Typically small granitic plutons that yield radiometric ages that range from Maastrichtian (Late Cretaceous) to Paleocene, or about 70 to 55 Ma, that are found throughout interior Alaska and, to a limited extent, elsewhere in the State. Compositionally variable, they tend to range from granite to quartz monzonite but do include more mafic varieties, as well as more alkalic varieties. They occur in a wide arcuate belt roughly paralleling the Tinitna and Denali Fault Systems and their extensions to the southwest. The belt continues into the Yukon (Mortensen and Hart, 2010). They also occur south of the Denali Fault System in the region west of Cook Inlet and the Susitna Valley, where some are associated with the Alaska-Aleutian Range batholith and, presumably, with arc magmatism. However, it appears that the vast majority of the plutons are not related to arc magmatism. In southwest Alaska and in the Yukon-Tanana Upland, slightly older volcano-plutonic complexes (unit Kmvi) and similar age caldera complexes (units Tpt and TKwt), respectively, may represent the more extrusive component of some of these igneous systems. Somewhat arbitrarily, we divide these plutons into a late Paleocene (~59 to 55 Ma) map unit and an older, more diverse unit. In southwest Alaska, high-alkali-content plutons are an important component of the older unit. As a group, the plutons of the subunits described below appear to crosscut the rocks of many of the defined tectonostratigraphic terranes (Silberling and others, 1994) without offset, providing a possible constraint on terrane accretion. Subdivided into the following units: Tpgr, Tpg, TKg, TKgd, and TKgb

Tpgr **Undivided granitic rocks (Tertiary, late Paleocene)**—Predominantly medium-grained composite plutons of granite and quartz monzonite and lesser granodiorite and quartz syenite. Biotite is the chief mafic mineral and hornblende is locally present, especially in the granodiorite phases. Muscovite is a common component of the granite. Unit is widespread, although the bulk of the exposure is in the western Alaska Range and Tyonek quadrangle or spatially associated with the Alaska-Aleutian Range batholith of Reed and Lanphere (1973) in the Lake Clark and Iliamna quadrangles. It is primarily distinguished from unit Tkg by age determinations. Unit includes the Styx River batholith of Reed and Elliott (1970), rocks of map units Ti7, Ti10, and Ti11 of Nelson and others (1983), much of the McKinley series of Reed and Nelson (1980) and unit Tbgd of Csejtey and others (1978). Outliers occur in Unalakleet and Table Mountain quadrangles. In the Lime Hills and western Tyonek quadrangles, it is difficult to distinguish between this map unit and unit TKg; without additional mapping and data, the density of lithologically similar plutons makes distinction of these two units especially difficult. On generalized map, included as part of unit TKgi

Tpg **Peralkaline granite (Tertiary, Paleocene?)**—Mostly medium-grained hypidiomorphic granular granite containing subhedral to euhedral perthite (Nelson and others, 1983) in the Lake Clark quadrangle. This peralkaline granite is spatially associated with the Alaska-Aleutian Range batholith. Alternatively, this pluton may be associated with plutons of unit Tgw. Also included here is the Middle Fork granite, the perthite-arfvedsonite-granite phase of the Middle Fork plutonic complex in the McGrath quadrangle (Gilbert and others, 1988a; Solie, 1988) which yields K/Ar ages of 57.7±1.7 and 55.6±1.7 Ma. This map unit may correlate with other peralkaline granite bodies in the Dillingham quadrangle (included in map unit TKg) that generally yielded $^{40}Ar/^{39}Ar$ ages from 64 to 60 Ma. On generalized map, included as part of unit TKgi

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 $^{40}Ar/^{39}Ar$ 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

TKgd **Granodiorite to quartz monzodiorite (Tertiary, Paleocene, or Late Cretaceous, Maastrichtian)**—Typically described as granodiorite, quartz diorite, tonalite, monzonite, and quartz monzodiorite, these plutons compositionally overlap with unit TKg, described above, but are the more mafic plutons in this age range. Also widespread, they tend lie at the periphery of the TKg belt of plutons. They are locally weakly foliated and hypidiomorphic-granular or seriate in texture. K/Ar ages on biotite and hornblende range between 73.5 and 60.0 Ma—very slightly older than unit TKg. An outlier to the belt, a fine-grained hornblende granodiorite, is found on Saint Matthew Island and yielded a K/Ar age on hornblende of 62.3±2.0 Ma (Patton and others, 1975). On generalized map, included as part of unit TKgi

TKgb **Gabbroic rocks (Tertiary to Late Cretaceous or older)**—Fresh to altered gabbroic and diabasic intrusive bodies including small plutons, dikes and sills. Widespread throughout western Alaska; distribution of unit mimics distribution of the more granitic rocks of units TKg and TKgd. Age control is limited relative to the granitic rocks and, in many cases, the age assigned by local geologic mappers is Devonian to Tertiary, hence, the rocks included here may, in part, be significantly older that the granitic rocks of units Tpgr, TKg, and TKgd. In the Ophir quadrangle, medium- to coarse-grained gabbro that has minor associated diorite and basalt intrudes rocks of inferred Mississippian to Triassic age and, locally, Cretaceous age. Contact relations are uncertain due to poor exposure, but Chapman and others (1985) indicate at least one gabbro body has a hornfels aureole. A similar unit of gabbroic sills, dikes, and small plugs in the adjoining Medfra quadrangle was given a provisional Devonian to Tertiary age (Patton and others, 1980). Unit also includes poorly exposed small bodies of mafic rocks in Talkeetna Mountains and Tyonek quadrangles. In the Talkeetna Mountains, Csejtey and others (1978) described a medium- to light-gray, coarse- to medium-grained plagioclase and pale-green hornblende-bearing leucogabbro. J.M. Schmidt (written commun., 2007) also described diorite associated with the gabbroic rocks. Reed and Elliot (1970) described diorite and olivine and (or) hornblende gabbro that occur as intrusive bodies and inclusions in other Tertiary intrusive rocks in Tyonek quadrangle. Age is poorly constrained, but samples of hornblendite and gabbro from Tyonek quadrangle yielded $^{40}Ar/^{39}Ar$ plateau ages of between about 84 and 69 Ma (P.J. Haeussler, unpub. data). Altered gabbro and diorite bodies crop out as small scattered bodies in the Russian Mission and southern Holy Cross quadrangles; the age of these bodies is uncertain, but not older than Jurassic. Unit TKgb includes dark-colored dikes and sills of diabase, basalt, and dioritic, gabbroic, and biotite lamprophyre that yield a K/Ar age of 64.6±2 Ma on biotite from the western Nushagak Bay quadrangle (Hoare and Coonrad, 1978). Unit also includes a medium- to coarse-grained pyroxene gabbro dike(?) on Saint Matthew Island (Patton and others, 1975). On generalized map, included as part of unit TKm

TKpd **Peridotite (Tertiary, Paleocene, or older)**—Peridotite forms the basement of Saint George Island in the Pribilof Islands. The peridotite is massive, originally was dunite, and is now largely altered to serpentine and magnetite (Barth, 1956). The erosional surface of the peridotite appears polished, has glacial striae and a brownish-black varnish (Barth, 1956, p. 117). Unit is overlain by Quaternary basalt flows and sedimentary rocks. Intruded by a garnet-bearing granitic dike dated at approximately 52 Ma by a K/Ar isochron (Hopkins and Silberman, 1978) and U/Pb zircon (Davis and others, 1989). On generalized map, included as part of unit TKm

TKhi **Dikes and subvolcanic rocks (Tertiary and (or) Cretaceous)**—Widely distributed in western Alaska, unit consists of a wide variety of shallow intrusive rocks including rhyolite, dacite, trachyte, and andesite plugs, domes, sills, and dikes, and larger, more coarsely crystalline bodies of granite, granodiorite, tonalite, and monzonite porphyry (Patton and others, 2009; Patton and others, in press). Typical rock is composed of a fine-grained felsic groundmass with phenocrysts of plagioclase, quartz, biotite, and hornblende. Unit forms numerous large sills, dikes, and domes intruding Cretaceous and older sedimentary rocks primarily in the Iditarod, Sleetmute, Russian Mission, northwestern Holy Cross, and northeastern Kwiguk quadrangles. Limited age control from K/Ar,

$^{40}Ar/^{39}Ar$, and U/Pb techniques in southwest Alaska suggests an age range between about 72 and 60 Ma. Unit is compositionally similar to, and, where age control exists, is also similar in age to units TKg and TKgd. Unit is texturally transitional between TKg, TKgd, and unit TKv. Unit is also found less commonly in the Selawik, Bettles, Hughes, Lime Hills, Dillingham, and Lake Clark quadrangles. In the Selawik, Bettles, and Hughes quadrangles, age control is lacking, but association with mid-Cretaceous plutons suggests that these small intrusions may be older than those in southwest Alaska. On generalized map, included as part of unit TPzi

## MESOZOIC AND PALEOZOIC

### Cretaceous to Paleozoic

MzPzi **Undivided dikes and sills, south-central Alaska (Mesozoic or Paleozoic)**—Dark-gray to greenish-gray dikes and sills ranging in composition from basalt to granodiorite in the Talkeetna quadrangle (Reed and Nelson, 1980). These undated bodies intrude sedimentary rocks of Paleozoic age (unit Pzsu); other nearby intrusions are granitic rocks of Eocene age (unit Toegr). Pillow basalt (unit JTRv), originally thought to be of Paleozoic, but now considered to be Jurassic or Triassic in age, is also in the vicinity; its original presumed Paleozoic age was used to infer the age of these dikes and sills because of proximity. On generalized map, included as part of unit TPzi

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Kgu **Plutonic rocks and dikes, granite to diorite (Cretaceous?)**—Consists of a variety of granitic rocks, typically granodiorite, tonalite, and quartz diorite bodies found primarily in two areas of the State. A significant area of these rocks were mapped by Nelson and others (1983) in the eastern Lake Clark quadrangle and extend into the Kenai and Tyonek quadrangles and are considered part of Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). They are medium- to coarse-grained, light-to medium-gray, and contain hornblende, biotite, and, rarely, muscovite; they locally have cataclastic textures. Although mapped as separate plutons by Nelson and others (1983), a number of these bodies may be fault-offset extensions of each other. Largely undated, the sparsely available K/Ar and $^{40}Ar/^{39}Ar$ dates from the west side of Cook Inlet range from 80.7 to 63.1±1.8 Ma (Reed and Lanphere, 1972; P.J. Haeussler, written commun., 2008); a number of these ages are either discordant or have disturbed spectra. These rocks are typically exposed between the Jurassic part of the batholith on the east and the early Tertiary to latest Cretaceous plutons of the batholith on the west. The second large exposure area of these plutons is in the Tanacross and Eagle quadrangles, where a significant part of these quadrangles consist of undated granitic rocks (Foster, 1970, 1976, 1992). In this area, these rocks may range in age from early Tertiary to Jurassic or possibly Triassic; the most likely ages are mid-Cretaceous or early Tertiary to latest Cretaceous. Other undated, but likely Cretaceous, plutons are in the Healy, Kateel River, Hughes, and Bendeleben quadrangles. The Hughes body is a medium- to coarse-grained albite granite, and the Kateel River plutons consist of albite granite and syenite (Patton, 1966; Patton and Miller, 1966). On generalized map, included as part of unit KJgu

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

Klqm **Quartz monzonite and monzonite (Late Cretaceous)**—Massive, coarse-grained, light-gray porphyritic quartz monzonite (Detterman and Reed, 1980; Nelson and others, 1983) is associated spatially with the Alaska-Aleutian Range batholith in the Iliamna and Lake Clark quadrangles. K/Ar ages range from 85.5 to 75.6 Ma (Reed and Lanphere, 1972). In northern Tyonek quadrangle, fine- to medium-grained pink monzonite or syenite intrudes sedimentary rocks of unit Kfy and contains primary pyroxene and has yielded a concordant U/Pb zircon age of 80.3±0.1 Ma (P.J. Haeussler, unpub. data). Pluton is distinctive in being more potassium-feldspar-rich and quartz-poor than other granitic rocks in the region. Unit also includes undated plutons in the Talkeetna Mountains quadrangle. In the west-central Dillingham quadrangle, an unusual highly potassic coarse-grained biotite-pyroxene granite or syenite yielded an $^{40}Ar/^{39}Ar$ age of 84.49 Ma; this pluton is similar to other potassium-rich rocks in the Dillingham area (see unit TKg) except for age. On generalized map, included as part of unit Klgr

Kmgr **Granitic rocks of central and southeast Alaska (Cretaceous, Coniacian to Albian)**—Primarily granodiorite and lesser quartz diorite, granite, and quartz monzonite that is widely exposed in central and southeastern Alaska. Exposed primarily in four areas: (1) southern southeast Alaska west of the Coast plutonic complex; (2) in the Yukon-Tanana Upland of east-central Alaska and northern Alaska Range; (3) on Saint Lawrence Island in western Alaska; and (4) in southwest Alaska in the Bethel and Russian Mission quadrangles. In southeast Alaska, the plutons tend to be more mafic than other areas and consist of granodiorite and quartz diorite and lesser tonalite; most rocks are medium-grained and moderately foliated and lineated parallel to the fabric in country rocks. Some bodies are tabular and oriented parallel to the foliation; epidote is a common accessory mineral, and garnet is less common. Radiometric ages (K/Ar) are commonly discordant and range from 112 Ma to as young as 22.8 Ma, but most age determinations yielded Coniacian (~86 Ma) or older ages. Mid-Cretaceous plutons in the Yukon-Tanana Upland tend to be biotite granite and biotite-hornblende granodiorite with minor diorite phases and are relatively well dated. Some bodies are batholithic in size, like the Goodpaster and Mount Harper batholiths. Analyses, such as those by Wilson and others (1985), have demonstrated that emplacement of these plutons postdate regional metamorphism and reflect relatively slow cooling. Gold mineralization is commonly associated with these plutons, such as at the Fort Knox and Pogo deposits. In the Eagle and Tanacross quadrangles, radiometric dating is sparse and many of the plutons shown as part of this unit are undated. Limited dating in the adjacent northeastern Big Delta quadrangle suggests that at least some of these plutons may be of latest Cretaceous or earliest Tertiary age. A significant part of Saint Lawrence Island is made of these plutons, which consist of fine- to coarse-grained granite and subordinate granodiorite, monzonite, syenite, and alaskite (Patton and others, 2011). In southwest Alaska, this unit includes the Nyac and nearby plutons. Age control on these plutons is somewhat imprecise; K/Ar and $^{40}Ar/^{39}Ar$ 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)

Kmqm **Quartz monzonite, monzonite, and syenite (Cretaceous, Coniacian to Albian)**—Large quartz monzonite plutons occur in three general areas of the state. The largest exposures are found in the Ruby terrane north of the Kaltag Fault in west-central Alaska. Plutons, such as the large Melozitna pluton, are largely quartz monzonite, but also have granite and monzonite phases. Locally, the Melozitna pluton intrudes granitic augen gneiss that has yielded a protolith emplacement age of 117.5 Ma (Roeske and others, 1995). On the southeastern Seward Peninsula, an elongate pluton 80 km long and 3 to 8 km wide extends along the crest of the Darby Mountains in the southeast part of the peninsula (Till and others, 2011). Other plutons of this unit are exposed in the Yukon–Koyukuk Basin in the Candle, Selawik, and Shungnak quadrangles, spatially associated with similar age syenite and nepheline syenite of unit Ksy. Additional exposures occur on the islands offshore of the Seward Peninsula—Little Diomede, King, and Sledge Islands. Plutons in these two areas range in age between about 112 and 85 Ma. In the transition zone between the Tintina and Kaltag Fault Systems in north-central Alaska, a number of 92- to 88-Ma quartz monzonite plutons lie in a belt parallel to the structural trend. In eastern Alaska, a number of large quartz monzonite plutons are found in the Tanacross and Nabesna quadrangles and extend into the Yukon of Canada. Age determinations on these plutons, of which there have been very few, are more restricted in age, between about 98 and 91 Ma. Included here is a small syenite body located just a few miles north of Fairbanks in central Alaska, which has been described by Newberry and others (1998a) and yielded a nearly concordant TIMS U/Pb date of 110.6±0.6 Ma. Also included is the quartz monzonite phase of the Mount Kashagnak pluton of the Skagway quadrangle, which is undated. On generalized map, included as part of unit Kmgr

Ksy **Syenitic rocks (Cretaceous, Coniacian to Albian)**—Nepheline syenite, syenite, monzonite, and subordinate alkaline plutonic rocks and dikes including malignite, ijolite, shonkinite, and pyroxenite (Patton and Miller, 1968). Part of the "western Yukon-Koyukuk plutonic suite" of Miller (1989), a potassic and ultrapotassic belt that outcrops from the northeast corner of the Bettles quadrangle to Saint Lawrence Island. K/Ar and $^{40}Ar/^{39}Ar$ ages range from about 95 to 113 Ma with the majority of ages between 105 and 109 Ma. On generalized map, included as part of unit Kmgr

Ksfg **Foliated granitic rocks of southeast Alaska (middle Cretaceous?)**—Medium-grained, very light-gray to gray biotite-hornblende granodiorite that has local quartz diorite, quartz monzodiorite, tonalite, and granite phases.

Foliation, defined by the alignment of mafic minerals, is usually present. This unit consists of plutonic bodies within the Skagway and Mount Fairweather quadrangles and a large area of foliated quartz monzonite and granodiorite in the Ketchikan quadrangle associated with the Coast plutonic complex of Brew and Morrell (1979b). Foliations generally parallel those in the host rocks except for local divergences near contacts. Contact aureoles in the host rocks are generally narrow zones of hornfels (D.A. Brew, written commun., 2002). Age control is generally lacking, but nonfoliated plutons of similar composition in the vicinity yield cooling ages of about 120 to 110 Ma. The rocks in the Ketchikan quadrangle yield Eocene K/Ar ages and a U/Pb lower intercept age of 107 Ma (Rubin and Saleeby, 2000). An unpublished U/Pb TIMS multigrain zircon age was much older, ~177 Ma (S.M. Karl, unpub. data); the sample, collected near Haines, displays some evidence of inheritance, yet may indicate inclusion of Jurassic plutonic rocks in this unit

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 $^{40}Ar/^{39}Ar$ 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, $^{40}Ar/^{39}Ar$, 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)

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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 KPzum

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 Ŧcs 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 KPzum

KPzum **Dunite and serpentinite, undivided (Cretaceous? to Paleozoic)**—Small bodies of serpentinite, peridotite, dunite, gabbro, diorite, metabasite, and minor talc schist and roddingite are widespread throughout the southern part of the State. They exhibit a broad range of intrusive and (or) metamorphic textures and fabrics. Age control is generally poor and inferred ages range from late Paleozoic to Mesozoic. In the Talkeetna quadrangle, unit includes serpentinite and minor talc schist that Reed and Nelson (1980, their units MzPzu and MzPzd) interpreted was derived from peridotite. In the Mount Hayes quadrangle, variably serpentinized pyroxenite, peridotite, dunite, schistose amphibolite and hornblende-plagioclase gneiss derived from gabbro (Nokleberg and others, 1992a) is exposed close to the Denali Fault System and along the Broxson Gulch thrust in the Mount Hayes quadrangle. These bodies are on the opposite side of the Denali Fault System relative to the ultramafic bodies of unit KJmu above. The protolith was thought to be either Paleozoic or Triassic and metamorphosed in the Early Cretaceous. K/Ar and $^{40}Ar/^{39}Ar$ analysis of biotite and hornblende from pyroxenite yielded nearly concordant ages between 125.9 and 121.2 Ma (Nokleberg and others, 1992b) for the part of the unit associated with the Denali Fault System and 97.67 to 91.89 Ma for the part of the unit associated with the Broxson Gulch thrust (Nokleberg and others, 1992b). Nokleberg and others (1992a) infer that the Broxson Gulch rocks may have been comagmatic with the Nikolai Greenstone of Triassic age (unit T̄Rn) or, alternatively, are Late Cretaceous intrusions

KJg **Quartz monzodiorite (Cretaceous to Jurassic)**—An elongate, medium-gray, medium-grained, hypidiomorphic granular hornblende-biotite quartz monzodiorite that contains variable amounts of clinopyroxene located in extreme northwest part of Kenai quadrangle, northeast part of Lake Clark quadrangle, and southwest part of Tyonek quadrangle (Nelson and others, 1983; Wilson and others, 2006a, 2009, 2012, in press [a]). Magmatic flow structures locally present; hornblende and plagioclase are aligned north-northeast. Body is sandwiched between Jurassic plutons on the east and early Tertiary or Late Cretaceous and Eocene plutons on the west, all considered part of the Alaska-Aleutian Range batholith of Reed and Lanphere (1969, 1972). Two samples yielded strongly discordant K/Ar biotite and hornblende ages between 97.5 and 58.8 Ma (Reed and Lanphere, 1973; Nelson and others, 1983). On generalized map, included as part of unit KJgu

Kum **Ultramafic rocks of southeast Alaska (Early Cretaceous)**—"Ultramafic intrusive bodies of magnetite-bearing hornblende clinopyroxenite and subordinate dunite, peridotite, and hornblendite (Taylor, 1967). Several complexes are concentrically zoned from a core of dunite to rocks containing progressively less olivine and more hornblende and magnetite. Zoned bodies commonly intrude a two-pyroxene gabbro known to be of Late Triassic age on Duke Island (Gehrels and others, 1987). Geologic and geochemical considerations suggest that rocks in these bodies may be genetically related to some Cretaceous and Jurassic volcanic rocks (Berg and others, 1972; Irvine, 1973). Potassium-argon apparent ages of the ultramafic rocks indicate emplacement during Early Cretaceous time (Lanphere and Eberlein, 1966)" Gehrels and Berg (1992). Himmelberg and Loney (1995) also provide extensive information on the characteristics and petrogenesis of many of these ultramafic intrusions. On generalized map, included as part of unit KPzum

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 Strelna 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 $^{40}Ar/^{39}Ar$ 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

KJdg **Diorite and gabbro of southeast Alaska (Cretaceous? and Jurassic)**—Extensively altered and sheared, green to gray-green, medium-grained, hornblende ± biotite diorite, gabbro, and minor quartz diorite that forms extensive sills and dikes within the Whitestripe Marble and along the contacts of the Whitestripe Marble and Goon Dip Greenstone southwest of the Peril Strait Fault. Mafic minerals are generally altered to chlorite and epidote or clinozoisite. Rocks are generally foliated and locally have extensive shear and cataclastic textures. Similar sheared dioritic rock intrudes marble and greenstone and also occurs as large blocks in the mélange facies of the Yakutat Group (unit KJyg here), which is thought to be correlative with the Kelp Bay Group (Johnson and Karl, 1985) (unit KŦm here). Unit spatially associated with rocks of unit KJse in southeast Alaska. On Halleck Island, unit has yielded several ages: a U/Pb zircon age of 192.8 ±2.4 Ma; $^{40}$Ar /$^{39}$Ar hornblende ages of 191.9±1.2 and 185.4±3.8 Ma; and an $^{40}$Ar /$^{39}$Ar white mica cooling age of 157.2±2.6 Ma (S.M. Karl, unpub. data). In the Juneau and Ketchikan quadrangles, unit also includes altered and (or) metamorphosed and undated diorite and quartz diorite that are exposed in small areas associated with rocks of the Gastineau Group (unit MzPzsv) and the Gravina-Nutzotin unit (unit KJgn) (Gehrels and Berg, 1992; Karl, 1992; S.M. Karl, unpub. data). On generalized map, included as part of unit KPzum

Jurassic to Paleozoic

Jtr **Trondhjemite (Jurassic)**—Composed of medium- to coarse-grained, seriate, leucocratic trondhjemite exposed as long, linear bodies, all trending northeast-southwest; unit is known from two occurrences. In south-central Alaska, the trondhjemite is considered a component of the Alaska-Aleutian Range batholith, where it is exposed on the west side of the Jurassic part of the batholith in the Kenai, Lake Clark, and Iliamna quadrangles and in much more areally extensive exposures in the batholith's northern extension in the Anchorage and Talkeetna Mountains quadrangles. The exposures near Anchorage and in the Talkeetna Mountains consist of locally altered, sheared, and faintly foliated trondhjemite in large, structurally discordant, northeast-trending plutons that intrude Jurassic quartz diorite and amphibolite (Winkler, 1992). Generally accepted K/Ar age determinations come from many sources and range from 151.6 to 129 Ma throughout the exposure area and can be considered cooling ages; U/Pb zircon ages range between 156.9 to 152.7 Ma in Talkeetna Mountains quadrangle (Rioux and others, 2007). A zircon analysis in the Iliamna quadrangle did not yield a concordant age (Rioux and others, 2010) but was estimated to be about 160 Ma. In the second area of exposure, in the Holy Cross and Unalakleet quadrangles (Patton and others, 2006, 2009, in press), unit is composed chiefly of trondhjemite and tonalite plutonic bodies that, locally, have been metasomatized by potassium-rich fluids to pink granite and granodiorite. Unit also includes subordinate amounts of quartz diorite, diorite, and gabbro. Some of the plutonic bodies have been cataclastically deformed. Unit confined to the north-central part of the Holy Cross quadrangle and the central Unalakleet quadrangle, where it intrudes a fault-bounded belt of undivided Koyukuk and Angayucham-Tozitna terranes (unit KMmu). Unit is assigned a Jurassic age on the basis of five K/Ar ages that range from 173 to 130 Ma (Patton and Moll-Stalcup, 1996), suggesting this trondhjemite is possibly slightly older than the exposures in south-central Alaska. On generalized map, included as part of unit Jlmgr

Jise **Granitic rocks of southeast Alaska (Jurassic)**—Consists of a variety of intrusive rocks including quartz monzonite, monzonite, tonalite, and quartz diorite on Chichagof and Baranof Islands generally west of or along the Peril Strait Fault (Loney and others, 1967; Karl, 1999). Dominant lithologies are white to medium-gray, medium- to coarse-grained, biotite-hornblende tonalite and garnet-muscovite-biotite tonalite, which have a wide range of quartz-to-plagioclase ratios (from approximately 1:4 to 1:1). Plagioclase-rich samples tend to contain hornblende and have a higher color index; quartz-rich samples tend to be hornblende free and leucocratic (Johnson and Karl, 1985). The tonalite contains local zones of fine-grained, rounded, mafic inclusions and occasional pink pegmatitic dikes. Subordinate to the tonalite is medium- to dark-gray-green, medium- to coarse-grained, foliated biotite-hornblende quartz diorite in which hornblende is always more abundant than biotite. Pyroxene-cored hornblende crystals are locally common (Johnson and Karl, 1985). K/Ar ages range from 182 to 143 Ma (Loney and others, 1967; Karl and others, 1988; S.M. Karl, unpub. data) and are commonly significantly discordant; the youngest ages are from samples collected close to the Peril Strait Fault. A single body is also found north of Tenakee Springs, east of the fault on Chichagof Island; it consists of buff to light-gray hornblende-quartz monzonite, hornblende monzonite, and biotite alaskite (Karl, 1999) and yields a K/Ar hornblende age of 147±7 Ma. S.M. Karl (unpub. data) also reports the presence of small areas of Jurassic plutonic rocks in the Tracy Arm area of the Sumdum quadrangle. On generalized map, included as part of unit Jlmgr

JŦob **Ophiolite of the Brooks Range (Jurassic to Triassic?)**—Predominantly mafic and ultramafic rocks considered by most workers to represent an essentially complete ophiolite sequence (Mayfield and others, 1988; Moore and others, 1994; Saltus and others, 2001; Dover and others, 2004). Unit grades upward from tectonized and serpentinized mantle peridotite, dunite, harzburgite, and lherzolite at the base through a crustal sequence of cumulate ultramafic rocks and layered gabbro, massive gabbro, high-level felsic igneous differentiates, and sheeted diabase dikes, and is capped by basalt tuffs (Dover and others, 2004). Located in the western Brooks Range and on western Saint Lawrence Island, this ophiolite is best studied at Siniktanneyak Mountain and Memorial Creek in the Howard Pass quadrangle and is commonly referred to as the Misheguk igneous sequence. Dover and others (2004) recognized six subunits in the sequence. At its base, an intrusive phase (1) consists of predominantly orange-weathering dunite, but harzburgite is common locally, as are lesser amounts of lherzolite, serpentinized peridotite, and olivine pyroxenite; most lithologies are typically tectonized and foliated. The next-higher intrusive phase in the complex is (2) a gray-green cumulate layered gabbro as thick as 4 km that includes interlayered ultramafic rocks in its lower part. The third level of the intrusive sequence is (3) predominantly grayish-weathering, medium- to coarse-grained, hypersthene-bearing hornblende-pyroxene gabbro that has a generally directionless texture but has locally well developed mineral banding. Diabase occurs in localized swarms of subparallel dikes as thick as 2 m and has chilled margins. Structurally overlying the gabbro and diabase is a subunit (4) that typically ranges from diorite to hornblende-plagiogranite; alaskite dikes are also common. Dover and others (2004) interpreted that this fourth subunit formed above, and by differentiation from, massive gabbro (5) that is the second-highest intrusive phase in the complex. Locally as thick as 2 km, it is intruded by late-stage diabase dikes. At the top of the section is (6) a predominantly brown to greenish-gray, vesicular and amygdaloidal, locally pillowed basalt and minor volcanic breccia, tuff, and volcaniclastic rocks, as well as lenses of interpillow radiolarian chert and fossiliferous limestone. Fossils in the chert and limestone are varied, and, depending on location, are pre-Permian (Mississippian?), Permian(?), Middle and Late Triassic, and Early(?) Jurassic radiolarians in chert; the limestone lenses have early Late Devonian to early Early Mississippian conodonts and Permian brachiopods. Mayfield and others (1987) inferred a Triassic age for the section in the Noatak quadrangle on the basis of lithologic correlation with similar rocks in Misheguk Mountain quadrangle. Mayfield and others (1987) also inferred a Jurassic age based on the possibility that gabbroic dikes and sills may have been feeders for some of the basalt. These dikes and sills are similar to those in Misheguk igneous sequence, which has yielded K/Ar dates that range from 164.0±7.0 on hornblende (Ellersieck and others, 1982) to 153.0±7.6 on biotite (Nelson and Nelson, 1982) in the Misheguk Mountain and Howard Pass quadrangles, respectively. Wirth and others (1993) reported widely ranging $^{40}Ar/^{39}Ar$ ages, between 196.6±12.6 and 134.3±5.8 Ma; very few samples yielded plateau ages, but those that did ranged between168.8±4.2 and 163.1±4.0 Ma. The Misheguk igneous sequence is generally considered to be far- traveled oceanic crust exposed as thin klippen at the highest structural level in the Brooks Range (see, for example, Patton and others, 1977; Roeder and Mull, 1978). Modeling of magnetic and gravity data by Saltus and others (2001), however, suggests that the ophiolite is at least 8 km thick, which they postulate is inconsistent with the interpretation that the sequence is a thin klippen. Saltus and others (2001) suggest that the ophiolite may have formed in an extensional basin on a broad continental shelf. Harris and others (2003) disagreed with that interpretation, arguing that field relations and petrochemical data support an allochthonous origin for the Misheguk igneous sequence and that Saltus and others' (2001) geophysical data had inadequate resolution. An interpretation that reconciles both points of view is yet to be published. On generalized map, included as part of unit JZu

JPzu **Ultramafic complexes of western Alaska (Jurassic or older)**—Consists of ultramafic rock complexes surrounding the Yukon-Koyukuk Basin and along the north side of the Yukon Flats basin. "The complexes consist of: (1) a cumulate magmatic suite composed of interlayered dunite, wehrlite, olivine clinopyroxenite, and gabbro, (2) a mantle suite composed of harzburgite, dunite, and minor clinopyroxenite, and (3) a metamorphic sole consisting of a highly tectonized layer of amphibolite, garnet amphibolite, and pyroxene granulite. The harzburgite in the mantle suite typically is partly to mostly serpentinized. Chromite is generally restricted to centimeter-scale layers in dunite and as an accessory mineral" (Patton and others, 2009). Also included in this unit are ultramafic rocks assigned to the Kanuti ultramafic belt (Patton, 1974) and the Pitka ultramafic complex (Brosgé and others, 1974). The Pitka ultramafic complex was originally described as an eclogite and amphibolite unit during a rapid reconnaissance of the Beaver quadrangle (Brosgé and others, 1973); more detailed analysis by Brosgé and others (1974) showed that it consists “largely of banded garnet-amphibolite, foliated dunite, and harzburgite with pronounced cleavage, gneissic leucogabbro, and only minor eclogite.” Ghent and others (2001) reported that the complex had undergone granulite facies metamorphism and reported $^{40}Ar/^{39}Ar$ ages between 169.5±0.3 and 164.8±1.1 Ma. The Kanuti ultramafic belt, whose range has been extended from the original 125-km-long belt (Patton and Miller, 1970) through additional mapping, occurs “as tabular masses as much as 1,000 m thick composed of partially serpentinized dunite-harzburgite in the lower part and gabbro in the upper part. They dip 10° to 60° northwestward beneath the Cretaceous and Tertiary volcanic and sedimentary deposits of the Yukon-Koyukuk basin” (Patton, 1974). In the Nulato quadrangle, two exposures of massive chromite as much as 1.5 m thick were noted in dunite (Patton and Moll-Stalcup, 2000). “The complexes are intruded by narrow dikes of fresh clinopyroxenite, hornblendite, gabbro, and gabbro pegmatite. K/Ar isotopic cooling ages from the magmatic suite average 159 Ma and two $^{40}Ar/^{39}Ar$ determinations yielded a plateau age of 162 Ma. K/Ar isotopic cooling ages from the metamorphic sole at the base of the complexes range from 172 to 155 Ma and one $^{40}Ar/^{39}Ar$ determination from the metamorphic sole yielded a plateau age of 161 Ma” (Patton and others, 2009). Unit includes the Dishna River mafic and ultramafic rocks of the Iditarod and Ophir quadrangles (Miller, 1990; Miller and Bundtzen, 1994), on which three questionable K/Ar ages have been determined on hornblende: 222±23 and 228±25 Ma (replicate) and 92.2±2.8 Ma. The older sample had extremely low $K_2O$ and was thought to have incorporated excess argon; the younger was possibly reset by nearby plutonism (Miller and Bundtzen, 1994). On generalized map, included as part of unit JZu

Jgr **Jurassic phase, Alaska-Aleutian Range batholith, undifferentiated (Jurassic)**—The Alaska-Aleutian Range batholith (Reed and Lanphere, 1972) ranges from granite and granodiorite to quartz diorite and tonalite and includes some quartz monzonite. As defined, the batholith includes Jurassic (included here and in unit Jtr), Cretaceous (included in unit Kgu), and Tertiary (included in units Tpgr and TKgd) phases. The Jurassic phase, in general, is exposed on the east side of the batholith. A subunit of the Jurassic phase, trondhjemite, is described in unit Jtr. The most extensive area of exposure is in the Aleutian Range on the west side of Cook Inlet, where the plutons lie to the southeast of the Castle Mountain and Lake Clark Fault Systems and are bounded on the east by the Bruin Bay Fault. The Aleutian Range exposures extend to the southwest a distance of 430 km to Becharof Lake and, on the basis of geophysical trends, have been inferred to continue in the subsurface along the Alaska Peninsula (Case and others, 1981, 1988) and possibly into the Bering Sea. The unit is also exposed in the Talkeetna Mountains and Anchorage quadrangles. The rocks there are truncated on the south by the Border Ranges Fault System. Generally thought to be the plutonic equivalent of volcanic rocks of Talkeetna Formation (unit Jtk, here), northern exposures of the plutons are commonly found in close proximity to the Talkeetna Formation. The Alaska-Aleutian Range batholith has been best described and dated by Reed and Lanphere (1969, 1972, 1973). Locally subdivided by lithology, significant phases are granite, granodiorite, quartz monzonite, quartz diorite, tonalite, and gabbro. The quartz diorite and tonalite phases form the majority of the batholith on the Alaska Peninsula and form the southwest part of the Talkeetna Mountains section. These rocks are typically medium-grained, gray equigranular rocks, and are locally foliated. Either clinopyroxene or hornblende is the dominant mafic mineral. Biotite increases in proportion to the presence of quartz and potassium feldspar. Detterman and Reed (1980) reported that rocks of unit in Iliamna region grade to diorite but they did not observe it grading into quartz monzonite or granodiorite (their unit Jqm). Inclusions of fine-grained mafic rocks or of porphyro-aphanitic volcanic rocks are common. K/Ar and $^{40}Ar/^{39}Ar$ ages generally range from 174.7±8.8 to 146±4.3 Ma (Reed and Lanphere, 1973; Magoon and others, 1976; Csejtey and others, 1978; Hacker and others, 2011); a number of samples yielded younger ages that were considered suspect or thought to be reset by younger plutonism; the majority of concordant ages are between about 165 and 160 Ma. U/Pb ages are bimodal—on the Alaska Peninsula they range between 183 and 164 Ma and no inheritance is indicated, whereas in the Talkeetna Mountains the ages range from as old as 208 Ma to 187 Ma, and most sample analyses indicate inheritance (Rioux and others, 2007). A diorite pluton has been mapped on the eastern side of the batholith in northeast Iliamna quadrangle and it mostly likely continues in the adjacent Lake Clark quadrangle (Detterman and Reed, 1980). Unit also includes a group of lamprophyre and basalt dikes on west side of Cook Inlet that intrude the quartz diorite. Two rocks sampled northeast of Lake Iliamna yielded mid-Cretaceous K/Ar age determinations (Reed and Lanphere, 1972) and may indicate presence of an otherwise unrecognized mid-Cretaceous magmatic event in the batholith or may more likely indicate resetting by nearby middle Tertiary plutons. Granodiorite and quartz monzonite phase is also widely distributed, occurring throughout the range of exposure. On the Alaska Peninsula, it is exposed on the eastern side of the batholith; mapping in the northern section of the batholith does not separate this phase from the quartz diorite and tonalite phase. The granodiorite is typically whitish-gray, medium-grained and biotite-bearing with minor hornblende and accessory primary muscovite, and the quartz monzonite is medium-grained, light-gray with a pinkish cast. K/Ar age determinations from both sections range from 180.4±5.0 to 140.0±4.2 Ma (Csejtey and others, 1978; Shew and Lanphere, 1992; Wilson and Shew, 1992), but the majority of ages and the most reliable ones are older than 157 Ma. U/Pb zircon ages range between 177 and 169 Ma, all from the northern section of the batholith (Rioux and others, 2007). Granite is the least common phase and is typically found at the southern end of the exposure range; it is typically light-gray, porphyritic, contains more biotite than hornblende, and is locally foliated (Riehle and others, 1993). K/Ar ages range between 173.6±2.0 and 159.6±2.0 Ma (Shew and Lanphere, 1992); no U/Pb ages have been determined on this granitic phase. Detterman and Reed (1980) and Riehle and others (1993) also reported small bodies of dark gray, diabase and gabbro, which are included here. Trondhjemite, a subunit of the Jurassic phase, is described in unit Jtr. On generalized map, unit Jgr included as part of unit Jlmgr

