U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Geologic Map of Central (Interior) Alaska

compiled by

Frederic H. Wilson[1], James H. Dover[1], Dwight C. Bradley[1], Florence R. Weber[2], Thomas K. Bundtzen[3], and Peter J. Haeussler[1]

1998

Text to accompany
U.S. Geological Survey Open-File Report OF 98-133

Prepared in cooperation with the Alaska Department of Natural Resources, Division of Oil and Gas and Division of Geological and Geophysical Surveys

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

[1] U.S. Geological Survey, 4200 University Dr., Anchorage AK 99508-4667;
[2] U.S. Geological Survey, P.O. Box 80586, Fairbanks, AK 99708-0586;
[3] Pacific Rim Geological Consulting, P.O. Box 81906, Fairbanks, AK 99708-1906

Geologic Map of Central (Interior) Alaska

Table of Contents

Oligocene and Eocene

Paleocene

Plutonic rocks

Oligocene

Oligocene or Eocene

Eocene

Paleocene

TERTIARY AND/OR CRETACEOUS
Sedimentary rocks

Igneous rocks
Volcanic and hypabyssal rocks

Intrusive rocks

JURASSIC AND TRIASSIC
Sedimentary rocks

Igneous rocks

TRIASSIC
Sedimentary rocks

Igneous Rocks
Volcanic rocks

Plutonic rocks

Metamorphic rocks

MESOZOIC AND PALEOZOIC
Assemblages and Sequences

Stratigraphic sequences

Sedimentary rocks

Igneous rocks

Metamorphic rocks

PALEOZOIC
Assemblages and Sequences

Sedimentary rocks

Igneous rocks

Metamorphic rocks

PALEOZOIC AND PRECAMBRIAN
Sequences and Complexes

Sedimentary rocks

PRECAMBRIAN
Metamorphic rocks

Geologic Map of Central (Interior) Alaska

compiled by

Frederic H. Wilson, James H. Dover, Dwight C. Bradley, Florence R. Weber, Thomas K. Bundtzen, and Peter J. Haeussler

Introduction

This map and associated digital databases are the result of a compilation and reinterpretation of published and unpublished 1:250,000- and limited 1:125,000- and 1:63,360-scale mapping. The map area covers roughly 416,000 km^2 (134,000 sq mi) and encompasses 25 1:250,000-scale quadrangles in central Alaska. The compilation was done as part of the U.S. Geological Survey National Surveys and Analysis project, whose goal is nationwide assemble geologic, geochemical, geophysical, and other data. This map is an early product of an effort that will eventually encompass all of Alaska and is the result of an agreement with the Alaska Department of Natural Resources, Division of Oil And Gas to provide data on interior basins in Alaska. Two geophysical maps that cover the identical area have been published earlier: Bouguer gravity map of Interior Alaska (Meyer and others, 1996); and Merged aeromagnetic map of Interior Alaska (Meyer and Saltus, 1995).

Compilation of this map began in September 1996, using published 1:250,000-scale mapping. As the project progressed, published maps at other scales and unpublished mapping were incorporated as we built an integrated map. Description and correlation of geologic units to produce map units was an iterative process that continued through technical review to publication. Digital files of the final compilation of each of the 25 1:250,000-scale quadrangles are *provided on this* CD-ROM. Cited in the text and on the map are the map sources we used; additional map sources are listed in Galloway and Laney (1994).

It takes little imagination to realize that many compromises have been made in strongly held beliefs to allow construction of this compilation. Yet even our willingness to make interpretations and compromises does not allow us to resolve mapping conflicts in some areas. Therefore, there are a number of 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. We believe that this map and its problems present a very good argument to justify and support further work in this area and elsewhere in Alaska. Nonetheless, we hope that geologists who have mapped in central Alaska will recognize that in incorporating their work, our regional correlations have required generalizing and lumping of units. Lead efforts on the map compilation were as follows: Cenozoic and Mesozoic sedimentary rocks and igneous rocks, Frederic Wilson; Paleozoic sedimentary rocks, Dwight Bradley; metamorphic rocks, James Dover; with supporting efforts for all rock types in the northeast and central part of the map area by Florence Weber; the southwest part of the map area by Tom Bundtzen; and the Tyonek area by Peter Haeussler.

Compiling this map was complicated because the original source maps were made by different generations of geologists, mapping with very different ideas. A few of the older maps were completed before the concepts of plate tectonics or accreted (suspect) terranes. On the other hand, some of the more recent maps were so governed by terrane analysis that conventional stratigraphic nomenclature was not used and is obscured. For the present compilation, we adopted a traditional stratigraphic approach and have avoided use of the controversial and inconsistently defined term "terrane." Our decision to adopt a traditional approach is reflected in a map that emphasizes age and lithology of map units, rather than differences among fault-bounded packages of rocks. For a map of the present scope and scale, the 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. One conception of the map area from a terrane point of view is that of Silberling and others (1994), shown as figure 2 on sheet 3 of this compilation. Another can be found in Nokleberg and others (1994). It will be apparent from examination of figure 2 that our lumpings of units results in a map having divisions only loosely similar to Silberling and others (1994)

Some of our groupings of map units use terms previously applied by other geologists 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 internally disrupted. Complexes are generally restricted to igneous or metamorphic rock assemblages and may have no apparent stratigraphic framework. An exception, however is the McHugh Complex, a tectonic melange 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 Nixon fork sequence. The ease with which this is done 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 we don't know any better. In other cases, such as the Nixon Fork sequence, we have reasonably good constraints on the nature of the rock units and can confidently package them.

In the following descriptions, units are generally listed in chronological order from youngest to oldest. In the unit descriptions, the age of the units, rather than their apparent stratigraphic position is given after the unit label and name. In the text of the descriptions, lower and upper is used to denote stratigraphic position, whereas late and early indicate age. Within each major age category, sequences, assemblages, and complexes are listed first, followed by sedimentary, igneous, and metamorphic rock units, listed in order of increasing 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 metamorphism, either known or inferred.

Acknowledgements

There is no way that a compilation on this scale could be done without the assistance of many geologists, far more knowledgeable about the geology of various regions of Alaska than we are. We have benefited greatly from the opportunity to use unpublished mapping by and to consult with Grant Abbott, Robert M. Chapman, Julie A. Dumoulin, Cynthia Dusel-Bacon, Bruce M. Gamble, Anita Harris, Marti L. Miller, Madelyn Millholland, Warren J. Nokleberg, Donald H. Richter, William W. Patton, Jr., Gary R. Winkler, and Wesley K. Wallace. In addition, support and encouragement from many of our peers, including Donald Grybeck, Thomas D. Light, and Alison B. Till, have made what at times seemed an overwhelming task, seem more possible and desirable.

The project to produce this map had short deadlines and would not have been possible without the able support of Nora Shew and her GIS support staff. Catherine G. Baxter, Kelly M. Brunt, Nathan S. Pannkuk, James D. Hall, S.M. Weems, Dolly Perea, and David Dempsey each made invaluable contributions to the project and helped us to meet our deadlines.

The Alaska Department of Natural Resources, Division of Oil and Gas provided strong encouragement and financial support to help with the preparation of this map; its assistance was invaluable in seeing to it that the map was completed.

In addition, organizational support from the Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys is greatly appreciated. Particularly, support and unpublished data made available by Ellie E. Harris and Rocky R. Reifenstuhl have helped to improve the map significantly.

Technical and editorial review of all or part of the manuscript by John C. Reed, Jr. and Henry C. Berg were greatly appreciated and have helped to improve the text and map.

DESCRIPTION OF MAP UNITS

[Note: Quadrangles are 1:250,000 scale unless otherwise noted.]

GENERAL UNITS

bu **Bedrock of unknown type or age**-- Includes rubble of metasiltstone and chert in the Kantishna River quadrangle and other areas of unknown bedrock throughout map area

QUATERNARY AND LATE TERTIARY ROCKS AND DEPOSITS

Qs **Surficial deposits, undifferentiated** (Quaternary)-- Unconsolidated silt, sand, and gravel of fluvial, glacial, colluvial, and other origins

Qv **Volcanic rocks, undivided** (Quaternary)-- Basalt to rhyolite flows, pyroclastic deposits, lahar deposits, and other volcanic deposits. Located in the south central part of map area. Largely associated with the Wrangell group of volcanoes in the Gulkana quadrangle (Nokleberg and others, in press), but also includes the northernmost of the Cook Inlet volcanoes in the Tyonek quadrangle (Miller and Smith, 1976; Magoon and others, 1976)

QTv **Volcanic rocks, undivided** (Quaternary and Late Tertiary)-- Includes the Wrangell Lava consisting chiefly of basalt and andesite in the southeastern part of the map area and olivine basalt and vesicular andesite in the northern part of the map area (Nokleberg and others, in press)

QTi **Intrusive rocks, undivided** (Quaternary and Late Tertiary)-- Rhyolitic to andesite domes, dikes swarms and plugs and other intrusive rocks exposed chiefly in the Wrangell Mountains (Nokleberg and others, in press)

TERTIARY ROCKS
Sedimentary rocks

Tsu **Sedimentary rocks, undivided** (Tertiary)-- Includes a number of different units mapped in various areas throughout the map area:

In the Healy quadrangle, unit Ts (Csejtey and others, 1992) consists of a sequence of poorly consolidated fluviatile dark-gray shale, yellowish-gray sandstone, siltstone, and pebble conglomerate of possible Eocene to Miocene age that may be in part correlative with the Tertiary coal-bearing sequence (unit Tcb).

In the Mount Hayes quadrangle, units Ts and Tsc of (Nokleberg and others, 1992a), consist of (unit Ts) brown sandstone and graywacke and interbedded conglomerate and argillite of possible Oligocene to Pliocene age and (unit Tsc) light-colored, fine-grained, poorly sorted sandstone, of Eocene to Miocene age, locally containing interbedded siltstone, pebbly sandstone, pebble to cobble conglomerate, and sparse, thin coal layers. Unit Tc of Nokleberg and others (1992a) consists of poorly sorted, crudely bedded to massive, polymictic conglomerate and subordinate sandstone. Assigned age of unit Tc is Eocene? because unit locally overlies volcanic rocks of Eocene age.

In the Circle quadrangle (Foster and others, 1983), unit Tcs 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), 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, unit Tsu, consists of fluviatile conglomerate, sandstone, and claystone which contain a few interbeds of lignitic coal and which may be correlative with the Chickaloon Formation (Csejtey and others, 1978)

In the McGrath quadrangle, consists of thick- to thin-bedded moderately indurated sandstone interbedded with poorly indurated, laminated, fissile, carbonaceous shale and fine-grained sandstone (Bundtzen and others, 1997a). Also included in map unit is limestone conglomerate of the McGrath quadrangle, unit Tcl of Bundtzen and others (1997a). Assigned age is pre-middle Eocene for the sandstone and shale unit as unit is intruded by a middle Eocene dike, whereas the limestone conglomerate unit is assigned an age of late Paleocene? to Oligocene

Tk **Kenai Group, undivided** (Pliocene to Oligocene)-- Poorly to moderately indurated pebble to cobble conglomerate, cross-bedded medium-grained sandstone to granule conglomerate, clay layers, and coal seams as much as 5 m thick (Solie and others, 1991). Consists of rocks assigned to the Beluga, Sterling, and Tyonek Formations and other unassigned fluvatile sedimentary rocks of Pliocene to Oligocene age. Units are typically estuarine and nonmarine clastic sedimentary rocks. Tertiary formations assigned to Kenai Group in the Cook Inlet basin by Calderwood and Fackler (1972). Locally subdivided into:

Tsf **Sterling Formation** (Pliocene)-- Orange, light-tan, or light-gray, massive-bedded, coarse conglomerate

Tkb **Beluga Formation** (Miocene)-- Sandstone, siltstone, and coal

Tty **Tyonek Formation** (Miocene)-- Carbonaceous sandstone, siltstone, shale, and claystone. Locally divided into two members, a sandstone member consisting of about 80 percent tan to light-gray sandstone, 20 percent light- to medium-gray siltstone and claystone, and less than 1 percent conglomerate, coal, and volcanic ash. Conglomerate member consists of 40 percent conglomerate, 20 percent sandstone, and less than 40 percent siltstone, claystone, and coal. Also includes the Hemlock Conglomerate of Oligocene age where units are undivided

Tn **Nenana Gravel** (Pliocene and late(?) Miocene)-- Yellowish-gray to reddish-brown well-sorted, poorly to moderately consolidated conglomerate and coarse-grained sandstone having 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, written commun., 1993)

Tcb **Coal-bearing rocks** (Miocene? to Paleocene?)-- Healy Creek, Sanctuary, Suntrana, Lignite Creek, and Grubstake Formations of the Nenana coal field, the sedimentary rocks of the Jarvis Creek coal field of Nokleberg and others (1992a), which have been divided into three members, and similar units in other Tertiary basins; located largely north of the Alaska Range. "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 (Csejtey and others, 1992)"

Ttw **Tsadaka, West Foreland, and Wishbone Formations, undivided** (Tertiary)-- Also includes unnamed fluvatile conglomerate and coal-bearing sandstone of the eastern Talkeetna Mountains. Locally subdivided into:

Tts **Tsadaka Formation** (Miocene or Oligocene)-- Poorly sorted cobble to boulder conglomerate, interbedded with lenses of feldspathic sandstone, siltstone, and shale. Unit is of terrestrial origin, deposited on alluvial fans and in braided streams from a northerly source. Clasts in the conglomerate are largely plutonic in contrast to the underlying Wishbone Formation. Age considered Oligocene on the Anchorage quadrangle geologic map (Winkler, 1992) and Miocene on the Talkeetna Mountains quadrangle geologic map (Csejtey and others, 1978)

Twf **West Foreland Formation** (Eocene)-- Conglomerate, sandstone, and siltstone; mostly tuffaceous (Magoon and others, 1976)

Tw **Wishbone Formation** (Eocene)-- Fluviatile conglomerate having thick interbeds of sandstone, siltstone, and claystone and containing local partings of volcanic ash. Deposited in a similar environment as the overlying Tsadaka Formation; however source terrain was largely volcanic, most likely the Talkeetna Formation

Tvs **Volcanic and sedimentary rocks, undivided** (Oligocene and Eocene)-- Light to medium greenish-gray to gray conglomerate, graywacke, siltstone, lignitic shale and bituminous coal (Weber and others, 1992). Also includes greenstone, basalt, and tuff interlayered with medium- to medium-dark-olive-gray graywacke and conglomerate grading upward to siltstone in the northern part of the Livengood quadrangle. Isom Creek section is overturned to the north. Unit may be in part correlative with units Tcb and Tfv of this map

Tfv **Fluviatile sedimentary rocks and subordinate volcanic rocks** (early Eocene?)-- Intercalated fluviatile 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). Finer grained parts contain carbonized plant fragments. Csejtey, (comment in Csejtey and others, 1992) suggests possible correlation with the Cantwell Formation. Other possible correlations are with units Tvs (preferred) and Tcb of this map. Unit as shown on map also includes similar units in the McGrath (Bundtzen and others, 1997a) and Mount Hayes (Nokleberg and others, 1992a) quadrangles

Tch **Chickaloon Formation** (Eocene and Paleocene)-- Predominantly fluviatile 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. Lower part of unit largely conglomerate and lithic sandstone derived from erosion of the Talkeetna Formation. Thickness is more than 1,500m

Tar **Arkose Ridge Formation** (Eocene, Paleocene, and Late Cretaceous?)-- Fluviatile and alluvial feldspathic and biotitic sandstone, conglomerate, siltstone, and shale containing abundant plant fragments. Deposition in a coarsening upward sequence was on alluvial fans and by overloaded braided streams carrying sediment derived from rapid erosion of uplifted mountains to the north. Thickness is as much as 700m. Age control is largely based on late Paleocene fossil plants and radiometric ages on locally associated volcanic flows and dikes. A pre-Tertiary age has been suggested for the part of the unit based on a questionable K-Ar age determination on biotite from a metamorphosed part of the unit (Csejtey and others, 1977; 1978); otherwise the age is considered broadly coeval with the Chickaloon Formation (Winkler, 1992)

Tovs **Orca Group, undivided** (Eocene and Paleocene)-- Thick complexly deformed accretionary sequence of flysch and tholeiitic volcanic rocks (Winkler, 1992). Consists of basaltic flows, pillow breccia, and tuff interbedded with flyschoid siltstone and sandstone. Outcrops within the Valdez and Anchorage quadrangles. Locally sub-divided into:

Tos **Sedimentary rocks of the Orca Group**-- Monotonous sequence of thin- to thick-bedded sandstone, siltstone, and mudstone. Primary sedimentary features indicate deposition by turbidity currents (Winkler, 1992)

Toc **Conglomerate of the Orca Group**-- Massive, clast-supported pebble, cobble, and boulder conglomerate grading to matrix-supported pebbly mudstone and sandstone (Winkler, 1992)

Tov **Volcanic rocks of the Orca Group, undivided** (Eocene? and Paleocene)-- Tholeiitic pillow basalt, pillow breccia, and minor aquagene tuff. Volcanic rocks are conformable with enclosing flyschoid sedimentary rocks and on a regional scale the tholeiitic rocks are lenticular in form (Winkler and others, 1981)

Igneous rocks

Volcanic and hypabyssal rocks

Tvu **Volcanic rocks, undivided** (Tertiary)-- Includes unit Tvv of the Healy quadrangle (Csejtey and others, 1992), consisting of volcanic flows ranging from basalt to rhyolite in composition, pyroclastic rocks and subordinate subvolcanic intrusive rocks. Similar volcanic rocks occur as unit Tv in the Anchorage and Talkeetna Mountains quadrangles, where they also include small lenses of fluviatile conglomerate. 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. In the Lime Hills quadrangle (Gamble and Reed, 1996), small "volcanic intrusive" centers of unit Tvi are included in this unit. Age control is sparse and unit is generally considered to range throughout the Tertiary; however most K-Ar age determinations are Eocene and older. In the Nulato quadrangle, this unit includes Patton's (written commun., 1997) unit Tr, rhyolite and dacite flows and shallow intrusive bodies and unit Ta, andesite and basalt flows, both of Eocene and Paleocene age

Trs **Rhyolitic volcanic and sedimentary rocks** (Tertiary?)-- Rhyolitic volcanic and minor(?) associated sedimentary rocks are mapped in a small area in the Tanana quadrangle (Chapman and others, 1982; Dover, unpublished data, 1997). Rhyolitic rocks consist of light- to very light-yellow and yellowish-gray to cream and white flows and breccia. Tuff and probable welded tuff, generally devitrified, are common and similar in color to the lavas. Sedimentary rocks include minor light- to medium-gray cherty rocks and very light-yellow to tan and light-olive- to medium-gray, generally thin-bedded to laminated siltstone and shale, grading to argillite

Tb **Basalt** (early Tertiary?)-- Brownish black olivine basalt. Vesicular in part, locally displays columnar jointing and possibly pillow structures in the Sleetmute quadrangle (Miller and others, 1989); also includes olivine basalt in the Livengood, Fairbanks and Lime Hills quadrangles

Thf **Hypabyssal felsic and intermediate intrusive rocks** (Miocene to Paleocene, mostly Early Tertiary or Eocene?)-- Includes unit Ti in the Anchorage (Winkler, 1992) and unit Tif, both of apparent Eocene age, in the Valdez (Winkler and others, 1980) and Talkeetna Mountains (Csejtey and others, 1978) quadrangles. Consists of small stocks, dikes, and sills of rhyolite to dacite. Also includes similar rocks in the Healy (Csejtey and others, 1992), Mount McKinley (Bela Csejtey, Jr., written commun., 1993) and Big Delta (Weber and others, 1978) quadrangles. In the McGrath quadrangle (Bundtzen and others, 1997) unit includes units Tid, Tif, and Tia, dikes and sills of a wide range of compositions but largely felsic to intermediate composition