Jit **Spruce Creek tonalite (Middle Jurassic)**—Tan- and recessive-weathering tonalite in fault-bounded exposures within the Kugruk Fault Zone of Till and others (2011). Unit described primarily from rubble-crop as "50 to 70 percent plagioclase, 5 percent hornblende, and 25 to 45 percent quartz. Alkali feldspar is absent. A more hornblende-rich (30 percent), quartz-free dioritic variety is locally present. Hornblende is preserved only in the northernmost exposures of the stock * * *. Elsewhere, no primary mafic minerals are present; hornblende is altered to mixtures of chlorite, opaque minerals, and epidote. * * * The tonalite yielded a U/Pb zircon age of 163±3 Ma" (Till and others, 2011). On generalized map, included as part of unit Jlmgr

Jum **Gabbronorite 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 gabbronorite, 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

Jag **Bokan Mountain peralkaline granite and syenite (Middle Jurassic)**—Alkalic granitic rocks, including light-gray peralkaline granite and syenite (MacKevett, 1963). The Bokan Mountain granite on Prince of Wales Island is characterized by diverse grain sizes and textures, high quartz content, and sodium-bearing mafic minerals. It ranges from fine- to coarse-grained, and its textures, dominantly porphyritic and cataclastic, include porphyritic, seriate porphyritic, protoclastic, cataclastic-hypidiomorphic granular, and xenomorphic granular. The porphyritic textures are characterized by euhedral quartz phenocrysts, which range from 5 to 20 mm in length and are embedded in a fine- or medium-grained groundmass. The cataclastic textures are characterized by granulated quartz or fractured minerals—chiefly quartz and feldspar (MacKevett, 1963). The Bokan Mountain peralkaline granite porphyry has a core of arfvedsonite granite and an outer ring of predominantly aegirine granite, which forms a nearly complete ring about 180 m in thickness around the core of arfvedsonite granite. The granite is characterized by 2–10 volume percent subhedral arfvedsonite and aegirine (Dostal and others, 2013). Aegirine syenite forms cylindrical to tabular masses that have sharp contacts in the southeastern part of the Bokan Mountain complex (Thompson and others, 1982) and the granite is intruded by late phase quartz-albite-K-feldspar pegmatite enriched in Th and rare earth elements (REE) relative to the main phase as well as late stage, light-colored aplite porphyry dikes. Similar alkaline granite porphyry at Dora Bay has a rim of migmatitic nepheline-eudialyte-bearing syenite, locally ~100 m thick (Eberlein and others, 1983). Lanphere and others (1964) reported K/Ar ages on riebeckite of 190±8 and 185±8 Ma for the Bokan Mountain granite, and de Saint-Ander and others (1983) reported a U/Pb age on discordant zircon fractions of 171±5 Ma; de Saint-Andre and Lancelot (1986) revised that age to 167+7/–5 Ma. A $^{87}Sr/^{86}Sr—^{87}Rb/^{86}Sr$ isochron age of 151±5 Ma was interpreted by Armstrong (1985) to be a minimum age. A concordant U/Pb zircon age of 177.2±0.2 Ma and two $^{40}Ar/^{39}Ar$ plateau ages of 176.3±0.8 and 175.5±06 Ma on amphibole suggest rapid cooling of the granite at Bokan Mountain (Dostal and others, 2013). Hornblende in the peralkaline granite at Dora Bay yielded a K/Ar age of 175.4±6.6 Ma (N. Shew, written commun., 1992). Mined for uranium in the past (Thompson and others, 1982; Thompson, 1988), Bokan Mountain is rich in rare earth elements (Philpotts and others, 1996)

Jg **Plutons of the Yukon-Tanana Upland (Early Jurassic)**—The plutons range from granite to granodiorite and also include more potassic phases that are exposed primarily in the Eagle, and to a lesser extent, the Tanacross quadrangles of east-central Alaska. Includes the hornblende syenite porphyry of Mount Veta of Foster (1976), which has been shown by Day and others (2014) to include quartz monzonite and diorite phases. Radiometric ages, including K/Ar, $^{40}Ar/^{39}Ar$ plateau, and U/Pb zircon, are generally between 193.2 and 178.7 Ma, but several other U/Pb ages have been published, both older and younger than this range (Foster, 1976; Newberry and others, 1998b; Dusel-Bacon and others, 2002; Werdon and others, 2001; Szumigala and others, 2002; Dusel-Bacon and others, 2009; Day and others, 2014). Unit includes rocks mapped as “gabbro, associated basalt and andesite(?), minor diorite and diabase, and undifferentiated mafic- and intermediate composition igneous rocks” by Foster (1992) and since shown to include a significant proportion of granodiorite of Early Jurassic age. Triassic parts of Foster’s unit are included in unit Ŧgd. In the Eagle quadrangle, unit includes migmatitic border phases of the plutons as mapped by Day and others (2014). On generalized map, included as part of unit Jegr

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

Jegd **Granodiorite of Hagemeister Island (Early Jurassic)**—Medium-grained biotite-hornblende granodiorite of Hagemeister Island; slightly altered (for example, sericitized plagioclase, chlorite partially replacing biotite and hornblende) as described by Box (1985). Intrudes Early Jurassic volcanic and sedimentary rocks (map unit JŦvs) with a narrow contact-metamorphic zone of hornblende-biotite-plagioclase hornfels. Box (1985) reported that clasts of similar granodiorite occur in conglomerate of adjacent interbedded volcanic and sedimentary rocks of map unit Jvc. An age reported variously by Box (1985) as on biotite (p. 26) or hornblende (p. 18) yielded a K/Ar age of 183±7 Ma; the reported $K_2O$ content for this sample is well below that typical for biotite and, conversely, very high for hornblende. As presented, the date must be considered suspect. No similar age granitic rocks are known elsewhere in southwestern Alaska, but rocks of this age are common in the plutonic rocks of the Hidden terrane and the Early Jurassic plutons of the Yukon-Tanana Upland to the east and north (units Jhg and Jg, respectively). Pluton originally mapped as part of map unit TKg by Hoare and Coonrad (1978). On generalized map, included as part of unit Jegr

## Triassic to Paleozoic

Ŧqd **Quartz diorite and granodiorite (Triassic)**—Granodiorite and similar rocks of Triassic age occur primarily in three parts of Alaska.

In southwest Alaska, the Afognak pluton is the largest exposure, but small exposures of rocks of similar age and composition are found in the Barren Islands of the Afognak quadrangle and in the Seldovia quadrangle of south-central Alaska. The Afognak pluton is exposed on the west side of the Kodiak Island archipelago in the Karluk, Kodiak, and Afognak quadrangles. It is a large, multiphase hornblende diorite, quartz diorite, and tonalite pluton that has a well-developed contact-metamorphic aureole in the Shuyak Formation; its boundary with the schist of Kodiak Island (unit Jsch) is apparently a fault (Roeske and others, 1989). In the Seldovia quadrangle, unit includes the diorite of Point Bede of Bradley and others (1999), which is a fine- to medium-grained quartz diorite, and the tonalite of Dogfish Bay of Bradley and others (1999), a medium-grained tonalite that shows chloritic alteration similar to that found in diorite of Point Bede and, hence, was assigned a similar age. Bradley and others (1999) originally assigned plutons in the Seldovia quadrangle a Jurassic age on the basis of correlation with the pluton in the Barren Islands that had yielded a K/Ar hornblende age of 191±1.3 Ma (Cowan and Boss, 1978). A Triassic age of 227.7±0.6 Ma was determined on zircon from the diorite of Point Bede (Bradley and Miller, 2006). Unit also includes diabasic hypabyssal intrusions in the Shuyak Formation (Connelly and Moore, 1979). A fission-track age determination on zircon yielded 153±10 Ma (Clendenen, 1991). K/Ar ages on hornblende from the Afognak pluton and associated migmatite range from 197±5.8 to 187.5±5.5 Ma (Roeske and others, 1989), which we interpret as a cooling age; a U/Pb age of 217±10 Ma is interpreted as the emplacement age (Roeske and others, 1989). We infer a similar history for the plutons of the Barren Islands.

The second major area of exposure of Triassic plutonic rocks is the Taylor Mountain batholith in the Eagle and Tanacross quadrangles of east-central Alaska (Foster, 1970, 1976). The batholith is medium- to coarse-grained, subequigranular biotite–hornblende quartz monzodiorite, tonalite, granodiorite, and quartz diorite that ranges from slightly foliated in its interior to strongly foliated at its margins (Werdon and others, 2001). Contacts with surrounding rocks are complex; zones of intimately foliated quartz dioritic dikes and sills are locally present in the country rocks near the batholith, but sheared contacts apparently predominate: Jurassic deformation, and later high-angle faulting, has disrupted most of the original contacts (Werdon and others, 2001). Rocks of the Taylor Mountain batholith have yielded a U/Pb (sphene) age of 214 Ma and zircon ages between 215.7±3.1 and 196±4 Ma (Aleinikoff and others, 1981; Dusel-Bacon and others, 2009; Day and others, 2014); K/Ar ages of 183 to 177 Ma (Wilson and others, 1985); and $^{40}Ar/^{39}Ar$ plateau ages of 209±3 Ma on hornblende and 204±9 Ma on biotite (Cushing and others, 1984a, b, written commun., 1992), and 210 Ma on biotite and 211 Ma on hornblende (P.W. Layer, University of Alaska-Fairbanks, unpub. data; see Werdon and others, 2001). The most likely magmatic age is about 214 Ma, with younger apparent ages caused by heating and deformation during the Early Jurassic (Werdon and others, 2001).

In southeast Alaska, the primary exposure of Triassic plutonic rocks is the Texas Creek granodiorite of Berg and others (1988) in the Ketchikan and Bradfield Canal quadrangles and adjacent British Columbia. The pluton consists mainly of recrystallized, locally cataclastically deformed granodiorite and minor quartz diorite. In general, the unit is relatively massive and lacks pronounced primary or metamorphic foliation. Where present, the intensity of the cataclastic texture generally is low, but locally the granodiorite is converted to mylonite (Berg and others, 1988). The Texas Creek granodiorite yields latest Triassic apparent ages, but discordant K/Ar dates on hornblende (Smith, 1977). U/Pb zircon age determinations by Alldrick and others (1987) on the pluton in adjacent British Columbia yield Early Jurassic apparent ages, which they interpreted to be metamorphic ages. Other small plutons, exposed on northern Admiralty Island, described as very light- to medium-gray, nonmagnetic, locally foliated, lineated, garnet-bearing granodiorite have reported U/Pb zircon ages of 227.3±2.0 and 221.8±3.0 Ma and an $^{40}Ar/^{39}Ar$ age of 236.3±3.8 Ma on hornblende; the plutons are locally migmatitic and some contacts are mylonitic (S.M. Karl, unpub. data). In the Skagway quadrangle, a number of dioritic dikes and small stocks mapped by Redman and others (1985) and Gilbert and others (1987) are of presumed Triassic age

MzPzyo **Peridotite of dismembered ophiolite of the Yukon-Tanana region (Mesozoic, Triassic? or older)**—Serpentinized peridotite, harzburgite, and dunite. Unit restricted to small outcrops in the Eagle, Charley River, Big Delta, Fairbanks, and Circle quadrangles (Foster, 1992; Foster and others, 1994). Corresponds to units assigned by many workers to the Seventymile terrane, which is thought to be a dismembered ophiolite. In the Big Delta quadrangle, unit includes units Pzd and Pzu of Weber and others (1978), and, in the Eagle quadrangle, unit Mzp of Foster (1976). Unit occurs as a klippe or is structurally infolded with mafic and pelitic schist of the Yukon-Tanana crystalline complex. Unit has not been dated, but age is inferred from association with sedimentary rocks of the Seventymile terrane, which contain early Late Triassic and late Paleozoic fossils (Dusel-Bacon and Harris, 2003). In the Eagle quadrangle, metagabbro mapped by Foster (1976) may be a component of the ophiolite; it is included in unit Pzyms here, mafic schist and amphibolite. The Joseph ultramafic body in the Eagle quadrangle yielded discordant hornblende and biotite dates of 174.7±5.1 Ma and 185.1±5.4 Ma, respectively (Foster, 1976). On generalized map, included as part of unit JZu

TRc **Carbonatite (Late Triassic)**—Found only in the Tanana quadrangle, unit consists of "medium to coarse grained, dolomite–calcite–magnetite–apatite-rich rock, which weathers to a deep red gossan and is characterized by an intense magnetic high. Occurs as two steeply-dipping sills (?) up to 30 m thick, which may be a single sill or dike that is repeated by isoclinal folding. Gradational contacts with hornfels with the carbonatite indicate that this was an igneous intrusion and not a flow * * *. Average composition is 87 percent carbonate (dolomite>calcite), 3 percent apatite, and 10 percent coarse magnetite. Minor phases include medium-grained barite, and fine-grained phlogopite, zircon, monazite, and columbite; all present at <1 percent abundance. Phyllite surrounding the carbonatite is altered to a carbonate–white mica-rich rock within 10 m of the carbonatite. Massive to foliated, fine-grained, clinozoisite–chlorite–dolomite, talc–clinozoisite–magnetite–dolomite, and actinolite–chlorite–dolomite–albite rocks, with variably elevated Ni and Cr contents, are present adjacent to the carbonatite body. The unusual mineralogy and composition of these rocks suggests that they are carbonate-altered mafic–ultramafic rocks genetically associated with the carbonatite. Since talc-chlorite-carbonate rocks with very high Ni, Cr, and MgO contents also contain substantial $Al_2O_3$, the protoliths must have included feldspathic peridotites (that is alkalic mafic rocks)" (Reifenstuhl and others, 1998b). An estimated $^{40}Ar/^{39}Ar$ age of 193±15 Ma on contact-metamorphosed phyllite was reported by Reifenstuhl and others (1998b), and they interpreted it to suggest an intrusion age of about 200 Ma. On generalized map, included as part of unit JZu

Ŧgb **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

Ŧum **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 Ŧqd. On generalized map, included as part of unit KPzum

Ŧdg **Mafic igneous rocks of Duke Island (Middle Triassic)**—"Much of central and eastern Duke Island is underlain by a large body of pyroxene gabbro that consists of varying proportions of olivine, hypersthene, augite, plagioclase, hornblende, and minor opaque minerals (Irvine, 1974). The gabbro intrudes deformed and metamorphosed Ordovician and Silurian sedimentary and igneous rocks [unit SOgi, here] and in turn is intruded by Cretaceous ultramafic rocks [unit Kum, here] * * *" (Berg and others, 1988). Gehrels and others (1987) report a U/Pb age of 226±3 Ma. On generalized map, included as part of unit KPzum

ŦPzig **Gabbro and diabase (Triassic or late Paleozoic)**—Light- to medium-green, medium- to coarse-grained, equigranular gabbro and diabase or diorite sills and dikes. Intrudes Globe quartzite unit (Mgq, here) in the Livengood quadrangle and is associated with one of the thrust splays of the Tintina Fault System. U/Pb zircon age of 232.1±4.5 Ma by J.K. Mortensen (Geological Survey of Canada, later at University of British Columbia, written commun., 1991), reported by Weber and others (1992). Also includes undated small exposures of green to greenish-brown, medium- to very coarse-grained, porphyritic diorite that intrudes the Cascaden Ridge and Beaver Bend combined unit (Dcr) in the Circle quadrangle (Foster and others, 1983). Apparently equivalent rocks are present in the Kantishna River and Ruby quadrangles (Wilson and others, 1998). On generalized map, included as part of unit JZu

## PALEOZOIC TO PROTEROZOIC

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

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 PzPrg) 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 $^{40}Ar/^{39}Ar$ 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

MDgi **Old Crow suite of Gordey and Makepeace (2003) and other granitic rocks of northeast Alaska (Mississippian to Devonian?)**—Granite and quartz monzonite, exposed in two large batholithic bodies in northeast Alaska and in two smaller plutons. The northernmost, the granite of the Romanzof Mountains, straddles the boundary of the Mount Michelson and Demarcation Point quadrangles (Reiser and others, 1971, 1980). Predominantly muscovite- or biotite-quartz monzonite with hornblende that is restricted to a small stock on the south side of the batholith. Age control is generally lacking. The pluton may intrude rocks as young as the Lisburne Group of Carboniferous age. A satellite pluton to the south that intrudes rocks of the Proterozoic Neruokpuk Quartzite yielded a K/Ar date on hornblende of 439 Ma; this date is hard to evaluate because it may reflect a separate magmatic event or, alternatively, may reflect the presence of excess argon inherited from the country rock. Extensive fission-track analyses (O'Sullivan and others, 1995; Peapples and others, 1997) indicate rapid uplift in the Eocene. The southern part of the unit, the Old Crow batholith, straddles the Alaska-Yukon border in the Coleen quadrangle of Alaska and the Old Crow sheet of Yukon. In Alaska, batholith consists of biotite granite and quartz monzonite, which locally contain muscovite. Northern contact with adjacent metamorphic rocks is intrusive; southern boundary is not well known and may be a fault in part. K/Ar ages on mica range from 354 to 302 Ma (Brosgé and Reiser, 1969) in Alaska. In northern Yukon, the Old Crow batholith and related plutons consist, in part, of syenite and yield radiometric ages between 382 and 362 Ma (Gordey and Makepeace, 2003). Plutons in the Table Mountain quadrangle were described as either Tertiary or Mississippian to Devonian (C.G. Mull, written commun., 2011). In Yukon, the plutons have been considered Devonian (Gordey and Makepeace, 2003); in the Table Mountain quadrangle, a rhyolite dike was dated at 56.4 Ma (Barker and Swainbank, 1986); whether this date reflects the age of any of the larger granitic plutons is uncertain. Devonian to Mississippian orthogneiss is also known farther west in the Brooks Range, in the Yukon-Tanana Upland and northern Alaska

Range, and in the Tanana and Melozitna quadrangles of central Alaska (see units MDag, Dmi, and Dogn). On generalized map, included as part of unit MDmg

DOgi **Syenite, trondhjemite, and granite (Early Devonian to Ordovician?)**—Exposed in southeast Alaska in three areas. On Chichagof Island in the Sitka quadrangle, the unit consists of a plutonic complex of trondhjemite and subordinate syenite, monzonite amd quartz monzonite. The trondhjemite is dominantly biotite trondhjemite and hornblende-biotite trondhjemite, but includes subordinate hornblende trondhjemite. Syenite is predominantly hornblende syenite, but includes subordinate sodalite syenite and sodalite-nepheline syenite. Also present on Chichagof Island is hornblende-bearing biotite monzonite, hornblende-bearing biotite syenodiorite, and biotite quartz monzonite (Loney and others, 1975). U/Pb TIMS-multigrain zircon dates range between 378 and 353 Ma (S.M. Karl, unpub. data), whereas existing K/Ar dates are significantly younger and discordant, at 121.9±5 and 253.1±10 Ma on biotite and hornblende, respectively (Lanphere and others, 1965). In the second area, in the Craig quadrangle, rocks mapped by Eberlein and others (1983) as Cretaceous diorite have yielded a $^{40}Ar/^{39}Ar$ age of 410 Ma (S.M. Karl, unpub. data) and are included here, presuming the age is a minimum age. In the Dixon Entrance quadrangle on southern Prince of Wales Island, leucocratic biotite ± aegirine ± arfvedsonite ± garnet syenite and subordinate leucodiorite yield a number of U/Pb TIMS-multigrain zircon upper intercept ages in the Ordovician (Gehrels and Saleeby, 1987). The plutons in the Craig and Dixon Entrance quadrangles are part of large igneous complex that consists of Ordovician granitic rocks (unit Ogi), the Bokan Mountain complex of Jurassic age (unit Jag), and these Early Devonian to possibly Ordovician plutons. Finally, in the Ketchikan and Prince Rupert quadrangles on Annette and Gravina Islands, rocks ranging from trondhjemite to granite to quartz diorite form another igneous complex (Loney and others, 1975; Berg and others, 1988; Karl, 1992; Brew, 1996) of Silurian age (Gehrels and others, 1987)

PzPmi **Mafic igneous rocks, central and northeast Alaska (early Paleozoic and (or) late Proterozoic)**—Unit consists primarily of gabbro and diabase sills(?) and serpentinite exposed in a linear belt in the Livengood and northwest Circle quadrangles. Gabbro and diabase are dark olive green and greenish-gray to dark greenish-black, medium- to coarse-grained, and very fine-grained on outer margins of sills; locally grades into diorite. These rocks are associated with greenstone and basalt, interbedded slate, siliceous shale, chert, and argillite of the Amy Creek unit of Weber and others (1992) (unit D€kb, here). Serpentinite is intruded by dikes of clinopyroxene gabbro, microgabbro, and diorite. Attempts to date these rocks have yielded $^{40}Ar/^{39}Ar$ (high temperature fraction) and K/Ar ages that range from 643 to 390 Ma (Weber and others, 1988, 1992; Reifenstuhl and others, 1998a; Athey and others, 2004). Unit also includes very small outcrops of poorly known, dense, dark-grayish-green, chloritized, locally schistose dikes and sills reported by (Reiser and others, 1980) in the Demarcation Point quadrangle, whose occurrence is restricted to within the Cambrian phyllite unit (included in €Pwn, here). On generalized map, included as part of unit JZu

DSum **Older ultramafic rocks of southeast Alaska (Devonian and Silurian)**—Pyroxenite, hornblendite, and related ultramafic rocks on southern Prince of Wales Island (MacKevett, 1963; Gehrels and Saleeby, 1986, 1987), on southern Dall Island (Gehrels, 1991), and on east-central Prince of Wales Island (Loney and others, 1987). Gehrels and Berg (1992) interpreted ultramafic rocks on southern Prince of Wales Island as Silurian on the basis of gradational relations with syenitic rocks of Silurian age (unit SOgi, here). Early Silurian K/Ar apparent ages have been determined on the body at Salt Chuck on east-central Prince of Wales Island (Loney and others, 1987) and on Sukkwan Island (Himmelberg and Loney, 1995). The intrusive body on Dall Island yielded a K/Ar apparent age of Early Devonian (400.1 Ma, from hornblende) (Himmelberg and Loney, 1995) although Gehrels (1991) had mapped it as Ordovician

Ogi **Granodiorite and related rocks (Ordovician)**—Part of the plutonic complex of southern Prince of Wales Island; unit consists of foliated and locally layered leucocratic granodiorite that is associated with diorite and subordinate hypabyssal diorite, gabbro, and rocks described as leucogranodiorite by Gehrels (1992) and as alaskite by Herreid and others (1978). Diorite is medium grained and consists of green hornblende locally intergrown with brown biotite, altered plagioclase, and subordinate quartz and K-feldspar; it is moderately layered or foliated and locally cataclastic (Gehrels, 1992). Granodiorite is fine-grained, and has a foliation that is defined by elongate hornblende and quartz grains. Highly foliated rocks are generally confined to narrow domains that may have been ductile shear zones. Contact relations and variability of foliation indicate granodiorite was emplaced and deformed prior to complete crystallization of diorite (Gehrels, 1992). Leucogranodiorite contains interlocking and commonly myrmekitic plagioclase, quartz, and microperthite; plagioclase is commonly altered to white mica, calcite, and epidote. Ferromagnesian minerals are totally altered to chlorite and opaque grains. Intrudes the diorite and rocks interpreted to be the Descon Formation (part of map unit SOd); overlain by Karheen Formation (Gehrels, 1992). These plutons yield U/Pb ages in the range of 472 to 445 Ma (Gehrels, 1992). On generalized map, included as part of unit DOgi

## METAMORPHIC ROCKS

CENOZOIC TO MESOZOIC

Quaternary or Tertiary

QTm **Contact metamorphosed and hydrothermally altered rocks (Quaternary or late Tertiary)**—Contact-metamorphosed and hydrothermally altered rocks found on the southwest Alaska Peninsula and Umnak Island in the Aleutian Islands. On the Alaska Peninsula, protoliths probably consist of, in order of importance: Late Cretaceous Hoodoo Formation (unit Khk), Tertiary volcanic rocks (unit Tvu), and Late Cretaceous Chignik Formation (unit Kcs); may also include Tertiary intrusive rocks (unit Tmi or Tgw) at lower elevations. Pervasive alteration prevents separation of altered rocks into their respective units. Rocks are hard, very fine-grained, and intensely fractured; sulfide mineralization is common, and resultant iron staining is ubiquitous on weathered surfaces (Wilson and others, 1995). On central Umnak Island, volcanic rocks are locally intensely silicified, potassium feldspathized, and hydrothermally altered over a large area (Byers, 1959)

Tertiary to Mesozoic

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 $^{40}Ar/^{39}Ar$ 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

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**MacLaren metamorphic belt of Smith and Lanphere (1971) (Tertiary to Jurassic or older?)**—Defined by Smith and Lanphere (1971) in the Talkeetna Mountains, Healy, and Mount Hayes quadrangles, units included are a relatively high grade metamorphic and igneous complex found south of the Denali Fault System in south-central Alaska; it was more completely described by Smith (1981). Correlative rocks are found northeast of the Denali Fault System in the Ruby Range batholith of Yukon and in the Coast plutonic complex of southeast Alaska and British Columbia. Divided into two units here, a largely granitic gneiss unit (TKgg) and a schist and amphibolite unit (MzMu), and the combined unit is shown as unit TMzmb on the generalized map

TKgg **Gneissose granitic rocks (Tertiary or Late Cretaceous)**—Chiefly gneissose granodiorite, quartz diorite, and minor granite referred to as the East Susitna batholith in the Mount Hayes quadrangle (Nokleberg and others, 1992a). In the Talkeetna Mountains quadrangle, Csejtey and others (1978) mapped an early Tertiary andalusite and (or) sillimanite-bearing pelitic schist, lit-par-lit migmatite, and granite unit that we have included here. In the Healy quadrangle, Csejtey and others (1992) mapped similar rocks as part of their unit Kgr, which is, in part, correlative with the East Susitna batholith of Nokleberg and others (1992a). The granitic bodies show moderately to well developed flow foliation and all internal contacts between phases are gradational, as is the contact with unit Mzmu. Unit has pervasive schistosity that generally strikes northeast to southwest and dips moderately to steeply west, is locally blastomylonitic, and contains relict porphyritic textures. Metamorphic grade is middle to upper amphibolite facies (Nokleberg and others, 1992a, 2013). Radiometric ages, including U/Pb zircon and sphene and K/Ar mica and hornblende ages have a wide range, between about 70 and 29 Ma (Nokleberg and others, 1992b; Csejtey and others, 1978, 1992). Youngest ages are close to and may be related to unroofing along the Denali Fault System. In the Healy quadrangle, rocks of this unit are described by Csejtey and others (1992) as their unit Kgr. South of the Susitna Glacier, these rocks are described as migmatitic and thought to reflect lit-par-lit intrusion of Tertiary magma into Cretaceous plutons (Csejtey and others, 1978). These rocks are a major component of the MacLaren metamorphic belt of Smith and Lanphere (1971) and have been correlated with the Ruby Range batholith in the Yukon and part of the Coast plutonic complex of Brew and Morrell (1979b) of southeast Alaska. In the Lime Hills and Tyonek quadrangles, a small area of undated gneiss is included in this unit. It consists of fine- to coarse-grained orthogneiss whose texture is locally cataclastic (Gamble and others, 2013). Primary composition is granodiorite, and as much as 5 percent garnet was noted locally, in contrast to the gneiss of the Mount Hayes and Healy quadrangles (B.M. Gamble, written commun., 1996). Structural grain strikes northeast to southwest and tends to be vertical or steeply dipping (80°) to the northwest; in a general sense, these rocks are on strike with the trend of the gneiss of the Mount Hayes and Healy quadrangles. On generalized map, included as part of unit TMzmb

M̶z̶mu **Metamorphic rocks of the MacLaren metamorphic belt of Smith and Lanphere (1971) (Cretaceous and Jurassic or older?)**—Dominantly fine- to medium-grained garnet-bearing schist and hornblende amphibolite, and subordinate calc-silicate schist and quartzite, all derived from siltstone, graywacke, marl, and andesite (Smith, 1981; Smith and others, 1988; Nokleberg and others, 1992a). Also includes intercalated gneissose granitic to gabbroic metaigneous rocks. Underwent regional metamorphism to amphibolite facies and, locally, subsequent greenschist facies retrograde metamorphism. Metamorphic grade appears to increase gradationally eastward from the Healy to Mount Hayes quadrangles and from south to north across a series of thrust faults mapped within the Mount Hayes quadrangle, toward the gneissose granitic rocks of unit TKgg (Smith, 1981). K/Ar hornblende and biotite ages range from 67.9 to 29.3 Ma; biotite consistently yields the youngest ages, which suggests prolonged cooling. U/Pb dates on zircon rims from phyllite using the SHRIMP (sensitive high resolution ion microprobe) were 153.3±2.7 to 147.9±3.0 Ma or Late Jurassic, and metamorphosed volcaniclastic rocks yielded 86.4±2.2 Ma or Late Cretaceous (Mooney, 2010). Includes units of the MacLaren terrane of Nokleberg and others (1992a) in the Mount Hayes quadrangle. In the southeastern part of the adjacent Healy quadrangle, rocks that Csejtey and others (1992) originally mapped as part of the flysch sequence, we infer had the same protolith as the ones in the rest of this unit and, therefore, we place those rocks in this unit. On generalized map, included as part of unit TM̶z̶mb

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Tvc **Victoria Creek metamorphic rocks (Tertiary, Paleocene metamorphism)**—Dominantly medium- to medium-dark-gray garnetiferous quartz-mica schist and amphibolite, but includes slate and shale in the Livengood quadrangle. Locally has gneissic texture. Minor white to light-gray, medium- to coarse-grained, thin- to medium-bedded, typically finely laminated marble and very minor quartzite occurs in the Tanana quadrangle. Unit outcrops as large fault slivers or "lozenges" along a strand of the Tintina-Kaltag Fault System in the Livengood (Weber and others, 1992) and Tanana quadrangles (Reifenstuhl and others, 1997). In the Tanana quadrangle, geophysical interpretation cited in Reifenstuhl and others (1997) and outcrop patterns suggest a steep northwest contact with rocks of the Tozitna assemblage and a moderately southeast-dipping southeast contact. Protolith age is unknown and, although Reifenstuhl and others (1997) and Dusel-Bacon and others (1989) suggest a Ruby or Yukon-Tanana metamorphic complex origin, Weber and others (1992) suggest a possible protolith of Tozitna sedimentary rocks (see section on the Angayucham, Tozitna, and Innoko assemblages and Rampart Group [unit KMm] and included subunits). Includes the Raven Creek Hill unit of Weber and others (1992) and units pTam, pTas, pTaq of Reifenstuhl and others (1997). Also includes light- to medium-gray, fine-grained, recrystallized sucrose-textured, hard, dense, cryptically layered quartz arenite interbedded with the pelitic schist unit. Exposures are rare and typically consist of blocky, black lichen-covered talus. A black opaque mineral composes as much as 3 percent of the quartzite. Quartzite unit is uncommon and differentiated where possible

## MESOZOIC TO PROTEROZOIC

### Cretaceous to Paleozoic

Kmig **Migmatite and metaplutonic rocks (Cretaceous)**—These migmatitic rocks are exposed in three areas of the state: southeast Alaska, the southern Brooks Range, and on the Seward Peninsula. In southeast Alaska, migmatite is widespread and associated with Cretaceous plutons and tends to be of granodioritic to quartz dioritic composition (Brew and others, 1984; Brew and Ford, 1985; Brew, 1996; Karl, 1999; Karl and others, 1999; D.A. Brew, written commun., 1997). It ranges from agmatite (brecciated migmatite) to gneiss. Locally, schist, gneiss, and marble inclusions are present. In the southern Brooks Range and Seward Peninsula areas, these migmatitic rocks are associated with the mid-Cretaceous quartz monzonite bodies of map unit Kmqm (Brosgé and others, 1973; Till and others, 2008, 2010). In the Chandalar quadrangle, the migmatite forms an annular ring around rocks interpreted as one of the metamorphosed Devonian plutons of the Brooks Range (unit Dogn) (Brosgé and Reiser, 1964). The migmatite also forms a roof pendant on a nearby mid-Cretaceous quartz monzonite. On the Seward Peninsula, the unit is a gneissic monzonite exposed between rocks of the Casadepaga Schist (unit Ocs) and the mid-Cretaceous Kachauik pluton (units Kmgd and Kmgm) (Till and others, 2010)

Khs **Rocks of Hammond River shear zone of Till and others (2008a) (Cretaceous)**—Heterogeneous mix of finely laminated, mostly mylonitic lithologies derived, in part, from adjacent units exposed in the eastern Wiseman and western Chandalar quadrangles. Unit is recessive, poorly exposed, and includes large (up to 0.5 km across) bodies of black quartzite and smaller exposures of quartz-rich schist, metagabbro, dark-brown marble, and relatively undeformed metasandstone and metasiltstone (Moore and others, 1997b; A.B. Till, unpub. data). In thin section, minerals are strained and broken. Protolith rocks may range in age from Proterozoic to Paleozoic; no age control is available. Age of unit is based on likely age of tectonic event that created the shear zone, which encompasses a zone of deformation between the Schist belt and Central belt of Till and others (2008a).

Equivalent to the Hammond River phyllonite of Moore and others (1997b); westernmost extent of the unit is approximately located

Kps **Pelitic schist (Late Cretaceous)**—Quartz-muscovite-albite-chlorite schist in southwestern Talkeetna Mountains, about 16 km north of Wasilla. Schist is remarkably uniform in lithology; no correlative rocks are known (Albanese and others, 1983; Winkler, 1992). Mineralogy indicates greenschist metamorphism, which Winkler (1992) interpreted as probably a retrograde from amphibolite facies metamorphism. A Jurassic age was inferred for the prograde metamorphism based on age of adjacent amphibolite of unit Jma of Winkler (1992; shown as unit JPam herein). Detrital zircon analysis, however, shows a peak at about 75 Ma, which may indicate deposition of the sedimentary protolith during the Late Cretaceous (D.C. Bradley, oral commun., 2007). K/Ar dates on muscovite from the schist are about 66 to 51 Ma (Csejtey and others, 1978; Silberman and others, 1978a, b; Winkler, 1992; M.L. Silberman, written commun., 1978) and were originally thought to reflect intrusion of adjacent tonalite and quartz monzonite. Corresponds to unit Jps of Winkler (1992) in Anchorage quadrangle, and schist at Willow Creek of Magoon and others (1976; their unit MzPzs)

MzPza **Metamorphic rocks of Admiralty Island, undivided (Mesozoic to Paleozoic)**—Clastic sedimentary rocks, subordinate mafic to felsic volcanic rocks, thin- to thick-bedded gray carbonate, chert, and minor ultramafic rocks that have been regionally metamorphosed to slate, phyllite, greenschist, schist, gneiss, and marble in many areas. Age and grades of metamorphism have yet to be reliably determined because these rocks have undergone multiple metamorphic and deformational events. Rocks assigned to unit on Admiralty Island belong to the “undifferentiated metamorphic rocks” and the “migmatite, gneiss, and feldspathic schist” units of Lathram and others (1965) and may belong to the Gambier Bay Formation (unit Dgb) and the Retreat Group, Cannery Formation, Hyd Group, and Gravina-Nutzotin sequence (units PzPrg, PDcf, Ƭhg, and KJgn, respectively). Lathram and others (1965) stated that “the most widespread rock types are hornblende-albite-epidote hornfels, micaceous schist, metamorphosed chert, coarse-grained marble, slate, and phyllite.” The unit, as shown here, also includes areas of migmatite, gneiss, feldspathic schist, and amphibolite mapped near exposures of plutonic rocks (Lathram and others, 1965). These rocks are primarily gray, green, and white banded hornblende-plagioclase orthogneiss (S.M. Karl, unpub. data). Also includes migmatite, schist that contains large feldspar porphyroblasts, and amphibolite. “Chloritization and sericitization are widespread in the higher grade rocks. Granite pegmatite dikes are common in the feldspathic schist * * *” (Lathram and others, 1965). S.M. Karl (unpub. data) reports a U/Pb zircon age of 227.3 ± 2.0 Ma and an $^{40}Ar/^{39}Ar$ hornblende age of 236.3±3.8 Ma on intrusive rocks that provide a minimum age for the metamorphism

MzPzmb **Metabasite (Mesozoic and Paleozoic)**—Consists of a variety of metabasite bodies exposed around the Yukon-Koyukuk Basin. Typically small bodies, these are found associated with the Schist belt of Till and others (2008a) in the Brooks Range (units DPaqm and DPacs, here), similar schist of the Ruby geanticline in the Nulato and Tanana quadrangles (included in unit PzPrqm, here) and also includes metamorphosed mafic rocks and serpentinite associated with the Kugruk Fault Zone of Till and others (2010). Varies from thinly layered greenschist to more massively layered greenstone bodies derived from altered mafic and intermediate volcanic and shallow intrusive rocks. Also includes small bodies of serpentinite, peridotite, dunite, gabbro, diorite, metabasite, and minor talc schist and roddingite. The rocks of this unit exhibit a broad range of intrusive and (or) metamorphic textures and fabrics. Age control is generally poor and inferred ages range from late Proterozoic to Mesozoic. Unit likely includes rocks of several different ages. Unit may include some rocks in the Brooks Range that might more appropriately be assigned to the Ambler sequence of Hitzman and others (1982; unit Das, here). Some of the bodies are interlayered with the Devonian felsic schist of unit Df of Nelson and Grybeck (1980) and Dillon and others (1986) and some of the bodies are part of a bimodal volcanic assemblage. Other bodies are interlayered with carbonate rocks that contain fossils of probable Devonian and Ordovician age (unit DPacs, here). Still other bodies may represent tectonically emplaced slices of unit JDv of the Angayucham-Tozitna terrane. The rocks associated with the Kugruk Fault Zone are “a tectonic assemblage of metagabbro, metabasalt, amphibolite, serpentinite, and minor chert, exposed in rubble fields and poor outcrops along the trend of the Kugruk Fault Zone. Mafic rocks within the fault zone include minor nonmetamorphosed (but altered) rocks, rocks with relict igneous textures and a single metamorphic overprint, and rocks that have experienced more than one metamorphic event. Pumpellyite- and prehnite-bearing veins that cross foliation are common in many lithologies” (Till and others, 2011). The “mafic rocks in the northern part of the fault zone (Bendeleben D-1 and Kotzebue A-1 quadrangles) display evidence of an albite-epidote amphibolite facies event overprinted by a lower grade event. Blue-green amphibole, epidote, and albite, with and without garnet, occur in equilibrium metamorphic textures. These albite-epidote-amphibolite-facies assemblages are slightly to significantly overprinted by epidote-blueschist or greenschist assemblages, largely on mineral rims or cracks. The later metamorphic event is likely the same event that affected mafic rocks in the unit further to the south” (Till and others, 2011)

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±4.8 Ma, and Bradley and Karl (2000) reported $^{40}Ar/^{39}Ar$ 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

Triassic to Proterozoic

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**Metamorphic rocks along the west side of the Coast plutonic complex of Brew and Morrell (1979b) (Triassic to Paleozoic)**—Along the west side of the Coast plutonic complex of Brew and Morrell (1979b), spanning the length of southeastern Alaska, is a belt of metamorphosed rocks that range from lower greenschist phyllite to amphibolite grade gneiss. The parent rocks of these metamorphosed and deformed units consist of carbonaceous shale, mudstone, and graywacke; subordinate limestone, chert, conglomerate, and mafic volcanic rocks; minor felsic volcanic rocks; and the metamorphosed and deformed equivalents of these rocks. Regional metamorphic grade in these increases from subgreenschist or greenschist facies on the southwest to amphibolite facies toward the northeast, where the rocks adjoin the Coast plutonic complex. Common rock types include phyllite, schist, and gneiss. Late Triassic fossils were recovered from carbonaceous slate and limestone assigned to this map unit near Juneau (Ford and Brew, 1977; H.C. Berg, unpub. data, 1981). Mappers have grouped and subdivided these rocks using different criteria such that it is generally not feasible to preserve those subdivisions at our map scale, so instead we have divided them into units that are dominantly metasedimentary (units MzPzss and Pm) and dominantly metavolcanic rocks (units MzPzsv and TrPvs):

MzPzss **Metasedimentary and minor metavolcanic rocks along the west side of the Coast plutonic complex of Brew and Morrell (1979b) (Triassic to Paleozoic)**—Predominately metasedimentary rocks, but locally includes metavolcanic rocks of unit MzPzsv where the occurrences are too small to map separately. This map unit includes a number of informally named rocks; these include (1) the Perseverance group of Gehrels and others (1992); (2) the Alava sequence of Rubin and Saleeby (1991); and (3) a number of unnamed units of Brew and others (1984) and Karl and others (1999). The Perseverance group of Gehrels and others (1992) consists of dark-gray carbonaceous shale and carbonaceous metalimestone. Unit MzPzss is interbedded with metavolcanic rocks (shown here as unit MzPzsv where possible). Three less abundant but locally conspicuous lithologies are also included with this unit: silvery gray pyritic phyllite; rusty-weathering phyllite or schist (possibly derived from felsic or intermediate tuff); and outcrops of massive to laminated gray marble similar to that of the Permian marble subunit (unit Pm here). Age control comes from fossils, including the Late Triassic *Halobia* cf. *H. superba* Mojsisovics, *Arceste*s or *Paraganides*, *Trachyceras* (*Prototrachyceras*) *lecontei* Hyatt and Smith, *Atractites* cf. *A. phillip*i Hyatt and Smith, (S.M. Karl, unpub. data), and indeterminate ammonites in the Sheep Creek area near Juneau (Martin, 1926, p. 95). The Perseverance group of Gehrels and others (1992) also contains ammonites of late Ladinian (Middle Triassic) age in the Ketchikan area, (Berg and others, 1988;

S.M. Karl, unpub. data). Gehrels and others (1992) suggested that the unit is as much as several kilometers thick but thins to the north. The Perseverance group overlies Permian volcanic rocks that were informally named the Gastineau group by Gehrels and others (1992); the Gastineau is included here in unit MzPzsv. Underlying the Gastineau group is a map unit we include here that Gehrels and others (1992, p. 570) described as pre-Gastineau strata that consists of "a heterogeneous sequence of dark gray to black phyllite derived from black shale and mudstone; silver to gray phyllite that was originally a tuffaceous mudstone; green to gray chloritic phyllite derived from basalt flows, breccia, and tuff; light green to buff siliceous phyllite probably derived from dacitic to rhyolitic tuff and breccia; and coarse-grained muscovite-actinolite-garnet schist that was probably intrusive in origin." The unit also includes the Alava sequence of Rubin and Saleeby (1991) mapped east of Ketchikan, which is equivalent to the combined Perseverance group, Gastineau group, and pre-Gastineau sequence of Gehrels and others (1992). The Alava sequence consists of an upper Paleozoic section of metamorphosed pillow basalt, mafic tuff, and crinoidal marble that show "* * * penetrative foliation, ductile folding and middle-greenschist- to amphibolite-facies metamorphic assemblages * * * divided into four groups" whose stratigraphic sequence is obscured by younger deformation: (1) marble, volcanic rocks, and argillite; (2) waterlain breccia and tuff; (3) interlayered marble and quartzite; and (4) crinoidal marble (Rubin and Saleeby, 1991, p. 884). These rocks contain late Early Pennsylvanian to late Permian conodonts, and early Permian brachiopods. Rubin and Saleeby (1991, p. 885) also describe a lower Mesozoic section of "carbonaceous phyllite, fine-grained argillaceous and siliceous limestone, metabasalt, mafic breccia, and tuff." The lower Mesozoic rocks contain fragments of halobiid bivalves (*Daonella*) as well as *Pentacrinite*s, conodonts, and ammonites, which indicate a Triassic age (Rubin and Saleeby, 1991). Between the Sumdum and Ketchikan areas, Brew and others (1984) and Karl and others (1999) mapped various unnamed metamorphic units that include biotite schist, phyllite, and biotite gneiss, which are undivided equivalents of the rocks above. On generalized map, included as part of unit MzPzcp. Unit locally subdivided into unit Pm

Pm **Marble along the west side of the Coast plutonic complex of Brew and Morrell (1979b) (Permian? protolith)**—Light-brown-weathering, massive to laminated, light-, bluish-, and dark-gray marble on Revillagigedo Island (Silberling and others, 1982; Berg and others, 1978, 1988). This marble contains locally conspicuous, dark-green, dark-gray, or rusty-weathering pyritic phyllite and semischist, polymictic sedimentary breccia or conglomerate that has angular to subrounded clasts of basalt, marble, and felsic(?) metatuff in a matrix of green metatuff and dark-gray argillite, schistose fragmental (volcaniclastic?) rocks, and greenish-black basalt dikes and sills (Berg and others, 1988). Marble on Revillagigedo Island and on the mainland east of Admiralty Island (the "Taku terrane") may not be correlative with Permian carbonate rocks elsewhere in southeast Alaska (the "Alexander terrane") based its association with Middle Triassic strata not present to the west (Silberling and others, 1982). Rocks of this unit are exposed widely in southeast Alaska west of the Coast plutonic complex of Brew and Morrell (1979b); where not mapped separately, included in unit MzPzss; on generalized map, included as part of unit MzPzcp

MzPzsv **Metavolcanic rocks west of the Coast plutonic complex of Brew and Morrell (1979b) (Triassic to Paleozoic)**—Interbedded or structurally intercalated with unit MzPzss are andesitic to basaltic metavolcanic rocks. In the northern part of southeast Alaska green, greenish-gray, and greenish-black very fine to fine-grained, massive to pillowed and amygdaloidal mafic volcanic flows and minor tuff constitute some of the least metamorphosed rocks of this unit (Plafker and Hudson, 1980; Redman and others, 1984). "Characteristically, the metabasalt is vesicular and (or) amygdaloidal, and the amygdules are mainly chlorite or quartz. Most of the metavolcanic unit appears to consist of massive to inconspicuously layered flows, with local breccia and thin zones of recrystallized tuff. At the top of the unit on the Chilkat Peninsula an estimated 300–400 m of section contains well developed pillow structures. * * * An incipient cleavage is present in some of the metavolcanic rocks on the Chilkat Peninsula. Epidotized shears and clots, chlorite patches, and disseminated pyrite are common throughout the unit" (Plafker and Hudson, 1980). This part of unit is up to 3.4 km thick (Redman and others, 1984). Plafker and Hudson (1980) report fossiliferous gray to dark-gray coquina limestone that commonly has nodular to layered black chert and abundant light-green fragments of devitrified glass that occurs in discontinuous lenses as thick as 90 cm between pillowed flows within a few tens of meters of the top of the volcanic unit. Late Triassic (Carnian?) well preserved ammonites, belemnites, and flat clams were found in situ and as float on the adjacent beach. The rocks of the Chilkat Peninsula are generally metamorphosed to lower greenschist facies; the metamorphic grade increases to lower amphibolite facies and the rocks become more strongly foliated near the Canadian border (Gilbert and others, 1987; Gilbert and others, 1988b; Dodds and Campbell, 1992). Southeast of the Chilkat Peninsula, Gehrels and others (1992) mapped Triassic metabasalt flows in their Perseverance group where "basalt low in the section is commonly massive and dark green, which contrasts with the light green color, chloritic foliation, and fragmental or pillowed nature of the underlying Permian metabasalt. Some of the massive layers are microgabbro sills. Higher in the section the metabasalt remains dark green but is commonly pillowed and feldspar porphyritic. Fragmental basalt and pillow flows with interpillow carbonate occur locally. Interpillow carbonate and associated thin limestone layers in the Carnian [Upper Triassic] part of the section commonly contain moderately deformed ammonites." Also included in this map unit are Permian metavolcanic rocks of the Gastineau group of Gehrels and others (1992) that consist of light green pillow flows, pillow breccia, flow breccia, tuff breccia, and tuff of basaltic composition; crinoid-rich marble layers that range from less than 1 meter to more than 50 m thick; interpillow carbonate and calcareous layers and matrix in tuffaceous rocks; and up to several-meter-thick layers of interbedded black phyllite and light gray chert. "In general, the proportion of marble, metapelite, and chert increases upsection, and the top of the sequence is in many areas a massive, semi-continuous marble layer. There is also an increase upsection in fragmental basalt relative to pillow flows. Most metabasalt is aphyric, but small pyroxene and/or feldspar phenocrysts are present in some areas" (Gehrels and others, 1992). The Gastineau group is up to 3 km thick and contains conodonts of probable Permian and Carboniferous(?) age (Gehrels and others, 1992). We include both the Triassic and Permian metavolcanic rocks in this unit because, in general, they are not separately mapped to the southeast where equivalent rocks are grouped together in the Alava sequence of Rubin and Saleeby (1991) or mapped as undivided and unnamed hornblende schist (Brew and others, 1984; Berg and others, 1988). The metavolcanic rocks of the Alava sequence are metamorphosed intermediate to mafic volcanic pillowed and flow rocks, breccia and tuff, agglomerate, volcaniclastic rocks, and subordinate marble and siliceous limestone, with preserved primary textures. The Triassic part of the Alava sequence is inferred to rest unconformably on the upper Paleozoic part of the unit and is associated with black phyllite and carbonaceous and argillaceous marble. The late Paleozoic volcanic rocks are associated with finely laminated light-brown to light-gray crinoidal marble and argillite. Generally the Triassic rocks are less deformed than the Paleozoic rocks; rocks closer to the Coast plutonic complex of Brew and Morrell (1979b) are higher metamorphic grade (Himmelberg and others, 1991; Stowell and Crawford, 2000). In the Juneau and Sumdum quadrangles the unit consists of mafic and quartzofeldspathic schist derived from basaltic, rhyolitic, and probably dacitic volcanic rocks, as well as biotite schist derived from pelitic strata, quartzite derived from quartz-rich clastic strata, marble. In general, the proportion of metavolcanic rocks increases upsection (southwestward). Quartz-porphyritic metarhyolite with large blue quartz phenocrysts in a centimeter-scale fragmental texture is a diagnostic rock type in the Sumdum quadrangle. Metarhyolite is commonly interlayered with metabasalt that displays fragmental and pillow structures. In the lower part of the section in these quadrangles, metaclastic quartzite and quartz-cobble conglomerate are common (Brew and Grybeck, 1984; Gehrels and others, 1992). Unit is mostly greenschist facies but is transitional to amphibolite facies to the southeast, where it consists of fine- to medium-grained, medium to dark green hornblende schist and gneiss, including significant amounts of biotite gneiss, quartzite, biotite-hornblende gneiss, and poorly foliated amphibolite. On generalized map, included as part of unit MzPzcp

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₸Pvs **Metamorphic rocks, southeast Alaska (Triassic to Permian)**—Recrystallized, relatively low-grade, andesitic volcanic and volcaniclastic rocks, flysch, and minor limestone in the central and eastern parts of the Coast plutonic complex of Brew and Morrell (1979b). Slightly metamorphosed basalt of the Stuhini group of Brew and others (2009) in the Atlin quadrangle is included; it has relict pillows in a 30-m-thick bed within a sequence of metamorphosed tuff, mudstone, and minor pebbly mudstone, as well as several hundred meters of semischistose graywacke (Brew and others, 2009). Brew and others (2009) also mapped 90 m of massive, locally laminated gray dolostone, dark-gray metamudstone, light-gray dolostone, and lesser dark-gray limestone that was locally fossiliferous. To the south, the dominant rocks are interbedded andesitic tuff breccia, volcanic graywacke, siltstone, and argillite. Coarse volcanic conglomerate, possible broken-pillow breccia, and dark-blue-gray marble occur as lesser constituents (Koch and Berg, 1996). Also included here is light- to dark-gray and medium-brown limestone, layers enclosed within metasedimentary and metavolcaniclastic rocks. Locally, the carbonate layers exceed 10 m thick (Koch and Berg, 1996). The sequence extends eastward into British Colombia and crops out discontinuously northwestward along the Alaska-Canada boundary. In the Atlin quadrangle, Brew and others (2009) report middle Early Triassic conodonts and Middle Triassic ammonites and conodonts, whereas in the Bradfield Canal quadrangle, Koch and Berg (1996) report fossils of Permian age including the conodonts *Adetognathus lautus* and *Adetognathus*(?), a brachiopod, *Yakovlevia*(?), fusulinids, *Pseudofusulinella* sp.(?), *Pseudoschwagerina* sp., *Schwagerin*a sp., and the gastropod *Omphalotrochus*(?)

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**Yukon-Tanana crystalline complex (Triassic and older)**—The Yukon-Tanana Upland of east-central Alaska is primarily composed of a variety of metamorphic rocks intruded by plutons of Triassic, Jurassic, Cretaceous, and Tertiary-to-Cretaceous age. Originally named the Birch Creek Schist, a name that has since been abandoned (Foster and others, 1973), the metamorphic rocks have proved to be a complex assemblage of schist, paragneiss, and orthogneiss (Foster, 1992; Foster and others, 1994). Foster (1976), Weber and others (1978), Foster and others (1983), Foster and others (1994) and others have demonstrated that the rocks can be divided into a number of “packages.” The map units described here are regional-scale generalizations that try to reflect the overall character of a number of these packages. Agreement on the components of any given assemblage is not always possible, and much research on these units remains to be done. Many of the map units are in some way associated with orthogneiss and other metaigneous rocks derived from Mississippian to Devonian protoliths. Radiometric dating of these gneiss bodies, as well as dating of metavolcanic rocks (which typically yield Early Mississippian to Late Devonian ages), is the primary means by which the protoliths of the country rocks are largely considered Mississippian to Devonian or older. U/Pb dating of a very limited population of detrital zircons has indicated the presence of Proterozoic and Archean zircons (Dusel-Bacon and Williams, 2009). K/Ar and $^{40}$Ar/$^{39}$Ar dating in much of the Yukon-Tanana Upland has shown that Cretaceous plutons yield ages distinctly younger than the ages on metamorphic rocks and that, in general, there is little indication of thermal resetting by these plutons. Therefore many of the K/Ar ages, typically between 120 and 105 Ma, are thought to indicate cooling after metamorphism (Wilson and others, 1985). Sparsely present throughout the upland, some metamorphic rocks yield Jurassic or older cooling ages (see, for example, Ragan and Hawkins, 1966; Bundtzen and Turner, 1978; Wilson and others, 1985; Newberry and others, 1996; Douglas and others, 2002; Werdon and others, 2004; Dusel-Bacon and others, 2002); these are most common in the area of the Jurassic and Triassic plutons in the Eagle and Tanacross quadrangles. Subunits described below are ŦMsm, Pks, Ꝑze, Ꝑzymi, ꝐzꝐygs, ꝐzꝐyqs, ꝐzꝐyqm, Ꝑzyms, ꝐzꝐybg, and Ꝑzkp:

ŦMsm **Seventymile assemblage (Triassic to Mississippian)**—Massive greenstone, amygdaloidal pillow basalt and metatuff and associated peridotite, metachert, quartzite, phyllite, silica-carbonate lenses, and other low metamorphic grade sedimentary rocks. White and orange-brown silica-carbonate lenses crop out in the northern Big Delta quadrangle (Weber and others, 1978). Foster (1992) interpreted the massive greenstone as “originally mostly basaltic pillow lava and mafic lava flows; generally associated with peridotite bodies. * * * In places, the greenstone contains amygdules (generally filled with calcite) and pillows. Locally tuff and silicified tuff, commonly red, gray, or green, are interlayered.” Foster (1992) reported that basalt metamorphosed to blueschist facies is included and also reported that a glaucophane-bearing sample associated with greenstone yielded a late Permian $^{40}$Ar/$^{39}$Ar age, based on a G.W. Cushing written communication in 1991 (Foster, 1992, p. 9); however, this age can not be confirmed. Cushing (written commun., 1992), the apparent source of the Permian date, does not report any age determinations on glaucophane-bearing rocks. Elsewhere the greenstone is intercalated with chert that yields Radiolaria and rare shelly fossils of Mississippian through Triassic age (Foster, 1976, 1992; Weber and others, 1978; Dusel-Bacon and Harris, 2003) of similar age and composition as rocks of the Angayucham and Tozitna assemblages (unit ŦDtz). Beranek and Mortensen (2011) analyzed detrital zircon samples of Triassic rocks from this assemblage as defined here; these zircon populations contain a significant number of Carboniferous and older Paleozoic zircons, as well as a smaller number of Proterozoic and rare Archean zircons. Includes units Pgc and Pq of Weber and others (1978) in the Big Delta quadrangle, unit Pzg of Foster and others (1983) in the Circle quadrangle, units Pq and MzPzb of Foster (1976) in the Eagle quadrangle, and units gs and gsi of Brabb and Churkin (1969) in the Charley River quadrangle

Pks **Klondike Schist (Permian)**—Poorly understood assemblage of generally low-grade metamorphosed pelitic and volcanic rocks and minor marble. Primarily exposed in the Eagle quadrangle in Alaska (Szumigala and others, 2002; Dusel-Bacon and others, 2006) and more broadly exposed in the Yukon (Gordey and Ryan, 2005; Beranek and Mortensen, 2011), it consists of gray-green to dark-greenish-black massive greenstone, amygdaloidal pillow basalt and metatuff and associated metachert, quartzite, phyllite, silica-carbonate lenses, and other low-grade metasedimentary rocks. Mortensen (1999) reported that the Klondike Schist yielded mid-Permian protolith ages as determined by U/Pb zircon analysis, and more recent analyses by Beranek and Mortensen (2011) bracket intrusion and metamorphism to between 260 and 252.5 Ma. In the Tanacross quadrangle, quartz-muscovite, quartzite, quartz-muscovite schist, actinolite schist, chert and other fine-grained silicic rocks, phyllite, metagraywacke, and schistose greenstone are also included here (Foster, 1970). On this map, assignment of rocks in the eastern Eagle quadrangle to the Klondike Schist or the Keevy Peak Formation (unit Ꝑzkp) must be considered tentative; Permian (~255 Ma) U/Pb zircon ages, as well as Mississippian and Devonian zircon ages are reported by Dusel-Bacon and others (2006) for the Nasina assemblage, here assigned to the Keevy Peak map unit (unit Ꝑzkp). On generalized map, included as part of unit Ꝑzkn

Ꝑze **Eclogite and associated rocks (Paleozoic)**—Garnet- and omphacite-bearing biotite-muscovite schist, micaceous marble, black quartzite, and amphibolite in thin interlayers within a metamorphic sequence, described as allochthonous, garnet-bearing, quartz-biotite-muscovite schist and quartzite (Swainbank and Forbes, 1975; Brown and Forbes, 1986; Weber and others, 1992; Foster and others, 1994) and designated as the Chatanika assemblage by Robinson and others (1990). The Chatanika assemblage is primarily epidote-amphibolite facies rocks, but also includes eclogitic rocks and has some lithologic similarities with the structurally underlying quartz and pelitic schist (unit PzPyqs). Protolith of eclogite was predominantly quartz-rich and pelitic to calcareous pelitic sedimentary rocks, impure limestone, and associated mafic volcanic and volcaniclastic rocks. Pressure and temperature conditions of 11 kbar and 600 to 700 °C were cited by Newberry and others (1996) on the basis of microprobe analyses and are supported by the high-pressure eclogite-facies mineral assemblage. Other estimates of pressure-temperature conditions range from 590 °C and 5.5 to 7.5 kbar (Swainbank and Forbes, 1975) to 600±50 °C and 13–15 kbar (Brown and Forbes, 1986) on the basis of mineral-pair geothermometers and geobarometers. Newberry and others (1996) inferred a Mississippian to Devonian protolith age from unspecified $^{40}Ar/^{39}Ar$, K/Ar, and Pb-Pb studies; Forbes (1982) reported a questionable K/Ar protolith age of 487±35 Ma on low-potassium amphibole and K/Ar ages on mica that range from 170.1±2.3 to 108.7±3.5 Ma, which he attributed to Mesozoic metamorphism. Includes parts of the Chatanika assemblage, units Pce and Pcu of Robinson and others (1990); unit PDe of Newberry and others (1996), unit Pzc of Weber and others (1992) in the Livengood quadrangle, and unit PzpCms of Foster and others (1983) in the Circle quadrangle

MDts **Totatlanika Schist (Early Mississippian to Late Devonian)**—Low-grade, multiply-deformed, locally mylonitic assemblage of gritty semischist that contains clear to bluish-gray quartz “eyes,” chloritic quartzo-feldspathic schist and augen gneiss, phyllitic schist and semischist, phyllite, metavolcanic rocks, quartzite, marble, and greenstone. Porphyritic volcanic and sedimentary textures preserved in places; metavolcanic compositions range from mafic to felsic. Fossil age is poorly defined; conodonts collected from one marble interbed were Middle Devonian to Early Mississippian, and crinoids, corals, and gastropods were less precisely dated (Wahrhaftig, 1968). Meta-andesite from the northeastern Big Delta quadrangle yields an upper intercept U/Pb zircon age of 375 Ma that is interpreted as an extrusive age of the protolith (Dusel-Bacon and others, 1993; revised to 374±3 Ma, Cynthia Dusel-Bacon, written commun., 2014). Dusel-Bacon and others (2006) report U/Pb (SHRIMP) zircon ages between 372±3 and 360±5 Ma for meta-igneous rocks included in the Totatlanika Schist. Unit consists of the Totatlanika Schist of the Fairbanks and Healy quadrangles (Péwé and others, 1966; Csejtey and others, 1992), various units of the Totatlanika Schist in the Chena River area (Smith and others, 1994), unit Pzsg of Weber and others (1978) in the Big Delta quadrangle, and the blastomylonite subunit of unit PzpCs of Foster (1992)

Pzymi **Orthogneiss and amphibolite of igneous origin (Mississippian, Devonian, and older?)**— Most common lithologies are granitic to trondhjemitic orthogneiss and lesser amphibolite. Includes quartz-biotite ± garnet gneiss, amphibolite, and minor pelitic gneiss, quartzite, schistose gneiss, augen gneiss, and quartz-mica schist (Weber and others, 1978; Foster, 1992; Dusel-Bacon and others, 2006). Unit is most extensive in the northern Alaska Range in the Tanacross quadrangle and sparsely exposed in the Yukon-Tanana Upland. Largely metamorphosed to amphibolite facies (Dusel-Bacon and others, 1993), locally unit has been retrograded to greenschist facies in the Mount Hayes quadrangle (Nokleberg and others, 1992a). Whole-rock trace-element data indicate a within-plate origin for most amphibolite (Dusel-Bacon and Cooper, 1999). Where possible, augen gneiss mapped separately as unit MDag. This unit is gradational with unit PzPygs, which is largely of metasedimentary origin, but includes some metaigneous components. On generalized map, included as part of unit MPgs

PzPygs **Gneiss, schist, and quartzite (Mississippian, Devonian, and older)**—Coarse- to fine-grained gneiss and quartzite; well-foliated and banded to massive; locally cataclastic; ranges from pelitic schist that contains abundant sillimanite to gneisses of probable igneous origin. All rocks are well foliated, and dominant foliation is folded. Protolith may include both Paleozoic and Precambrian sedimentary and igneous rocks (Weber and others, 1978). Unit is widespread throughout the Yukon-Tanana Upland and the included meta-plutonic rocks may be equivalent to the Pelly Gneiss in Yukon, Canada. Also includes gray, medium-grained, mylonitic, quartzofeldspathic biotite-sillimanite gneiss that forms core of a gneiss dome in the central Big Delta quadrangle (Dusel-Bacon and Foster, 1983). Several U/Pb zircon ages have been determined on this unit, and Mississippian to Devonian crystallization ages are common for the metaigneous rocks within this unit and within unit Pzymi (Aleinikoff and Nokleberg, 1985; Aleinikoff and others, 1986). Day and others (2003), Dusel-Bacon and Williams (2009), Aleinikoff and Nokleberg (1985) all indicate that inheritance of zircon grains is common. Detrital zircon analyses by Aleinikoff and others (1984, 1986) and Dusel-Bacon and Williams (2009) from quartzite in the unit yielded Proterozoic and Archean zircons. On generalized map, included as part of unit MPgs

PzPyqs **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 DPsq

PzPyqm **Pelitic schist, including Chena River sequence (Devonian and older)**—Medium- to high-grade pelitic schist that contains subordinate quartzite, quartz schist, calc-silicate rocks and calc-schist, marble, amphibolite, graphitic schist, and augen gneiss interlayers. Compared to unit PzPyqs, this unit contains less quartzite and quartz schist, more marble interlayers, and is of generally higher grade; however, it may have strong similarities in lithology, polymetamorphic history, and metamorphic grade with unit PzPyqs. The contact with PzPyqs was interpreted as a thrust fault by Foster and others (1983) in the Circle quadrangle and was also locally mapped as such by Smith and others (1994). In the Eagle quadrangle, unit is closely associated with metaplutonic rocks of unit MDag, possibly as roof pendants to the original plutons. On generalized map, included as part of unit DPsq

Pzyms **Mafic schist and amphibolite (Devonian or older Paleozoic)**—"Green, quartz-chlorite-carbonate schist, commonly having abundant plagioclase porphyroblasts. Associated with amphibolitic schist and minor marble, quartzite, and pelitic schist. Thought to represent metamorphosed mafic pyroclastic rocks interbedded with schists of unit PzPyqs" in the Circle quadrangle (Wilson and others, 1998; see also Foster and others, 1983). In the south-central Circle and adjacent Big Delta quadrangle unit varies from greenish-gray actinolitic greenschist to dark green, fine- to coarse-grained, schistose amphibolite of unit PzPyqm, which is interlayered or interlaminated with muscovite-feldspar-quartz felsite (Smith and others, 1994). In the southeast Big Delta quadrangle, unit is similarly composed of dark-green, fine- to medium-grained, strongly foliated, hornblende-biotite amphibolite gneiss associated with augen gneiss of unit MDag or interlayered with foliated, medium-grained, equigranular calc-silicate schist and, locally, quartzite of unit Pzymi (Day and others, 2007). In the southeastern Eagle quadrangle, unit consists of moderately- to nonfoliated, fine- to medium-grained hornblende metagabbro and metadiabase (Werdon and others, 2001).Unit also contains a green and white, medium- to coarse-grained, slightly- to nonfoliated metaigneous rock that has pseudomorphs after clinopyroxene and plagioclase of fine-grained actinolite, chlorite, epidote, clinozoisite, albite, and (or) sphene (Szumigala and others, 2002). On generalized map, included as part of unit DPga

PzPybg **Biotite gneiss, marble, schist, quartzite, and amphibolite (Devonian or older)**—Primarily exposed in the southeastern Eagle and northeastern Tanacross quadrangles, this unit is considered part of the Fortymile River assemblage (Werdon and others, 2001; Szumigala and others, 2002; Dusel-Bacon and others, 2006). Dominantly a metasedimentary unit, according to Foster (1992), the most common rock type is quartz-biotite gneiss. The unit also includes a component of amphibolite they interpreted as metamorphosed mafic volcanic rocks. Important metasedimentary components include quartzite, paragneiss, biotite and muscovite schist, and marble. As shown here, map unit includes the PzpCb of Foster (1976) and the Pzgn and Pzbg units of Foster (1992). Foster had included abundant orthogneiss in these units; more detailed mapping by Werdon and others (2001) and Szumigala and others (2002) separated the orthogneiss, which is here included in unit MDag. Werdon and others (2001) and Szumigala and others (2002) described these rocks as the amphibolite-facies units of the Fortymile River assemblage and subdivided them on lithologic grounds. Among their units is a mixed unit, (pMa of Werdon and others [2001] and Szumigala and others [2002]), that is dominantly amphibolite. Dusel-Bacon and Cooper (1999) reported that this amphibolite has arc chemistry. Rocks of this map unit that have metasedimentary origin contain small amounts of staurolite or kyanite (Werdon and others, 2001; Szumigala and others, 2002). Werdon and others (2001) describe a coarse-grained, mostly light-gray marble that Foster (1992) reports is abundant and found in layers, lenses, and pods, including some large masses 1 $km^2$ or more in area. The rocks were regionally metamorphosed to amphibolite facies under moderate- to high-pressure conditions (Dusel-Bacon and others, 1995). Locally, retrograde contact metamorphic effects are superimposed on the regional metamorphism (Foster, 1992). The ages of the protoliths are unknown, but a few poorly preserved echinoderm fragments (Foster, 1976) suggests that they are Paleozoic in age. U/Pb zircon dating of the associated metaigneous rocks yields Mississippian and Devonian ages, providing a minimum age for the metasedimentary rocks (Dusel-Bacon and others, 2006). The major regional metamorphism is believed to have occurred in Late Triassic to Early Jurassic time on the basis of incremental heating experiments (Cushing and others, 1984a, b; Foster and others, 1987; Hansen and others, 1991; Dusel-Bacon and others, 2002). On generalized map, included as part of unit DPga

Pzkp **Keevy Peak Formation and similar rocks (early Paleozoic)**—Multiply deformed siliceous and carbonaceous assemblage of phyllite, meta-argillite, quartzite, metachert(?), and lesser amounts of interlayered calcareous phyllite, marble, and mafic and felsic metavolcanic rocks at lower to upper greenschist facies (Foster, 1992; Dusel-Bacon and others, 1993). Includes rocks in the northern Big Delta and southern Circle quadrangles that are referred to as the Blackshell quartzite and phyllite and the Blackshell calcschist and marble (Smith and others, 1994). Contains minor stretched pebble conglomerate in the Healy and Denali quadrangles. In the Big Delta quadrangle, U/Pb zircon ages from felsic metatuff interlayers yielded dates of 372±5 and 353±7 Ma, indicating Early Mississippian and Late Devonian extrusion ages and, therefore, the depositional age for at least part of the sequence (Dusel-Bacon and others 2004); Pb-isotope data from syngenetic galena in a carbonaceous, phyllite-hosted, stratiform zinc-lead deposit also indicate a Mississippian or Devonian age for mineralization (Dusel-Bacon and others, 1998, 2004; Mortensen and others, 2006). Late and Middle Devonian fossils have been reported in rocks of this unit in the Denali quadrangle (Gilbert and Redman, 1977). Regionally, unit appears to occupy a stratigraphic position between the Totatlanika Schist and unit Pz₽yqs of this map. As mapped, it includes the Keevy Peak Formation as originally defined by Wahrhaftig (1968) in the Healy and Denali quadrangles; new age data support extension of the unit to the Big Delta, Circle, and Fairbanks quadrangles (Dusel-Bacon and others, 2004) and correlation with the Nasina assemblage in Yukon, as proposed by Weber and others (1978). Dusel-Bacon and others (2006) wrote that the Blackshell unit of Smith and others (1994) was previously correlated with the Nasina assemblage in Canada (Foster and others, 1994; Smith and others, 1994), but Dusel-Bacon and others (1996) proposed that the use of the Nasina assemblage name in Alaska be restricted "to the rocks in the eastern Yukon-Tanana Upland that contain Permian and Mississippian felsic rocks and appear to grade into the Fortymile River assemblage." The Permian U/Pb zircon dates reported by Dusel-Bacon and others (2006) are unusual for this map unit and are coeval with ages determined for the Klondike Schist (unit Pks here) and, as mentioned in the Klondike Schist map unit description, Dusel-Bacon and others (2006) also reported Mississippian and Devonian zircon ages. Other rocks included in this map unit are units Pzq and Pzm of Weber and others (1978) in the Big Delta quadrangle, units Pzq and Pzm of Foster and others (1983) in the Circle quadrangle, units Pzgs Pzcp, and Pzq of Foster (1992) in the Eagle and Tanacross quadrangles, units MDq, MDkq, and MDda of Szumigala and others (2002) in the Eagle quadrangle, units uPzst, and uPzv of Werdon and others (2001) also in the Eagle quadrangle, unit Pzk of Csejtey and others (1992) in the Healy quadrangle (which Bela Csejtey, Jr. [written commun., 1993] has indicated also occurs in the Denali quadrangle and we include here), and the Birch Hill sequence (units Dbs and Dbcs of Newberry and others, 1996) in the Fairbanks mining district of the southeastern Livengood and northeastern Fairbanks quadrangles, as well as units Pzbc, Pzbp, and Pzbr of Smith and others (1994). Unit is typically exposed in close proximity to the Totatlanika Schist (MDts). On generalized map, included as part of unit Pzkn

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Ŧms **Metavolcanic and metasedimentary rocks (Late Triassic)**—Consists, in part, of the informal Amphitheatre group of Smith (1981), which ranges in western exposures from thinly stratified greenish volcaniclastic metasedimentary rocks, chert, and greenschist interbedded with basalt and dark carbonaceous argillite to thicker bodies of undifferentiated pelitic and volcaniclastic metasedimentary rocks. The thinly stratified volcaniclastic sedimentary rocks have common graded laminae, cross bedding, and other depositional textures. The thicker undifferentiated pelitic and volcaniclastic 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 P₽ms and subunits), but available data does not allow distinction at map scale. On generalized map, included as part of unit Ŧ₽ms