Thm **Hypabyssal mafic intrusive rocks** (Miocene to Paleocene, mostly Early Tertiary or Eocene?)-- Widely exposed small stocks and irregular-shaped dikes and sills of diorite porphyry, diabase, basalt and lamprophyre. Includes unit Tim, of apparent Eocene age, in the Anchorage (Winkler, 1992) and Talkeetna Mountains (Csejtey and others, 1978) quadrangles. Also includes similar rocks in the Healy (unit Tvim, Csejtey and others, 1992) and Mount McKinley (unit Tvim, Bela Csejtey, Jr., written commun., 1993) quadrangles, and unit Td, porphyritic to equigranular andesite and basalt dikes in the Lime Hills quadrangle (Reed and Gamble, 1988). Unit also tentatively includes unit TJds of the Anchorage quadrangle (Winkler, 1992) consisting of mafic to intermediate dikes, sills, stocks, for which Tertiary to Jurassic age was assigned Winkler (1992)

Pliocene

Thd **Hornblende dacite**-- Subvolcanic intrusive hornblende dacite of Jumbo dome in the Healy quadrangle. K-Ar age 2.79 +/- 0.25 Ma age (Csejtey and others, 1992)

Miocene

Tba **Basaltic andesite**-- Very fine-grained to aphanitic, dark- to medium-gray, locally vesicular basaltic andesite. K-Ar ages 6.9 +/- 0.2 and 13.0 +/- 0.5 Ma (Miller and Bundtzen, 1994)

Oligocene and Eocene

Tvr **Crystal and crystal-lithic ash-flow tuff** (early Oligocene to late Eocene)-- Tuff and subordinate flows and hypabyssal intrusive rocks of apparently felsic composition in small exposures in the eastern Lime Hills and the Melozitna quadrangles. Also includes local accumulations of volcaniclastic sedimentary rocks. In some areas of the Lime Hills quadrangle, rocks range from andesite to dacite in composition, in general the composition was not reported (Gamble and Reed, 1996). Units included here consist of the informally defined Seabee, Lime Hills A-2, Snowcap, North Volcanic Center, and Styx River Volcanics of Gamble and Reed (1996). In the Melozitna quadrangle, includes rocks formerly mapped by Patton and others (1978) in their unit TKv, now know to be of Tertiary age. Exposures are found in the Indian River, Takhakhdona Hills, and Dulbi River areas of the Melozitna quadrangle

Tvb **Andesite and basalt** (Oligocene and Eocene)-- Andesite breccia and tuff called the Mount Galen Volcanics (Gilbert, 1979) that is the eruptive equivalent of the Mount Eielson pluton. K-Ar age of 38 Ma (Gilbert, 1979). Includes a variety of volcanic rocks assigned to the Sheep Creek, Windy Fork, and Terra Cotta volcanic fields by Bundtzen and others (1997a). Also includes the Roundabout Mountain volcanic field (see description of unit KJv, Patton, 1966), composed of mildly deformed vesicular basalt and pyroclastic rocks in the Kateel River quadrangle. According Moll-Stalcup and others (1994), the Roundabout Mountain volcanic field is andesite of 30-45 Ma age. W.W. Patton, Jr. (oral commun., 1997) explained that the age range of the volcanic field was assigned by inference from the

Takhakhdona and Indian Mountain volcanic fields to the east (Moll-Stalcup and others, 1994)

Paleocene

Tcv **Volcanic rocks of the Cantwell Formation**-- 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 is sometimes used in the literature as a synonym for this unit. Herein includes, unit Tv of Nokleberg and others (1992a), which consists chiefly ash-flow tuff, breccia, agglomerate, flows, dikes, and sills in the Mount Hayes quadrangle. Also includes minor volcanic sandstone, conglomerate, and fossiliferous limestone. Nokleberg and others (1992a) refer this unit to the Eocene on the basis of a single whole-rock 49 Ma K-Ar age determination on a rhyodacite tuff

Plutonic rocks

Tiv **Granitic and volcanic rocks, undivided** (Oligocene to Paleocene)-- Extensive border zone between a Tertiary granitic batholith (unit Tgr of this map) and slightly younger felsic dikes and small subvolcanic intrusive bodies that cut the pluton. Also includes erosional remnants of rhyolitic flows overlying the pluton (unit Tgrv, Csejtey and others, 1992) in the south central Healy quadrangle

Oligocene

Togr **Granite**-- Biotite-bearing peralkaline alkali-feldspar granite and biotite-plagioclase granite of 29 to 31 Ma age and biotite or biotite-amphibole granite of 25 to 27 Ma age in the Lime Hills (units Twf, Tnep, Gamble and Reed, 1996), McGrath (unit Twg, Bundtzen and others, 1997a) and Tyonek quadrangles. Unit also includes biotite granite of 32 Ma age in the Anchorage quadrangle (unit Tmg, Winkler, 1992)

Oligocene or Eocene

Toegr **Granitic rocks** (early Oligocene or late Eocene)-- Includes a wide variety of granitic rocks exposed throughout much of the southern part of the map area. Rocks range from alkali-feldspar granite, through biotite or biotite-hornblende granite to granodiorite and minor quartz monzonite. Locally, the rocks are porphyritic and hypabyssal. Rocks of the unit are exposed in the Lime Hills quadrangle (Gamble and Reed, 1996) as well as the Mount Hayes (Nokleberg and others, 1992a), and Anchorage (Winkler, 1992) quadrangles. Also included are small quartz monzonite plutons of the southeastern Sleetmute quadrangle (Miller and others, 1989). Radiometric ages on these plutons range from about 34 Ma to as much as 45 Ma, however most of the plutons yield ages of about 38 Ma

Toem **Granodiorite to tonalite** (early Oligocene or late Eocene)-- Biotite, biotite-hornblende, and hornblende granodiorite, quartz diorite, and quartz monzodiorite. Rocks of the unit are exposed in the Lime Hills (Gamble and Reed, 1996), Mount McKinley (Bela Csejtey, Jr., written commun., 1993), Talkeetna (Reed and Nelson, 1980), and Anchorage quadrangles (Winkler, 1992)

Eocene

Tegr **Granite and granodiorite**-- Undated biotite-hornblende granite and granodiorite and altered biotite and hornblende tonalite yielding ages about 45 Ma in the Valdez quadrangle (units Tg and Tt, Winkler and others, 1980); biotite-hornblende granodiorite dated at 44 and 48 Ma in the Talkeetna Mountains quadrangle (unit Tgd, Csejtey and others, 1978); and porphyritic hornblende granodiorite dated at 52.8 Ma in the Iditarod quadrangle (unit Tp, Miller and Bundtzen, 1994)

Td **Felsic intrusive rocks**-- Widely distributed leucocratic dikes, sills, and small stocks south of Border Ranges fault in the Anchorage quadrangle (Winkler, 1992). Bodies are generally thin, but some have lateral extents of several kilometers; some can be traced as far as 30 km across the strike of the enclosing Valdez Group. Dacite is the most common composition, rhyolite is also present. Radiometric ages fall in two clusters, one at 55-48 Ma and another at 44-43 Ma. However, a dike near Anchorage crosscutting the Valdez Group (unit Kvs) and McHugh Complex (unit KTRm) yielded a 34.8 Ma age

Paleocene

Tpgr **Granitic rocks**-- Widely distributed biotite-muscovite granite to quartz monzonite. Granitic rocks of this unit in the southern part of the map area are part of the informally defined McKinley Sequence (Gamble and Reed, 1996) in the Lime Hills quadrangle (Gamble and Reed, 1996) yielding radiometric ages between 57 and 65 Ma and in the Talkeetna quadrangle dated at 56 to 52 Ma and 65 to 64 Ma (Reed and Nelson, 1980) are also part of the unit. Farther north, 60 million-year-old quartz monzonite plutons in the Livengood quadrangle (Weber and others, 1992), 62 to 65 million-year-old plutons in the Tanana quadrangle (Chapman and others, 1982), and a 55 Ma granite pluton in the Mount Hayes quadrangle (unit grgr, Nokleberg and others, 1992a) are all part of this unit

Thgd **Granodiorite and other intermediate plutonic rocks**-- Consists of biotite and biotite-hornblende granodiorite, largely in the southern part of the map area. Includes an unnamed quartz diorite pluton (58 Ma) and the Mount Estelle pluton of the Lime Hills (Gamble and Reed, 1996) and Talkeetna (Reed and Nelson, 1980) quadrangles, plutons in the western and northern parts of the Talkeetna Mountains quadrangle (Csejtey and others, 1978), all generally yielding ages between 61 and 66 Ma. Also includes a number of small monzonite or monzodiorite bodies in the Livengood quadrangle (unit Tm, Weber and others, 1992)

Tgl **Gabbro** (Paleocene)-- Dark-colored, fine- to medium-grained hornblende and pyroxene-hornblende gabbro (62 Ma) in the Lime Hills A-2 1:63,360-scale quadrangle (Gamble and Reed, 1996)

TERTIARY AND/OR CRETACEOUS
Sedimentary rocks

TKcg **Conglomerate, sandstone, and lignite** (Tertiary(?) and Cretaceous)-- Rocks exposed in a 25-m-thick section along the Sethkokna River in the Medfra quadrangle (Patton and others, 1980). Conglomerate contains clasts of quartz, chert, felsic volcanic rocks, and talc-schist. Unit is overlain by rhyolite and dacite flows of the *Volcanic rocks of the Sischu Mountains* unit (included in unit TKvr here). Provisionally assigned a Latest Cretaceous age (Campanian-Maestrichtian) on the basis of pollen in the lignite beds.