ŦPzbi **Metamorphic rocks of Baranof Island (Triassic or older)**—High-grade metamorphic rocks composed chiefly of amphibolite, gneiss, and schist, locally intercalated with thin units of marble and calc-silicate granofels, as described by Johnson and Karl (1985). These rocks are faulted against a lower grade heterogeneous unit of metasedimentary and metavolcanic rocks to the west, which are of higher metamorphic grade than the adjacent Goon Dip Greenstone (unit Ŧn here), and grade through a migmatitic phase to dioritic rocks (unit KJse) to the east. The contact with the Kelp Bay Group to the southeast is likely a fault. The most common lithologies in the higher grade part of the unit are quartz-andesine-biotite-hornblende schist and andesine-hornblende amphibolite (Loney and others, 1975). The lower grade part consists of a lower unit of sandstone and siltstone, a middle unit of limestone, and thin-bedded chert at the highest stratigraphic level (Loney and others, 1965). Correlation of this unit is equivocal; Johnson and Karl (1985) suggested that, as it appears to occupy a stratigraphic position similar to that of the Skolai Group (unit PIPms) relative to the Nikolai Greenstone (TRn), these rocks might be equivalent to the Skolai Group; however, they acknowledge that there is very little lithologic correspondence between these units and the Skolai Group. Another correlation, based on age and stratigraphic position (S.M. Karl, unpub. data), could be with the Sicker Group of Vancouver Island (Muller, 1980; Massey and Friday, 1986), but again, the lithologic correspondence is questionable, as these rocks have significantly more carbonate than the Sicker Group, and the Sicker Group has significant thicknesses of chert in its upper part (Massey and Friday, 1986) that are not present in this unit. Johnson and Karl (1985) thought that the protoliths of this unit, on the basis of bulk composition, were probably mafic volcanic rocks and marine sedimentary rocks. Chert nodules and contorted ribbon chert are abundant at some localities (D.A. Brew, unpub. data)

TRPzgp **Metagraywacke and phyllite (Triassic? and late Paleozoic)**—“Dark-gray to black phyllite and brown-weathering lithic sandstone, sandstone, and mudstone are exposed along the southern boundary of the schist belt. The unit varies in breadth along strike. In the Wiseman and Chandalar quadrangles, two subunits are recognized * * *: a northern dark, fine-grained phyllite or phyllonite, and a southern metamorphosed lithic sandstone-rich unit. * * * The northern unit is lithologically homogeneous, locally well foliated, and locally contains small bodies of mafic schist similar in composition to those in the underlying schist belt (Dsq; Moore and others, 1997b; Gottschalk and others, 1998). * * * Rocks in the southern subunit retain relict sedimentary features that may reflect contrasting depositional settings. Sedimentary structures, such as Bouma sequences, have been recognized and are thought to indicate deep-water turbidite fan deposition (Murphy and Patton, 1988); others, such as hummocky cross-stratification and oscillation ripple marks, were seen elsewhere and are indicators of shallow-water deposition (Gottshalk and others, 1998). Palynflora from sandstones with shallow-water structures are Early Devonian (Gottschalk, 1998)” (Till and others, 2008a). Correlative phyllite and metagraywacke is described by Patton and others (2009) in the Yukon-Koyukuk Basin. There, the “phyllite and metagraywacke are overprinted by a low-grade penetrative metamorphic fabric, but turbidite features, such as sole marks and graded bedding, are locally discernible. * * * Unit locally contains slices of little deformed shallow-water Devonian carbonate rocks that are enveloped in basalt flows and debris-flow(?) breccias composed of blocks of vesicular basalt in a matrix of volcanic and carbonate debris” (Patton and others, 2009). As shown here, unit also includes rocks mapped by Till and others (2008a) as “Phyllite, fine-grained schist, and phyllonite of the Central belt that underlie areas of poor exposure in the northeastern Baird Mountains quadrangle, western Ambler River quadrangle, and northwestern Chandalar quadrangle. Locally contains minor lenses of metalimestone and metaconglomerate.” Also includes in the Ruby quadrangle “phyllite and subordinate fine-grained metagraywacke cut by abundant vein quartz. The phyllite and metagraywacke are overprinted by a low-grade penetrative metamorphic fabric, but turbidite features, such as sole marks and graded bedding, are locally discernible. Age of unit is uncertain, probably Devonian or late Paleozoic” (Patton and others, 2009)

## PALEOZOIC TO PROTEROZOIC

### Permian to Pennsylvanian

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)

Pzps **Porcupine slate of Redman and others (1985) (late Paleozoic)**—Limonite-stained black slate and dark-gray phyllite with subordinate black argillite and banded siltstone in the Skagway quadrangle (Gilbert and others, 1987). As originally described, includes gray bioclastic limestone and marble, but we show those rocks as part of unit Pzce herein. The Porcupine slate of Redman and others (1985) intertongues with rocks mapped here as part of the Hyd Group (unit Trhg) and, because of locally intense deformation, in many places workers could not distinguish a difference between the Porcupine slate, older rocks, and the Hyd Group (Green and others, 2003). The Porcupine slate contains Devonian to Triassic fossils and locally overlies marble (unit Pzce, here) that contains Devonian to Mississippian fossils (Gilbert and others, 1987). We suggest, however, that the Triassic fossils are more likely associated with the interleaved Hyd Group. The Porcupine slate has been correlated with the Cannery Formation (unit PDcf) (Karl and others, 2010). On generalized map, included as part of unit PDcf

Pzgn **Roof pendants of the Coast plutonic complex of Brew and Morrell (1979b) (Paleozoic)**—Dominantly grayish-brown-weathering, well foliated, well layered, locally lineated, fine- to coarse-grained quartz-biotite- feldspar gneiss and lesser amounts of garnet-quartz-biotite-plagioclase schist, as well as greenish-gray or grayish-green-weathering, moderately to poorly foliated and layered, medium- to coarse-grained hornblende gneiss and subordinate hornblende and biotite schist; largely consists of roof pendants of or large xenoliths within the Coast plutonic complex of Brew and Morrell (1979b) in eastern southeast Alaska. Unit crops out as irregular and elongate masses within the Coast plutonic complex of Brew and Morrell (1979b) (Brew and Ford, 1985). In the Ketchikan quadrangle, unit is characterized by rusty-brown-weathering pelitic paragneiss and schist that has conspicuous root-beer-brown biotite and by subordinate quartzofeldspathic gneiss distinguished mainly by its light color and low content of mafic minerals. Unit also includes migmatite, gneissic plutonic rocks, marble and calcsilicate gneiss, pegmatite, quartzite, amphibolite, and aplite (Berg and others, 1988). Widely distributed throughout unit is light-gray-weathering marble and calcsilicate rock in lenses associated with minor muscovite-quartz gneiss and biotite gneiss (Brew and others, 2009). Marble is fine- to coarse-grained and locally occurs in marble several hundreds of meters thick, which may have been reefs and (or) may be large detached fold hinges (S.M. Karl, unpub. data). Marble also occurs as 1-cm- to 10-cm-scale layers intercalated with equal amounts of biotite schist (Brew and Grybeck, 1984; S.M. Karl and D.A. Brew, unpub. data). In the Atlin quadrangle, well-foliated, homogeneous biotite-hornblende-plagioclase orthogneiss and heterogeneous migmatite are present in minor amounts (Brew and others, 2009). Metamorphic grade ranges from amphibolite to granulite facies (Gehrels and others, 1992). In the Sumdum quadrangle, quartzite layers adjacent to marble in western Tracy Arm contain detrital zircons that have a variety of Precambrian ages: 1.24 to 1.0 Ga and 1.68 Ga for multigrain fractions, and 1.40 to 1.37 Ga for a single grain (Gehrels and others, 1991). Quartzite in eastern Tracy Arm contains detrital zircons that yielded U/Pb zircon ages of 2.0–1.79 Ga, ~2.31 Ga, 2.75–2.53 Ga, and ~3.0 Ga (Gehrels and others, 1991). Rocks of this unit have been correlated with rocks of the Yukon-Tanana terrane, but the multigrain detrital zircon data are of limited value in this analysis and the lithologic correlation is equivocal. On generalized map, included as part of unit MzPzcp

Pzce **Marble, southeast Alaska (early Permian to Devonian)**—Ranges from dark-gray to white, purple, or tan partly recrystallized limestone to coarsely crystalline marble and dolostone (Redman and others, 1985; Gilbert and others, 1987; Gilbert, 1988). Unit may be sooty, thin-bedded to massive, and locally contains argillite, greenstone, and marble breccia. Exposed primarily in the northern part of southeast Alaska, unit is spatially associated with the Cheetdeekahyu group of Redman and others (1985) (unit Pzfw, here) and the Porcupine slate of Gilbert and others (1987) (unit TrDps, here). Includes Paleozoic marble in the Glacier Bay area (D.A. Brew, written commun., 1997) and on Chichagof Island (Loney and others, 1963). S.M. Karl, (unpub. data) suggests that the marble on Chichagof Island is likely of Silurian age and possibly part of the Point Augusta Formation. Redman and others (1985) reported brachiopods of Mississippian to early Permian age and corals of Late Mississippian age, and Green and others (2003) reported Devonian conodonts from the same unit. Gilbert and others (1987) reported Mississippian and Devonian fossils for limestone associated with his Porcupine slate unit (MDm) and reported Triassic and Devonian fossils for the Glacier Creek volcanics of Redman and others (1985, their units uPzva, uPzvs, and uPzvb). The Triassic fossils, however, were most likely from Hyd Group limestone. In the southern part of southeast Alaska, in the Ketchikan region, a similar but unrelated marble is massive to platy, white, gray, and bluish gray, and weathers light-brown; it consists of a sugary to coarse-grained aggregate of calcite or dolomite and contains subordinate to minor amounts of muscovite, phlogopite, quartz, graphite, garnet, and pyrite (Berg and others, 1988). This marble contains relict fossils, thought to be crinoids, which suggest possible correlation of some marble lenses with the Permian crinoidal marble on Revillagigedo Island (unit TrMa). It is mapped in the Ketchikan and Prince Rupert quadrangles, where it is associated with the Kah Shakes sequence of Rubin and Saleeby, (1991) (unit Pzks here). On generalized map, included as part of unit Pzc

Pzcn **Marble, north Alaska (early Paleozoic)**—Ranges from light-gray to white, partly recrystallized limestone to coarsely crystalline marble to dark, finely crystalline dolomitic marble. Subordinate interbedded calc-schist, chloritic schist, and quartzite. Unit ranges in age from Ordovician to Mississippian and may locally include rocks as old as Cambrian. Contains scattered fossils (Patton and others, 2009). Primarily exposed in the Baird Mountains quadrangle. On generalized map, included as part of unit Pzc

MDtv **Tuffaceous volcanic rocks (Mississippian? to Devonian)**—Consists of sheared, schistose, green andesitic tuff and volcanic breccia that weathers yellow and orange and is altered to chlorite, epidote, clinopyroxene, and clay (Brosgé and others, 2000) in the northeast Arctic and northwest Table Mountain quadrangles. Also includes crystal and lithic tuff, volcanic breccia, and minor porphyry of rhyolitic composition, now mostly recrystallized to fine crystalline quartz-sericite schist (Brosgé and others, 2000; C.G. Mull, unpub. data). Associated with Mississippian rocks of the Lisburne Group and the Kekiktuk Conglomerate (units PMlg and Mek), as well as the Mississippian and Devonian Endicott Group (unit MDe), but is distinct from similar rocks in the southwest Arctic quadrangle and farther west in the Brooks Range, which are associated with Devonian rocks (units Das and Dv). Age control is lacking. On generalized map, included as part of unit CDbrv

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. Plafker, 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).

MDag **Augen gneiss and orthogneiss (Early Mississippian and Late Devonian)**—Peraluminous granitic gneiss that contains augen of potassium feldspar generally interpreted as a blastoporphyritic texture. These metaigneous bodies are exposed in the Tanacross, Eagle, Big Delta, Circle, Mount Hayes, Tanana, Melozitna, and Chandalar quadrangles and range from weakly to strongly foliated quartzofeldspathic orthogneiss. Augen gneiss in the Big Delta quadrangle has yielded a 341±3 Ma U/Pb (TIMS) and 371±3 Ma (SHRIMP) age; the SHRIMP age is interpreted as a crystallization age (Dusel-Bacon and others, 2004). Similar augen gneiss in the other quadrangles yield U/Pb SHRIMP ages between about 370 and 332.6±5.7 Ma (Aleinikoff and others, 1986; Dusel-Bacon and Aleinikoff, 1996; Newberry and others, 1998a; Dusel-Bacon and others, 2004; Day and others, 2014). Although the body in the Tanana quadrangle yielded an age that was interpreted as 390±25 Ma (Patton and others, 1987)—significantly older than other dated bodies in this unit and similar to the age of orthogneiss in the Brooks Range (which ranges from 395 to 365 Ma; unit Dogn)—this age was interpreted on the basis of the upper intercept of a concordia plot (Patton and others, 1987) where the discordia cord was nearly parallel with the concordia; the large uncertainty is indicative of this poor fit. Unit also includes augen gneiss associated with the West Point complex of Smith and others (1994) and foliated, muscovite-biotite granitic orthogneiss bodies within the West Point complex. The West Point complex of Smith and others (1994) is exposed in the northeastern part of the Big Delta quadrangle and consists of upper amphibolite facies metamorphic rocks that were intruded by abundant pre- and post-metamorphic, felsic to intermediate igneous rocks. Smith and others (1994) reported a TIMS U/Pb age of 671±34 Ma for the orthogneiss, but a U/Pb SHRIMP analysis reported by Dusel-Bacon and others (2003a) reported an average age of 113±2 Ma, from 7 of the most concordant rim analyses, a subset of 16 rim samples analyzed from a total of 33 zircon grains. Both authors interpreted their ages as emplacement ages, but the majority of the zircons reported by Dusel-Bacon and others (2003a) had Devonian-age cores, which leads us to suggest that this was likely a Devonian pluton metamorphosed in the Cretaceous; nearby augen gneiss has yielded a U/Pb age of 355±4 Ma (Dusel-Bacon and others, 2006) interpreted as an intrusion age. Boundaries of the West Point complex are gradational (Smith and others, 1994). The gneiss bodies in the Melozitna and Chandalar quadrangles are as yet undated. Although the Chandalar body included here is near the Brooks Range, its position south of the Kobuk Fault System leads us to assign it to this unit, whereas all the metaigneous bodies north of the Kobuk Fault System are assigned to map unit Dogn. Many of these augen gneiss and orthogneiss bodies yield Cretaceous cooling ages, typically between 115 and 105 Ma, but some are as young as 90 Ma. Rb-Sr biotite, K-feldspar, plagioclase, and whole-rock isochron ages of about 110 Ma on some of these rocks were interpreted by Wilson and others (1985) and Nokleberg and others

(1992a, b) as the age of metamorphism. Emplacement age determinations on the orthogneiss bodies of this map unit overlap ages determined on orthogneiss in the Brooks Range (unit Dogn). On generalized map, included as part of unit MDmg

Devonian to Proterozoic

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 ₮Pzvs. On generalized map, included as part of unit MDmg

Dgb **Gambier Bay Formation, undivided (Devonian)**—Medium-green actinolite schist, semischist, and dark-green garnet amphibolite that was first named by Loney (1964) on Admiralty Island. Unit also contains subordinate gray pelitic schist, calc-schist, chloritic quartzite, and felsic schist and marble. On Kupreanof Island, unit includes chlorite phyllite, schist, and semischist, graphitic schist, siliceous sericite schist, chloritic calc-schist, greenstone, marble, and meta-limestone. Subordinate light-tan to gray quartz-sericite semischist contains quartz porphyroblasts in a groundmass of feldspar, sericite, and pyrite and may have a quartz-porphyritic volcanic protolith. Greenstone semischist locally retains relict primary structures, including vuggy volcaniclastic textures and marble lenses and clasts. Metamorphic mineral assemblages include chlorite-epidote-calcite, quartz-muscovite-chlorite-albite, quartz-talc-calcite, and quartz-albite-muscovite-chlorite, which indicate greenschist-grade metamorphism (S.M. Karl, unpub. data). Unit thickness is unknown. On Kupreanof Island, Karl and others (1999) report brachiopods from the late Emsian and Eifelian (latest Early to Middle Devonian), conodonts from the late Emsian to Late Devonian, and corals from the Silurian to Middle Devonian; together, the fossils have been interpreted to indicate a unit age of Middle Devonian. Unit yields Permian metamorphic ages (S.M. Karl, unpub. data). Locally, marble separated as map unit Dgbm

Dgbm **Marble of the Gambier Bay Formation (Devonian)**—Dark-gray to white, thin- to thick-bedded, fine- to medium-grained marble that is locally dolomitic, intercalated with greenstone and greenschist of the Gambier Bay Formation (S.M. Karl, unpub. data). On Admiralty Island, Lathram and others (1965) reported Middle Devonian(?) corals from the Gambier Bay Formation, but suggested that rocks older than Devonian may be included in the unit. On Kupreanof Island a possibly equivalent unit of schist and marble contains Silurian or Devonian crinoid, conodont, stromatoporoid, and rugose coral fossils, but age-diagnostic fossils suggested an age of Emsian (late Early Devonian) to Famennian (Late Devonian) (Karl and others, 1999). A Triassic age was inferred for this unit by Kelley (1990b), but the fossil of that age was most likely from the Triassic Hyd Group (unit ₮hg). A probable correlation is with the limestone of map unit Dlse, which consists of the Wadleigh, Black Cap, and similar limestone units. On generalized map, included as part of unit Dgb

Das **Bimodal metavolcanic rocks (Devonian)**—Interlayered white- to medium-gray-weathering metarhyolite and dark-green-weathering metabasite, exposed primarily within the Schist belt of Till and others (2008a) in the Brooks Range. Unit also includes minor pale-gray-weathering marble and brown- to dark-gray-weathering calcareous, pelitic, and carbonaceous schist. Unit occurs as large lenses interfolded within unit DPaqm and DPacs. Generally known as the Ambler sequence of Hitzman and others (1982) or Ambler metavolcanic rocks, it is best studied near the boundary of the Ambler River and Survey Pass quadrangles, largely because of the presence of the world-class Arctic mineral deposit (Hitzman and others, 1986; Schmidt, 1986), but a much larger area of exposure occurs in the Wiseman quadrangle (Dillon and others, 1986). The felsic part of the unit is characterized by porphyritic metarhyolite that has megacrysts of feldspar and quartz eyes, as well as aphanitic metarhyolite showing rare flow banding, breccia textures, and possible welded shard textures (Hitzman and others, 1986). Hitzman and others (1986) report that metabasite occurs as pods and lenses where exposures in the Ambler River quadrangle retain remnant pillow structures. Metarhyolite, including at the Arctic deposit, has yielded U/Pb zircon ages that range from 386 to 378 Ma with one outlier at 405 Ma (see Till and others, 2008a). A conodont collection from marble in the Wiseman quadrangle yielded a Devonian age (Till and others, 2008a). Till and others (2008a) discuss megafossil collections that "have been reported but are not now considered definitive. In an abstract, Smith and others (1978) reported that poorly preserved favositid corals, crinoid columnals, bryozoans, and ichnofossils were found at a locality in the Ambler district, and assigned the rocks a tentative Middle Devonian to Early Mississippian age. The faunal assemblage was examined by two researchers. G.D. Webster (written commun. to I.L. Tailleur, 1977) indicated a Devonian age for the corals, and considered crinoid columnals to be of probable Middle Devonian and possible Devonian or Mississippian age. William A. Oliver, Jr. (written commun. to I.L. Tailleur, 1977) suggested that the solitary corals indicate a post-Middle Ordovician age and that possible thamnoporoid corals suggested a Silurian-Devonian age. Both paleontologists have reconsidered their findings (written commun. to A. Till, 1992), and neither now suggest a Middle Devonian to Early Mississippian age for the assemblage. Therefore, the age reported in Smith and others (1978) and derivative publications (for example, Hitzman and others, 1982; 1986) can not be supported by megafossil collections." However, Till and others (2008a) report Devonian conodonts and interpret, given this and available radiometric ages, that the unit is at least in part Devonian

Dv **Metavolcanic rocks and sills (Devonian)**—Mafic and lesser felsic metavolcanic rocks and greenstone sills interlayered in Hunt Fork Shale and Beaucoup Formation (Brosgé and Reiser, 2000) and, locally, in the Kanayut Conglomerate (Mull and Werdon, 1994). It is mappable as two separate metavolcanic units in most places: a mafic metavolcanic and a felsic metavolcanic unit. Mafic unit consists of pillow basalt, amygdaloidal basalt, and basalt capped by tuffaceous limestone, commonly schistose and altered to calcic greenstone; may, in part, have been olivine basalt flows, about 10 to 80 m thick (Brosgé and others, 1979). Unit also includes younger (presumed Carboniferous) mafic to intermediate metavolcanic rocks in the Howard Pass quadrangle that are associated with limestone of the Lisburne Group and the Nuka Formation (Mull and Werdon, 1994). Felsic rocks, a minor part of the unit, include metamorphosed crystal and lithic tuff, volcanic breccia, and minor porphyry of rhyolitic compositions, now mostly recrystallized to fine crystalline quartz-sericite schist (Brosgé and Reiser, 2000). This unit is distinct form the Ambler sequence (unit Das) in being typically associated with the Hunt Fork Shale (unit Degh) and in being a dominantly mafic unit. On generalized map, included as part of unit CDbrv

Dogn **Granitic gneiss (Late and Middle Devonian)**—Generally consists of "metamorphosed intrusive rocks that are predominantly muscovite-biotite granite ranging in composition from alkali-feldspar granite to tonalite" (Nelson and Grybeck, 1980). Primarily exposed in the Survey Pass and Chandalar quadrangles, but other small exposures of this unit occur on the Seward Peninsula and in the Wiseman, Ambler River, Shungnak, and Baird Mountains quadrangles. In the Survey Pass quadrangle, unit is coarse-grained augen gneiss and granite gneiss that occur locally within Arrigetch Peaks and Mount Igikpak plutons (Nelson and Grybeck, 1980). Brosgé and Reiser (1964) and Dillon and others (1996) described the unit in the Chandalar quadrangle as generally gneissic chloritized biotite granite, quartz monzonite, and granodiorite that locally includes chloritized hornblende granite and granodiorite, all of which are white to tan or cream-colored. On the Seward Peninsula, unit consists of texturally homogeneous, light-brownish-gray, light-orange to gray, fine-grained, biotite-plagioclase-quartz gneiss and granitic orthogneiss. The foliation in the gneiss is defined by aligned and segregated muscovite and minor biotite (Till and others, 2011). Variously mapped as Cretaceous, Mesozoic, or Paleozoic, U/Pb dating has shown these bodies to be Late and Middle Devonian intrusions that have undergone a Cretaceous resetting and therefore yield Cretaceous K/Ar and $^{40}Ar/^{39}Ar$ ages. Early Rb/Sr analysis yielded an age of 373±25 Ma (Silberman and others, 1979; Nelson and Grybeck, 1980). Dillon and others (1979, 1980) reported the first modern U/Pb ages (there were earlier, discredited, Pb-alpha ages in the Ambler River and Shungnak quadrangles; see Mayfield and others, 1983) that indicate a Late Devonian age (365±15 Ma) for the Arrigetch Peaks and Mount Igikpak plutons. Subsequently, Aleinikoff and others (1993) determined additional U/Pb ages ranging from 395 to 388 Ma in the Chandalar quadrangle, and Till and others (2008a) reported a U/Pb age of 386±1 Ma in the Shungnak quadrangle. These ages overlap the age range of augen gneiss and orthogneiss in the Yukon-Tanana Upland and Ruby terrane (unit MDag). Till and others (2011) repot a U/Pb age of 390±3 Ma age for orthogneiss on the Seward Peninsula. On generalized map, included as part of unit MDmg

DOtu **Metasedimentary and metavolcanic rocks of Tukpahlearik Creek, undivided (Devonian to Ordovician)**—"Black carbonaceous quartzite and siliceous argillite with lenses of dolostone and marble, silvery gray to silvery green pelitic schist, gray chert pebble metaconglomerate, green calc-schist, orange-weathering micaceous marble, dark green mafic metavolcanic rocks, gray or white metachert and gray- to white-weathering marble" (Karl and others, 1989a). Karl and others (1989a) reported greenschist and blueschist facies mineral assemblages are present. Exposed in two areas of the Baird Mountains and adjoining Selawik quadrangle, pelitic schist is composed of quartz, albite, chlorite, and biotite in the southern part of the unit, whereas biotite is not present in pelitic schist in the northern part of the unit. Chert pebble metaconglomerate and graphitic quartzite commonly contain chloritoid and locally contains stilpnomelane throughout the unit (Karl and others, 1989a). Normal-marine, cool-water Ordovician conodonts from the black quartzite and Ordovician to Devonian conodonts from gray marble define the age of the unit (Karl and others, 1989a). More common black carbonaceous rocks and less carbonate distinguish these rocks from similar age rocks in the Baird Mountains quadrangle. Locally subdivided into units DOtm and DOtp:

DOtm **Marble of Tukpahlearik Creek**—Orange-weathering, gray micaceous marble and gray, medium-grained, massive to thick-bedded marble in lenses tens of meters thick intercalated with green chloritic quartz schist, gray calcareous quartz schist, and black carbonaceous quartz semischist (Karl and others, 1989a). "Marble forms sections up to 300 m thick, alternating with black quartzite or semischist that is typically a few meters thick but may be as much as 100 m thick" (Karl and others, 1989a). On generalized map, included as part of unit DOtu

DOtp **Pelitic schist and metavolcanic rocks of Tukpahlearik Creek**—"Greenish-gray, green, or gray, fine- to medium-grained chloritic quartz schist and siliceous chlorite schist * * *" that locally includes "* * * intercalated masses of dark green metabasite, mafic dikes, mafic extrusive rocks and white metachert. Mafic rocks form resistant outcrops up to 100 meters in diameter and sometimes have associated lenses of white ribbon metachert as much as 30 m thick. Metachert occurs in cm thick beds with crenulated chloritic partings. Metachert lenses or blocks also occur in pelitic schist independent of metabasite" (Karl and others, 1989a). On generalized map, included as part of unit DOtu

Pzm **Marble of the Brooks Range (Devonian and older)**—As described by Till and others (2008a), unit consists of "white to gray (less commonly black), fine to coarsely crystalline, massive to platy marble and subordinate metalimestone and dolostone occurs discontinuously in all quadrangles within the map area. Pzm locally contains abundant disseminated quartz or mica grains, and (or) interlayers of schist, quartzite, or phyllite. In some areas, these strata contain no relict sedimentary textures and few or no fossils; elsewhere, relict sedimentary structures and fossils occur, but rocks have not been studied in sufficient detail to allow assignment to * * *" other better defined carbonate units of Devonian and older age. "Existing fossil data and regional relationships suggest that most Pzm is Cambrian through Mississippian in age" (Till and others, 2008a). As shown here, unit includes exposures in the Ambler River, Survey Pass, Wiseman, Chandalar, Philip Smith Mountains, Christian, and Arctic quadrangles that were traditionally assigned to the Skajit Limestone of Baird Group, a formal unit not used herein. It excludes part of unit Pzm of Till and others (2008a) in the Baird Mountains quadrangle, which is here included in unit Pzcn. On generalized map, included as part of unit Pzc

Pzks **Metamorphic rocks of the Kah Shakes sequence of Rubin and Saleeby (1991), undivided (early Paleozoic)**—Quartzite, carbonate-rich metaturbidites, siliceous, quartzofeldspathic, and pelitic schist, as well as subordinate marble, dark-gray gneiss, dark-green hornblende schist and gneiss, and orthogneiss defined as the Kah Shakes sequence in southeast Alaska by Rubin and Saleeby (1991). Metamorphic grade increases eastward from greenschist to amphibolite facies. Occurrences of sillimanite, kyanite, and staurolite are localized near the intruding plutons of unit Kmgr. Includes part of units MzPzms and MzPzu of Berg and others (1988). U/Pb zircon age determinations, including on silicic metavolcaniclastic rocks, typically range from about 422 Ma to 383 Ma, with the majority of the dates older than 400 Ma; the dates have been interpreted as protolith ages (Saleeby, 2000). Quartz-rich metasedimentary rocks contain detrital zircon populations that yield a wide range of Mesozoic lower intercept ages and upper intercept U/Pb ages that cluster around 1,700–1,650 Ma (Saleeby, 2000). Saleeby (2000) correlated these rocks with the Yukon-Tanana terrane as it was defined by Mortensen (1992) or with the Nisling terrane of Wheeler and others (1991). Early Devonian or Silurian protolith ages are not known from the Yukon-Tanana terrane, but are common in the Alexander terrane and multigrain detrital zircon analyses are difficult to interpret, making the correlation with the Yukon-Tanana terrane questionable. On generalized map, included as part of unit MzPzcp

Pzarqm **Pelitic and quartzose schist of the Alaska Range (Devonian or older)**—Dominantly pelitic and quartz-rich schist and quartzite in the Mount Hayes (Nokleberg and others, 1992a), Healy (Csejtey and others, 1992), and Denali (B. Csejtey, Jr., written commun., 1993) quadrangles; includes subordinate calc-schist and feldspathic schist. Generally underwent greenschist to amphibolite facies metamorphism, with or without greenschist facies retrogression. Unit is lithologically similar to units PzPyqs and PzPyqm in the Yukon-Tanana Upland; all three units contain metaigneous rocks that yield Devonian zircon ages. On generalized map, included as part of unit D€sp

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 DꞒsp

DꝐsgm **Schist, paragneiss, and marble (Devonian to Neoproterozoic)**—Spatially associated with the Arrigetch Peaks orthogneiss, this unit includes pelitic schist, metaquartzite, mafic schist, and rocks originally mapped as the Skajit Limestone and an orange dolomitic marble by Nelson and Grybeck (1980) in the Survey Pass quadrangle and as banded schist by Dillon and others (1986) in the western Wiseman quadrangle. In the Survey Pass quadrangle the unit consists largely of granoblastic, massive, light-gray weathering, cream to very light-gray, fine- to medium-grained marble and orange-weathering, medium- to coarse-grained dolomitic marble. In the Wiseman quadrangle, unit is interlayered, locally gneissic, coarse-grained quartz-mica schist, quartzite, calcareous schist, marble, graphitic phyllite, and metabasite. “Upper greenschist facies rocks predominate, but includes amphibolite facies paragneiss, and local relict blueschist and eclogite facies metabasite” (Dillon and others, 1986). The informally named Ernie Lake pluton (unit Ꝑgn), an orthogneiss, intrudes this unit and has yielded a U/Pb zircon age of 971±5 Ma (McClelland and others, 2006), which indicates that at least part of this unit is early Neoproterozoic or older. Till and others (2008a) report that gneissic textures are particularly common where the unit is closest to metaplutonic rocks of the Arrigetch Peaks and Mount Igikpak orthogneiss (unit Dogn). Mafic rocks within the unit contain assemblages of the albite-epidote-amphibolite facies (Dusel-Bacon and others, 1989; Vogl, 2002); exposures west of the major orthogneiss bodies appear to be lower in grade (Nelson and Grybeck, 1980; Toro, 1998). Unit may, in part, represent a higher metamorphic grade equivalent of a number of units of the Brooks Range, including SꞒbs, Dbf, Degh, DꞒcs, and ꝐzꝐaqm. On generalized map, included as part of unit DꝐcn

DꝐaqm **Quartz-mica schist of the Brooks Range (Devonian to Proterozoic)**—Exposed along the southern flank of the Brooks Range, unit is largely equivalent to unit Dsq of Till and others (2008a). Quoting Till and others (2008a) from their description of Dsq, this unit consists of “gray, dark-gray, or brownish-gray weathering, dominantly pelitic or semipelitic schist that constitutes the major lithologic unit of the Schist belt. Outcrops vary from blocky and resistant (quartz-rich varieties) to platy and less resistant (mica-rich varieties), as the abundance of quartz versus mica and albite varies at centimeter to meter scales. Scattered lenses of mafic schist, calcareous schist, albite-mica schist, graphitic metaquartzite, and marble up to 10’s of meters thick are typical of the unit but volumetrically minor. Mafic lenses may be massive or schistose. In the Wiseman area, rare lenses of ultramafic rocks are up to 10’s of meters thick. The dominant foliation is defined by parallel millimeter- to meter-scale variations in quartz versus mica or albite, or discontinuous layers and lens-shaped quartz segregations (Gottschalk, 1990; Little and others, 1994; Till, A.B., 2008, unpublished data). * * * At map scales, the dominant foliation is typically broadly arched or folded around axes that are subparallel to the east-west trend of the Schist belt.” No fossils have been collected from the schist, but protolith age can be partially bracketed by the age of detrital zircons from the unit. Twenty-seven detrital zircons from micaceous metaquartzite varied from pitted spherical to slightly abraded euhedral grains (Moore and others, 1997b); the rounded population (n=16) yielded single-grain $^{207}$Pb/$^{206}$Pb ages that suggest the quartz-mica schist protolith included Archean and Proterozoic rocks. The euhedral grains (n=11) gave concordant single-grain $^{238}$U/$^{206}$Pb ages between 371 and 361 Ma, which indicates that at least part of the protolith package is Devonian in age (Moore and others, 1997b). Middle Devonian granitic orthogneiss (unit Dogn, here) is present within the quartz-mica schist unit in the Chandalar quadrangle, but geologic mapping is insufficient to show whether there was an original intrusive relationship between Till’s units Dg and Dsq, or if the orthogneiss was folded in with unit Dsq during penetrative Mesozoic deformation (Till and others, 2008a). Therefore, it is not clear whether or not the age of the orthogneiss bears directly on the age of the protolith of the quartz-mica schist. “The quartz-mica schist shared its early deformational and metamorphic history with other units of the Schist belt * * *. Common metamorphic minerals in pelitic schist include quartz, muscovite, chlorite, plagioclase, chloritoid, and accessory sphene, tourmaline, rutile, opaque, graphite, and calcite. Some pelitic schists contain garnet, and many contain glaucophane or pseudomorphs of chlorite and albite after glaucophane. Metabasite typically contains a combination of actinolite, albite, epidote, garnet, chlorite, sphene, and quartz; many contain glaucophane or pseudomorphs after glaucophane. This unit may be a lithologic and metamorphic correlative to the Solomon schist of the Nome Group, Seward Peninsula, which has also yielded detrital zircons as young as Late Devonian (Till and others, 1986, 2006b)" (Till and others (2008a). On generalized map, included as part of unit DƂsb

DƂacs **Calcareous schist of Brooks Range (Devonian to Proterozoic)**—"Light-gray-, brown- and locally orange-weathering, lithologically heterogeneous mix of marble and carbonate-rich, quartz-rich, and mafic schist derived from metasedimentary and metaigneous protoliths; one of two major units that extends along the length of the Schist belt [of Till and others, 2008a]. Within the unit, lithologies are interlayered at scales varying from millimeters to 10's of meters. Calcareous schist, albitic schist, marble, and metaquartzite (massive, mica-poor varieties of pelitic schist) are commonly interlayered; pelitic interlayers and pelitic components in calcareous schists are also characteristic" (Till and others, 2008a). Marble generally forms less than 25 percent of unit but locally may represent as much as 40 percent of the unit. The marble is in layers, lenses, and boudins of coarsely crystalline, pure calcite meters to tens of meters thick forming bare, steep slopes and ledges. Rare dolostone occurs as lenses up to several meters thick. Graphitic carbonate rocks (marble and dolostone), quartz-rich schist, and albite-rich schist are typical of the unit, as are chlorite-bearing marble, dolostone, and metaquartzite. Metabasite, metadiorite, and chlorite-albite schist vary greatly in abundance along the length of the unit (Till and others, 2008a). "It is likely that the calcareous schist unit is composed of several lithologic packages that have unknown depositional relationships. In the western part of the schist belt, * * * calcite-chlorite-albite schists, chlorite-albite schists, and marbles were apparently derived from sources rich in carbonate and mafic components. * * * Near Wiseman, two subunits can be distinguished, though some lithologies occur in both. One subunit is similar to the carbonate-mafic association in the west. The other * * * is dominated by metachert * * * and calcareous schist, and contains several types of metaconglomerates. The metachert commonly contains cm-scale lenses and thin, mm-thick layers of spessartine (Mn-rich) garnet and mafic metatuff. Metabasite bodies are associated with the metachert as well (A.B. Till, unpublished data)" (Till and others, 2008a). In discussing age control for this unit, Till and others (2008a) report conodont collections that range in age between Middle Ordovician and Middle Devonian. In the Baird Mountains quadrangle granitic orthogneiss that has yielded a Neoproterozoic U/Pb zircon age (705±35 Ma, Karl and Aleinikoff, 1990, in rocks assigned to unit Zgn here) apparently intrudes marble of this unit, which Till and others (2008a) interpreted to mean that "at least part of the unit must be Late Proterozoic or older." Spatially associated with this unit are Middle and Late Devonian orthogneiss bodies (unit Dogn); Newberry and others (1997) report skarn around the Middle Devonian orthogneiss in the Chandalar quadrangle. "Metamorphic assemblages in the calcareous schist unit show that it experienced the same early high-pressure/low-temperature metamorphic and deformational history as the quartz-mica schist [unit DƂaqm, here, and unit Dsq of Till and others, 2008a, who cite Gottschalk, 1990; Little and others, 1994; and Dinklage, 1998]. Chloritoid, glaucophane, pseudomorphs after glaucophane, and pseudomorphs after lawsonite are present in pelitic and mafic layers in the unit (Little and others, 1994; Dinklage, 1998; Till, A., unpublished data)" (Till and others, 2008a). On generalized map, included as part of unit DƂsb

DƂasm **Mixed assemblage of metasedimentary and metavolcanic rocks in the Brooks Range (Devonian to Proterozoic)**—"Heterogeneous assemblage of interlayered calcareous, mafic, and siliceous rocks exposed in the * * * Ambler River and Wiseman quadrangles. Includes black quartzite, meta-argillite, and marble; white quartzite; green, buff, and black phyllite and calcareous phyllite; orange-weathering dolostone, orange weathering chloritic marble, chloritic dolomitic marble, gray marble, medium- and dark-green mafic metavolcanic rocks; pale green and orange calcareous schist, and gray-green pelitic schist" (Till and others, 2008a). Unit represents two units of Till and others (2008a), units PzZcm and PzZm, except that they had included in PzZcm a unit called "Metasedimentary and metavolcanic rocks of Tukpahlearik Creek, undivided," of Karl and others (1989a) in the Baird Mountains quadrangle; that is unit DOtu of this map. Unit DƂasm also includes a unit that straddles the Ambler River and Survey Pass quadrangle boundary and consists of "Massive dark greenstone commonly composed of albite, actinolite, epidote, and chlorite, and greenschist composed of albite, chlorite, and minor magnetite" (unit Pzgg of Nelson and Grybeck, 1980). Locally, the greenstone appears to be altered gabbro that intruded Devonian sedimentary rocks, which have been metamorphosed to dark hornfels within 2 meters of altered gabbro. The largest area of greenstone, in the western part of the Survey Pass quadrangle, was previously mapped as biotite schist by Brosgé and Pessel (1977) and by Mayfield and Tailleur (1978) in the adjacent Ambler River quadrangle, but more likely is a metamorphosed volcanic sequence. "Poorly developed pillows in compositionally layered biotite-quartz-chlorite schist and semischist, garnet-epidote-albite amphibolite, and feldspathic biotite-epidote-quartz gneiss with lenticular chloritic patches suggest that these are metamorphosed volcanic rocks of various types" (Nelson and Grybeck, 1980). Also includes unit PzZqs of Till and others (2008a), which they described as a relatively homogeneous assemblage dominated by light greenish-gray fine-grained schist that contains minor layers of metaconglomerate, marble, and calcareous schist. Its eastern exposure has a laminated appearance and contains marble that yielded a conodont of Ordovician to Triassic age (Moore and others, 1997b). These rocks are all part of the Central belt of Till and others (2008a). On generalized map, included as part of unit DꝒcn

Silurian to Proterozoic

SZfw **Four Winds complex of Gilbert and others (1987) and similar rocks (Silurian to Neoproterozoic)**—Consists of a variety of rocks, including interbedded black phyllite, mafic and felsic schist, metachert and medium-gray marble, amphibolite, greenschist, and greenstone; also includes sheared metabasalt and orthogneiss along the west side of Chilkat Inlet and the Chilkat River. Gilbert and others (1987) divided these rocks into four informal units that consist of intercalated metasedimentary and metavolcanic rocks, metabasite, metavolcanic rocks, and gneiss. For partially contiguous rocks to the south in the Skagway quadrangle, Redman and others (1985) used the informal term Cheetdeekahyu group. According to Gilbert and others (1987), metamorphic grade of the Four Winds complex increases to the northeast from greenschist to amphibolite facies. Gilbert and others (1987) suggested that the Four Winds complex is overlain by Mississippian to Devonian age rocks, and hence assigned a pre-Devonian age. Karl and others (2006) report a U/Pb TIMS age of 455±5 Ma from zircon in a metamorphosed(?) felsic dike within the complex on Mount Cheetdeekahyu. They also dated a xenocrystic zircon from the dike that yielded a concordant age of 544±9 Ma, which is similar to the age of orthogneiss that intrudes the Retreat Group at False Point Retreat on Admiralty Island, as well as other orthogneiss bodies that intrude schist of the Wales Group on Prince of Wales Island

SOmi **Heterogeneous metamorphic rocks, southeast Alaska (Silurian and Ordovician)**—Unit consists of unnamed rocks on Revillagigedo, Gravina, Annette, Mary, and Duke Islands. This heterogeneous assemblage includes metamorphosed mafic, intermediate, and subordinate felsic volcanic and volcaniclastic rocks; clastic and carbonate sedimentary rocks; and subordinate intermediate and mafic intrusive rocks. Extrusive protoliths, which are partly altered to spilite and keratophyre, include basaltic tuff, agglomerate, and pillow flows and intermediate and felsic tuff. Sedimentary protoliths include argillite, graywacke-siltstone, limestone, conglomerate, and, in the matrix of some of the pillow flows, red chert. Intrusive protoliths include medium- and coarse-grained diorite and quartz diorite. Metamorphic minerals include plagioclase, hornblende, biotite, epidote, chlorite, actinolite, sericite, almandine garnet, and possibly staurolite. Amphibolite-facies minerals define a foliation that predates randomly oriented greenschist facies minerals (Berg and others, 1988). Zircon populations do not include any inherited or entrained zircons that have ages older than Phanerozoic (Saleeby, 2000). U/Pb zircon ages ranging between 436 and 404 Ma are inferred crystallization ages for intrusive dioritic rocks (Saleeby, 2000)

ꝐzꝒrqm **Pelitic and quartzitic schist of the Ruby terrane (early Paleozoic to Proterozoic?)**—Poorly exposed unit of mainly muscovite- and quartz-rich schist, and subordinate calc-schist, quartzofeldspathic schist, biotite granite, and granite gneiss that includes augen gneiss. Also includes amphibolite and quartzite metamorphosed to upper amphibolite to lower granulite facies; unit also includes minor marble and calc-silicate rocks. In the north-central Tanana quadrangle, unit has a polymetamorphic history including metamorphism to greenschist, local blueschist, and amphibolite facies. The apparent grade of metamorphism varies depending on depth of exposure and proximity to zones of ductile deformation and (or) buried plutons or other thermal hot spots (Miyaoka and Dover, 1990; Dover, 1994). Evidence for blueschist-facies metamorphism has been largely obliterated by a greenschist to granulite facies overprint in the Kokrines Hills in the Ruby quadrangle (Roeske and others, 1995). South of the Kaltag Fault, these rocks are even more poorly exposed and little studied. Unit locally is interlayered with carbonate rocks of unit Ꝑzls and therefore is, at least in part, Paleozoic in age; however, some of the unit is inferred to be as old as Proterozoic (Patton and others, 2009). Unit also appears to be intruded by orthogneiss of unit MDag. Regional metamorphism predates the widespread intrusion of the Early Cretaceous granitic bodies of unit Kmqm. Metamorphic minerals yielded K/Ar isotopic cooling ages between 144.5±1.3 Ma (white mica) and 108±3 Ma (biotite); the oldest ages were determined on glaucophane-bearing schist (Dillon and others, 1985; Miller and Bundtzen, 1994; Roeske and others, 1995). U/Pb zircon ages from gneiss range between 147.8 and 117.5 Ma (Dillon and others, 1985; Roeske and others, 1995)

Sbs **Black phyllite and metalimestone (Silurian)**—"Black siliceous phyllite and metalimestone, metasandstone, metasiltstone, phyllite, and graphitic calcareous schist in the eastern Ambler River and western Survey Pass quadrangles. Conodonts and graptolites indicate Silurian ages for these strata in the Ambler River quadrangle (Dumoulin and Harris, 1988); rocks included in this unit in the Survey Pass quadrangle are undated * * *" (Till and others, 2008a). Unit has variable lithologic characteristics; according to Till and others (2008a), in the western Ambler River quadrangle, unit consists of black siliceous phyllite that contains recrystallized radiolarians and interlayers of black metalimestone. In northeastern Ambler River quadrangle, the unit is interlayered metasandstone, metasiltstone, phyllite, and metalimestone that displays turbidite features including convolute laminae, flute casts, and graded beds. “Metasandstone is made up of quartz, carbonate, feldspar, and chert grains, as well as sedimentary and volcanic lithic clasts. Carbonate interlayers are also gravity deposits, and consist of redeposited shallow-water carbonate detritus; they contain a variety of megafossils such as corals, gastropods, bryozoans, brachiopods, conularids, and orthocone cephalopods, as well as conodonts of late early to early late Silurian (Wenlockian to Ludlovian) age” (Till and others, 2008a). In the east-central Ambler River quadrangle, the unit contains a higher proportion of calcareous rocks. Sedimentary features and fossil assemblages denote an off-platform and (or) edge-of-platform setting for these rocks (Dumoulin and Harris, 1988). On generalized map, included as part of unit DPcn

PzPrg **Retreat Group (Paleozoic and Proterozoic)**—Dominantly quartz-rich schist and semischist, as well as marble; at Point Retreat in the Juneau quadrangle, unit also includes a distinctive, very fine-grained, black graphitic quartzite associated with albite-chlorite-white mica schist and semischist that locally contain garnet, calcite and (or) biotite. First named by Barker (1957) for rocks on the Mansfield Peninsula of northern Admiralty Island, Lathram and others (1965) extended the Retreat Group to include rocks southward to the contact with a Cretaceous pluton of unit Keg on central Admiralty Island. More recent mapping and analysis by S.M. Karl (unpub. data) indicates that the Retreat Group, as originally delineated by Barker (1957), should be restricted to rocks similar in age and lithology to the rocks at Point Retreat on the Mansfield Peninsula. Karl’s analyses suggest that at least some of these rocks are intruded by several metamorphosed and highly strained plutons of intermediate composition, which have U/Pb zircon ages that range between 546.9±3.2 and 544.08±0.8 Ma (S.M. Karl, unpub. data). The Retreat Group is considered pre-Silurian, as it is apparently intruded by Silurian plutons. The rocks south of the Mansfield Peninsula are compositionally different and yield younger ages. Mineral assemblages indicate that metamorphic grade ranges from greenschist facies to lower amphibolite facies with no systematic spatial distribution, suggesting that conditions were in the general range of the greenschist-amphibolite facies transition. On Kupreanof Island, greenschist-facies schist, including graphitic schist and subordinate marble, are tentatively included here also. No age control is available for these rocks on Kupreanof Island other than being intruded by foliated granodiorite of presumed Cretaceous age (unit Ksfg). The rocks of the Retreat Group may be correlative with rocks of the Wales Group on Prince of Wales Island and with the informally defined Four Winds complex of northern southeast Alaska, both of which are also apparently intruded by plutons that yield late Neoproterozoic ages. No pre-Cretaceous metamorphic mineral ages are available for the Retreat Group. The Four Winds complex (unit SPfw, here) may be the same unit structurally offset along the Lynn Canal. On generalized map, included as part of unit SZfwr

## Cambrian to Proterozoic

ЄPwg **Wales Group, undivided (Cambrian to Proterozoic)**—Complex assemblage of intercalated metabasite, metafelsite, metaclastic rocks, marble, and siliceous and carbonaceous black phyllite derived predominantly from andesitic to basaltic marine fragmental volcanic rocks and flows, graywacke, mudstone, and shale that contains locally interlayered marble (unit ЄPwgm). All rocks of the unit have been regionally deformed and metamorphosed to greenschist and, locally, amphibolite facies. The most abundant and widely distributed lithology is greenish-gray, thinly foliated, commonly crenulated albite-epidote ± quartz ± actinolite schist that is compositionally layered parallel to schistosity and is probably derived from tuffaceous mudstone, siltstone, and graywacke (Eberlein and others, 1983; S.M. Karl, unpub. data). Pillows and centimeter-scale pyroclastic rock fragments are locally preserved. Metasedimentary rocks show relict rhythmic and graded bedding, but other protolith features are mostly obscured by metamorphic recrystallization, penetrative foliation, high degree of flattening, and moderate elongation. Unit includes subordinate black phyllite and schist, meter-thick layers of silicic metavolcanic rocks, and light-colored, coarsely recrystallized marble. Metakeratophyre layers up to 3 m thick are common and typically contain rounded blue quartz eyes and phenocrysts or glomeroporphyritic clots of twinned albite set in a chert-like microscopic groundmass of quartz and albite (Herreid and others, 1978, Eberlein and others, 1983). Unit is folded, crenulated, and lineated (showing preferred orientation of minerals such as actinolite), and has quartz and carbonate boudins up to 5 m thick and 20 m long. Quartz segregation layers parallel and crosscut the foliation, and are concentrated in the crest regions of folds. There is evidence for at least two, and as many as four deformation events in these rocks. Unit believed to be at least several thousand meters thick (Eberlein and others, 1983). K/Ar hornblende age of 483 Ma (Turner and others, 1977) suggests deformation and metamorphism happened prior to the end of the Early Ordovician. Available constraints indicate that rocks in the Wales Group were deposited prior to Late Cambrian time and regionally metamorphosed and deformed before or during Early Ordovician time (Gehrels, 1992)

€Ꝑwgm **Wales Group marble (Cambrian to Proterozoic)**—Medium- to fine-grained, medium- to light-gray marble in thin layers associated with schistose metavolcanic rocks of the Wales Group. Locally, the marble is massive and ranges up to 300 m in thickness (Eberlein and others, 1983). Herreid and others (1978) describe dolomitic marble that forms thick, planar, fine-grained, medium- to light-gray beds that stand out in relief relative to interlayered marble. Near the contact with Wales Group greenschist, tabular dolostone bodies in the marble have been deformed into boudins 10 to 30 m long and up to 10 m thick. Locally, irregular, folded dolostone bodies have marble beds draped around them, suggesting deformation of the rocks after deposition of the dolomite. In a few places, dolomite veinlets crosscut the marble (Herreid and others, 1978). On generalized map, included as part of unit €Ꝑwg

PzꝐb **Metasedimentary rocks of Bluecloud Mountain (early Paleozoic to Proterozoic?)**—Light- to dark-gray phyllite, dark-gray to black metaquartzite, dark-gray and grayish-brown calcareous phyllite, and reddish-brown-weathering impure marble exposed in fault-bounded lenses along the Schist belt-Central belt contact in the Wiseman quadrangle, as described by Till and others (2008a). Lithologic layering is visible in outcrop where it crosses foliation; locally, lithologic layering is transposed by foliation, which is defined by fine-grained mica. In thin section, lithologic layering and relict clasts are recognizable; metamorphic minerals include white mica, chlorite, stilpnomelane(?), and very fine-grained garnet or albite. No protolith age control is available; the protolith may have been a sequence of turbidites (Till and others, 2008a). On generalized map, included as part of unit DꝐcn

PzꝐgb **Gabbro and metagabbro (early Paleozoic and Proterozoic?)**—Dark-green- to black-weathering coarse-grained gabbro, diabase, and their altered equivalents (Sainsbury, 1972; Till and others, 2011) on the Seward Peninsula. Sainsbury (1972) suggested that the mafic rocks were of two ages; he described the older rocks in the east as being completely recrystallized and the younger rocks as having retained igneous textures. Sainsbury (1972) mapped rocks of this unit associated with and intruding his "Slate of the York region" and the Nome Group [now Complex] (here shown as units OꝐpt and PzꝐnc and subunits); Sainsbury (1972) reported that the gabbro does not intrude rocks of Paleozoic age. Till and others (2011) mapped metagabbro in their units Pzgb and Pznp as part of their York terrane and Nome Complex, respectively. Unit PzꝐgb only includes unit Pzgb of Till and others (2011). According to Sainsbury (1972), the older rocks in the east have been metamorphosed to blueschist facies; Till and others (2011) indicate Jurassic blueschist facies metamorphism impacted all of the older bedrock of the Seward Peninsula. Till and others (2011) reported that the mafic rocks east of the York Mountains contain relict clinopyroxene grains partially recrystallized to actinolite and other igneous minerals that are completely recrystallized, whereas in the "Teller quadrangle, igneous minerals are more completely retained but show undulatory extinction and are cut by brittle cracks." Amato and others (2009) report a U/Pb zircon age from one of the less recrystallized bodies of 539±11 Ma

PzꝐkg **High-grade metamorphic rocks of the Seward Peninsula (earliest Paleozoic to Proterozoic)**—Consists of brown, light-brown, reddish-brown, black, and gray-weathering schist and gneiss, in part derived from blueschist-facies rocks of the Nome Complex (PzꝐnc) that have undergone another metamorphic episode (Till and others, 2011). Exposed in the Kigluaik, Bendeleben, and Darby Mountains on the Seward Peninsula, assemblages in all three ranges record multiple metamorphic events; the highest event reached upper amphibolite to granulite grade. Metamorphic foliation is gneissic to schistose, though locally no foliation is apparent (Till and others, 2011). The unit is lithologically variable on a scale of centimeters and meters; lithology also varies between the three mountain ranges, but generally includes schist and gneiss of pelitic, quartzose, calcareous, mafic, graphitic, and other compositions (Till and others, 2011). "Till and others (1986) recognized sequences of rocks lithologically similar to those mapped within the Nome Complex in western Bendeleben and northern Darby Mountains. * * * Metamorphic foliations and lithologic layering in the Kigluaik Mountains define a dome, with highest-grade rocks in its core. Metamorphic grade decreases towards the flanks of the dome, where biotite-grade metamorphic assemblages overprint low-grade metamorphic assemblages of the Nome Complex (Thurston, 1985; Hannula and others, 1995; Amato and Miller, 2004). * * * Metamorphic foliations in the Bendeleben Mountains define a dome that spans the area between the large, ovoid pluton in the eastern part of the range and the smaller, irregularly shaped pluton in the west part of the range; the dome coincides with sillimanite-bearing peak thermal assemblages (Gottlieb and Amato, 2008). * * * Metamorphic rocks in the Darby Mountains lack any domal structure; instead, map-scale folds of lithologic sequences with near-vertical axial planes are present where rocks exhibit higher-grade assemblages (Till and others, 1986). * * * In all three mountain ranges, decompression post-dated the thermal peak, and is recorded in aluminum- and iron-rich metasedimentary rocks. In these volumetrically minor but significant rocks, assemblages containing sillimanite or kyanite (± hercynite spinel) and orthoamphibole were overprinted by assemblages containing cordierite and staurolite or garnet. * * * While decompression assemblages apparently formed at about 82 Ma in the Bendeleben range (Gottlieb and Amato, 2008), similar assemblages in the Darby range are probably older: the 100-Ma Darby pluton cross-cuts the metamorphic gradient in the Darby range * * *" (Till and others, 2011). Associated with the metamorphic rocks of the Bendeleben Mountains are foliated lenses and sill-shaped bodies, thought to be metavolcanic rocks, that are exposed in outcrop and rubble fields in the southwest part of the mountains. According Amato and others (2009), contacts and internal foliation are conformable to the foliation of the enclosing metamorphic rocks. Till and others (2011) report that these are the oldest dated rocks on Seward Peninsula: a U/Pb date from zircon gave a protolith age of 870 Ma (Gottlieb and Amato, 2007, 2008; Amato and others, 2009).

€Zogn **Orthogneiss (Cambrian to Neoproterozoic)**—Foliated, lineated, and gneissic biotite-hornblende quartz diorite and granodiorite with minor diorite exposed on southern Prince of Wales, Dall, and northern Admiralty Islands. Most rocks retain recognizable intrusive textures. The more deformed rocks have 5- to 20-cm layers of alternating leucocratic and mafic composition. In most outcrops these compositional layers are thought to be different intrusive phases; in some, however, compositional layering may have resulted from metamorphic segregation (Gehrels, 1991). The False Point Retreat pluton has U/Pb zircon ages of ~545 Ma, 546.9±3.2 Ma, and 544.08±0.84 Ma (S.M. Karl, unpub. data). Elsewhere in southeast Alaska, the Kaigani pluton on Dall Island has U/Pb zircon age of 554±4 Ma (Gehrels, 1990) and orthogneiss at Sunny Cove on Prince of Wales Island has a U/Pb zircon age between 540 Ma and 520 Ma (J.B. Saleeby, unpub. data, cited in Gehrels and others, 1987). Orthogneiss on Bronaugh Islands near Ketchikan has a U/Pb zircon age of 540–510 Ma (Gehrels and others, 1987). On generalized map, included as part of unit SZfwr

## PROTEROZOIC

Zam **Metasedimentary and metavolcanic rocks of Mount Angayukaqsraq (Neoproterozoic)**—"Amphibolite, metaquartzite, calcareous schist, metapelite, and a few small bodies of metagranite and metagabbro, exposed in the northeastern Baird Mountains quadrangle around Mt. Angayukaqsraq and in the northeastern Ambler River quadrangle" (unit Zam, Till and others, 2008a). Primarily dark-gray- to black-weathering, massive amphibolite that is composed of hornblende, plagioclase, sphene and quartz and contains pink garnets as large as 1.5 cm in diameter. Metapelitic rocks are light-green and typically interlayered with metaquartzite on a scale of centimeters. Metaquartzite forms tan-, green-, and gray-weathering layers interlayered on a millimeter to centimeter scale with tan- and brown-weathering calcareous schist. Mineral assemblages of these rocks reflect amphibolite-facies conditions (Till, 1989) and garnet is common to each lithology (Till and others, 2008a). Light-gray- to tan-weathering metagranite and cream to brownish-green metagabbro occurs as small bodies up to 100 m across that are volumetrically minor (Till, 1989; Karl and others, 1989b). U/Pb zircon ages from the meta- granite (included in unit Ꝑgn here) indicate that it crystallized around 750 Ma (Karl and others, 1989b). White mica from a metapelite yielded a late Proterozoic metamorphic age (680 Ma; Till and Snee, 1995; Till and others, 2008a). A blueschist-facies overprint affected both the amphibolite facies and albite-epidote amphibolite facies rocks, and an $^{40}$Ar/$^{39}$Ar age on white mica was 120±0.2 Ma; evidence of this event is primarily detectable only in thin section (Till and Snee, 1995; Till and others, 2008a)

Zgn **Granite and orthogneiss (Neoproterozoic?)**—Granitic and metagranitic rocks of presumed Proterozoic age are exposed in the southern Baird Mountains and western Wiseman quadrangles and in an isolated exposure in the Black River quadrangle of east-central Alaska. In the Baird Mountains quadrangle, light-gray, medium- to fine-grained, foliated to gneissic metamorphosed granite is associated with unit DꝐacs. This body is coarsely porphyritic and contains centimeter-sized albite porphyroblasts; Karl and Aleinikoff (1990) reported a fairly discordant upper intercept TIMS U/Pb zircon age of 705±35 Ma. Granodiorite that intrudes the metamorphic complex at Mount Angayukaqsraq, in the northeastern Baird Mountains quadrangle, yielded a nearly concordant TIMS U/Pb zircon age of 750.4±6.3 Ma (Karl and others, 1989b). Other exposures in the Baird Mountains quadrangle are undated and may be of Proterozoic age or of Devonian age, as is relatively common in the Brooks Range. To the east, in the Central belt of Till and others (2008a), Proterozoic metagranitic rocks span the boundary between the Survey Pass and Wiseman quadrangles. The Ernie Lake pluton yielded a SHRIMP U/Pb zircon age of 971±5 Ma (McClelland and others, 2006); Dillon and others (1980) reported TIMS analyses of zircons from both the Ernie Lake orthogneiss and nearby Sixtymile River orthogneiss bodies yielded discordant zircons likely indicating a Proterozoic age. There is no age control for the exposure in the Black River quadrangle; it is a small exposure of granite (Brabb, 1970) intruding phyllite of presumed Precambrian age (shown here as unit €Ꝑt)

Zgns **Orthogneiss of the Seward Peninsula (Neoproterozoic)**—Pale-gray-, tan- and orangish-tan-weathering outcrops and rubble fields of foliated and nonfoliated metagranitic syenogranite to monzogranite that form a large, tabular, concordant body within high-grade rocks (unit PzꝐkg) of the Kigluaik Mountains on the Seward Peninsula (Till and others, 2011). Foliation is apparent because of local alignment of potassium feldspar, plagioclase, and biotite; quartz and biotite lenses or layers up to a centimeter thick also parallel foliation. Allanite is locally 1 to 2 percent of the rock and is zoned with brown cores and orange rims; accessory zircon is also present. Layers of quartz amphibolite 1–2 m thick parallel the metamorphic foliation in the orthogneiss. Amato and Miller (2004) show the orthogneiss on both the north and south flanks of the antiform in the core of the Kigluaik Mountains (their unit pCtog). Orthogneiss has yielded a TIMS U/Pb zircon protolith age of 555±15 Ma (Amato and Wright, 1998) and a SHRIMP age of 565±6 Ma (Amato, 2004). On generalized map, included as part of unit Zgn

Ꝑqm **Schist of the Telsitna River (Proterozoic)**—Chiefly pelitic and quartzose metasedimentary rocks of greenschist facies exposed in west-central Alaska in the northeastern Medfra, southeastern Ruby and southwestern Kantishna River quadrangles. Micaceous quartzite and quartz-chlorite schist grade into quartz-muscovite-biotite-garnet schist; calc-schist and marble are subordinate. Unit locally includes small bodies of greenstone and green-schist-facies metabasite, granitic gneiss, and metamorphosed quartz porphyry. The porphyry is fine-grained, foliated, and banded felsic volcanic rock composed of large phenocrysts of embayed quartz and plagioclase in a very fine-grained quartzo-feldspathic groundmass that has a distinct micaceous overprint. Zircon fractions from two suites of samples of metamorphosed quartz porphyry yielded upper intercept ages of 850±30 Ma and 1,265±50 Ma, interpreted to be crystallization ages (Patton and others, 1980, 2009). Metamorphic minerals from the schist yield K/Ar isotopic cooling ages that range from 921 to 284.2 Ma (Patton and others, 2009), which indicate that this terrane of metamorphic rocks likely did not experience the mid-Cretaceous metamorphism commonly seen in other metamorphic rocks in Alaska

Ꝑm **Marble, calcareous and quartz-mica schist, and greenstone (Proterozoic?)**—Calcareous schist, thin-bedded schistose impure marble, and fine-grained massive sandy marble spatially associated with the schist of the Telsitna River. Contains subordinate quartz-mica schist and small bodies of greenstone (Patton and others, 2009). Marble is light- and medium-gray, largely recrystallized limestone; schist is light- to medium-green and gray, partly calcareous, intensely folded and interbedded with marble. Greenstone is light- to medium-green and apparently basaltic (Chapman and others, 1975). On generalized map, included as part of unit Ꝑqm

Xio **Kanektok metamorphic complex and Idono Complex (Paleoproterozoic)**—The Kanektok metamorphic complex, informally named by Hoare and Coonrad (1959a, 1961a, 1978, 1979), crops out in the northwest Goodnews Bay quadrangle as a narrow belt that trends northeast and extends northward 160 km into the southern part of the Bethel quadrangle. The Idono Complex of Gemuts and others (1983; Miller and others, 1991; Miller and Bundtzen, 1994; Wilson and others, 1998) is similar in many respects to the Kanektok metamorphic complex and crops out in a number of small isolated exposures in the Iditarod quadrangle. The Kanektok metamorphic complex, which was also called the Kilbuck terrane by Jones and others (1981), is composed of gneiss and schist derived from sedimentary, volcanic, and plutonic rocks that range from upper greenschist to granulite facies (Hoare and Coonrad, 1978; Turner and others, 2009). It is an antiformal crystalline complex cored by amphibolite facies orthogneiss that range in composition from granite to diorite intercalated with metavolcanic and metasedimentary rocks (Turner and others, 2009; Moll-Stalcup and others, 1996). Orthogneiss of the core is intercalated with pyroxene granulite, garnet amphibolite, locally kyanite-bearing garnet-mica schist, and rare quartzite and marble (Turner and others, 2009). The amphibolite-facies rocks grade to greenschist-facies rocks that dip away from the core on the northwest and southeast. These lower grade rocks are schist and quartzite, as well as calc-phyllite, marble, and metaconglomerate (Turner and others, 2009). The character of the main complex changes at the Kanektok River. South of the river, mineral foliation tends to parallel compositional layering, and both consistently strike northeast; "* * * dip of the foliation changes from northwest to southwest two to four times across the width of the complex" (Hoare and Coonrad, 1979). Compositional layering and foliation are disrupted by northwest-trending faults, including a significant left-lateral offset at the Kanektok River. North of the river, the rocks are more highly deformed, and the dip and trend of foliation are more variable (Hoare and Coonrad, 1979). The Kanektok metamorphic complex is fault-bounded on the southeast; the complex is thrust over calcareous schist (unit ŦPs), the Kuskokwim Group (unit Kk), calcareous graywacke and conglomerate (unit Kcgc), and the undivided Togiak-Tikchik Complex (unit KDt) in the Goodnews Bay quadrangle, and green amphibole-bearing schist (unit Jgs) in the Bethel quadrangle. It is depositionally overlain by the Kuskokwim Group (unit Kk) in the Goodnews Bay and Bethel quadrangles. Turner and others (2009) report extensive radiometric dating on the Kanektok metamorphic complex using a variety of techniques; later studies by Box and others (1990), Moll-Stalcup and others (1996), and Miller and others (1991) in both the Kanektok and Idono complexes confirm Turner and others' results. Most K/Ar and $^{40}Ar/^{39}Ar$ samples yielded discordant Mesozoic ages when multiple minerals from the same sample were dated. The relative within-sample discordance increases west to east across the complex as the apparent ages also increase. If these ages are considered simply as cooling ages, they suggest that a latest Jurassic or Early Cretaceous thermal event affected the metamorphic complex most strongly in the west. Upper intercept U/Pb ages of zircon from granite gneiss and tonalite gneiss cluster around 2.05 Ga (Turner and others, 2009; Box and others, 1990; Moll-Stalcup and others, 1996). Turner and others (2009) also report multiple K/Ar and $^{40}Ar/^{39}Ar$ analyses of biotite from three pyroxene granulite samples that yielded ages as old as 2.5 Ga. Turner and others (2009) suggested that these rocks may have excess argon, but no other technique has been used on the granulite-facies rocks to confirm that interpretation. Turner and others (2009) also reported a K/Ar age on hornblende from a garnet amphibolite that yielded an age of 1,770±53 Ma, identical to a sphene U/Pb age of 1,770 Ma, they interpreted these dates as a 1.8-Ga event that affected the Kanektok metamorphic complex. Marble in the complex is locally mapped separately as p€km:

p€km **Kanektok marble (Precambrian)**—White, gray, and brownish garnetiferous marble generally associated with quartzose schist (Hoare and Coonrad, 1978) within the Kanektok metamorphic complex (informally named by Hoare and Coonrad 1959a, 1961a, 1978, 1979). Mapped separately only where it forms the dominant rock unit; similar rocks also occur as thin, discontinuous bands in the lower grade marginal rocks of the complex and, rarely, in the high-grade core. Locally may contain incipient diopside, white mica, phlogopite, quartz, plagioclase, and epidote as minor phases (Turner and others, 2009). On generalized map, included as part of unit Xio

## TECTONIC ASSEMBLAGES AND MÉLANGE

### CENOZOIC AND MESOZOIC

TKm **Ghost Rocks Formation (early Tertiary and latest Cretaceous)**—"Complexly deformed assemblage of sandstone and mudstone with interbedded volcanic rocks and minor pelagic limestone" (Plafker and others, 1994) metamorphosed to prehnite-pumpellyite facies on Kodiak Island; also called the wildflysch of Moore (1969). Turbiditic sandstone- and argillite-rich clastic units contain local channelized conglomerate that has chert, sandstone, limestone, and greenstone clasts (Plafker and others, 1994). "The argillite-rich units include interbedded pillow basalt, tuff, chert-rich pebble conglomerate, and minor limestone * * *" (Plafker and others, 1994). Sandstone is dominantly composed of volcanic lithic fragments and lesser quartz and feldspar in roughly equal proportion (Plafker and others, 1994). Volcanic rocks in the unit consist of both tholeiitic basalt whose composition is most consistent with an oceanic source and calc-alkaline basaltic-andesite and andesite thought to have a hybrid origin by assimilation of sediments in a basaltic magma (Plafker and others, 1994). The unit is sheared, faulted, and folded; Nilsen and Moore (1979) estimated a thickness of about 5,000 m. All contacts with other units, other than intrusive contacts, are faults. Poorly preserved planktonic foraminifers reported by Plafker and others (1994) suggest a latest Cretaceous and Paleocene age for limestone within this unit. On generalized map, included as part of unit TKgr

### MESOZOIC TO PALEOZOIC

#### Cretaceous to Paleozoic

KJmy **Mélange 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 mélange facies, which is described here. The mélange 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). Mélange 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

Kmar **Alaska Range mélange (Cretaceous)**—Fault-bounded tectonic and probably sedimentary mélange (olistostrome) of Paleozoic and upper Mesozoic rocks that consist of three distinct, intensely deformed, sheared, and intermixed rock suites (Csejtey and others, 1992). Suite one consists of "medium- to thin-bedded, greenish-gray to tan-colored, locally black, cherty tuff, chert, argillite, and fine-grained volcanic sandstone" that commonly shows slightly graded bedding (Csejtey and others, 1992). It contains "Radiolaria, and conodont fragments in cherty tuffs and associated rocks range in age from Late(?) Devonian to Mississippian" (Csejtey and others, 1992, p. 29). Suite two consists of "dark-gray to black, flysch-like rocks of argillite, slate, shale, fine- to medium-grained graywacke, subordinate bedded chert, and both chert-pebble and polymictic conglomerate" (Csejtey and others, 1992, p. 29) that is lithologically identical to flysch of unit Kfy. In the Mount Hayes quadrangle, minor andesite and dacite are associated with the flysch-like assemblage (Nokleberg and others, 1992a). Suite three is "lenses and elongate blocks of medium-gray, generally medium-bedded and rarely massive, fine- to medium-grained fossiliferous limestone" that contains megafossils and conodonts of Silurian to Middle Devonian age (Csejtey and others, 1992). North of the Denali Fault System, Csejtey and others (1992) report that the mélange contains a "poorly exposed small sliver of serpentinized ultramafic rocks, altered basalt, green and maroon tuff, and recrystallized chert, all of unknown age." In general, the mélange is spatially associated with the Denali Fault System; however, a large area of the exposure extends along the west side of Broad Pass, trending away from the fault system. On generalized map, included as part of unit M̶zm

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KDt **Togiak-Tikchik Complex, undivided (Mesozoic to Devonian)**—Thick marine unit that consists of volcanic, sedimentary, and possibly plutonic rocks including pillow basalts, intermediate to mafic flows, breccia, crystal-lithic tuff, thin-bedded to massive tuffaceous chert and siltstone, argillite, graywacke, pebble-cobble conglomerate, and limestone. Formerly called the Gemuk Group (Hoare and Coonrad, 1959a, 1961a, b), this unit consists of a wide variety of rock types in a structural collage of blocks. As originally defined, the Gemuk Group consisted chiefly of dense, dark, massive siltstone that contained interbeds of chert, volcanic rocks, limestone, graywacke, and breccia (Cady and others, 1955). The assemblage was subsequently redefined as the Togiak-Tikchik Complex on the basis of its structural character (Wilson and Coonrad, 2005). Unit crops out in a wide belt through the Taylor Mountains, Bethel, and Goodnews Bay quadrangles from the Eek Mountains in the north, southwest to Goodnews Bay, making up most of the northwestern Ahklun Mountains. It is unconformably overlain by rocks of the Late Cretaceous Kuskokwim Group (unit Kk) and Early Cretaceous (Valanginian) calcareous graywacke and siltstone (unit Kcgc). Early Cretaceous rocks have been reported in the northern part of the Togiak-Tikchik Complex (Miller and others, 2007; unit KT̶Rvs here). Permian limestone (unit Ptls) that contains *Atomodesma* sp. is interbedded throughout the unit. Hoare and Coonrad (1978, see also samples 74B61, 70ACo6, or 70Ahr28, among others, at www.alaskafossil.org, accessed July 30, 2015) collected samples that contain corals of Permian age and crinoids, bryozoans and *Halobia* of Triassic age. They also collected brachiopods (including several productoid forms, *Cleiothyridinoid* genus, and a spiriferoid), a pleurotomarian gastropod, and pelecypods of late Paleozoic (probably Permian) age. Hoare and Coonrad (1978) reported that the unit contains volcanic rocks of Triassic, Permian, and Devonian ages. D.C. Bradley (oral commun., 2011) reported a U/Pb zircon age that suggested the presence of a Pennsylvanian pluton in the Bethel quadrangle. Included here are mildly altered pillow and columnar-jointed amygdaloidal basalt flows, breccia, diabasic intrusive rocks, and a few sandy tuffs; these were previously mapped and described as unit Pb of Box (1985) and unit Pv of Hoare and Coonrad (1978). Unit crops out near Goodnews Bay and north of Nuyakuk Lake. In the Goodnews Bay area, unit is interbedded with volcaniclastic sedimentary rocks. Hoare and Coonrad (1978) did not separate these rocks from their undivided unit MzPz in the vicinity of Goodnews Bay. In the Nuyakuk Lake area, unit lies stratigraphically above and grades downward into Permian limestone (Mertie, 1938, p. 45–46). Near lowest part of section north of Nuyakuk Lake, fossils identified in an interbed or fault sliver of limestone include brachiopods *Calliprotonia* sp., *Neochonetes*(?), *Neophricadothyris* sp., *Neospirifer*(?) sp., *Thamnosia* sp., *Waagenoconcha*(?) sp., and *Yakovlevia* sp. of Permian age; foraminifera *Schwagerina jenkinsi* Thorsteinnson of Permian age; stenoporoid bryozoans of Permian age; and echinoderm debris of Permian age (see sample 79AHr 2, www.alaskafossil.org). Outcrops in the vicinity of Goodnews Bay were included in the Goodnews terrane by Box (1985); outcrops near Nuyakuk Lake lie within his Togiak terrane. Subdivided into the following 11 units:

M̶zP̶zm **Southwest Alaska mélange (Mesozoic and Paleozoic)**—Mélange that consists of chert, cherty tuff, siliceous siltstone, limestone and dolostone, pillowed and massive basalt, gabbro, and graywacke in an argillite matrix (Box and others, 1993; Hoare and Jones, 1981; Wilson and others, 2006a, in press [a]). Chert was described by Hoare and Jones (1981) as gray and thin-bedded with shale partings or red siliceous silt and massive or thick-bedded gray, black, white, and brownish. They also described calcareous sandstone and shale, white crystalline limestone, and pyroclastic rocks altered to greenstone. Consists of unit TrPzm of Box and others (1993) in the Bethel quadrangle and part of unit MzPz of Hoare and Coonrad (1978) in the Goodnews Bay and adjacent Dillingham and Taylor Mountains quadrangles, which was subdivided based on work reported in Wilson and others (2006a, in press [a]). Unit crops out in the Tikchik Lakes area of the Bethel and Goodnews Bay quadrangles and extends into the adjacent Taylor Mountains and Dillingham quadrangles. The mélange may contain rocks of multiple map units described by Wilson and others (2006a, in press [a]). Unit is structurally complex and is dismembered along anastomosing cleavage (Box and others, 1993). According to Hoare and Jones (1981), "* * * the rocks were deformed twice by isoclinal folding and offset by northwest-trending high-angle faults and northwest-dipping low- and high-angle reverse faults. The older folds trend west or northwest; the younger folds are post-Cretaceous in age, trend northeast, and are commonly recumbent to the southeast." Unit structurally underlies greenstone and schist (unit MDv, here) to the northwest beneath a low-angle(?) fault, and it is juxtaposed against volcanic and sedimentary rocks (unti K₸vs, here) along the high-angle Togiak-Tikchik Fault (Box and others, 1993). Where rock units can be distinguished they are mapped separately, such as the limestone of Permian age (unit Ptls, here). Reported are Late Triassic and Permian megafossils and radiolarians of Paleozoic(?), Devonian, pre-Late Devonian, and Triassic age (Hoare and Jones, 1981; Box and others, 1993; see sample 50AHr240, for example, at www.alaskafossil.org, accessed July 30, 2015). The eastern exposures of map unit MzPzm, east of the Togiak-Tichik Fault, were included in the Tikchik terrane by Box and others (1993). West of the main part of the unit is a rock unit described by Box and others (1993) as a weakly to intensely fractured, foliated, black to green argillaceous mélange that contains discontinuous phacoids of radiolarian chert, limey sandstone, blocks of limestone, and subphyllitic, amygdaloidal basalt. These rocks crop out in the Eek Mountains near the southern boundary of the Bethel quadrangle. They are unconformably overlain by Cretaceous rocks of the Kuskokwim Group (unit Kk) and calcareous graywacke and siltstone (Kcgc). Conodonts of Permian age were found in limy siltstone, and Permian pelecypods (*Atomodesma* sp. fragments) were found in a basalt-limestone block (Box and others, 1993; see also samples 84JM145B or 84JM216A, for example, at www.alaskafossil.org, accessed July 30, 2015). Box and others (1993) included these western exposures, which are west of the Togiak-Tichik Fault, in the Goodnews terrane. On generalized map, included as part of unit Mzm

JPs **Calcareous and metabasaltic schist and phyllite (Early Jurassic to Permian)**—Consists of a number of interrelated map units defined by Hoare and Coonrad (1978) and Box (1985) in the Goodnews Bay and Hagemeister Island region of southwest Alaska. Consists of three main subunits; the rocks of the first subunit include recrystallized schistose and phyllitic calcareous sandstone, shale, limestone, limestone conglomerate, greenish tuffaceous rocks, mafic volcanic rocks, and volcanic conglomerate; the second subunit consists of metamorphosed conglomerate, sandstone, and shale; and the third subunit is partially to completely recrystallized glaucophane-hornblende epidote schistose rocks derived from mafic igneous rocks that include pillow basalt, angular volcanic breccia, diabase, and gabbro and associated sedimentary rocks that include pebbly mudstone, fine-grained tuffaceous sedimentary rocks, and rare chert (Box, 1985). Turbidite characteristics are locally preserved in clastic metasedimentary rocks. Mineral assemblages indicate greenschist to transitional greenschist-blueschist facies metamorphism (Box, 1985; Dusel-Bacon and others, 1996); structurally the unit shows evidence of multiple metamorphic events (Box, 1985). Metamorphic fabric is similar in all three subunits, which suggests that all three units were deformed during the same metamorphic event (Box, 1985). Locally, unit is structurally overlain by Devonian to Ordovician limestone and the Kanektok metamorphic complex (Wilson and others, 2013). West of Goodnews Bay, the unit structurally overlies Permian volcaniclastic rocks and underlies Permian limestone. Intruded by nonfoliated Middle Jurassic gabbroic rocks (unit Jgb). Schist has yielded K/Ar mica ages of 155±8 Ma and 150±8 Ma (Wilson and others, 2013), possibly related to a Late Jurassic thermal event suggested by Box (1985). The ages are suspect, however, because the $K_2O$ content of the mica (1.71 and 2.94 percent, respectively) is much lower than typical for mica (8 to 10 percent), suggesting alteration. A K/Ar cooling age on amphibole of 231.2±6.9 Ma (Wilson and others, 2013) from the metasedimentary rocks suggests Middle Triassic metamorphism; age is constrained to be older than the intrusion of Middle Jurassic gabbroic rocks. Age of protolith may be Permian or older (Hoare and Coonrad, 1978; Box, 1985). Main part of unit is spatially associated with a Triassic ophiolite complex

Pcs **Clastic and volcaniclastic rocks (Permian)**—These clastic rocks are typically associated with limestone of Permian age (unit Ptls). Exposed in two separate areas, the northern of the two exposures consists of well-bedded, cleaved sandstone, shale, thin limestone interbeds, and cobble conglomerate as described by Box and others (1993) in the Bethel quadrangle and extended by inference to the Taylor Mountains quadrangle (unit Pcs of Wilson and others, 2006a, in press [a]). The sandstone and conglomerate are composed predominantly of chert clasts (containing radiolarian ghosts and internal quartz veins) and minor phyllite and porphyritic volcanic clasts; the shale-rich section has thin limestone turbidite beds and thin beds of volcaniclastic composition (Box and others, 1993). Unit depositionally overlies the greenstone and schist (unit MDv) of Box and others (1993). Permian limestone (Ptls) is interbedded with this unit in many places in the Taylor Mountains quadrangle to the east (Wilson and others, 2006a, in press [a]). Conodonts of Middle(?) Triassic and Early Mississippian to Late

Devonian age were reported by Box and others (1993). With respect to the Devonian conodonts, Anita Harris (written commun., 1989) suggested they may have been derived from redeposited clasts or "interweaved" tectonic slices (see comments for sample 87AMM 69 at www.alaskafossil.org). The southernmost exposure of this unit in the Goodnews Bay quadrangle is composed of volcaniclastic sedimentary rocks, which range from coarsely bedded volcanic breccia to finely bedded calcareous tuffaceous rocks and include limestone cobble conglomerate and red to black laminated argillite with local radiolarian ghosts. Age constrained by several occurrences of fragmentary *Atomodesma* sp. fossils (Box, 1985)

Ptls **Limestone of southwest Alaska (Permian)**—Thin-bedded and massive light- to dark-gray, locally cream-colored, fine-grained recrystallized limestone; previously mapped and described as unit Pl of Hoare and Coonrad (1978) and Box (1985). Tuffaceous and locally cherty, unit has a fetid odor upon breaking (Hoare and Coonrad 1978; Box, 1985). Unit is commonly intercalated in the Togiak-Tikchik Complex and mélange units (KDt, MzPzm, respectively). Hoare and Coonrad (1978) reported the unit is "commonly closely associated with mafic volcanic rocks into which it grades through medium of calcareous breccias and tuffs." Commonly contains the pelecypod *Atomodesma* of Permian age, as well as crinoid stems, brachiopods, other pelecypods, and possible bryozoan reported (J.M. Hoare and W.H. Condon, unpub. data; Box, 1985; see many samples at www.alaskafossil.org, accessed July, 30, 2015). On generalized map, included as part of unit Plss

Crc **Rainbow chert (Carboniferous?)**—Mostly highly deformed white, gray, red, and minor green or black, thin-bedded to massive chert. Locally banded or brecciated and interbedded with minor red siliceous shale, argillite, dolomitic limestone, graywacke, and rare red volcanic rocks and agglomerate. Hoare and Jones (1981) reported Paleozoic(?) radiolarians in rocks of this unit along the shore of Chikuminuk Lake in southwest Alaska, as well as Permian megafossils in associated and presumably overlying limestone. One of their localities on the shore of Chikuminuk Lake yielded Triassic radiolaria, which is yet to be explained due to lack of map data, but may be due to the structural inclusion of slivers of younger rocks. East of Chikuminuk Lake, unit is apparently overlain by rocks of the Kuskokwim Group (unit Kk, here). Mertie (1938) considered these rocks to be Mississippian(?) in age; clearly a Mississippian age is highly speculative

MDv **Greenstone and schist (Mississippian? and Devonian?)**—Exposed in the eastern Bethel quadrangle, this unit consists of "weakly to moderately foliated and flattened pillowed and massive basalt, andesite, dacite, rhyolite flows, and breccia with greenschist metamorphic-mineral assemblages" and has whole-rock trace-element signatures that indicate an arc-alkaline arc affinity (Box and others, 1993). In the adjacent Taylor Mountains quadrangle, Wilson and others (2006a, in press [a]) described "Fine- to coarse-grained, massive green to purple altered greenstone, occasionally calcareous or schistose, rarely interbedded with green chert, argillite, and tuff. Greenschist with occasional chert boudins is a minor part of unit as is shale-chip agglomerate. Greenstone is locally cut by quartz and calcite veins containing epidote and copper sulfides" based on the 1969 and 1970 field notes of J.M. Hoare and W.H. Condon. Unit crops out near the head of Chikuminuk Lake. Unit is interbedded with the basal part of unit Pcs; clastic rocks and phyllite of map unit JTRp may overlie this map unit (Wilson and others, 2006a, in press [a]). Age inferred by Box and others (1993) on the basis of conodonts of Late Devonian to Early Mississippian age near the base of unit shown herein as Pcs. (Note that unit Pcs was mapped as Triassic to Devonian age by Box and others [1993].) A Permian age cannot be ruled out because of the association of these with clastic rocks of presumed Permian age (Pcs) and because of the Permian limestone (unit Ptls) interbeds in the Taylor Mountains quadrangle (Wilson and others, 2006a, in press [a]). Unit was included in the Tikchik terrane by Box and others (1993)

**Rock units of the Kisaralik anticlinorium of Box and others (1993) (Jurassic metamorphism, early Mesozoic or Paleozoic protolith)**—A structurally imbricate package of Mesozoic to Paleozoic deep-marine sedimentary and mafic volcanic rocks described by Box and others (1993). Subdivided into a number of lithologic packages by Box and others (1993), the metamorphic rocks are placed in a few composite units here. The structurally stacked units decrease in metamorphic grade downward from greenschist, through transitional greenschist-blueschist to prehnite-pumpellyite facies. These rocks are unconformably overlain by conglomeratic rocks of the Kuskokwim Group (unit Kkn), which provides an upper-limit age of Late Cretaceous for the metamorphism and protolith

MzPzgs **Green amphibole-bearing schist (Jurassic metamorphism)**—Schist recrystallized in part to greenschist metamorphic facies mineral assemblage of albite-epidote-chlorite-actinolite. Schist contains interbeds of thin-bedded, white or green metachert that contains white mica-rich laminae (Box and others, 1993); overlain by crystalline limestone, phyllite, and minor amounts of chlorite, graphite, and quartz-sericite schist (Hoare and Coonrad, 1959a). Mapped as Mesozoic to Paleozoic metabasalt and minor metachert (MzPzb) by Box and others (1993); protolith was diabase and basalt and "trace-element chemical compositions of lavas are similar to modem mid-ocean ridge basalts and range from light REE-depleted to slightly light REE-enriched varieties" (Box and others, 1993). Although protolith age is unknown, it was suggested to be Devonian to Ordovician by Hoare and Coonrad (1959a). Unit is bounded on west by the Golden Gate Fault; nearshore facies of the Kuskokwim Group (Kkn) depositionally overlie unit at the north end of its exposure. Age of metamorphism may be Late Jurassic based on a K/Ar age of 146.0±15.0 Ma on actinolite. MzPzgs is physically separate from the other rocks of this group; Box and others (1993) inferred that a thrust fault placed the other rocks of the anticlorinorium structurally over this schist. On generalized map, included as part of unit MzPzka

MzPzp **Phyllite of the Kisaralik anticlinorium (early Mesozoic or Paleozoic)**—"Relatively homogenous unit of finely foliated and crenulated phyllite ***. Protolith was probably fine-grained tuffaceous sediment of uncertain age. Structurally overlies unit MDm and is intruded by serpentinite of unit KJmu" Box and others (1993). Unit is strongly foliated and metamorphosed to greenschist facies. On generalized map, included as part of unit MzPzka

MzPzsk **Metasedimentary rocks of the Kisaralik anticlinorium (early Mesozoic or Paleozoic)**—Rocks that lie structurally below unit MDm and are of lower metamorphic grade; they include a variety of metachert, quartzite and phyllite units. Uppermost is "Finely crystalline, thin-bedded quartzites (metachert) and finely interlayered quartzite and black phyllite. Composed of fine aggregates of quartz with seams to centimeter-thick bands rich in fine-grained white mica. Recrystallized radiolarian tests present in some horizons. Thickness is uncertain" (Box and others, 1993). Unit is strongly foliated and metamorphosed to greenschist facies. Structurally below the quartzite and phyllite is "Strongly cleaved, medium-grained, generally thin-bedded, arkosic sandstone and slate. * * * Turbidite depositional features locally preserved. Thickness is uncertain" (Box and others, 1993). Intercalated (structurally?) in 100-m-thick zones with the chert and phyllite unit (Box and others, 1993). The chert and phyllite part of unit consists of "White, gray-green, and blue-green crystallized chert in 2- to 5-cm-thick beds interbedded with black to dark-green phyllite or slate beds of similar thickness. * * * Structurally(?) intercalated unit MzPzs" (Box and others, 1993). [MzPzs is Box and others' (1993) arkosic sandstone and slate unit, which is also included here.] "Turbiditic, thin-bedded, medium- to fine-grained, volcaniclastic sandstones, and dark-green to black argillites with weak to nonexistent slaty cleavage" (Box and others, 1993). Structurally, this sandstone and argillite subunit is both overlain and underlain by the arkosic sandstone and is locally overlain by the metachert subunit. The arkosic sandstone, chert and phyllite, and volcaniclastic sandstone subunits have a weak to strong slaty cleavage and are metamorphosed to the prehnite-pumpellyite facies (Box and others, 1993). On generalized map, included as part of unit MzPzka

MDm **Metabasalt and marble of the Kisaralik anticlinorium (Early Mississippian to Late Devonian)**—"Light-gray to white calcitic and dolomitic marble cut by pre-metamorphic basaltic dikes. * * * Locally contains as much as 20 percent clastic grains of feldspar, quartz, and plutonic rock fragments. Rare metamorphic blue amphiboles (magnesioriebeckite) in metabasaltic dikes indicate relatively high-pressure, low-temperature metamorphism (Sarah Roeske, Univ. of California-Davis, written commun., 1988). Ranges from 100 to 300 m thick. Unit found structurally above unit MzPzsk and structurally below unit MzPzp; original depositional relations are uncertain. Age constrained by conodonts of latest Devonian to earliest Mississippian age (Stephen Box and others, unpub. data)" (Box and others, 1993). Unit is metamorphosed to transitional greenschist-blueschist facies (Box and others, 1993; Dusel-Bacon and others, 1996). On generalized map, included as part of unit MzPzka

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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, serpentinized 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 serpentinized 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

KŦm **Kelp Bay Group, undivided (Cretaceous to Triassic)**—Consists of volcanic rocks, sandstone, chert, the mélange of the Khaz Complex (formerly Khaz Formation) of Karl and others (2015), the Pinnacle Peak Phyllite and the phyllite of Rodman Bay. Primarily exposed in the Sitka and Port Alexander quadrangles, also included here is an outlier of similar rocks associated with the Tarr Inlet Suture Zone in the Mount Fairweather and Skagway quadrangles. The undivided Kelp Bay Group consists of phyllite, quartzite, greenschist, greenstone, graywacke, and graywacke semischist and has been locally subdivided and mapped as two informal members, a sandstone member and a volcanic rocks and chert member, as well as the more formally defined members. The sandstone member consists of altered and recrystallized dull-green graywacke, volcanic wacke, turbiditic argillite, and subordinate polymictic conglomerate. Unit also includes gray and green, thin- to medium-bedded volcaniclastic turbidites and interbedded tuff (Karl and others, 2015). The volcanic rocks and chert member consists of dark-green, fine-grained pillow basalt flows and breccia that has meter-scale lenses of ribbon chert, subordinate mudstone and sandstone, and massive greenstone that may be sills or may have a volcaniclastic protolith. Geochemical analysis of the volcanic rocks indicate that compositions range from alkaline to tholeiitic, and trace elements plot in ocean floor, within plate, and island arc fields (Karl, 1982). The volcanic rocks and chert do not have a penetrative fabric, though locally the greenstone has a cataclastic or mylonitic texture (Karl and others, 2015). Karl and others (2015) reports that the volcanic rocks and chert member can be correlated with chert and volcanic rock units in the McHugh Complex in southern Alaska. Both the Kelp Bay Group and the McHugh Complex are considered part of the Chugach accretionary complex. Here we also include small slivers of serpentinite and partially serpentinized peridotite on Baranof Island that were found enclosed in the phyllite unit

Kkbm **Khaz Complex (Cretaceous and older)**—Formerly mapped as the Khaz Formation of the Kelp Bay Group, Karl and others (2015) renamed it the Khaz Complex, which reflects that the unit is a mélange and does not have an internal stratigraphy, nor clear stratigraphic relation to surrounding unit. The Khaz Complex includes chaotically deformed rocks composed of blocks of greenstone, greenschist, tuff, graywacke, argillite, chert, limestone, and phyllite in a foliated argillaceous and tuffaceous matrix (Johnson and Karl, 1985). Unit is dominantly slaty argillite and tuff enclosing blocks of varying lithology, where the blocks and matrix are disrupted and displaced along thrust, strike-slip, and extensional-slip faults (Karl and others, 2015). As shown here, unit also includes the Freeburn assemblage of Johnson and Karl (1985), a collage composed of kilometer-scale, fault-bounded, lozenge-shaped blocks of metasedimentary and metavolcanic rocks, which form a continuous belt on Chichagof and Yakobi Islands immediately west of the Border Ranges Fault. The dominant lithologies include tuffaceous argillite, tuff, massive greenstone, and graywacke turbidite. Other common lithologies include chert, limestone, and phyllite. Age of formation of the mélange is not well controlled; Brew and others (1988) reported late Tithonian (Late Jurassic) *Buchia fischherina* from argillite matrix, and Valanginian to Hauterivian radiolarians were reported from float near Sitka. Limestone blocks in the mélange contain poorly preserved scleractinian corals, and sandstone blocks contain *Buchia piochii*(?) of Tithonian age and *Buchia subokensis* and *Buchia okensis* of Berriasian (earliest Cretaceous) age (Karl and others, 2015). Potassium-argon ages of 98 to 95 Ma (Decker and others, 1980), on sericite concentrated from phyllite, yielded an apparent metamorphic age for the Khaz Complex of early Late Cretaceous. On generalized map, included as part of unit KŦm

JŦpp **Pinnacle Peak Phyllite (Jurassic or Triassic?)**—Pinnacle Peak Phyllite and the similar phyllite of Rodman Bay of Karl and others (2015) consist of dark-gray to black carbonaceous phyllite alternating on a meter to decameter scale with subordinate light green phyllite, metagraywacke, metachert, and thin layers of black marble. Protolith is inferred to be carbonaceous mudstone, graywacke, chert, and fine-grained mafic volcaniclastic rocks (Karl and others, 2015). Unit includes a significant amount of chloritic and graphitic schist, as well as graywacke semischist, phyllite, and nonfoliated metagraywacke turbidite and includes the highest grade metamorphic rocks in the Kelp Bay Group (Johnson and Karl, 1985). Graphitic phyllite is locally calcareous and contrasts with siliceous argillites of the Khaz Complex mélange. The unit is bounded by faults; stratigraphic relations to other components of the Kelp Bay Group are not clear (Karl and others, 2015). Inclusion of this unit within the Kelp Bay Group is considered provisional here. Age control is not definitive for this unit; Karl and others (2015) report a white mica $^{40}Ar/^{39}Ar$ age of 155 Ma from a quartz boudin in phyllite near Rodman Bay, which suggests that the phyllite is no younger than Late Jurassic. Loney and others (1975) inferred a Triassic age for the unit based on an apparent stratigraphic relation with the Whitestripe Marble (unit ŦRlm). Johnson and Karl, (1985) showed that the Pinnacle Peak does not have a stratigraphic tie to the Whitestripe Marble. Hence, assignment of a Triassic age to this unit is not justified on the basis of direct evidence. The Pinnacle Peak Phyllite is considered part of the Kelp Bay Group because of the inferred presence of retrograde high-pressure metamorphic minerals, which then are used to correlate this unit with blueschist-bearing units associated with the Border Ranges Fault System in southcentral and southwest Alaska (unit Jsch). These blueschist units, however, are not generally considered part of the Chugach accretionary complex (units Kaf, Kafv, Ksg, Kumc, and KŦRm). The character of Pinnacle Peak Phyllite is unique to the Kelp Bay Group part of the accretionary complex; S.M. Karl (unpub. data) suggests that the unit is a phyllonite. While this may hold for the Pinnacle Peak Phyllite proper, which is exposed in a long linear belt; all coauthors do not agree on whether this is likely for the phyllite of Rodman Bay part of the map unit, which does not have a similar outcrop pattern. On generalized map, included as part of unit KŦRm

Jurassic to Permian

JPk **Kakhonak Complex and Tlikakila complex of Carlson and Wallace (1983) (Jurassic, Triassic, and older?)**—Kakhonak Complex is a lithologically diverse and complex assemblage of metamorphosed mafic plutonic, volcanic, and sedimentary rocks found on west side of Cook Inlet, defined by Detterman and Reed (1980), associated with the Alaska-Aleutian Range batholith and similar rocks in the Talkeetna Mountains. Detterman and Hartsock (1966) mapped metalimestone, argillite, quartzite, metatuff, greenstone, and phyllite as undivided metamorphic rocks in the Kenai and Iliamna quadrangles. Detterman and Reed (1980) named these rocks the Kakhonak Complex and described unit that largely consists of roof pendants within the Alaska-Aleutian Range batholith and along the eastern margin of the Jurassic part of the batholith. They thought that the Kakhonak Complex represented, in part, the metamorphic equivalent of Upper Triassic Kamishak and Lower Jurassic Talkeetna Formations, which are in the vicinity. However, quartzite and quartz-mica schist within the Kakhonak Complex have no direct equivalent within the sedimentary rocks of the area, which indicates that other protoliths may have contributed to the complex. Because Permian rocks were known from Puale Bay, south of the map area, a possible Paleozoic age was not ruled out by Detterman and Reed (1980); subsequent analysis of Alaska Peninsula drill cores has conclusively demonstrated the presence of Paleozoic rocks on the peninsula (R.B. Blodgett, written commun., 2011). Internal contacts are typically faults, resulting in a tectonic mix of lithologies. Although most of the rocks of this complex are greenschist facies, the rocks range in metamorphic grade from not metamorphosed to granulite facies. Intrusive rocks provide a minimum age for the Kakhonak Complex. On the west side of the batholith, the lithologically similar Tlikakila complex of Carlson and Wallace (1983; see also Wallace and others, 1989; Amato and others, 2007) straddles Lake Clark and the Lake Clark Fault without apparent offset. Nelson and others (1983) mapped a unit somewhat more extensive than the Tlikakila complex as shown by Wallace and others (1989) or Amato and others (2007); Nelson and others (1983) described “a diverse complex of metamorphosed and highly deformed rocks, whose protoliths include calcareous to siliceous clastic rocks, limestone, thin-bedded chert, massive basalt, massive to layered gabbro and pyroxenite, and ultramafic rocks. Most of complex metamorphosed to greenschist facies but ranges from nonmetamorphosed to amphibolite facies” (Nelson and others, 1983). $^{40}Ar/^{39}Ar$ ages on mica from metasedimentary rocks range between 192 and 176 Ma (Amato and others, 2007) and provide a minimum age for metamorphism, which is somewhat older than K/Ar and U/Pb ages determined on nearby parts of the Jurassic phase of the Alaska-Aleutian Range batholith (unit Jgr, 172 to 160 Ma). Detrital zircon data from a single sample of chert-pebble conglomerate (Amato and others, 2007) potentially indicates a Paleozoic source terrane for the conglomerate. The age distribution of the zircons is similar to that for the Terra Cotta Mountains Sandstone (D.C. Bradley, oral commun., 2012; unit Stc here). Unit also includes migmatitic border rocks of the Jurassic plutons and undifferentiated metamorphic and plutonic rocks in the Talkeetna Mountains quadrangle (units Jpmu and Jgdm of Csejtey and others, 1978)

JŦRos **Newenham ophiolite complex (Jurassic and Triassic)**—Considered a dismembered ophiolite (Box, 1985; Decker and others, 1994), the ophiolite assemblage, as defined, also includes the serpentinized ultramafic rocks of Cape Newenham, which are included in map unit Jmu. Included here is aphanitic to porphyritic pillow basalt that contains interbedded pillow breccia, aquagene tuff, and inter-pillow and interbedded red and white radiolarian chert as described by Box (1985). Basalt is commonly amygdaloidal; abundant vesicles are filled with chlorite, clinozoisite, prehnite, pumpellyite, and (or) calcite. Box (1985) reported a number of radiolarian collections, but only two were age diagnostic, yielding Middle Triassic to Early Jurassic and Middle to Late Triassic ages.

Box (1985) considered the pillow basalt to be Late Triassic. Also part of the ophiolite is light-gray, medium-grained trondhjemite (Hoare and Coonrad, 1978; Box, 1985) in small bodies in the Hagemeister Island and Goodnews Bay quadrangles. Box (1985) indicated that, in addition to the mapped bodies, other small trondhjemite bodies occur within altered diabase near Cape Newenham. Locally, Box (1985) described the trondhjemite as "a northeast-dipping slab faulted above and below against schistose rocks * * *." Box (1985) tentatively assigned a Late Triassic age based on probable co-genesis with the Late Triassic pillow basalt (his unit Trub; unit J₸os here) and other components of the ophiolite, whereas Hoare and Coonrad (1978) assigned a Jurassic age based on the association of the trondhjemite with Jurassic gabbro and ultramafic rocks (unit Jmu). Additional components of the ophiolite include subophitic, holocrystalline plagioclase-clinopyroxene diabase and altered clinopyroxene gabbro that locally contains up to 5 percent orthopyroxene (Box, 1985), which locally grades into the diabase. Plagioclase is partially to completely replaced by a fine aggregate of albite, epidote, chlorite, calcite, and iron oxides. Box (1985) mapped the gabbro as a thrust sheet, and locally mylonite is found along contacts; similar mylonite is found sporadically along the contact between gabbro and structurally underlying diabase near Cape Newenham. Serpentinite, medium-grained serpentinized dunite, wehrlite, clinopyroxenite, and other ultramafic rocks form a number of intrusive bodies and tectonic blocks(?) within fault zones that separate the pillow basalt from the pyroxene gabbro (Hoare and Coonrad, 1978; Box, 1985). The margins of these bodies are cut by numerous coarsely pegmatitic hornblendite dikes that have contact metamorphic zones as much as 800 m wide (Box, 1985). According to Box (1985), the northeast flank of one ultramafic body appears to grade into hornblende gabbro of map unit Jgb, which yielded a K/Ar age of 162.4±4.9 Ma—significantly younger than the dated dikes that cut another one of the ultramafic bodies, whose K/Ar ages were 186.9±5.6 Ma and 176.4±5.3 Ma on amphibole from the cross-cutting hornblendite dikes

## PALEOZOIC TO PROTEROZOIC

Pz₽nc **Nome Complex, undivided (early Paleozoic to Proterozoic)**—A wide variety of largely metasedimentary rocks and some metaigneous rocks was renamed the Nome Complex from the earlier named Nome Group because the unit does not represent related lithostratigraphic units, but rather a structurally deformed assemblage on the Seward Peninsula (Till and others, 2011). In addition to common metamorphic features, the units of the Nome Complex also display common structural features (Till and others, 2011). Till and others (2011) recognized three main components in the Nome Complex; the dominant one they called the "layered sequence," which consists of mappable lithologic units that occur in a consistent, layer-cake structural relation to one another over much of central Seward Peninsula. The layered sequence is represented here by units Pzncs, DOnx, Ocs, Onim, and ₽ngn. A subunit of granitic orthogneiss in the layered sequence is included in unit Dogn and a subunit of felsic schist is included in unit Das because of their clear correlation with those other map units in northern Alaska. Unit Pznp of the layered sequence is separated here into what Till and others (2011) called the "low-grade layered sequence" because it is of significantly lower metamorphic grade than other rocks of the layered sequence. A second component, called the "scattered metacarbonate rocks" (Till and others, 2011) consists of volumetrically minor dolostone and marble that are widely distributed on the Peninsula and are included here in the undivided Nome Complex. The final component, named "metaturbidites" (Till and others, 2011) is exposed only on the north and southeast coast of the Seward Peninsula and is here included in unit DЄmt. The descriptions here are largely abstracted from Till and others (2011), but some units described by Till and others (2011) have been grouped here, and, as mentioned above, some have been included with correlative rocks that outcrop elsewhere in northern Alaska. Analysis of available data by Till and others (2011) for the Nome Complex and for correlative rocks in the Brooks Range and Ruby geanticline suggests that the blueschist metamorphic event that affected the Nome Complex occurred during the Late Jurassic. Subsequent lower-pressure greenschist metamorphic-facies assemblages overprint the blueschist assemblages; the best estimate for the timing of the greenschist episode is during the middle Cretaceous (A.B. Till, oral commun., 2012). In this undivided Nome Complex unit, we have included Till and others' (2011) units Pznm, Pzm, Ddm, Sd, Od, Cd, and PzPxm. Their map units lumped together here, all carbonates of different ages, are typically light- to medium-gray, fine-grained marble and dolostone and coarsely crystalline marble, and also include medium- to dark-gray-weathering, dark-gray to black dolostone, metalimestone and marble and minor associated chert. The unit is widely distributed on the Seward Peninsula and in the western parts of the adjacent Candle and Norton Bay quadrangles. Fossils ranging in age from Early Cambrian to Late Devonian have been collected from these carbonate rocks; one conodont collection in the eastern Bendeleben quadrangle may be Early Mississippian in age (Till and others, 2011). Available data suggest that rocks of Devonian age form the dominant part of unit, but a number of the subunits defined by Till and others (2011) lack specific age control and are presumed to be Paleozoic in age. Well-defined conodont collections and megafauna definitively indicate the presence of Devonian, Silurian, and Ordovician rock units, and all suggest shallow, warm-water biofacies, although at least one collection, of middle to late Early Ordovician age, indicates a cooler and (or) deeper water setting (Till and others, 2011). The limited exposures of Cambrian dolostone and more widely exposed black marble (in unit D€mt) in the Nome Complex "contain lapworthellids, a phosphatic microfossil indicative of Early (to possible early Middle) Cambrian age and a shallow-water depositional environment" (Till and others, 2011) Subdivided into three broad categories described below: a low-grade layered sequence, a layered sequence, and metaturbidites

**Low-grade layered sequence**

Pznp **Metagabbro and metasedimentary rocks (Paleozoic?)**—Metagabbro and poorly exposed metasedimentary rocks on the western side of the Kigluaik Mountains exposed in tors and rubble (Till and others, 2011). Unit description derived from Till and others (2011) for their unit Pznp. Coarse-grained metagabbro bodies form flat-topped hills generally less than a kilometer across; one body exposed along sea cliffs is 9 km long. Metasedimentary rocks include metagraywacke and tuffaceous metasedimentary rocks, and both metaigneous and metasedimentary rocks preserve original igneous and sedimentary features. Metagabbro is geochemically similar to metabasite from Till's units Ocs and DOx (Ayuso and Till, 2007; units Ocs and DOnx, here). The geometries of outcrop-scale structures are similar to those in the more completely recrystallized and deformed part of the Nome Complex. Hannula and others (1995) reported three pumpellyite- and actinolite-bearing samples from northern parts of the unit and one crossite-bearing sample from the central part, which indicate that metamorphic grade increases from northwest to southeast within the unit. The contact between Till and others' (2011) units Pznp and Ocs to the southwest corresponds to the garnet isograd of Hannula and others (1995). Pznp may be equivalent to Ocs

**Layered sequence**

Pzncs **Younger schist (Devonian and Silurian?)**—Unit is a composite of units best described by Till and others (2011, units Dcs and Ds) and consists of pelitic, calcareous, and graphitic schist interlayered on a scale of centimeters to meters in the Nome and Solomon quadrangles. Unit is predominantly pale-brown and gray, weakly to well foliated schist that consists primarily of plagioclase, calcite, quartz, white mica, and graphite. Pelitic schist weathers light- to dark-gray and contains chloritoid, glaucophane, or pseudomorphs of chlorite and albite after glaucophane, and rarely, garnet. Calcareous schist is light- to dark-brownish-gray and commonly contains chloritoid and rare garnet, as well as dolomite. Locally gray pelitic schist is interlayered with orange- or brown-weathering impure marble, calcareous schist, or mica- and graphite-rich schist. Dark-gray- to black-weathering, graphitic, locally micaceous schist "contains mm-scale laminae enriched in graphite, white mica, and iron oxide, and occurs in layers meters to tens of meters thick" (Till and others, 2011). Unit Dcs of Till and others (2011) consists of pelitic, calcareous, and graphitic schist and typically does not outcrop; rather, it usually occurs as loose rubble on hills, or in stream cuts; in low areas unit is covered by tundra. Unit Ds, Till's pelitic schist unit, forms tors of resistant, well-foliated quartz-rich schist; pelitic schist is the dominant lithology in this unit and calcareous schist is minor. This schist also contains chloritoid and locally graphite, glaucophane, and garnet. Many detrital zircon samples collected from the Dcs unit contain small populations of Middle and Late Devonian zircons and large populations of early-middle Silurian zircons, as well as older populations (Till and others, 2006b, 2008b). Only a single sample from Ds yielded sufficient detrital zircons for analysis; the youngest zircon population contains grains that are Early to Middle Devonian (Till and others, 2006b). Till and others (2011) described a distinctive white to light gray, generally impure marble that occurs in small lenses within or adjacent to this unit in the Nome quadrangle. The clast-bearing marble typically contains sand- to pebble-size clasts of dark-gray to black, organic-rich marble. Most clast-bearing intervals appear to be clast-supported, some may be graded, and the clasts are rounded to angular, commonly laminated, and generally about 2 cm in diameter, though some are as big as 12 cm long. Two collections of conodonts having CAI values of 5 are known. "One collection yielded a single element of Silurian(?) through Triassic age. The other collection, also a single conodont, is an Sb element of late Permian through Triassic (likely Triassic) age" Till and others (2011). Till and others (2011) suggest that the Triassic marble was juxtaposed with the rocks of the Nome Complex prior to metamorphism and, therefore, chose to not extend the protolith age of the Nome Complex to Triassic; the Jurassic metamorphism of the unit (Armstrong and others, 1986) provides an upper limit for the age of the protolith of the unit. On generalized map, included as part of unit PzZncl

DOnx **Marble, graphitic rocks, and schist (Devonian to Ordovician?)**—Interlayered pure and impure marble, graphitic metasiliceous rock, pelitic schist, calc-schist, and mafic schist, unit DOx of Till and others (2011) is defined, in part, by a position structurally below the Casadepaga Schist (unit Ocs, here). The most common rock types are gray- and orange-weathering, pale-gray to white, coarse crystalline marble forming rounded ridges that may extend along strike for several kilometers, and generally homogeneous, dark gray-black-weathering graphitic metasiliceous rock forming rounded hills that can be recognized from great distances (Till and others, 2011). Good exposures are rare; minor lithologies generally do not crop out. Lithologic units vary in thickness along strike on a scale of kilometers, a characteristic that may be depositional as well as structural. "In the western Solomon quadrangle and Nome quadrangle, there is a consistent general stacking pattern of lithologies within DOx. The structurally upper part of the unit is composed of mixed schist and marble, including pelitic schist, gray marble, orange-weathering impure marble, black schistose marble, and black metasiliceous rock * * * interlayered on scale of meters and decameters. The uppermost lithology is commonly an orange-weathering chlorite marble * * *. The structurally lower parts of the unit are dominated by gray marble or black metasiliceous rock. Where the gray marble is dominant, it reaches thicknesses of 1–2 km and contains minor thin (less than 50 meters) layers of metaquartzite, pelitic schist, and chlorite-albite schist. Where the black metasiliceous rock is dominant, it reaches thicknesses of around 500 meters. It is underlain by 10–30 meters of gray marble interlayered with thin bands of pelitic schist" (Till and others, 2011). Metabasite that consists of boudins or layers of glaucophane-epidote-garnet bearing metabasite, or chlorite-albite-actinolite-bearing metabasite, similar to that found in the Casadepaga Schist (unit Ocs), is found in both the mixed schist and marble package and within the gray marble and black metasiliceous rock. "The age range of DOx is not strictly known. Conodonts of Ordovician age were obtained from relatively pure marble in the Solomon quadrangle; marble in the Nome quadrangle produced conodonts of early Paleozoic age. * * * Recrystallized radiolarians collected in the northern Darby Mountains in banded calcite-bearing graphitic metasiliceous rock are of probable pre-Devonian age (B.K. Holdsworth, written commun., 1985)" (Till and others, 2011). In the Teller quadrangle "* * * conodonts of late Silurian-Devonian age have been recovered from two localities; a third locality produced a fauna of Silurian (late Llandovery-Ludlow) age. Sedimentary structures and conodont biofacies suggest a warm, shallow-water depositional setting. Faunal and lithofacies data indicate that these rocks may correlate, at least in part, with unit Sd [unit P̶zncm, here] in the Nome Complex * * *. Shallow-water Silurian rocks also occur widely in the Brooks Range" (Till and others, 2011). Three detrital zircon samples have been collected from the unit on the southern Seward Peninsula. One yielded largely Neoproterozoic zircons, another yielded zircon populations as young as Silurian, and the third yielded a robust population of Middle and Early Devonian zircons (J.M. Amato, Univ. of New Mexico, written commun., 2008); apparently part of this unit must be Devonian or younger (Till and others, 2011). On generalized map, included as part of unit P̶zZncl