Igneous rocks
Volcanic and hypabyssal rocks

TKv **Flows, tuff, and breccia, undivided**-- Basaltic, andesitic, and rhyolitic flows, tuff, and breccia and a few dacite flows, minor interbedded sandstone and shale. Exposed primarily in the Ruby and Ophir quadrangles (Cass, 1959; Chapman and Patton, 1979; Chapman and others, 1985). Unit also includes unit TKvd, dacite flows and dikes; and unit TKvt, intermediate composition tuff of the Veleska Lake volcanic field of Bundtzen and others (1997a) in the McGrath quadrangle and felsic tuff of the Tyonek quadrangle (Solie and others, 1991)

TKd **Dikes and subvolcanic rocks of intermediate composition**-- Exposed in widely scattered areas throughout map area. Includes pilotaxitic dacite-andesite plugs in the Iditarod quadrangle (Miller and Bundtzen, 1994)

TKgp **Hypabyssal granite porphyry dikes and rhyolitic sills, and plugs**-- Exposed in widely scattered areas

TKvr **Rhyolite and related rocks**-- Consists of light gray to pink rhyolitic volcanic rocks and minor dacite, including flows, tuff, welded(?) tuff and breccia. Exposures of this unit include the volcanic rocks of the Big Creek -- Tokatjikh Creek area of the Melozitna quadrangle (mapped as unit TKv by Patton and others, 1978), the northwestern part of the Tanana quadrangle, the Nowitna River and Nixon Fork-Upper Sulukna River areas, and the Sischu Mountains and northeast in the Medfra (Patton and others, 1980), Ruby (Cass, 1959), Mount McKinley (Bela Csejtey, Jr., written commun., 1993), Tanana (Chapman and others, 1982), and Kantishna River quadrangles (Chapman and others, 1975). Also includes felsic volcanic rocks associated with volcano-plutonic complexes of the Sleetmute quadrangle, as mapped by Miller and others (1989) and rhyolitic tuff and dacite dikes of the Veleska Lake volcanic field of Bundtzen and others (1997a). Where determined, age ranges between approximately 70 and 50 Ma

TKvi **Andesite and related rocks**-- Largely andesite but includes minor dacite and basalt flows, tuff, and breccia. Consists of that part of the Iditarod Volcanics that overlie the sedimentary rocks of the Kuskokwim Group (unit Kk) in the Iditarod quadrangle. Also includes the "Volcanic rocks of the Yetna River," also in the Iditarod quadrangle (Miller and Bundtzen, 1994), and the "Volcanic rocks of the Nowitna River" area of the Medfra quadrangle (Patton and others, 1980), basaltic andesite of Veleska Lake volcanic field of Bundtzen and others (1997a)

TKiv **Mafic to intermediate volcano-plutonic complexes**-- Chiefly altered basaltic andesite and trachyandesite porphyry flows and hypabyssal intrusive bodies. Mostly in the southwestern part of the map area, in the Iditarod, Sleetmute, and Medfra quadrangles. Ages range between approximately 71 and 65 Ma

Intrusive rocks

TKi **Intrusive rocks, undivided**-- Composition ranges from granite to diorite. Radiometric ages not available for most bodies. Largely in the southwestern and western part of the map area

TKg **Granitic rocks**-- Widely distributed and exposed granitic intrusive rocks, chiefly biotite and biotite-hornblende granite. Includes lesser granodiorite, quartz monzonite and alkali granite

TKgd **Granodiorite, tonalite, and monzonite dikes, and stocks**-- Limited to the southeastern part of the map area, except for the monzonite bodies, which tend to occur farther west and north. Available K-Ar radiometric ages range from 59 to 75 Ma

TKqd **Quartz diorite and diorite dikes and stocks**-- Fine- to medium-grained, hypautomorphic granular quartz diorite and diorite dikes and stocks. Mapped only in the Mount Hayes quadrangle (Nokleberg and others, 1992a)

TKl **Lamprophyre, alkali gabbro, and alkali diorite**-- Mapped in the Mount Hayes quadrangle

TKgb **Gabbro and leucogabbro**-- Fine- to medium-grained hypidiomorphic granular textured gabbro and leucogabbro, typically in small plutons. Mapped in the Lime Hills (Gamble and Reed, 1996) and Talkeetna Mountains (Csejtey and others, 1978) quadrangles. Age is poorly constrained

TDg **Gabbro** (Tertiary? to Devonian?)-- Medium- to coarse-grained gabbro with minor diorite and basalt which intrude(?) rocks of inferred Triassic to Mississippian age and locally, Cretaceous age. Contact relations are uncertain due to poor exposure but Chapman and others (1985) indicate at least one gabbro body is clearly intrusive and has a hornfels aureole. A similar unit of gabbroic sills, dikes, and small plugs in the adjoining Medfra quadrangle was given a provisional Tertiary to Devonian age. Includes unit TMg the Ophir quadrangle (Chapman and others, 1985) and unit TDg in the Medfra quadrangle (Patton and others, 1980)

Metamorphic rocks

TKc **Melange or cataclastite of the Orca Group** (Tertiary and Cretaceous)-- Extensive serpentinized ultramafic rocks, including dike-like bodies of rodingite, blocks of layered gabbro, crossite schist, pillow basalt, marble, chert and diverse other rock types. Conglomerate clasts within unit resemble lithologies in the Chickaloon Formation (Winkler and others, 1980; Winkler, 1992). Chert clasts are of probable Late Triassic or Early Jurassic age. Emplacement of the melange or cataclastite is inferred to have been during Cretaceous or Tertiary time. Outcrops within the Valdez and Anchorage quadrangles

TKgg **Gneissose granitic rocks** (early Tertiary to Early? 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 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 well as the contact with unit Mzpca. Unit has pervasive schistosity generally striking northeast to southwest and dipping moderately to steeply west, is locally blastomylonitic and contains relict porphyritic textures. Metamorphic grade is middle to upper amphibolite facies. 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, 1992a; 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 included in unit Kgr, Cretaceous granitic rocks. 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. The youngest ages for this unit tend to occur in close proximity to the Denali Fault. In the Lime Hills and Tyonek quadrangles, unit TKgs, gneiss is included in this unit. An orthogneiss as above, its texture appears mylonitic. Composition is primarily granodiorite, however up to 5 percent garnet was noted locally in contrast to the gneiss of the Mount Hayes and Healy quadrangles. Structural grain strikes northeast to southwest and tends to be vertical or dip steeply (80°) to the northwest

TPza **Amphibolite facies metamorphic rocks** (Earliest Tertiary to Paleozoic)-- 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 marble and very minor quartzite occur in unit 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. Includes the Raven Creek Hill unit of Weber and others (1992) and units pTam, pTas, pTaq of Reifenstuhl and others (1997)

UNDIVIDED MESOZOIC ROCKS
Sedimentary rocks

KTRg **Gemuk Group** (Early Cretaceous to Late Jurassic and Triassic to Mississippian?)-- Chiefly massive and thin-bedded, fine-grained, siliceous rocks, includes some volcanic rocks, calcareous siltstone, and limestone. Miller and others (1989) described Gemuk Group in the Sleetmute quadrangle as chiefly siltstone interbedded with lesser chert and volcanic rocks and minor limestone, graywacke and breccia. Only Early Cretaceous and Cretaceous fossils are known from the Sleetmute quadrangle. Early Cretaceous, Late Jurassic, and Triassic to Mississippian(?) fossils have been collected from the Gemuk Group (Hoare and Coonrad (1959a) elsewhere. Originally defined by Cady and others (1955), Hoare and Coonrad (1959a, b) subdivided the unit in the Bethel and Russian Mission quadrangles. Box and others (1993) described rocks of this unit in the Bethel and southern Russian Mission area as a series of distinct terranes and further subdivided it

Igneous rocks

Mzi **Intrusive rocks** (Mesozoic?)-- Undated parts of the Alaska-Aleutian Range batholith in the Tyonek quadrangle. Chiefly quartz diorite, diorite, and gabbro (Reed and Elliott, 1970)

Mzum **Ultramafic and associated rocks** (Mesozoic?)-- Chiefly variably serpentinized pyroxenite, peridotite, dunite, schistose amphibolite and hornblende-plagioclase gneiss derived from gabbro (Nokleberg and others, 1992a). Exposed close to the Denali Fault and along the Broxson Gulch thrust in the Mount Hayes quadrangle. Protolith thought Paleozoic, metamorphosed in the Early Cretaceous. K-Ar analysis of biotite and hornblende from pyroxenite yielded nearly concordant ages of 123 and 126 Ma (Nokleberg and others, 1992a)

Metamorphic rocks

Mzsa **Schist and amphibolite** (Late Cretaceous or older?)-- Dominantly fine- to medium-grained garnet-bearing schist and hornblende amphibolite, with subordinate calc-silicate schist and quartzite, and intercalated gneissose granitic to gabbroic metaigneous rocks. Includes migmatitic rocks of the MacLaren metamorphic belt (Smith, 1981) near East Susitna batholith (unit TKgg). Metamorphic grade increases gradationally eastward and northward toward the East Susitna batholith (unit TKgg). Underwent amphibolite facies and local greenschist facies retrogressive metamorphism. K-Ar hornblende and biotite ages range from 65.9 to 31.9 Ma, with biotite yielding the consistently youngest ages. Includes the sa, mig, and mgsh units in the MacLaren terrane of Nokleberg and others (1992a) in the Mount Hayes quadrangle. We interpret rocks originally mapped as the Kahiltna flysch sequence by Csejtey and others (1992) in the southeastern part of the adjacent Healy quadrangle to the west, had the same protolith as these units. We have therefore placed those rocks in this unit