Ocs **Casadepaga Schist (Ordovician)**—Light green, silvery green and greenish-brown mafic, feldspathic, and calcareous schist interpreted to have a largely igneous protolith. "Tors of metabasite, abundant plagioclase porphyroblasts in dark-green, chlorite-rich schist, and the quartz-poor nature of the rocks are characteristic of this unit" (Till and others, 2011). Smith (1910) provides illustrations that demonstrate characteristics that strongly suggest an intrusive igneous character of this unit. Dark-green-weathering schist is interpreted to be metamorphosed mafic rock and is rich in chlorite, epidote, actinolite, and plagioclase (Till and others, 2011). Medium- to pale-grayish-green-weathering pelitic schist is common; plagioclase, chlorite, white mica, and quartz are the dominant minerals, present in roughly equal amounts, and epidote, carbonate, and glaucophane (or pseudomorphs of chlorite and plagioclase after glaucophane) are also typical minerals of many of these schists (Till and others, 2011). Based on major-element chemistry, the protoliths of these pelitic schists were shale and graywacke (Werdon and others, 2005). Carbonate-rich schist layers are typically buff- or pale-brown-weathering and tend to be more recessive in outcrop than other lithologies. Pure carbonate layers are rare and thin and weather pale brown, black, or gray (Till and others, 2011). Greenish-black boudins, lenses, and layers of fine- to coarse-grained, massive metabasite in tors within the unit are composed of glaucophane, actinolite, chlorite, epidote, garnet, albite, white mica, titanite, and locally quartz, Fe-carbonate, pyroxene, and barroisite. No direct evidence exists for the age of this unit (Till and others, 2011). Seven detrital zircon samples, collected from widely distributed parts of the unit, contain very similar grain populations; most grains fall into the range of 700–600 Ma; several samples contain small populations of Ordovician or Cambrian grains (Amato and others, 2003; Till and others, 2006b; 2008b, 2011). No fossils have been found in the Casadepaga Schist, but its age may be somewhat constrained by its inclusion in the layered sequence with units DOnx and Onim, both of which contain Ordovician conodonts. On generalized map, included as part of unit P̶zZncl

Onim **Impure marble (Ordovician)**—"Buff- to orange-weathering, chlorite-, white mica-, and albite-bearing calcite marble that underlies rounded hills. The unit crops out poorly; rare outcrops show well foliated impure marble to calcareous schist. Impurities are most commonly chlorite and albite. Lenses (up to a meter across) and fine layers of chlorite and albite are diagnostic of the unit, and [they] trace [the] foliation and folds. Chlorite-albite lenses and layers are more abundant near the base of the unit; pods of fine-grained metabasite are also more common in the lower part of the unit. The pods can be recognized in the field as piles of massive medium-gray rubble several meters across; one is 0.5 km across. In rare instances the unit may include pure marble or orange-weathering dark-gray dolostone. The unit is a minimum of 1.2 km thick. Conodonts of Early through

Middle Ordovician age have been obtained from a dolostone lens in the upper part of the unit in the Solomon D-6 quadrangle * * *" (Till and others, 2011). On generalized map, included as part of unit PzZncl

Zngn **Metagranitic rocks (Neoproterozoic)**—Pale-gray to pale-greenish-tan, locally green-weathering, small granitic, granodioritic, and tonalitic orthogneiss bodies in rubble-crop and outcrop (Till and others, 2011). Weakly to well foliated, fine- to coarse-grained, with foliation defined by weak to strong alignment of micas. Coarsest grained varieties may contain lozenge-shaped feldspar grains and thin, millimeter-thick lenses of quartz that also parallel foliation. Plagioclase and quartz, ± microcline, are dominant phases; chlorite, biotite, and white mica are minor phases and are associated with epidote, garnet, and calcite at some localities (Till and others, 2011). Phengitic white mica compositions in microcline-bearing orthogneiss bodies are consistent with crystallization at blueschist-facies conditions (Evans and Patrick, 1987). In outcrop, foliation parallels the surrounding schist; the metagranitic rocks were apparently folded in with metasedimentary rocks of the Nome Complex during the Mesozoic. Detrital zircons from metasedimentary rocks of unit Ocs of Till and others (2011), collected immediately adjacent to part of this unit in east-central Nome quadrangle, include a significant 600-Ma population, which is younger than the metagranitic rock (669±5 Ma; Till and others, 2006b). Late Proterozoic (Neoproterozoic) intrusive age based on several U/Pb zircon analyses that range from approximately 685 to 665 Ma (Patrick and McClelland, 1995; Amato and Wright, 1998; Till and others, 2006b, 2011). On generalized map, included as part of unit PzZncl

**Metaturbidites**

D€mt **Metaturbidite marble and calcareous schist (Devonian to Cambrian)**—Consists of three units of Till and others (2011). First, their unit D€bm is dark-gray to black marble and subordinate impure fissile marble, calcareous schist, and mafic schist that is best exposed in sea cliffs along Norton Bay and in rubble-covered hills inland. Marble is in layers 1 to 20 cm thick and has rhythmically alternating purer, coarse-crystalline and more impure, fine-crystalline layers. Green-weathering, fine-grained chlorite, actinolite, albite, and white mica assemblages that Till and others (2011) interpreted to be mafic dikes, sills, and plugs intruding the carbonate rocks are common. Glaucophane inclusions are found in the albite. Till and others (2011) report that contact metamorphic effects are preserved, including bleached carbonate rocks and skarn assemblages. Mafic minerals also commonly form layers or are disseminated in the fine crystalline carbonate rocks, suggesting that some mafic volcanism accompanied deposition of the carbonate strata. Seven conodont faunas were obtained from six localities in this subunit. Two faunas are middle to early late Silurian, one is middle Early Devonian, and one is late Silurian to Early Devonian. Two faunas from westernmost exposures are considerably older: middle Early through Late Ordovician and Early Cambrian. Thus, there is a gap of over 100 million years between the oldest and youngest faunas; Till and others (2011) infer a number of scenarios to explain the gap, possibly involving limited collection and therefore missing intervals, hiatus, and (or) reworking of older units. The second of Till and others' units (DObm) that we include in this unit consists of dark-gray to black metalimestone and marble and subordinate dolostone exposed in sea cliffs on Kotzebue Sound. "A 15- to 20-m-thick interval of dominantly matrix-supported carbonate breccia, with rounded and angular clasts as much as 5 m in diameter, occurs in the section, as well as thinner (≤1 m thick) intervals of carbonate-clast breccia. Local solution collapse features occur, and dedolomitization textures were seen in thin sections. Subordinate argillite, phyllite, and radiolarian chert are found about 2.4 km west of Cape Deceit; quartz-graphite schist and impure marble (containing as much as 20% graphite, quartz, albite, and white mica) are abundant in the western exposures" (Till and others, 2011). This subunit "has yielded tightly dated fossil collections of Middle Ordovician through late Silurian age and some longer ranging collections that could be as young as Devonian (Ryherd and Paris, 1987). The argillite-dominated interval west of Cape Deceit contains abundant Middle and Late Ordovician graptolite assemblages, as well as Ordovician conodonts (Ryherd and Paris, 1987; Harris and others, 1995; Ryherd and others, 1995; Dumoulin and others, 2002). Higher in the unit, a continuous section of allodapic carbonate rocks, at least several hundred meters thick, produced a middle to late Silurian (Wenlock to Ludlow) conodont succession (Dumoulin and others, 2002). Several conodont collections from eastern exposures of the unit could be as young as Devonian" (Till and others, 2011). Subunit three (Till and others' [2011] unit D€ks) is a dark-brownish-gray, rust-spotted, well-foliated, medium-grained schist composed predominantly of quartz, calcite, white mica, chlorite, plagioclase, and graphite. It locally shows millimeter-scale dark to light layering. It is interlayered on a meter to kilometer scale with the other subunits upon which its age was assigned

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## BEDROCK

bu **Bedrock of unknown type or age or areas not mapped**

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[*, Provisional regional maps published for the state digital compilation; #, sources that appear in digitial databases; +, sources that are used in the radiometric age databases]


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**Table 2.** Alphabetical list of map units.

[**Map unit label**: Label for generalized unit on printed map. **Map unit name**: *bold*, generalized unit shown on printed map; *not bold*, component unit included in generalized unit on map (described in Description of Map Units and included in digital files, but not shown on generalized map as separate unit). Names within parentheses indicate higher level groups that include map unit; Angayucham is an abbreviation for the group "Angayucham, Tozitna, and Innoko assemblages and Rampart Group." **Age or stratigraphic position**: Relative age or stratigraphic position of map unit (*bold*) or component map unit (*not bold*). **Region (fig. 2, sheet 1)**: AL, Aleutian Islands; AP, Alaska Peninsula; CN, central; EC, east-central; NE, northeast; NR, northern; NW, northwest; SC, south-central; SE, southeast; SO, southern; SP, Seward Peninsula; ST, statewide; SW, southwest; WC, west-central. **Page No.**: Location of description of map unit or component unit in Description of Map Units. Labeled units without page numbers do not have separate descriptions in the Description of Map Units (see component unit descriptions)]

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| bu | **Bedrock of unknown type or age or areas not mapped** | **unknown** | ST | 142 |
| CDbrv | **Volcanic rocks and sills** | **Pennsylvanian? to Devonian** | | |
| | Clgv—Volcanic rocks and sills associated with Lisburne Group | Pennsylvanian? and Mississippian | NR | 87 |
| | MDtv—Tuffaceous volcanic rocks | Mississippian? to Devonian | NW | 121 |
| | Dv—Metavolcanic rocks and sills | Devonian | NR | 123 |
| Clg | **Lisburne Group, undivided** | **Carboniferous** | NR | 50 |
| Clgne | **Wahoo, Alapah, and Wachsmuth Limestones (Lisburne Group)** | **Middle Pennsylvanian to Mississippian** | | |
| | ℙlgw—Wahoo Limestone | Middle and Lower Pennsylvanian and Upper Mississippian? | NE | 51 |
| | Mlga—Alapah Limestone | Upper Mississippian | NE | 52 |
| | Mlgw—Wachsmuth Limestone | Mississippian | NE | 52 |
| Clgtk | **Tupik and Kogruk Formations (Lisburne Group)** | **Pennsylvanian to Upper Mississippian** | | |
| | Clgt—Tupik Formation | Pennsylvanian and Upper Mississippian | NW | 50 |
| | Clgk—Kogruk Formation | Upper Mississippian | NW | 50 |
| Crc | **Rainbow chert (Togiak-Tikchik Complex)** | **Carboniferous?** | SW | 135 |
| Єa | **Adams Argillite** | **Cambrian** | EC, NE | 73 |
| ЄꝐt | **Tindir Group** | **Cambrian? and Proterozoic** | EC, NE | 73 |
| ЄꝐwg | **Wales Group, undivided** | **Cambrian to Proterozoic** | SE | 128 |
| | ЄꝐwgm—Wales Group marble | Cambrian to Proterozoic | SE | 129 |
| ЄꝐwn | **Wickersham and Neruokpuk units** | **Cambrian and Proterozoic** | EC, CN, NE | 73 |
| Das | **Bimodal metavolcanic rocks** | **Devonian** | NR | 122 |
| Dbf | **Beaucoup Formation, undivided** | **Devonian** | NR | 56 |
| | Dbfl—Limestone and similar rocks | Upper and Middle Devonian | NR | 56 |
| | Dbfw—Wacke member | Upper Devonian | NR | 56 |
| Dcc | **Karheen and Cedar Cove Formations** | **Devonian** | SE | 63 |
| DЄbg | **Baird Group and similar rocks** | **Middle Devonian to upper Cambrian** | NE, NW | 64 |
| | Dke—Kugururok Formation and Eli Limestone | Devonian | NE, NW | 65 |
| DЄmt | **Metaturbidite marble and calcareous schist (Nome Complex)** | **Devonian to Cambrian** | SP | 142 |
| DЄsp | **Schist and phyllite of the Alaska Range** | **Devonian or older** | | |
| | Pzarqm—Pelitic and quartzose schist of the Alaska Range | Devonian or older | SC | 124 |
| | DOmvs—Yanert Fork sequence of Csejtey and others (1992) and correlative rocks | Devonian to Ordovician? | SC | 124 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| D€wbl | **Farewell basinal facies carbonate rocks** | **Devonian or older** | | |
| | D€d—White Mountain sequence, basinal facies | Devonian to Cambrian or older | SW, WC | 59 |
| | DSbr—Barren Ridge Limestone and correlative units | Devonian to Silurian? | WC | 59 |
| | DSpf—Paradise Fork Formation and correlative units | Lower Devonian and Silurian | SW | 60 |
| Degh | **Hunt Fork Shale (Endicott Group)** | **Devonian** | NR | 54 |
| Degn | **Noatak Sandstone (Endicott Group)** | **Upper Devonian** | NR | 54 |
| Dgb | **Gambier Bay Formation, undivided** | **Devonian** | SE | 122 |
| | Dgbm—Marble of the Gambier Bay Formation | Devonian | SE | 122 |
| DOgi | **Older plutonic rocks of southeast Alaska** | **Early Devonian to Ordovician** | | |
| | DOgi—Syenite, trondhjemite, and granite | Early Devonian to Ordovician? | SE | 108 |
| | Ogi—Granodiorite and related rocks | Ordovician | SE | 108 |
| DOls | **Thin-bedded limestone** | **Lower Devonian to Ordovician** | SW | 66 |
| DOsc | **Shale, chert, and argillite** | **Lower Devonian to Ordovician** | | |
| | DOka—McCann Hill Chert, Road River Formation, and Troublesome unit of Weber and others (1992) | Lower Devonian to Ordovician | EC | 66 |
| | DOhb—Hood Bay Formation | Lower? Devonian to Ordovician | SE | 66 |
| | St—Turbidite deposits of southeast Alaska | Silurian | SE | 69 |
| | Slc—Lost Creek unit | Silurian | CN | 70 |
| DOtu | **Metasedimentary and metavolcanic rocks of Tukpahlearik Creek, undivided** | **Devonian to Ordovician** | NW | 123 |
| | DOtu—Metasedimentary and metavolcanic rocks of Tukpahlearik Creek, undivided | Devonian to Ordovician | NW | 123 |
| | DOtm—Marble of Tukpahlearik Creek | Devonian to Ordovician | NW | 124 |
| | DOtp—Pelitic schist and metavolcanic rocks of Tukpahlearik Creek | Devonian to Ordovician | NW | 124 |
| DPcn | **Metasedimentary and metavolcanic rocks of the Central Belt and Northern Thrust assemblage of Till and others (2008a)** | **Devonian to Proterozoic** | | |
| | DPasm—Mixed assemblage of metasedimentary and metavolcanic rocks in the Brooks Range | Devonian to Proterozoic | NR | 126 |
| | DPsgm—Schist, paragneiss, and marble | Devonian to Neoproterozoic | NR | 125 |
| | Sbs—Black phyllite and metalimestone | Silurian | NR | 127 |
| | PzPb—Metasedimentary rocks of Bluecloud Mountain | Early Paleozoic to Proterozoic? | NR | 129 |
| DPga | **Gneiss, amphibolite, schist, quartzite, and marble (Yukon-Tanana crystalline complex)** | **Devonian or older** | | |
| | Pzyms—Mafic schist and amphibolite | Devonian or older Paleozoic | EC | 117 |
| | PzPybg—Biotite gneiss, marble, schist, quartzite, and amphibolite | Devonian or older | EC | 117 |
| DPnl | **Older carbonate rocks of northern Alaska** | **Lower Devonian to Proterozoic?** | | |
| | DZnl—Mount Copleston Limestone and Nanook Limestone | Lower Devonian to Ediacaran | NE | 65 |
| | OPls—Limestone, northern Alaska | Ordovician through Proterozoic? | NR | 72 |
| DPsb | **Brooks Range schist belt** | **Devonian to Proterozoic** | | |
| | DPaqm—Quartz-mica schist of the Brooks Range | Devonian to Proterozoic | NR | 125 |
| | DPacs—Calcareous schist of Brooks Range | Devonian to Proterozoic | NR | 126 |

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| DⱣsq | **Pelitic schist and quartzite and mafic interbeds (Yukon-Tanana crystalline complex)** | **Devonian and older** | | |
| | PzⱣyqs—Quartzite and pelitic schist | Devonian and older | EC | 116 |
| | PzⱣyqm—Pelitic schist, including Chena River sequence | Devonian and older | EC | 117 |
| DSsm | **Shallow-marine, carbonate-dominated rocks** | **Devonian and Silurian** | | |
| | DSld—Shallow-marine, carbonate-dominated rocks | Devonian and Silurian? | CN | 62 |
| | Dlse—Carbonate rocks of southeast Alaska | Devonian | SE | 63 |
| | DSt—Tolovana Limestone | Middle Devonian to Silurian, Llandovery? | CN | 64 |
| | Dof—Ogilvie Formation | Middle to Lower Devonian | CN | 64 |
| | Sl—Limestone, southeast Alaska | Silurian | SE | 70 |
| DSum | **Older ultramafic rocks of southeast Alaska** | **Devonian and Silurian** | SE | 108 |
| DSv | **Basalt, andesite, and sedimentary rocks** | **Devonian** | | |
| | Dfr—Freshwater Bay and Port Refugio Formations | Late Devonian | SE | 87 |
| | Dmv—Mixed volcanic rocks of southeast Alaska | Middle to Early Devonian | SE | 87 |
| | Sv—Volcanic rocks in southeast Alaska | Silurian | SE | 88 |
| Dvec | **Woodchopper Volcanics and Schwatka unit of Weber and others (1992)** | **Devonian** | EC | 87 |
| DZwp | **Farewell platform facies** | **Upper Devonian, Frasnian, to Neoproterozoic** | SW | 61 |
| | DSwc—Whirlwind Creek Formation and correlative units | Upper Devonian, Frasnian, through Silurian, Ludlow | SW | 61 |
| | Ols—Lime mudstone | Ordovician | SW | 61 |
| | ЄZls—Dolostone, limestone, orthoquartzite, and minor chert | Cambrian and Neoproterozoic? | SW, WC | 62 |
| DZyf | **Clastic and carbonate rocks of the Yukon Flats Basin** | **Devonian to Neoproterozoic?** | | |
| | Dnr—Nation River Formation | Upper and Middle? Devonian | EC | 57 |
| | Dcr—Cascaden Ridge and Beaver Bend combined correlative units | Devonian | CN | 57 |
| | Dq—Quail unit of Weber and others (1992) | Upper Devonian | CN | 57 |
| | Dyp—Phyllite, slate, and black shale | Devonian? | NE | 57 |
| | Dyss—Clastic and calcareous clastic rocks | Devonian | NE | 58 |
| | Pzpr—Older clastic strata of the Porcupine River sequence of Brosgé and Reiser (1969) | Lower Paleozoic | NE | 58 |
| | DZkb—Older carbonate strata of the Porcupine River sequence of Brosgé and Reiser (1969) and equivalent units | Middle Devonian to Neoproterozoic? | CN, NE | 58 |
| DZyk | **Sedimentary and metasedimentary rocks of York terrane** | **Lower Devonian to Ordovician** | | |
| | Pzgp—Phyllite and argillite, Grantley Harbor Fault Zone | Lower Paleozoic | SP | 67 |
| | DSyl—Limestone of the Seward Peninsula | Lower Devonian and (or) Silurian | SP | 67 |
| | SOyl—Dark limestone | Silurian and Upper Ordovician | SP | 67 |
| | SOyld—Limestone, dolostone, and shale | Silurian and Ordovician | SP | 67 |
| | Oyl—Argillaceous limestone and limestone | Middle and Lower Ordovician | SP | 68 |
| Jag | **Bokan Mountain peralkaline granite and syenite** | **Middle Jurassic** | SE | 103 |
| JDmc | **Mystic structural complex, undivided** | **Jurassic to Devonian** | SW | 37 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| JDoc | **Igneous rocks (Angayucham)** | **Jurassic to Devonian** | NE, NR, SW, WC | 30 |
| Jegr | **Intermediate to mafic plutonic rocks** | **Early Jurassic** | | |
| | Jg—Plutons of the Yukon-Tanana Upland | Early Jurassic | EC | 104 |
| | Jhg—Plutonic rocks of Hidden terrane | Early Jurassic | SC | 104 |
| | Jegd—Granodiorite of Hagemeister Island | Early Jurassic | SW | 104 |
| Jk | **Graywacke of Kulukak Bay of Hoare and Coonrad (1978)** | **Upper to Middle Jurassic** | SW | 39 |
| Jlmgr | **Plutonic rocks** | **Late and Middle Jurassic** | | |
| | Jtr—Trondhjemite | Jurassic | SC, SW, WC | 100 |
| | Jise—Granitic rocks of southeast Alaska | Jurassic | SE | 100 |
| | Jgr—Jurassic phase, Alaska-Aleutian Range batholith, undifferentiated | Jurassic | SC, SW | 102 |
| | Jit—Spruce Creek tonalite | Middle Jurassic | SP | 103 |
| JMct | **Cherty tuff and breccia (Angayucham)** | **Jurassic? to Mississippian** | WC | 31 |
| JMps | **Clastic and carbonate rocks, Porcupine River region** | **Jurassic to Mississippian** | | |
| | JMpu—Younger strata of the Porcupine River sequence of Brosge and Reiser (1969), undivided | Jurassic to Mississippian | EC, NE | 39 |
| | JMsu—Strangle Woman Creek sequence of Brosgé and Reiser (1969), undivided | Jurassic to Mississippian | EC | 39 |
| JPk | **Kakhonak Complex and Tlikakila complex of Carlson and Wallace (1983)** | **Jurassic, Triassic, and older?** | SC, SW | 138 |
| JPs | **Calcareous and metabasaltic schist and phyllite (Togiak-Tikchik Complex)** | **Early Jurassic to Permian** | SW | 134 |
| JIPe | **Etivluk Group, undivided** | **Middle Jurassic to Pennsylvanian** | NR | 40 |
| | JꞦo—Otuk Formation | Middle Jurassic to Triassic | NR | 40 |
| | ꞦIPeg—Siksikpuk Formation and Imnaitchiak Chert | Triassic to Pennsylvanian | NR | 41 |
| JPzc | **Chulitna sequence, undivided** | **Jurassic to upper Paleozoic** | | |
| | JꞦct—Crystal tuff, argillite, chert, graywacke, and limestone | Upper Jurassic to Upper Triassic? | SC | 36 |
| | JꞦrb—Red and brown sedimentary rocks and basalt | Lower Jurassic and Upper Triassic | SC | 36 |
| | Ꞧlb—Limestone and basalt sequence | Upper Triassic, Norian | SC | 37 |
| | ꞦPzvs—Volcanic and sedimentary rocks | Lower Triassic to upper Paleozoic | SC | 37 |
| | Ꞧrs—Red beds | Triassic, Norian and older? | SC | 46 |
| JPzs | **Northern Alaska sedimentary rocks** | **Middle Jurassic to Carboniferous** | NR | 41 |
| Jsct | **Shelikof and Chinitna Formations and Tuxedni Group** | **Middle Jurassic** | | |
| | Jsc—Shelikof and Chinitna Formations | Middle Jurassic, Callovian | AP, SC | 39 |
| | Jt—Tuxedni Group | Middle Jurassic | AP, SC | 40 |
| Jtk | **Talkeetna Formation** | **Early Jurassic** | AP, SC | 84 |
| JꞦkp | **Limestone and volcanic rocks of the Kenai Peninsula** | **Early Jurassic and Late Triassic, Norian** | | |
| | Ꞧpg—Port Graham formation of Kelley (1980) | Upper Triassic, Norian | SC | 44 |
| | JꞦpf—Pogibshi formation of Kelley (1980) | Early Jurassic and Late Triassic? | SC | 85 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| JTRmv | **Tatina River volcanics of Bundtzen and others (1997a) (Mystic structural complex)** | **Jurassic and Triassic** | | |
| | JTRmv—Tatina River volcanics of Bundtzen and others (1997a) and similar mafic volcanic rocks | Jurassic and Triassic | WC | 37 |
| | JTRv—Tatina River volcanics of Bundtzen and others (1997a), gabbro and diorite | Jurassic and Triassic | SC, WC | 38 |
| JTRos | **Newenham ophiolite complex** | **Jurassic and Triassic** | SW | 138 |
| JTRsch | **Blueschist of southern Alaska** | **Early Jurassic to Triassic** | SC, SW | 112 |
| JTRsr | **Spiculitic rocks** | **Lower Jurassic and Upper Triassic** | | |
| | JTRmc—McCarthy Formation | Lower Jurassic and Upper Triassic | SC | 42 |
| | TRsl—Spiculite and sandy limestone | Upper Triassic, Norian | WC | 42 |
| JZu | **Mafic and ultramafic rocks in central, western, and northern Alaska** | **Jurassic to late Proterozoic** | | |
| | JTRob—Ophiolite of the Brooks Range | Jurassic to Triassic? | NW | 101 |
| | JPztu—Ultramafic complexes of western Alaska | Jurassic or older | NE, NW, WC | 101 |
| | MzPzyo—Peridotite of dismembered ophiolite of the Yukon-Tanana region | Mesozoic, Triassic? or older | EC | 105 |
| | TRc—Carbonatite | Late Triassic | CN | 105 |
| | TRPzig—Gabbro and diabase | Triassic or late Paleozoic | CN | 106 |
| | PzᵽPmi—Mafic igneous rocks, central and northeast Alaska | Early Paleozoic and (or) late Proterozoic | CN, NE | 108 |
| Kcca | **Coquina and calcarenite** | **Lower Cretaceous** | | |
| | Kqcs—Quartz-carbonate sandstone and pebbly mudstone | Lower Cretaceous, Aptian to Valanginian | SW | 32 |
| | Kcm—Calcareous mudstone | Lower Cretaceous | SE | 33 |
| | Khnl—Herendeen Formation and similar units | Lower Cretaceous | AP, EC, NR, SC, SW | 33 |
| Kcgc | **Calcareous graywacke and conglomerate** | **Lower Cretaceous, Albian to Aptian** | SW, WC | 26 |
| Kchf | **Chugach accretionary complex** | **Cretaceous** | | |
| | Kaf—Chugach flysch | Upper Cretaceous | SC, SE, SW | 17 |
| | Kafv—Volcanic rocks of Chugach accretionary complex | Upper Cretaceous | SC, SE | 18 |
| | Ksg—Sitka Graywacke, undivided | Cretaceous | SE | 21 |
| Kcvg | **Calcareous graywacke and mudstone, volcanic graywacke and conglomerate** | **Lower Upper or upper Lower Cretaceous** | WC | 23 |
| KDt | **Togiak-Tikchik Complex, undivided** | **Mesozoic to Devonian** | SW | 133 |
| Keg | **Granodiorite and other plutonic rocks** | **Early Cretaceous, Aptian to Hauterivian** | SC, SE, WC | 98 |
| Kfy | **Flysch** | **Upper and Lower? Cretaceous** | SC | 23 |
| Khs | **Rocks of Hammond River shear zone of Till and others (2008a)** | **Cretaceous** | SP | 110 |
| Kipc | **Mafic igneous-clast conglomerate, sandstone, and mudstone** | **Lower Cretaceous** | WC | 26 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| KJab | **Andesite and basalt** | **Early Cretaceous and Jurassic** | | |
| | KJiv—Andesitic volcanic rocks | Early Cretaceous and Late Jurassic? | NW, SW, WC | 83 |
| | Jab—Andesite and basalt | Jurassic | SW | 84 |
| KJgn | **Gravina-Nuzotin unit** | **Lower Cretaceous and Upper Jurassic** | SC, SE, SW | 28 |
| | KJgv—Volcanic rocks of the Gravina-Nutzotin belt | Lower Cretaceous or Upper Jurassic? | SC, SE | 28 |
| KJgu | **Plutonic rocks and dikes** | **Cretaceous to Jurassic** | | |
| | Kgu—Plutonic rocks and dikes, granite to diorite | Cretaceous? | EC, SC, SP, SW, WC | 96 |
| | KJg—Quartz monzodiorite | Cretaceous to Jurassic | SC, SW | 99 |
| KJs | **Fine-grained sedimentary and metasedimentary rocks** | **Cretaceous or Jurassic** | EC | 22 |
| KJse | **Saint Elias suite of Gordey and Makepeace (2003) and similar rocks** | **Early Cretaceous and Late Jurassic** | SC, SE | 99 |
| KJsnk | **Staniukovich and Naknek Formations, Kotsina Conglomerate, and similar rocks of southern Alaska** | **Lower Cretaceous to Jurassic, Pliensbachian** | | |
| | Kst—Staniukovich Formation | Lower Cretaceous | AP | 35 |
| | Jnk—Naknek Formation and Kotsina Conglomerate | Upper Jurassic, Tithonian to Oxfordian | AP, SC | 35 |
| | Js—Marine sedimentary rocks of the Wrangell Mountains, undivided | Jurassic, Kimmeridgian to Pliensbachian | EC | 35 |
| KJvp | **Volcano-plutonic complexes** | **Cretaceous and Jurassic** | | |
| | Kmvi—Mafic to intermediate volcano-plutonic complexes | Late Cretaceous | SW, WC | 83 |
| | KJv—Highly altered volcanic rocks in southwest Alaska | Cretaceous or Jurassic | SW | 83 |
| KJyg | **Yakutat Group, undivided** | **Lower Cretaceous and Upper Jurassic?** | SC, SE | 22 |
| KJyh | **Graywacke of the Yenlo Hills** | **Cretaceous? and uppermost Jurassic** | SC | 22 |
| Kk | **Kuskokwim Group, undivided** | **Upper Cretaceous to upper Lower Cretaceous** | SW | 20 |
| Kke | **Kemik Sandstone** | **Lower Cretaceous, Hauterivian** | NR | 27 |
| Kkg | **Flysch and quartzite, Kandik Group and equivalents** | **Lower Cretaceous, Albian to Valanginian** | EC | 27 |
| Klgr | **Intermediate granitic rocks** | **Late Cretaceous** | SC, SP, SW, WC | 96 |
| | Klqm—Quartz monzonite and monzonite | Late Cretaceous | SC, SW | 96 |
| Kmgr | **Granitic rocks of central and southeast Alaska** | **Cretaceous, Coniacian to Albian** | EC, SC, SE, WC | 97 |
| | Kmqm—Quartz monzonite, monzonite, and syenite | Cretaceous, Coniacian to Albian | CN, EC, SE, SP, WC | 97 |
| | Ksy—Syenitic rocks | Cretaceous, Coniacian to Albian | NW, WC | 97 |
| Kmig | **Migmatite and metaplutonic rocks** | **Cretaceous** | EC, NE, SC, SE | 110 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| KMm | **West-central Alaska mélange (Angayucham)** | **Cretaceous or older** | | |
| | KJm—Mélange facies | Cretaceous or Jurassic? | NR, WC | 30 |
| | KMmu—West-central Alaska mélange-like rocks | Cretaceous or older | WC | 30 |
| Kms | **Mafic and shoshonitic volcanic rocks** | **Early Cretaceous** | | |
| | Ksbd—Spilitic pillow basalt and diabase | Early Cretaceous? | NW | 83 |
| | Ksv—Shoshonitic flows and tuff | Early Cretaceous | WC | 84 |
| Kmss | **Marine sandstone and siltstone** | **Cretaceous, Cenomanian to Albian** | SC, WC | 24 |
| Kmuc | **McHugh and Uyak Complexes and similar rocks** | **Late Cretaceous** | | |
| | Kumc—McHugh and Uyak Complexes | Late Cretaceous | AP, SC | 136 |
| | Kcct—Cape Current terrane | Upper Cretaceous | SW | 19 |
| Knmt | **Nonmarine to shelf sedimentary rocks** | **Tertiary? and Cretaceous** | | |
| | Kcs—Chignik Formation and similar units in southern Alaska | Upper Cretaceous | AP, SW | 16 |
| | Khk—Hoodoo and Kaguyak Formations | Upper Cretaceous | AP | 17 |
| | Kmf—Minto unit | Upper Cretaceous? | EC | 19 |
| | Ksd—Sandstone, shale, and conglomerate deltaic deposits | Upper and upper Lower Cretaceous | EC, SC, SW, WC | 19 |
| | TKis—Intricately intruded areas of volcanic graywacke and mudstone | Tertiary or Upper Cretaceous | WC | 20 |
| | Kcc—Carbonate-rich conglomerate and sandstone deltaic rocks | Cretaceous | SP, NW | 21 |
| | Kqc—Quartz-pebble conglomerate, west-central Alaska | Lower Upper Cretaceous to upper Lower Cretaceous | WC | 22 |
| | Ktu—Tuluvak Formation | Upper Cretaceous, Coniacian to upper Turonian | NR | 22 |
| Kns | **Sedimentary rocks of the North Slope** | **Cretaceous, Cenomanian to Albian** | | |
| | Knf—Nanushuk Formation | Cretaceous, Cenomanian to Albian | NR | 24 |
| | Kto—Torok Formation | Cretaceous, Cenomanian to Aptian | NR | 24 |
| | Kfm—Fortress Mountain Formation | Cretaceous, Albian | NR | 25 |
| Kok | **Okpikruak and Kongakut Formations** | **Lower Cretaceous** | | |
| | Kof—Okpikruak Formation and similar units | Lower Cretaceous | NR | 25 |
| | Kgk—Kongakut Formation | Lower Cretaceous, Hauterivian and younger | NR | 26 |
| Kpf | **Pedmar Formation** | **Lower Cretaceous, Albian** | AP | 26 |
| Kps | **Pelitic schist** | **Late Cretaceous** | SC | 111 |
| KPss | **Kingak Shale, Shublik Formation, and Karen Creek Sandstone, undivided** | **Lower Cretaceous to Permian** | | |
| | KPu—Kingak Shale, Shublik Formation, and Karen Creek Sandstone, undivided | Lower Cretaceous to Permian | NE | 33 |
| | KJks—Kingak Shale and similar units | Lower Cretaceous to Lower Jurassic | NR | 34 |
| | Kit—Tingmerkpuk Member of the Ipewik Formation | Lower Cretaceous, Valanginian | NW | 34 |
| | Ƭkc—Karen Creek Sandstone | Upper Triassic | NR | 34 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| KᵽZum | **Mafic and ultramafic rocks in southern Alaska** | **Cretaceous to late Paleozoic** | | |
| | Kgb—Gabbro and diorite of southeast Alaska | Cretaceous | SE | 98 |
| | KJmu—Mafic and ultramafic rocks | Cretaceous to Jurassic or older | SC, SE, SW | 98 |
| | KᵽZum—Dunite and serpentinite, undivided | Cretaceous? to Paleozoic | EC, SC, SE | 99 |
| | Kum—Ultramafic rocks of southeast Alaska | Early Cretaceous | SE | 99 |
| | KJdg—Diorite and gabbro of southeast Alaska | Cretaceous? and Jurassic | SE | 100 |
| | Jum—Gabbronorite and other mafic and ultramafic rocks of Hidden terrane | Early Jurassic | SC, SW | 103 |
| | Ꞧgb—Gabbro and quartz gabbro | Late Triassic? | SC | 106 |
| | Ꞧum—Mafic and ultramafic rocks in the vicinity of the Denali Fault System | Triassic? | SE | 106 |
| | Ꞧdg—Mafic igneous rocks of Duke Island | Middle Triassic | SE | 106 |
| | ᵽZgb—Gabbro and orthogneiss | Late Paleozoic | SC | 106 |
| Ksb | **Schrader Bluff Formation** | **Upper Cretaceous, Maastrichtian to Santonian** | NR | 19 |
| Ksbf | **Seabee Formation and Hue Shale** | **Upper Cretaceous, Coniacian to Turonian** | NR | 23 |
| Ksfg | **Foliated granitic rocks of southeast Alaska** | **Middle Cretaceous?** | SE | 97 |
| Ksmd | **Shallow to moderate depth sedimentary rocks** | **Upper Cretaceous to upper Lower Cretaceous** | | |
| | Kkn—Nearshore facies (Kuskokwim Group) | Upper Cretaceous, Santonian to Cenomanian | SW | 20 |
| | Km—Matanuska Formation and correlative rocks | Upper Cretaceous to upper Lower Cretaceous | SC | 21 |
| KꞦm | **Kelp Bay Group, undivided** | **Cretaceous to Triassic** | SE | 137 |
| | Kkbm—Khaz Complex | Cretaceous and older | SE | 137 |
| | JꞦpp—Pinnacle Peak Phyllite | Jurassic or Triassic? | SE | 137 |
| KꞦvs | **Volcanic and sedimentary rocks of southwest Alaska** | **Cretaceous to Triassic?** | SW | 28 |
| | KꞦs—Restricted Gemuk Group | Lower Cretaceous to Triassic? | SW | 29 |
| | Jvs—Marine volcaniclastic and arkosic sandstone | Jurassic | SW | 29 |
| | Jvc—Volcaniclastic and volcanic rocks | Upper and Middle Jurassic | SW | 35 |
| | JꞦvs—Coarse volcaniclastic sedimentary rocks | Jurassic and (or) Triassic | SW | 29 |
| | Jms—Micaceous graywacke | Lower Jurassic | SW | 41 |
| | JꞦp—Phyllite and chert | Lower Jurassic to Upper Triassic | SW | 41 |
| | JꞦls—Limestone, shale, and chert | Lower Jurassic and Upper Triassic, Norian | SW | 41 |
| Kvgc | **Volcanic graywacke and conglomerate** | **Lower Cretaceous, Hauterivian and older** | SW | 34 |
| Kvu | **Volcanic rocks, undivided** | **Cretaceous** | EC, NW, SC, SE, SW | 82 |
| Kyg | **Volcanic graywacke and mudstone** | **Lower Cretaceous** | WC | 26 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| MDe | **Endicott Group, undivided** | **Mississippian to Devonian** | NR | 53 |
| | Mek—Kekiktuk Conglomerate | Mississippian | NE, NR | 53 |
| | Meks—Kapaloak sequence of Moore and others (2002) | Mississippian | NW | 54 |
| | Mes—Kurupa Sandstone | Lower Mississippian | NR | 54 |
| | Du—Mangaqtaaq formation of Anderson and Watts (1992) and Ulungarat formation of Anderson (1993) | Upper Devonian | NE | 55 |
| MDegk | **Kanayut Conglomerate and Noatak Sandstone, undivided (Endicott Group)** | **Lower Mississippian and Upper Devonian** | NR | 54 |
| MDip | **Iyoukeen and Peratrovich Formations** | **Mississippian and Devonian** | SE | 52 |
| MDmg | **Granitic rocks and orthogneiss** | **Mississippian to Devonian** | | |
| | MDgi—Old Crow suite of Gordey and Makepeace (2003) and other granitic rocks of northeast Alaska | Mississippian to Devonian? | NE | 107 |
| | MDag—Augen gneiss and orthogneiss | Early Mississippian and Late Devonian | EC, WC | 121 |
| | Dmi—Metamorphosed mafic igneous rocks | Late Devonian | CN | 122 |
| | Dogn—Granitic gneiss | Late and Middle Devonian | NR, SP | 123 |
| MDts | **Totatlanika Schist (Yukon-Tanana crystalline complex)** | **Early Mississippian to Late Devonian** | EC, SC | 116 |
| MDv | **Greenstone and schist (Togiak-Tikchik Complex)** | **Mississippian? and Devonian?** | SW | 135 |
| Mgq | **Globe quartzite of Weber and others (1992)** | **Mississippian** | CN | 52 |
| Mk | **Kayak Shale (Endicott Group)** | **Mississippian** | NR | 53 |
| Mlgac | **Akmalik Chert and other black chert of the Lisburne Group** | **Mississippian** | NE, NW | 51 |
| Mlgk | **Kuna Formation (Lisburne Group)** | **Mississippian** | NW | 50 |
| Mlgnu | **Nasorak and Utukok Formations (Lisburne Group)** | **Mississippian** | NW | 51 |
| MOkg | **Kaskawulsh group of Kindle (1953)** | **Mississippian and older** | SC | 121 |
| MꝐgs | **Gneiss, schist, and amphibolite (Yukon-Tanana crystalline complex)** | **Mississippian, Devonian, and older** | | |
| | Pzymi—Orthogneiss and amphibolite of igneous origin | Mississippian, Devonian, and older? | EC | 116 |
| | PzꝐygs—Gneiss, schist, and quartzite | Mississippian, Devonian, and older | EC | 116 |
| Mzm | **Mélanges** | **Mesozoic to Paleozoic** | | |
| | KJmy—Mélange of the Yakutat Group | Cretaceous and Jurassic? | SC, SE | 132 |
| | Kmar—Alaska Range mélange | Cretaceous | SC | 132 |
| | MzPzm—Southwest Alaska mélange | Mesozoic and Paleozoic | SW | 133 |
| MzPza | **Metamorphic rocks of Admiralty Island, undivided** | **Mesozoic to Paleozoic** | SE | 111 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| MzPzcp | **Metamorphic rocks associated with the Coast plutonic complex of Brew and Morrell (1979b)** | **Triassic to Paleozoic** | | |
| | MzPzss—Metasedimentary and minor metavolcanic rocks along the west side of the Coast plutonic complex of Brew and Morrell (1979b) | Triassic to Paleozoic | SE | 112 |
| | Pm—Marble along the west side of the Coast plutonic complex of Brew and Morrell (1979b) | Permian? protolith | SE | 113 |
| | MzPzsv—Metavolcanic rocks west of the Coast plutonic complex of Brew and Morrell (1979b) | Triassic to Paleozoic | SE | 113 |
| | Pzgn—Roof pendants of the Coast plutonic complex of Brew and Morrell (1979b) | Paleozoic | SE | 120 |
| | Pzks—Metamorphic rocks of the Kah Shakes sequence of Rubin and Saleeby (1991), undivided | Early Paleozoic | SE | 124 |
| MzPzka | **Rocks of the Kisaralik anticlinorium of Box and others (1993) (Togiak-Tikchik Complex)** | **Jurassic metamorphism, early Mesozoic or Paleozoic protolith** | SW | 135 |
| | MzPzgs—Green amphibole-bearing schist | Jurassic metamorphism | SW | 135 |
| | MzPzp—Phyllite of the Kisaralik anticlinorium | Early Mesozoic or Paleozoic | SW | 136 |
| | MzPzsk—Metasedimentary rocks of the Kisaralik anticlinorium | Early Mesozoic or Paleozoic | SW | 136 |
| | MDm—Metabasalt and marble of the Kisaralik anticlinorium | Early Mississippian to Late Devonian | SW | 136 |
| MzPzmb | **Metabasite** | **Mesozoic and Paleozoic** | NR, SP, WC | 111 |
| Oc | **Chert of interior Alaska** | **Ordovician** | CN | 71 |
| O€jr | **Jones Ridge Limestone and related units** | **Ordovician to Cambrian** | EC, NE | 72 |
| O€v | **Fossil Creek Volcanics and similar rocks** | **Ordovician and Cambrian** | EC, NE, NR | 88 |
| OꝐpt | **Older rocks of York terrane and Grantley Harbor Fault Zone** | **Middle Ordovician to Proterozoic** | SP | 68 |
| Pcs | **Clastic and volcaniclastic rocks (Togiak-Tikchik Complex)** | **Permian** | SW | 134 |
| PDcf | **Cannery Formation and Porcupine slate of Redman and others (1985), undivided** | **Permian to Devonian** | | |
| | PDcf—Cannery Formation and Porcupine slate of Redman and others (1985), undivided | Permian to Devonian | SE | 48 |
| | Pzps—Porcupine slate of Redman and others (1985) | Late Paleozoic | SE | 120 |
| PDms | **Sedimentary rocks of the Mystic structural complex** | **Permian to Devonian** | | |
| | PDsc—Sheep Creek formation of Bundtzen and others (1997a) and correlative siliciclastic units of the Mystic structural complex | Permian to Devonian | SC, SW, WC | 38 |
| | Dls—Limestone of the Mystic structural complex | Devonian | SW, WC | 38 |
| Plss | **Limestone and calcareous clastic rocks** | **Permian** | | |
| | Pls—Limestone | Permian | AP | 47 |
| | Plps—Pybus Formation and correlative? limestone | Permian | SE | 47 |
| | Ph—Halleck Formation and similar sedimentary rock units | Permian | SE | 47 |
| | Ptl—Tahkandit Limestone | Lower Permian | EC, NE | 48 |
| | Ptls—Limestone of southwest Alaska (Togiak-Tikchik Complex) | Permian | SW | 135 |
| PIPgi | **Granodiorite, syenite, and other granitic rocks** | **Early Permian and Pennsylvanian** | SC, SE | 107 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| PℙPsm | **Strelna Metamorphics and related rocks** | **Early Permian to Middle Pennsylvanian** | SC | 119 |
| Pstc | **Step Conglomerate** | **Lower Permian** | EC | 48 |
| Pv | **Andesite and basalt of southern Alaska** | **Early Permian** | | |
| | Pv—Volcanic rocks of Puale Bay | Early Permian | AP | 86 |
| | Phb—Volcanic rocks of the Halleck Formation and related rocks of southeast Alaska | Early Permian | SE | 86 |
| ℙDcf | **Calico Bluff and Ford Lake Shale, undivided** | **Lower Pennsylvanian to Devonian** | EC | 52 |
| ℙMn | **Nuka Formation** | **Carboniferous** | NW | 49 |
| ℙsb | **Upper Saginaw Bay Formation and similar rocks of southeast Alaska** | **Pennsylvanian** | SE | 49 |
| Pzc | **Marble** | **Early Permian to early Paleozoic** | | |
| | Pzce—Marble, southeast Alaska | Early Permian to Devonian | SE | 120 |
| | Pzcn—Marble, northern Alaska | Early Paleozoic | NW | 121 |
| | Pzm—Marble of the Brooks Range | Devonian and older | NR | 124 |
| Pzcu | **Black chert** | **Lower Paleozoic, Devonian or older** | SW | 55 |
| Pze | **Eclogite and associated rocks (Yukon-Tanana crystalline complex)** | **Paleozoic** | CN | 115 |
| Pzkn | **Klondike Schist, Keevy Peak Formation, and similar rocks (Yukon-Tanana crystalline complex)** | **Permian to early Paleozoic** | | |
| | Pks—Klondike Schist | Permian | EC | 115 |
| | Pzkp—Keevy Peak Formation and similar rocks | Early Paleozoic | CN, EC | 117 |
| Pzls | **Limestone and marble** | **Paleozoic** | EC, NR, WC | 47 |
| Pznp | **Metagabbro and metasedimentary rocks (Nome Complex)** | **Paleozoic?** | SP | 140 |
| PzᏢgb | **Gabbro and metagabbro** | **Early Paleozoic and Proterozoic?** | SP | 129 |
| PzᏢkg | **High-grade metamorphic rocks of the Seward Peninsula** | **Earliest Paleozoic to Proterozoic** | SP | 129 |
| PzᏢnc | **Nome Complex, undivided** | **Early Paleozoic to Proterozoic** | SP | 139 |
| PzᏢrqm | **Pelitic and quartzitic schist of the Ruby terrane** | **Early Paleozoic to Proterozoic?** | NR, WC | 127 |
| PzZncl | **Layered sequence (Nome Complex)** | **Devonian to Neoproterozoic** | | |
| | Pzncs—Younger schist | Devonian and Silurian? | SP | 140 |
| | DOnx—Marble, graphitic rocks, and schist | Devonian to Ordovician? | SP | 140 |
| | Ocs—Casadepaga Schist | Ordovician | SP | 141 |
| | Onim—Impure marble | Ordovician | SP | 141 |
| | Zngn—Metagranitic rocks | Neoproterozoic | SP | 142 |
| Ꮲkd | **Katakturuk Dolomite** | **Proterozoic** | NE | 74 |
| Ꮲqm | **Basement of the White Mountain sequence** | **Proterozoic** | | |
| | Ꮲqm—Schist of the Telsitna River | Proterozoic | WC | 131 |
| | Ꮲm—Marble, calcareous and quartz-mica schist, and greenstone | Proterozoic? | WC | 131 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| Ꝑv | **Basalt and red beds member (Tindir Group) and Mount Copleston volcanic rocks of Moore (1987)** | **Proterozoic** | | |
| | Ꝑtnm—Basalt and red beds member (Tindir Group) | Proterozoic | EC, NE | 88 |
| | Ꝑv—Mount Copleston volcanic rocks of Moore (1987) | Proterozoic | NE | 89 |
| QTgm | **Yakataga and Tugidak Formations** | **Quaternary and uppermost Tertiary** | SO | 5 |
| QTm | **Contact metamorphosed and hydrothermally altered rocks** | **Quaternary or late Tertiary** | AL, AP | 109 |
| QTs | **Unconsolidated and poorly consolidated surficial deposits** | **Quaternary and uppermost Tertiary** | | |
| | Qs—Unconsolidated surficial deposits, undivided | Quaternary | ST | 5 |
| | QTs—Poorly consolidated surficial deposits | Quaternary, Pleistocene, and uppermost Tertiary | AL, AP, SW, WC | 5 |
| QTvi | **Young volcanic and shallow intrusive rocks** | **Quaternary or late Tertiary** | | |
| | Qv—Youngest volcanic rocks | Quaternary and latest Tertiary? | AL, AP, EC, SC, SE, SW, WC | 75 |
| | QTv—Young volcanic rocks, undifferentiated | Quaternary or Tertiary | AL, AP, EC, SP, SW, WC | 75 |
| | QTi—Young shallow intrusive rocks | Quaternary or late Tertiary | AL, AP, SC, SE | 89 |
| QTvs | **Kiska Harbor and Milky River Formations** | **Quaternary? and late Tertiary** | AL, AP | 76 |
| SЄda | **Older rock units of the Doonerak Window** | **Silurian to Cambrian** | | |
| | SЄs—Sedimentary rocks of Doonerak Window | Silurian to Cambrian | NR | 69 |
| | OЄdv—Oldest volcanic rocks | Ordovician and Cambrian? | NR | 69 |
| SЄwbc | **Farewell basinal facies clastic rocks** | **Silurian to upper Cambrian** | | |
| | Stc—Terra Cotta Mountains Sandstone | Silurian | WC | 60 |
| | SЄpl—Post River Formation and correlative units | Middle Silurian, Wenlock, to upper Cambrian | SW | 60 |
| SOig | **Iviagik group of Martin (1970)** | **Silurian, Llandovery, to Ordovician** | NW | 70 |
| SOmi | **Heterogeneous metamorphic rocks, southeast Alaska** | **Silurian and Ordovician** | SE | 127 |
| SOpw | **Sedimentary and volcanic rocks of Prince of Wales Island** | **Silurian, Llandovery, and Ordovician** | | |
| | SOd—Descon Formation and other sedimentary and volcanic rocks of Prince of Wales Island | Silurian, Llandovery, and Ordovician | SE | 70 |
| | SOdc—Associated carbonate rocks | Silurian, Llandovery, and Ordovician | SE | 71 |
| | SOv—Associated volcanic rocks | Silurian, Llandovery, and Ordovician | SE | 71 |
| SZfwr | **Four Winds complex of Gilbert and others (1987), Retreat Group, and orthogneiss** | **Silurian to Proterozoic** | | |
| | SZfw—Four Winds complex of Gilbert and others (1987) and similar rocks | Silurian to Neoproterozoic | SE | 127 |
| | ꟼꝐrg—Retreat Group | Paleozoic and Proterozoic | SE | 128 |
| | ЄZogn—Orthogneiss | Cambrian to Neoproterozoic | SE | 130 |
| Tbk | **Basalt and keratophyre** | **Tertiary, Paleogene, or older** | AL | 79 |
| Tcb | **Coal-bearing sedimentary rocks** | **Tertiary, Pliocene to Eocene?** | CN, SO | 8 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| Tcc | **Gneiss and amphibolite** | **Tertiary, Miocene** | EC, SC | 109 |
| Tcl | **Copper Lake Formation** | **Tertiary, Eocene to Paleocene** | AP | 15 |
| Tcp | **Younger phase, Coast plutonic complex of Brew and Morrell (1979b)** | **Tertiary, Eocene** | SE | 91 |
| Tcpp | **Porphyritic granodiorite phase of Coast plutonic complex of Brew and Morrell (1979b)** | **Tertiary, Eocene** | SE | 92 |
| Tehi | **Felsic dikes, sills, and small stocks in southern Alaska** | **Tertiary and older?** | | |
| | Tephi—Felsic hypabyssal intrusions | Tertiary, Eocene | SC | 93 |
| | Tehi—Felsic dikes, sills, and small stocks in southern Alaska | Tertiary and older? | SC | 93 |
| Tgb | **Gabbroic rocks in southern Alaska** | **Tertiary** | | |
| | Tgbe—Younger gabbro of southeast Alaska | Tertiary, Miocene to Eocene | SE | 89 |
| | Tgba—Diabase and gabbro, Aleutian Islands | Tertiary, Miocene to Paleocene? | AL, AP | 90 |
| | Tgbw—Gabbro, southwest Alaska | Tertiary, Paleogene? | SC, SW | 90 |
| Thi | **Hypabyssal intrusions** | **Tertiary** | AL, AP, CN, SO | 79 |
| Tk | **Kootznahoo Formation** | **Tertiary, lower Miocene to upper Eocene** | SE | 10 |
| TKcf | **Canning Formation** | **Lower Tertiary, Oligocene? to Cretaceous, Albian** | NE | 15 |
| TKgi | **Granitic rocks of southern and interior Alaska** | **Tertiary, Paleocene to Cretaceous, Maastrichtian** | | |
| | Tpgr—Undivided granitic rocks | Tertiary, late Paleocene | SC, SO, SW | 94 |
| | Tpg—Peralkaline granite | Tertiary, Paleocene? | SW | 94 |
| | TKg—Felsic granitic rocks | Tertiary, Paleocene, or Late Cretaceous, Maastrichtian | EC, SC, SO, SW | 94 |
| | TKgd—Granodiorite to quartz monzodiorite | Tertiary, Paleocene, or Late Cretaceous, Maastrichtian | EC, SC, SW | 95 |
| TKgr | **Ghost Rocks Formation and similar rocks** | **Tertiary, Paleocene, and Upper Cretaceous** | | |
| | TKm—Ghost Rocks Formation | Early Tertiary and latest Cretaceous | AP | 132 |
| | TKgrs—Ghost Rocks sedimentary rocks | Tertiary, Paleocene, and Upper Cretaceous | SW | 16 |
| | Kcv—Chert and volcanic sequence | Upper Cretaceous | AP | 19 |
| TKkf | **Krugoli Formation, undifferentiated** | **Tertiary, Paleogene, or Cretaceous** | AL | 13 |
| TKm | **Mafic intrusive rocks** | **Tertiary to Late Cretaceous or older** | | |
| | TKgb—Gabbroic rocks | Tertiary to Late Cretaceous or older | SC, SW, WC | 95 |
| | TKpd—Peridotite | Tertiary, Paleocene, or older | SW | 95 |
| TKnt | **Nearshore and nonmarine sedimentary rocks in southern Alaska** | **Tertiary** | | |
| | Tkn—Kenai Group, undivided | Tertiary, Miocene to Oligocene | AP, SC | 6 |
| | Tts—Tsadaka Formation | Tertiary, Oligocene | SC | 10 |
| | Ttk—Nearshore and nonmarine sedimentary rocks | Tertiary, Eocene to Paleocene | AP, SC, SO, SW | 11 |