Mzpca **Phyllite, pelitic schist, calc-schist, and amphibolite of the MacLaren metamorphic belt** (Mesozoic)-- Mainly phyllite, quartz-mica schist, calc-schist, amphibolite, and subordinate marble and meta-andesite, derived from siltstone, graywacke, marl, andesite, and gabbro. Underwent amphibolite facies metamorphism and local greenschist retrograde metamorphism, and at least two phases of folding having opposite vergence. 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. K-Ar mica ages range from 48.0 to 30.6 Ma and an amphibole age was 69.6 Ma (Nokleberg and others, 1992a). Separated from unit Mzsa, schist and amphibolite, by the Meteor Peak fault, and distinguished lithologically from unit Mzsa by its calcareous component. Includes the msh, mph, and ma units of Nokleberg and others (1992a) in the MacLaren metamorphic belt of the Mount Hayes quadrangle. A lithologically similar part of the Kahiltna flysch sequence (KJf) of Csejtey and others (1992) in the southeastern part of the Healy quadrangle has been correlated on this compilation with the above units of Nokleberg on the basis of mapping in the Healy A-1 (Smith, 1981) and A-2 (Smith and others, 1984) quadrangles. This correlation includes units Ks, Kp, pJa, pJt, and pJcg of Smith (1981) and Smith and others (1984). Rocks of this unit are considered by most workers as part of the MacLaren metamorphic belt (Smith, 1981; Smith and others, 1984; Csejtey and others, 1992; Nokleberg and others, 1992a)

CRETACEOUS ROCKS
Sedimentary rocks

Kcs **Cantwell Formation, sedimentary rocks subunit** (Paleocene(?) and Late Cretaceous)-- Unit consists of a fluviatile, intercalated sequence, in various proportions, of dominantly polymictic conglomerate, sandstone (including arkose), siltstone, argillite, shale, and a few thin coal beds Csejtey and others (1992). Locally thin volcanic flows and thin tuff layers are present. Conglomerate clast lithology varies greatly within the outcrop area, indicating different geologic source areas and deposition by a number of river systems. Plant fossils suggest a Paleocene age; however some K-Ar ages suggest the unit might locally contain strata of Cretaceous age (Csejtey and others, 1992) and recent palynological analyses reported by Ridgeway and others (1994) suggest an early Campanian to late Maestrichtian age for the Cantwell and a thickness of as much as 4,000 m. As mapped here, unit also includes continental sedimentary rocks that crop out in the Talkeetna quadrangle. These consist of chiefly medium- to dark-gray phyllitic shale, sandstone, grit, and conglomerate containing minor carbonaceous shale and tuffaceous sandstone

Kms **Minto unit** (Late Cretaceous(?)-- Interbedded yellowish-gray, iron-stained siltstone, light-gray to light-yellowish-gray mudstone locally containing pyritized plant fragments, light- to medium-olive-gray, very fine- to medium-grained graywacke, hard quartzo-feldspathic sandstone, light-yellowish-gray shale, and medium-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, unit thought post-Albian

Km **Matanuska Formation** (Late Cretaceous (Maestrichtian) to late Early Cretaceous (Albian))-- Well-indurated, thinly-bedded, dark-gray fossiliferous shallow marine shale containing conspicuous calcareous concretions, volcanic-lithic siltstone, sandstone, graywacke, and subordinate conglomerate. Diverse shallow to deep marine (in part, turbiditic) deposits derived from a northern source, either an unidentified mid-Cretaceous magmatic arc or the Jurassic arc represented in part by the Talkeetna Formation (Winkler, 1992). Upper part of unit is coeval with the flysch of the Valdez Group to the south. Rests with pronounced angular unconformity on Early Cretaceous and older strata (Csejtey and others, 1978)

Kuskokwim Group-- Divided into:

Kk **Kuskokwim Group, deep marine rocks** (Late Cretaceous and late Early Cretaceous)-- Sandstone, siltstone, shale, and conglomerate. Includes fine- to coarse-grained, greenish-gray to gray, thinly cross-bedded sandstone and quartz-chert pebble conglomerate having poorly exposed interbeds of dark shale and siltstone. Locally, light- to medium-gray, fine- to coarse-grained, resistant turbiditic sandstone and medium to dark-gray shale and siltstone displaying graded bedding, cross-bedding, flute clasts, and ripple marks. Includes 15 to 40 percent shale and siltstone. Bouma ABCD and BCDE intervals are present. Also includes well-indurated volcaniclastic sandstone containing as much as 40 percent volcanic clasts; locally siliceous, and very resistant in outcrop. May be lateral equivalent of agglomerate, chert, tuff, and sandstone unit herein included in the Kuskokwim Group volcanic rocks (mapped here as unit Kvl). Flysch trace fossil *Paleodictyon* abundant locally. Woody fragments, plant stems, dicotyledon leaf fragments, and *Inoceramus* prisms locally abundant (Bundtzen and Laird, 1980, 1982; cited in Chapman and others, 1985). Unit is widely distributed in southwestern Alaska (see Decker and others, 1994). Mapped as units Ksu and Ksc in Medfra (Patton and others, 1980), unit Kks in Iditarod (Miller and Bundtzen, 1994), unit Kk in Sleetmute (Miller and others, 1989), unit Kku in Lime Hills (T.K. Bundtzen, unpublished data, 1998), units Ku, Kss, and Kls in Ophir (Chapman and others, 1985), and units Kcs, Kss, Kls, Kus, and Ksh in McGrath (T.K. Bundtzen, unpublished data, 1998) quadrangles. In the Lime Hills quadrangle, distinction between the Kuskokwim Group and the Kahiltna flysch sequence (unit KJf) is difficult and placement of the boundary is controversial

Kkn **Kuskokwim Group, non-marine and shallow-marine rocks** (early Late Cretaceous)-- Predominantly very fine- to medium-grained, medium- to medium-dark-gray and greenish-gray, in part calcareous, graywacke and sandstone(?), medium-dark gray siltstone and shale, and minor granule to pebble polymictic conglomerate. Unit is the non-marine facies of the Kuskokwim Group and is recognized in the Ophir (Chapman and others, 1985), Iditarod (Miller and Bundtzen, 1994), Medfra (Patton and others, 1980), McGrath, and Sleetmute (T.K. Bundtzen, unpublished data, 1998) quadrangles. Commonly thin-bedded; weathers to various shades of yellow, brown, and red. Largely shallow marine to nonmarine and unfossiliferous (Chapman and others, 1985)

Sedimentary rocks of the Yukon-Koyukuk region (late Early Cretaceous to Late Cretaceous)-- Thick packages of very similar sedimentary rocks are found rimming the Yukon-Koyukuk region which in the past were called the Bergman or Shaktolik Group. However, both names have since been abandoned (Patton, 1973). These rocks consist of turbiditic basin fill covered by deltaic marine and nonmarine sedimentary rocks that prograded over the turbidites largely from the east in the map area, but also from the west, west of the map area. Right lateral offset along the Kaltag Fault has juxtaposed rocks of the eastern Kobuk-Koyukuk sub-basin against rocks of the western Lower Yukon sub-basin (Patton and others, 1994a). This map shows the rocks of the two sub-basins as different units, informally called the Melozitna and Norton Bay sequences in order to clearly show the distinction. The deltaic rocks of the Melozitna sequence, from the Kobuk-Koyukuk sub-basin are proportionally thicker and as a result this group contains a higher percentage of conglomerate, which in itself contains a higher proportion of metamorphic and granitic clasts.

Kme **Melozitna sequence** (Late Cretaceous to late Early Cretaceous)-- Graywacke, shale, grit, and conglomerate. Lower part consists of shallow marine sandstone and shale that grades upward into nonmarine dark-gray to green sandstone, siltstone, shale, and quartz-chert pebble conglomerate. Locally, coal beds are reported (Martin, 1926, p. 407). Similar, unnamed unit, has been described in the Unalakleet (Patton and Moll-Stalcup, 1996), Nulato (W.W. Patton, Jr., written commun., 1997), and Ophir quadrangles (Chapman and others, 1985). Cretaceous sedimentary rocks of unit Ksu of Patton (written commun., 1997) south of the Kaltag Fault or east of the Koyukuk Flats in the Nulato quadrangle are here mapped as part of this unit, but rocks of unit Ksu north of the Kaltag Fault are mapped as unit Knbg. This distinction is made because descriptions from the source maps suggest a mixed granitic and metamorphic source for rocks south of the Kaltag Fault and a volcanic rock dominated source north of the Fault. Many of the rocks in this unit were originally included in the now abandoned Shaktolik Group (Patton, 1973). Locally subdivided into:

Kss **Nonmarine sandstone, quartz conglomerate, shale, and siltstone** (Late(?) Cretaceous)-- Olive-green, fine- to coarse-grained, cross-bedded, quartzose sandstone and grit; quartz-pebble conglomerate, and dark micaceous shale and siltstone. Interbedded fine-grained to gritty, dark-gray to green graywacke and mudstone. Abundant plant debris. Probably correlative with Upper Cretaceous nonmarine strata in Kateel River quadrangle (Patton and others, 1978; Patton, 1966)

Kqc **Quartz-pebble conglomerate** (early Late Cretaceous)-- Light-gray quartz-pebble conglomerate and quartzose sandstone containing minor intercalated ashy tuff. Intruded by granodiorite of Late Cretaceous (~82 Ma) age. Limited areal extent in the northeast quadrant of the Melozitna quadrangle

Kcg **Igneous pebble-cobble conglomerate** (Late Cretaceous? and Albian)-- Massive, poorly sorted conglomerate having pebble- to cobble-sized clasts chiefly of mafic intrusive and extrusive rocks and chert of various colors. Locally clasts of quartz, quartzite, granitic rocks, schist, and limestone are abundant but otherwise only occur in minor amounts. Interbedded fine-grained to gritty, dark-gray to green graywacke and mudstone. Grades upward into unit Kss and in part overlies and in part laterally gradational with unit Kvgm (Patton and others, 1978). Unit thought largely Albian but may include beds as young as Late Cretaceous (Patton and others, 1978)

Kvm **Volcanic graywacke and conglomerate** (early Late or late Early Cretaceous?)-- Poorly sorted, fine- to coarse-grained graywacke, sandstone, grit, and pebble- to cobble conglomerate composed chiefly of volcanic rock and chert detritus in the Medfra and Ophir quadrangles (Patton and others, 1980; Chapman and others, 1985)). Contains locally abundant large *Inoceramus*, brachiopods, and worm tubes. Includes massive volcanic conglomerate mapped as part of unit Kgs of Patton (1966) in the northwesternmost Kateel River quadrangle. This conglomerate is probably gradational with coarse breccia and agglomerate of unit Kve