**Table 2.** Alphabetical list of map units.—Continued

| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| TKpc | **Prince Creek Formation** | **Lower Tertiary, Paleocene, to Upper Cretaceous, Campanian** | NR | 15 |
| TKpr | **Flows and pyroclastic rocks** | **Early Tertiary to Late Cretaceous** | | |
| | TKv—Volcanic rocks in southern Alaska | Early Tertiary to Late Cretaceous | NE, NW, SC, SW, WC | 80 |
| | Tpt—Pyroclastic rocks | Tertiary, early Eocene or Paleocene | EC, SE, SW, WC | 81 |
| | TKwt—Welded tuff and other felsic volcanic rocks | Early Tertiary and early Late Cretaceous | EC | 82 |
| TKs | **Conglomerate, sandstone, and lignite** | **Lower Tertiary to Upper Cretaceous** | CN, EC, SP | 13 |
| TKtsp | **Foliated tonalite sill and pegmatite, Coast plutonic complex of Brew and Morrell (1979b)** | **Tertiary, Eocene? to latest Cretaceous** | | |
| | TKts—Foliated tonalite sill of Coast plutonic complex of Brew and Morrell (1979b) | Tertiary, Paleocene, and latest Cretaceous | SE | 92 |
| | TKpeg—Trondhjemitic pegmatite | Tertiary, Eocene? or older | SE | 94 |
| Tmi | **Younger granitic rocks** | **Tertiary, Pliocene to Miocene** | AL, AP, SE | 89 |
| TMzmb | **MacLaren metamorphic belt of Smith and Lanphere (1971)** | **Tertiary to Jurassic or older?** | | |
| | TKgg—Gneissose granitic rocks | Tertiary or Late Cretaceous | SC | 109 |
| | Mzmu—Metamorphic rocks of the MacLaren metamorphic belt of Smith and Lanphere (1971) | Cretaceous and Jurassic or older? | SC | 110 |
| TMzu | **Basement rocks, undifferentiated, Aleutian Islands** | **Tertiary or older** | AL | 14 |
| Tng | **Nenana Gravel** | **Tertiary, Pliocene and upper Miocene** | SC | 6 |
| Toeg | **Granitic rocks in southern Alaska** | **Tertiary, Oligocene and Eocene** | | |
| | Tgw—Granite, southwest Alaska and Aleutian Islands | Tertiary, Oligocene, or older | AL, AP, SW | 90 |
| | Togr—Granite and granodiorite | Tertiary, Oligocene | SC, SE, SW | 90 |
| | Tod—Granodiorite, quartz diorite, and diorite | Tertiary, Oligocene and late Eocene | AP, SC, SE | 91 |
| | Toegr—Granitic rocks | Tertiary, early Oligocene and Eocene | SC, SE, SW | 91 |
| Togum | **Mafic and ultramafic rocks of the Valdez and Orca Groups** | **Tertiary, Eocene to Paleocene** | SC | 92 |
| Togv | **Volcanic rocks of the Orca Group and Ghost Rocks Formation** | **Tertiary, Eocene to Paleocene** | AP, SC | 80 |
| Top | **Redwood and Poul Creek Formations** | **Tertiary, Miocene to Eocene?** | SC | 7 |
| Tovs | **Sedimentary and volcanic rocks of the Orca Group, undivided** | **Tertiary, Eocene to Paleocene** | SC | 14 |
| | Tos—Sedimentary rocks of the Orca Group | **Tertiary, Eocene to Paleocene** | SC | 14 |
| Tpgi | **Granitic intrusive rocks of the Chugach accretionary complex** | **Tertiary, Paleocene** | SC, SW | 93 |
| TPzi | **Undivided dikes and sills** | **Tertiary to Paleozoic?** | | |
| | TKhi—Dikes and subvolcanic rocks | Tertiary and (or) Cretaceous | SW, WC | 95 |
| | MzPzi—Undivided dikes and sills, south-central Alaska | Mesozoic or Paleozoic | SC | 96 |
| Tsf | **Sagavanirktok Formation** | **Tertiary, Miocene to Paleocene** | NR | 7 |

**Table 2.** Alphabetical list of map units.—Continued

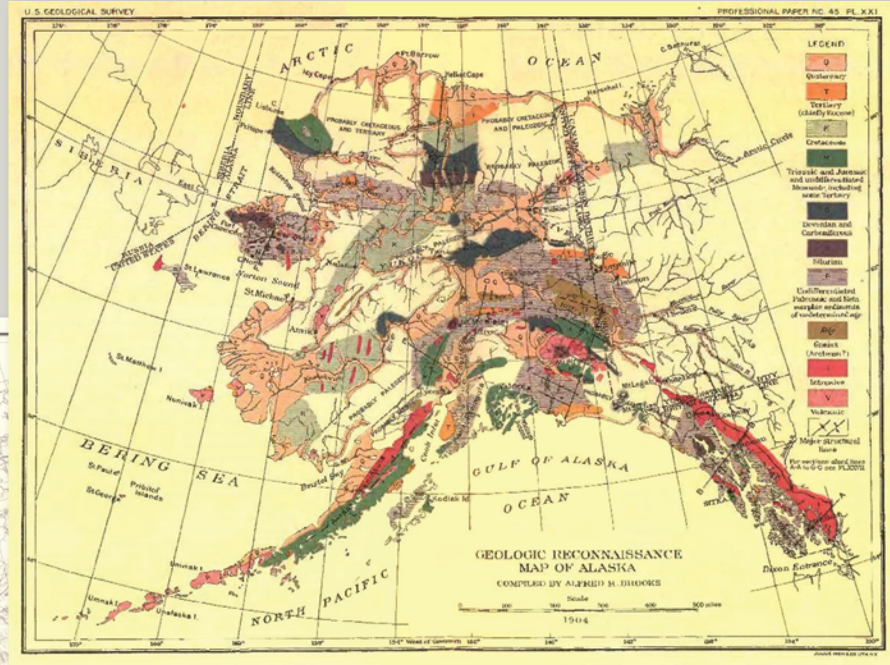
| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| Tski | **Sitkinak and Sitkalidak Formations** | **Tertiary, Oligocene to Eocene** | | |
| | Tsk—Sitkinak Formation | Tertiary, Oligocene | SW | 12 |
| | Tsi—Sitkalidak Formation | Tertiary, Oligocene to Eocene | SW | 12 |
| Tsmo | **Sedimentary rocks of southwest Alaska** | **Tertiary, Miocene and Oligocene** | | |
| | Tms—Tachilni, Bear Lake, Chuniksak, Nevidiskov, and Chirikof Formations | Tertiary, Miocene and upper Oligocene | AL, AP | 8 |
| | Tnc—Narrow Cape and Topsy Formations | Tertiary, Miocene | AP, SC | 9 |
| | Tuu—Unga, Belkofski, and Unalaska Formations | Tertiary, Miocene | AL, AP | 9 |
| | Tsti—Siltstone of Trinity Islands | Tertiary, Miocene and Oligocene | AP | 10 |
| Tsu | **Sedimentary rocks, undivided** | **Tertiary** | ST | 6 |
| Ttsr | **Sedimentary rocks of eastern Prince William Sound** | **Tertiary, Eocene** | | |
| | Tes—Tokun and Stillwater Formations and similar rocks | Tertiary, Eocene | SC | 12 |
| | Tkf—Kulthieth Formation | Tertiary, Eocene | SC, SE | 13 |
| Tv | **Volcanic rocks, undivided** | **Tertiary** | | |
| | Tvu—Volcanic rocks of southern Alaska | Tertiary, Pliocene? and older | AL, AP, CN, EC, SC, SW | 76 |
| | Twv—Wrangell Lava | Tertiary, Pliocene to Oligocene | EC, SC | 77 |
| | Tepv—Andesite and basalt flows | Tertiary, Eocene and Paleocene | SC, WC | 80 |
| | Tpcv—Cantwell Formation, volcanic rocks subunit | Tertiary, Paleocene | SC | 82 |
| | Tsr—Soda rhyolite and basalt | Tertiary, Paleocene | NW | 82 |
| Tvc | **Victoria Creek metamorphic rocks** | **Tertiary, Paleocene metamorphism** | CN | 110 |
| Tvcs | **Volcanic and sedimentary rocks** | **Tertiary, Oligocene and Eocene** | | |
| | Tarcs—Volcaniclastic sedimentary rocks | Tertiary, Oligocene to Eocene | AL, AP | 10 |
| | Tvs—Volcanic and sedimentary rocks, undivided | Tertiary, Oligocene and Eocene | SC | 11 |
| Tvme | **Older volcanic rocks, undivided** | **Tertiary, early Miocene to Eocene** | | |
| | Tca—Admiralty Island and Cenotaph Volcanics | Tertiary, Miocene to Oligocene | SE | 78 |
| | Tmv—Meshik Volcanics and similar rock units | Tertiary, Oligocene to Eocene | AL, AP, SC, WC | 78 |
| | Tev—Felsic volcanic rocks of southwest Alaska | Tertiary, Oligocene? and Eocene | SW | 79 |
| Tvpm | **Younger volcanic rocks, undivided** | **Tertiary, Pliocene and Miocene** | | |
| | Tpv—Basalt and tuff | Tertiary, Pliocene | SW | 77 |
| | Tvm—Volcanic rocks of the Aleutian Islands and Alaska Peninsula | Tertiary, Miocene | AL, AP, SW | 77 |
| | Tob—Olivine basalt flows | Tertiary, Miocene | EC | 78 |
| ŦRcs | **Calcareous sedimentary rocks** | **Upper Triassic, middle? Norian and upper Carnian** | SC | 44 |
| ŦRDtz | **Sedimentary rocks and chert (Angayucham)** | **Triassic to Devonian** | | |
| | ŦRDtz—Sedimentary rocks | Triassic to Devonian | EC, NE, NR, SW, WC | 32 |
| | IPMch—Chert | Carboniferous and older | WC | 32 |

**Table 2.** Alphabetical list of map units.—Continued

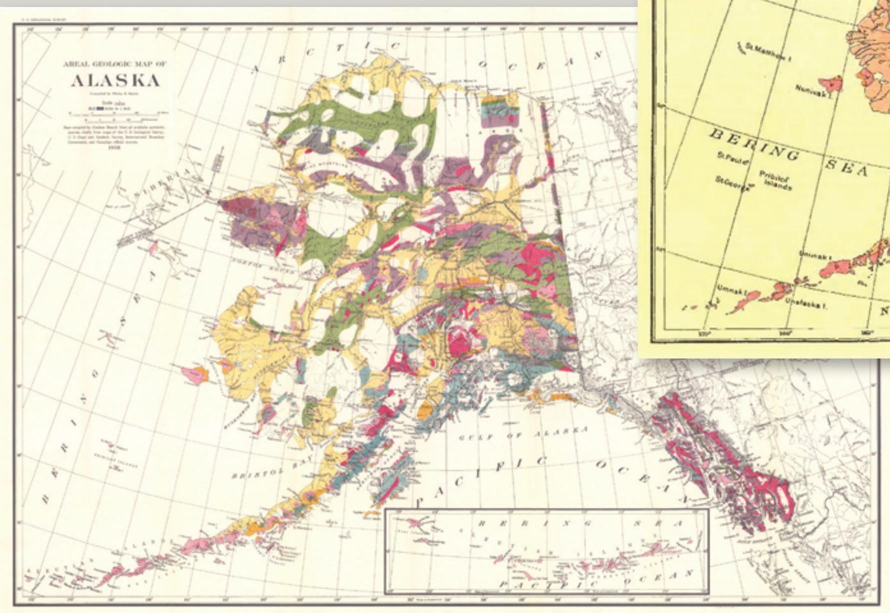
| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| Ŧgs | **Shublik Formation and lower Glenn Shale** | **Triassic** | | |
| | Ŧgs—Shublik Formation | Triassic | NR | 34 |
| | Ŧgsl—Glenn Shale, lower unit | Triassic | EC | 42 |
| Ŧhg | **Hyd Group, undivided** | **Upper and Middle Triassic** | SE | 43 |
| | Ŧhgs—Hyd Group sedimentary rocks, undivided | Upper Triassic | SE | 43 |
| | Ŧhgv—Hyd Group igneous rocks, undivided | Upper Triassic | SE | 44 |
| Ŧmb | **Massive basalt and greenstone** | **Triassic** | | |
| | Ŧvs—Volcanic and sedimentary rocks of Nakwasina Sound | Triassic | SE | 85 |
| | Ŧb—Mafic volcanic rocks of Chilkat Peninsula | Late Triassic | SE | 85 |
| | Ŧn—Nikolai and Goon Dip Greenstones and equivalent rocks | Late and Middle Triassic | SC, SE | 86 |
| | Ŧcb—Cottonwood Bay and Chilikradrotna Greenstones | Late Triassic, Norian? | AP, SW | 86 |
| | Ŧvsw—Older volcanic rocks of southwest Alaska | Triassic | SW | 86 |
| Ŧmls | **Marble and limestone of Wrangellia** | **Triassic** | | |
| | Ŧls—Carbonates and associated rocks | Triassic | SW | 45 |
| | Ŧcnk—Chitistone and Nizina Limestones and Kamishak Formation | Upper Triassic, Norian to Carnian | AP, SC, SW | 45 |
| | Ŧwm—Whitestripe Marble of southeast Alaska | Triassic? | SE | 45 |
| ŦMsm | **Seventymile assemblage (Yukon-Tanana crystalline complex)** | **Triassic to Mississippian** | EC | 115 |
| ŦPsg | **Sadlerochit Group, undivided** | **Lower Triassic to Permian** | NE | 46 |
| | Ŧif—Ivishak Formation | Lower Triassic | NE | 46 |
| | Pe—Echooka Formation | Permian | NE | 46 |
| ŦPvs | **Metamorphic rocks, southeast Alaska** | **Triassic to Permian** | SE | 114 |
| ŦIPms | **Skolai and Mankomen Groups, undivided** | **Triassic to Pennsylvanian** | | |
| | PIPms—Mankomen and Skolai Groups, undivided | Lower Permian and Pennsylvanian | SC | 48 |
| | Peh—Eagle Creek and Hasen Creek Formations | Lower Permian | SC | 48 |
| | Pehls—Limestone of the Hasen Creek and Eagle Creek Formations | Lower Permian | SC | 49 |
| | PIPt—Slana Spur and Station Creek Formations and Tetelna Volcanics | Lower Permian to Middle Pennsylvanian | SC | 49 |
| | Ŧms—Metavolcanic and metasedimentary rocks | Late Triassic | SC | 118 |
| ŦIPsf | **Flysch-like sedimentary rocks** | **Triassic to Pennsylvanian** | SC | 42 |
| ŦPzbi | **Metamorphic rocks of Baranof Island** | **Triassic or older** | SE | 118 |
| ŦPzgp | **Metagraywacke and phyllite** | **Triassic? and late Paleozoic** | CN, NR, WC | 119 |
| Ŧqd | **Quartz diorite and granodiorite** | **Triassic** | EC, SE, SW | 104 |
| Ŧsf | **Shuyak Formation, undivided** | **Upper Triassic** | | |
| | Ŧsy—Sedimentary member | Upper Triassic | AP | 42 |
| | Ŧsyv—Volcanic member | Upper Triassic | AP | 42 |
| Xio | **Kanektok metamorphic complex and Idono Complex** | **Paleoproterozoic** | SW | 131 |
| | p€km—Kanektok marble | Precambrian | SW | 132 |

**Table 2.** Alphabetical list of map units.—Continued

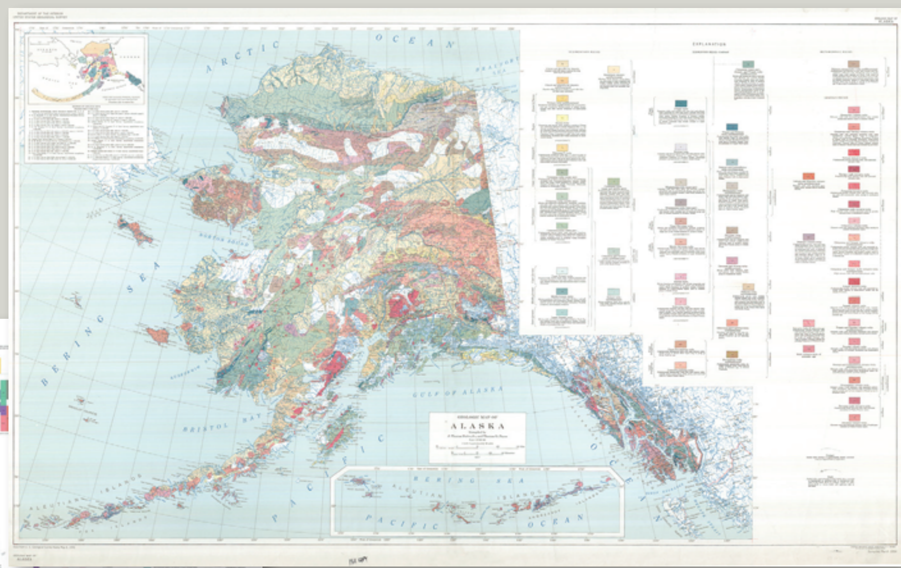
| Map unit label | Map unit name (including list of component unit names and labels) | Age or stratigraphic position | Region | Page No. |
|---|---|---|---|---|
| Zam | **Metasedimentary and metavolcanic rocks of Mount Angayukaqsraq** | **Neoproterozoic** | NW | 130 |
| Zgn | **Gneiss of northern Alaska** | **Neoproterozoic** | | |
| | Zgn—Granite and orthogneiss | Neoproterozoic? | NR | 130 |
| | Zgns—Orthogneiss of the Seward Peninsula | Neoproterozoic | SP | 130 |



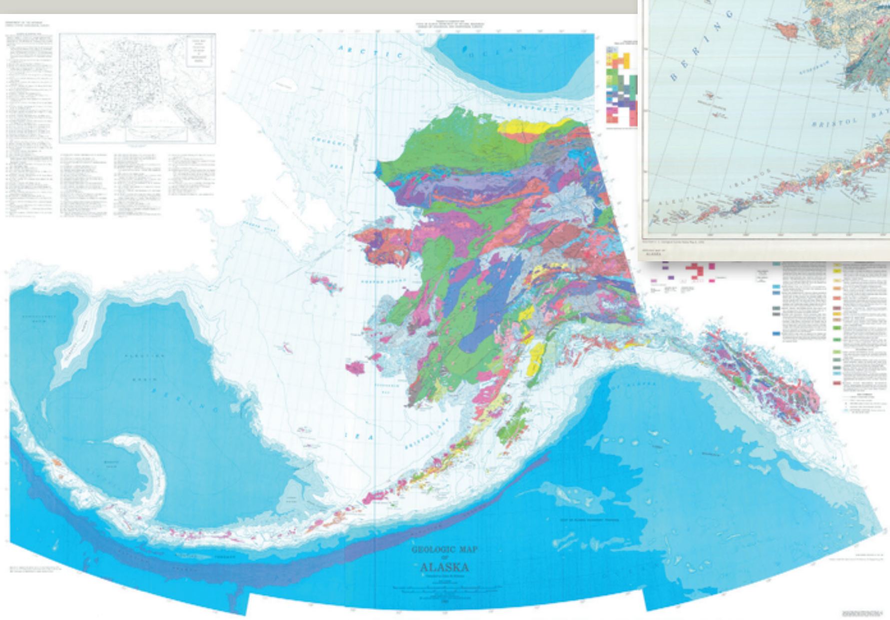

1906




1939




1957




1980