Knb **Norton Bay sequence** (Late Cretaceous to late Early Cretaceous)-- Marine and nonmarine deltaic shale, siltstone, and sandstone. Northwestern part of the map area; locally subdivided here as nonmarine Kshn and marine Ksse. Also includes units Kgw and Km described below. In the Kateel River quadrangle, the juxtaposition of the various rock units of the Norton Bay sequence is probably due to thrusting, followed by normal faulting (W.W. Patton, Jr., oral commun, 1998)

Kshn **Nonmarine shale, siltstone, and sandstone** (Late Cretaceous)-- Dark-gray to olive-gray micaceous shale and siltstone, and light-olive-gray to yellowish-orange, fine- to coarse-grained cross-bedded sandstone. Massive sandstone beds near base of units forms resistant ridges. North of the Kateel River, sandstone contains pyroclastic debris. White quartz and dark chert pebble conglomerate lenses near base of unit. Bituminous coal beds as much as 6 inches [10 to 15 cm] thick are present in unit as are abundant plant fossils. Unit has an estimated thickness of 5,000 feet [1,500 m] (Patton, 1966)

Ksse **Marine sandstone and siltstone** (Early Cretaceous, Albian)-- Littoral and offshore marine deposits of dark-gray shale and siltstone interbedded with subordinate dark-greenish-gray fine-grained sandstone in lower part and light-olive fine- to coarse-grained sandstone in upper part. Local volcanic conglomerate at contact with unit Kve, andesitic volcanic rocks. Sandstone better sorted and more quartzose than unit Km, below. Albian age assigned on the basis of abundant molluscan fauna, particularly the occurrence of *Inoceramus altifluminis McLearn* (Patton, 1966)

Kmm **Marine mudstone and sandstone** (Early Cretaceous, Albian)-- Chiefly medium- to dark-gray mudstone and medium-gray to dark-greenish-gray moderately to highly calcareous fine-grained sandstone. Sandstone is composed largely of mafic and intermediate volcanic detritus, including some pyroclastic material, but locally contains lenses of feldspar and chert grit. Mudstone commonly banded and finely cross-bedded. Age assignment based on the occurrence of *Gastropilites*. Unit interpreted as prodelta turbidite (W.W. Patton, Jr., oral commun., 1998)

Kgw **Graywacke sandstone and mudstone** (Cretaceous, Albian{?} in part)-- Chiefly dark-greenish-gray to pale-olive tuffaceous and feldspathic fine- to very coarse-grained sandstone and subordinate dark-gray mudstone. Abundant lenses of feldspar and chert grit. Sandstone composed largely of mafic and intermediate volcanic detritus, including some pyroclastic material. Unit interpreted as submarine fan turbidite (W.W. Patton, Jr., oral commun., 1998)

Kwcf **Wilber Creek flysch** (Albian)-- Interlayered siltstone, shale, sandstone, and conglomerate originally subdivided into coarse- and fine-grained units (Weber and others, 1992). 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, ranges in grain size 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, large- to medium-scale, graded and amalgamated, having 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. Albian age based on presence of *Paragastroplites flexicostatus*. Graywacke rich in volcanic detritus is locally characteristic and may correlate with the Kathul Graywacke in the Charley River quadrangle east of the map area (Dover and Miyaoka, 1988)

Kvgm **Volcanic graywacke and mudstone** (Albian)-- Chiefly dark-greenish-gray, fine-grained to gritty, poorly sorted turbiditic graywacke composed largely of first- and second-cycle volcanic debris, but locally containing abundant granitic and metamorphic rock debris. Dark-gray mudstone interbeds. Graded bedding common. Contains some intercalated crystal tuff. Age assignment based on correlation with similar unit in Hughes quadrangle to north of map area (Patton and others, 1978). Unit stratigraphically underlies Norton Bay and Melozitna sequence sedimentary rocks and is thickest in Lower Yukon sub-basin (Patton and others, 1994a) on west. Unit interpreted as submarine fan turbidite (W.W. Patton, Jr., oral commun., 1998)

Ksm **Quartz-carbonate sandstone and pebbly mudstone** (Valanginian-Aptian)-- Fine- to coarse-grained quartz-carbonate sandstone and conglomerate, quartzose limestone, and dark-gray pebbly mudstone and siltstone. Clast lithologies consist of quartz, carbonate, and quartz-mica schist. Fossil age control extensive; *Buchia subleavis*, *B. crassicolis*, and *Cylindroteuthis* in the lower beds, indicate a Valanginian age, *Inoceramus* and *Arcoteuthis* in middle beds indicate a Hauterivian and Barremian age, and rare cephalopods including *Tropaeum* indicate an Aptian age for the upmost beds (Patton and others, 1980). Unit limited to small areas of outcrop in the Medfra quadrangle

Knl **Nelchina Limestone** (Hauterivian and Barremian)-- Shallow water marine sequence of thinly bedded calcareous sandstone, siltstone, claystone, minor conglomerate, and thick-bedded to massive clastic limestone, as mapped by Grantz (1960) in the Talkeetna Mountains quadrangle. The Nelchina Limestone rests with slight angular conformity on the Late Jurassic Naknek Formation

Kb **Berg Creek Formation** (Early Cretaceous?)-- Marine sandstone, siltstone, mudstone containing many interbeds of pebble- and cobble-conglomerate. Greenish-gray sandstone, in many places calcareous and cross-stratified, is predominant in lower part of the sequence. Framework grains in the sandstone and conglomerate clasts indicate largely volcanic source terrain. Dark-greenish-gray siltstone and mudstone are predominate in the upper part of the section; uppermost strata include rusty-weathering calcareous siltstone interbeds and concretions. Originally mapped as unit Js on the Valdez map

(Winkler and others, 1980), according to George Plafker (G.R. Winkler, written commun., 1998), unit is now considered the lower part of the Berg Creek Formation

Melange

KTRm McHugh Complex (Cretaceous to Triassic?)-- Tectonic melange consisting largely of Triassic through mid-Cretaceous protoliths of oceanic affinity. Blocks are boudins and fault slices of relatively competent rocks: basalt, chert, graywacke, and conglomerate, plus rare blueschist, gabbro, ultramafic rocks, and limestone. Matrix consists of relatively incompetent argillite, and locally, light-green tuff. Intermixing of blocks in the matrix occurs at scales ranging from that of a thin section to that of a 1:250,000-scale quadrangle. Gabbro, basalt, chert, argillite, and graywacke are interpreted as an oceanic-plate succession conveyed by plate motions into a subduction zone and deformed into a tectonic melange. Triassic through mid-Cretaceous radiolaria date the chert, and by inference, abyssal-plain sedimentation. Limestones, possibly originating on seamounts, have yielded Permian fusilinids and conodonts of tropical, Tethyan affinities. The time during which the various protoliths were intermixed to form a melange is not well constrained, but most likely spanned the Jurassic and Cretaceous

Kmar Melanges of the Alaska Range (Silurian to Cretaceous protoliths; Cretaceous melange formation). Consists of four rock suites, intensely deformed and intricately intermixed by tectonic and perhaps also sedimentary processes. Suites are: 1) cherty tuff, chert, argillite, and volcaniclastic sandstone. Radiolaria and conodont fragments from the Healy quadrangle indicate a Mississippian to Late(?) Devonian age (Csejtey and others, 1992); 2) flysch-like assemblage of dark-gray to black argillite, slate, shale, graywacke, and subordinate chert, chert-pebble conglomerate, and polymict conglomerate. It has yielded *Buchia* sp. of Late Cretaceous to Late Jurassic age in the Healy quadrangle (Csejtey and others, 1992), and a Cretaceous ammonite in the Mt. Hayes quadrangle (Nokleberg and others, 1992b). In the Mt. Hayes quadrangle, minor andesite and dacite are associated with the flysch-like assemblage; 3) limestone, of Silurian, Devonian, and Triassic ages, is mapped and described separately as unit TRSl in the Healy quadrangle; in the Mt. Hayes quadrangle, limestone is present but not differentiated from the main body of melange (Nokleberg and others, 1992a); and (4) ultramafic rocks, of unknown age, mapped and described separately as unit mlu. This melange unit crops out in two belts in the Healy quadrangle, and two belts in the Mt. Hayes quadrangle. South of the Denali fault in the Healy quadrangle, Csejtey and others (1992) mapped the main body of melange as unit Kms, and limestone blocks within it as unit msl. This southerly belt of melange corresponds to the Broad Pass terrane of Jones and others (1982; see fig. 2, herein). Farther north in Healy quadrangle, Csejtey and others (1992) assigned a narrow belt of melange between two strands of the Denali fault to their unit Kmn; associated limestone blocks in this northerly belt were mapped as unit mnl (shown here as unit TRSl), and associated ultramafic rocks were mapped as unit mno. The northerly belt of melange corresponds to the Windy terrane of Jones and others (1982). The two belts of melange in Healy quadrangle are similar in that both contain large proportions of intensely deformed Kahiltna-like flysch (unit KJf, herein) enclosing blocks of Devonian shallow-marine limestone; they differ, however, in that ultramafic rocks and Triassic limestones occur only in the northerly belt, whereas Paleozoic cherty rocks occur only in the southerly belt. In the Mt. Hayes quadrangle, Nokleberg and others (1992a) mapped two belts of melange between strands of the Denali fault system, and correlated these with the Windy terrane of Jones and others (1982)

TRSl Limestone blocks (Silurian to Triassic)-- Lenses and elongate blocks, up to several kilometers long, of medium-bedded to rarely massive, fine- to medium-grained, gray, fossiliferous limestone. Occurs in two outcrop belts in the Healy quadrangle, one south of the Denali fault, the other between strands of the Denali fault (Csejtey and others, 1992). Megafossils and conodonts from the southerly belt range from Silurian to Middle Devonian; megafossils and conodonts from the northerly belt are of Middle Devonian and Late Triassic ages (Csejtey and others, 1992). Comparable carbonate blocks occur in two outcrop belts of melange in Mt. Hayes quadrangle (unit Kmar of present map; unit wm of Nokleberg and others, 1992a) but were not mapped separately. The most closely dated of these has yielded a Middle Devonian (Givetian) age based on megafossils (Nokleberg and others, 1992b)

mlu Ultramafic and associated rocks (Unknown age, assigned to melange)-- Serpentinized ultramafic rock, altered baslat, green and maroon tuff and recrystallized chert. Unit occurs in a small fault sliver within the Denali Fault system in the Healy quadrangle

(Csejtey and others, 1992). Jones and others (1982) suggested these rocks might comprise an ophiolite assemblage

Igneous rocks

Volcanic and hypabyssal rocks

Kvl **Volcanic rocks** (Late Cretaceous)-- Largely dacite, andesite, and basalt and subordinate andesitic to basaltic subvolcanic rocks. Ranges from flows, including agglomerate, to tuff and also dikes and sills; all are variably hydrothermally(?) altered. Subvolcanic rocks are chiefly found in the southwestern part of the map area, but are also sparsely distributed in the Healy quadrangle. In the Iditarod quadrangle these rocks were mapped as part of two units, the Kuskokwim Group and part of the Iditarod Volcanics. Distinction between unit TKvi of this map, which also includes the Iditarod Volcanics, is on the basis of the contact relation between these rocks and the underlying or interfingering Kuskokwim Group sedimentary rocks. This map unit consists of those rocks where the interfingering relationship is most apparent

Ktg **Volcaniclastic rocks** (Early Cretaceous)-- Largely andesitic and dacitic crystal-lithic tuff and lithic tuff, volcanic graywacke, and mudstone. Rare andesite flows. Mapped only along northern edge of Melozitna quadrangle and in the adjoining Hughes quadrangle outside of the map area. Overlies unit Kve and may grade laterally into unit Kvgm

Kve **Andesite and related rocks** (Early Cretaceous, Neocomian and Albian?)-- Chiefly porphyritic pyroxene andesite and trachyandesite flows, pillow basalt, andesitic and dacitic tuff, volcanic conglomerate, and breccia, tuffaceous graywacke, chert and fine-grained cherty tuff, and limestone, generally restricted to the northwest part of the map area. In the vicinity of the Koyukuk River these rocks are widely altered to a hard dark green hornfels near granitic intrusions. Elsewhere, the volcanic rocks are altered and pale green. Limestone is in part coquina composed largely of *Buchia* and in part impure limestone containing *Buchia*. Mildly deformed and unaltered vesicular basalt and associated pyroclastic rocks along the Koyukuk River near Roundabout Mt. originally mapped by Patton (1966) as part of this unit may be Tertiary (Patton, oral commun., 1997) and are shown on this map as part of unit Tvu. In the Tyonek quadrangle, small areas of basaltic rocks of probable early Cretaceous age are interbedded within Cretaceous(?) sedimentary rocks. While included here for display convenience, we do not mean to imply these Tyonek flows and those near the Koyukuk River are related

Intrusive rocks

Kg **Granitic rocks**-- Largely granitic, but range from tourmaline-bearing granite to diorite. Intrusions range from dikes and sills, to small and large plutons. Widely distributed includes granite plutons in the Mount Hayes quadrangle, and quartz monzonite and granodiorite plutons in the Anchorage, Fairbanks, Livengood, Tanana, and Melozitna quadrangles. Radiometric ages are as old as 120 Ma and as young as 70 to 65 Ma, but typically range between 105 and 90 Ma. Plutons yielding ages of 110 Ma or greater than are shown with a vertical crosshatch pattern, whereas those yielding ages of 85 Ma or less are shown with a horizontal crosshatch pattern

Kmum **Mafic and ultramafic rocks**-- Gabbro, diorite, serpentinite, and mafic volcaniclastic rocks. Ranges from small, structurally bounded, pervasively sheared, discordant bodies of serpentinized ultramafic rocks wholly enclosed in pelitic schist in the Anchorage quadrangle (Winkler (1992) to dikes and lense-like masses of dark-greenish gray, medium- to coarse-grained gabbro and massive, medium-gray, medium-grained diorite, including the 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, Nokleberg and others, 1992a). Restricted to bands through the central part of the map area in the Tanana and Kantishna River, Anchorage, and the Big Delta and Mount Hayes quadrangles

Ktt **Leucotonalite and trondhjemite** (Early Cretaceous)-- Plugs and sills of leucocratic medium-grained plutonic rocks in a zone about 5 km wide along the Border Ranges fault in the Anchorage quadrangle. Generally foliated; apparently syntectonically emplaced during ductile and then brittle thrusting on the Border Ranges fault system. K-Ar, Rb-Sr, and U-Pb age determinations range between 103 and 133 Ma, overlapping ages of large

Jurassic trondhjemite plutons (unit Jtr, this map) to the north of the Border Ranges fault system (Winkler, 1992)

Metamorphic rocks

Rocks of unknown protolith age metamorphosed during Cretaceous and possibly Early Tertiary time.

Kvs **Metasedimentary rocks of the Valdez Group** (Late Cretaceous)-- Drab, rhythmically alternating, deformed turbidites, including meta-sandstone, meta-siltstone, argillite, slate, phyllite, and pebble- to cobble conglomerate. Beds are typically a few centimeters to a few meters thick. Locally, massive meta-sandstone and less abundant matrix-supported pebble- to cobble-conglomerate occurs in channel sequences many tens of meters thick. In some places, turbiditic sedimentary structures, including graded bedding, current-ripple cross-lamination, convolute lamination, and sole marks have been preserved (Winkler, 1992). Adjacent to the thrust contact with McHugh Complex melange, includes a tectonic melange consisting of blocks of Valdez Group meta-sandstone enclosed in a phacoidally cleaved matrix of Valdez Group argillite; this monomict melange is quite distinct from the polymict melange of the McHugh Complex. Assigned a Late Cretaceous (Campanian? to Maestrichtian) age on the basis of scattered occurrences of *Inoceramus*. Mapped in Anchorage and Valdez quadrangles. Metamorphic grade ranges from prehnite-pumpellyite to lower greenschist facies

Kvv **Metavolcanic rocks of Valdez Group** (Late Cretaceous)-- Mafic metatuff and minor massive or weakly foliated greenstone with rare pillows (Winkler and others, 1981). Mapped in Valdez and Anchorage quadrangles. Dated by association with the sedimentary part of the Valdez Group, with which it is interbedded. Metamorphic grade ranges from prehnite-pumpellyite to lower greenschist facies

CRETACEOUS AND/OR JURASSIC
Sedimentary rocks

KJw **Wolverine quartzite** (Early Cretaceous or Late Jurassic)-- Light- to dark-gray, very fine- to medium-grained, well-sorted, quartzite containing 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. Unit exposed in the Livengood, western Circle, and eastern Tanana quadrangles. In the Tanana quadrangle, the Wolverine quartzite includes rocks mapped as the Vrain unit (KJvr) elsewhere (F.R. Weber, unpublished data, 1998)

KJwc **Wilber Creek flysch and Wolverine quartzite, undivided** (Early Cretaceous or Late Jurassic)-- Locally mapped unit consisting of units KJwc and Kwcf in the Tanana quadrangle

KJs **Argillite, chert, sandstone, and limestone** (Early Cretaceous to Late Jurassic)-- Dark-gray argillite, dark-gray to greenish-gray bedded chert, thin-bedded gray sandstone, and rare thin-beds of shelly limestone in thrust slivers, sandwiched between Triassic and Jurassic strata in the southwest Healy quadrangle. Late Jurassic and Early Cretaceous radiolaria occur in the chert; *Inoceramus sp.* of Hauterivian to Barremian age and *Buchia subleavis* of Valanginian age occur in the limestone. Csejtey and others (1992) suggest these rocks may be tectonically emplaced distal facies of unit KJf. Metamorphic grade in these rocks is no higher than prehnite-pumpellyite facies, significantly lower metamorphic grade than rocks of unit KJf (as mapped by Csejtey and others, 1992) to the east

KJf **Kahiltna flysch sequence** (earliest Late Cretaceous to Late Jurassic?)-- Monotonous sequence of intensely deformed and locally highly metamorphosed turbidites described by Csejtey and others (1992) and Reed and Nelson (1980). Includes dark-gray to black argillite, fine- to coarse-grained, generally dark-gray graywacke, dark-gray polymictic pebble conglomerate, subordinate black chert pebble conglomerate, a few thin layers of dark-gray to black radiolarian chert and thin, dark-gray impure limestone interbeds. Locally includes distinctively reddish brown weathering feldspathic wacke having interbeds of siltstone. Tightly isoclinally folded and complexly faulted. Highly indurated, many are sheared and pervasively cleaved. Fossils in this broadly defined unit range from Early Jurassic ammonites to Early Cretaceous (late Hauterivian to early Barremian) *Inoceramus* to indeterminate broadleaf plant fossils. In the Tyonek quadrangle, a Valanginian *Buchia sublaevis Keyserling* was identified from coquina beds along the lower Chickak River (William P. Elder, USGS, unpublished data; fossil collection by Madelyn Millholland, Cominco Alaska Exploration). A middle Turonian *Inoceramus hobetsensis Nagao* and *Matsumoto* was also found within this unit 1 km east of the Skwentna River 3 km north of its confluence with Emerald Creek (William P. Elder, USGS, unpublished data, 1989). Reported plant fossils occur in rocks lithologically similar to the largely Late Cretaceous Matanuska Formation (unit Km, this map). Previously unpublished $^{40}Ar/^{39}Ar$ age determinations on hornblende in igneous clasts in conglomerate range from 94.6+/-1.5 Ma to 101.0+/-0.7 Ma (Paul Layer, written commun., Sept., 1997; see also Layer and Solie, 1991). In the Talkeetna quadrangle, unit is mapped as Jurassic and Cretaceous. However, the only fossil localities having Jurassic ages are at the northwestern extent of the outcrop area and all other ages were considered Cretaceous. This unit, widespread in southern Alaska, is often the repository for miscellaneous dark-colored sedimentary rock units and as such may not represent a coherent package of rocks. In the southwest part of the map area, the nature of the transition from this unit to the Kuskokwim Group is undefined. Both units are of similar lithology and character and available mapping is not sufficient to either distinguish the units or to indicate that they should be mapped as the same unit. Locally, the presence of interbedded light tuffaceous deposits indicates contemporaneous volcanism; in these same areas, extremely angular grains of oscillatory zoned plagioclase, volcanic rock fragments, hornblende, epidote, and calcite, suggest derivation from the now buried Jurassic magmatic arc to the south (Reed and Nelson, 1980). Unit as mapped in the Tyonek quadrangle includes rocks mapped by Reed and Elliott (1970) as units Km, Kw, Mzu, and Mzs. In the southeastern part of the Healy quadrangle, east of the Susitna lineament of Smith and others (1984) this unit is highly metamorphosed and included within rocks mapped as part of the Maclaren metamorphic belt (units Mzsa and Mzpca), of mid-Cretaceous age (Csejtey and others, 1992) or Tertiary age (Smith, 1981). The Kahiltna flysch unit is sub-divided on this map into three sections. The two sub-divisions off the main part of the unit consist of unit KJfn, occurring north of the main strand of the Denali fault system, and unit KJfk, which is found in a klippe south of the Denali fault system. Locally subdivided into:

KJfk **Flysch sequence** (Early Cretaceous and Late Jurassic)-- Rocks identical in lithology and age to unit KJf, found in a large folded klippe or thrust sliver that may be as large as 30 by 60 km, perhaps a remnant of a much larger thrust sheet (Csejtey and others, 1992). There are three fossil localities within this unit, two of which have yielded Valanginian *Buchia* fossils and one yielding Jurassic or Cretaceous radiolaria

KJfn **Flysch sequence** (Late Cretaceous and Late Jurassic)-- Rocks identical in lithology and age to unit KJf, found north of the main strand of the Denali fault system. Reed and Nelson (1980) were uncertain about assigning a Jurassic age as no Jurassic age fossils have been found in the unit in the Talkeetna quadrangle. In general, these rocks are not adjacent to those of unit KJf south of the fault system. May represent a separate part of the flysch depositional basin or a separate fault-juxtaposed basin

KJfm **Metasedimentary rocks** (Early Cretaceous and Late Jurassic)-- Principally deep-marine turbidite deposits consisting of graded beds of metamorphosed dark-gray to gray argillite, siltstone, and graywacke that locally alternate with beds of massive graywacke, pebbly graywacke, pebble to cobble conglomerate and sparse andesite flows(?) or sills(?) in the Mount Hayes quadrangle (Nokleberg and others, 1992a). Unit is thought to constitute a part of the Gravina-Nuzotin belt (Berg and others, 1972, cited in Nokleberg and others, 1992a) which extends to the southeast

KJcg **Conglomerate, sandstone, siltstone, shale, and volcanic rocks** (Early Cretaceous and Late Jurassic)-- Intercalated polymictic pebble and cobble conglomerate, sandstone, siltstone, shale, and flows and dikes of andesitic and latitic feldspar porphyry (Csejtey and others, 1992). In two thrust slivers along the Talkeetna thrust fault in the southeastern part of the Healy quadrangle and the northeastern part of the Talkeetna Mountains quadrangle. Locally strongly sheared, displaying shear planes that cut conglomerate clasts. Age based on collections of *Buchia spp.* of Late Jurassic to Early Cretaceous age in the Healy quadrangle (Csejtey and others, 1992) and *Buchia Rugosa*, suggesting a Kimmeridgian age in the adjacent Talkeetna Mountains quadrangle (Csejtey and others, 1978). Csejtey and others (1992) suggest these rocks were probably deposited at the base of the continental slope as part of submarine fan sequence and that they may constitute the westernmost outcrops of the Gravina-Nuzotin belt of Berg and others (1972)

KJvr **Vrain unit** (Early Cretaceous and (or) Jurassic)-- 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 Nation River area in the eastern Charley River quadrangle (east of the map area). Crops out in northeast and southwest parts of the Livengood quadrangle (Weber and others, 1992) and northwestern part of the Circle quadrangle (F.R. Weber, unpublished data, 1998). Unit is thought to continue into the Tanana quadrangle, however mapping there did not separate it from the Wolverine quartzite. As shown here, also includes unit MzPzp of the Livengood quadrangle (Weber and others, 1992), possibly a more highly metamorphosed and tectonically disrupted equivalent unit

Intrusive rocks

KJg **Granitic rocks** (Early Cretaceous or Jurassic)-- Consists of granitic rocks ranging from granite to quartz diorite and including minor monzonite and diorite. Restricted to the Mount Hayes and Gulkana quadrangles south of the Denali fault system, although widely distributed in these quadrangles. Generally in small stocks, dikes, and sills. Granite porphyry of Caribou Lake (unit grcl, Nokleberg and others, 1992a) has outcrop exposures as much as 5 km in area. The age of many of these intrusive bodies is inferred, however several of the plutons have been dated as Early Cretaceous and Late Jurassic (Nokleberg and others, 1992a)

Metamorphic rocks

KJhc **Haley Creek metaplutonic and metasedimentary rocks** (Early Cretaceous to Late Jurassic)-- Metaplutonic rocks predominantly diorite and quartz diorite, but range from trondjemite to hornblende gabbro and hornblendite; metasedimentary rocks include schistose marble, pelite, and meta-arenite. Plutonic and sedimentary protoliths vary in relative abundance from place to place. Subjected to two metamorphic events, an earlier epidote-amphibolite event and a pervasive greenschist event that produced the predominant metamorphic and cataclastic fabrics. Four K-Ar ages of hornblende from metaplutonic rocks range from 148 to 122 Ma; K-Ar ages of biotite from metasedimentary rocks are 123, 110, and 50 Ma (Winkler and others, 1980). Protolith previously correlated with the Skolai Group by MacKevett and Plafker (1974), but the unit is fault-bounded and may be unrelated to juxtaposed units. Includes the Khc and Kag units of MacKevett and Plafker (1974)

JURASSIC
Sedimentary rocks

Jn **Naknek Formation** (Late Jurassic)-- Thin- to thick-bedded, intercalated fossiliferous gray siltstone, shale, sandstone, and conglomerate more than 1,400-m-thick (Csejtey and others, 1978). Originally named Naknek Series by Spurr (1900, p. 169-171, 179, 181) for exposures at Naknek Lake on the Alaska Peninsula. Megafossils, particularly the pelecypod *Buchia* (Detterman and Reed, 1980, p. B-38; J.W. Miller, written commun., 1982-88), are common, and the fauna, which also includes ammonites, indicates age range of Oxfordian to late Tithonian. The Jurassic Alaska-Aleutian Range batholith was a major sediment source for the Naknek Formation; hence, uplift and erosion of the batholith occurred shortly after emplacement. The unit mapped here is probably correlative with the Indecision Creek and possibly Katolinat Conglomerate Members on the Alaska Peninsula (see Detterman and others, 1996) and therefore represents the upper part of the unit. Correlation has been suggested with the Root Glacier Formation of the Wrangell Mountains, east of the map area (E.M. MacKevett, in Csejtey and others, 1978)

Jct **Chinitna Formation, Tuxedni Group, and coeval sedimentary rocks** (Late and Middle Jurassic)-- Largely shallow-marine clastic rocks ranging from shale and siltstone to conglomerate. All rock units contain a mixture of plutonic and volcanic detritus and clasts that are presumed to have been derived from erosion of the Talkeetna Formation and related plutonic rocks of the early Jurassic magmatic arc. Overlies the Talkeetna Formation with angular uniformity. Internal contacts between stratigraphic units in this package are disconformities or slight angular unconformities. The uppermost part of this map unit, the Chinitna Formation, is disconformably or with slight angular unconformity overlain by the Naknek Formation. Restricted to the southern tier of quadrangles in the map area; widely distributed in the Valdez, Anchorage, Talkeetna Mountains, and Tyonek quadrangles. The same and correlative rock units are especially well-exposed on the Alaska Peninsula to the southwest (Detterman and others, 1996). Locally sub-divided into:

Jc **Chinitna Formation** (Middle Jurassic, late Bathonian(?) and early and middle Callovian)-- Shallow-marine shale, siltstone, and subordinate sandstone containing numerous large limestone concretions. Contains mixture of plutonic and volcanic detritus presumed to have been derived from erosion of the Talkeetna Formation and related plutonic rocks of the early Jurassic magmatic arc. Correlative with Shelikof Formation of the Alaska Peninsula (Detterman and others, 1996). Unit mapped only in the Anchorage quadrangle, south of the Castle Mountain fault system

Jkt **Kotsina Conglomerate** (Middle and/or Late Jurassic?)-- Thin- to thick-bedded, well-indurated conglomerate containing locally derived pebbles and cobbles and subordinate sandstone and shale. Reflects rapid local marine deposition in response to Middle Jurassic orogenesis. Restricted to the Valdez and adjacent McCarthy quadrangles; correlative rocks occur in the upper part of the Tuxedni Group and the Bowser Formation to the west. No fossils are known; age inferred from K-Ar age determinations on dikes that cut the unit

Jtx **Tuxedni Group** (Middle Jurassic, Bajocian-Bathonian)-- Fossiliferous shallow-marine siltstone, shale, and sandstone. Upper part is thin- to thick-bedded dark siltstone and shale; lower part consists of thin- to thick-bedded sandstone and local pebbly sandstone. Unconformably overlies the Talkeetna Formation and is disconformably overlain by the Chinitna Formation. Unit crops out only in the Anchorage quadrangle (Winkler, 1992), where it is much thinner than in areas to the southwest, where divided into three Formations

Igneous rocks

Jmu **Mafic and ultramafic rocks** (Jurassic?)-- Various mafic and ultramafic rocks, widely distributed chiefly in the southern part of the map area:

In the Valdez quadrangle (Winkler and others, 1980), dunite, harzburgitic dunite, wehrlite, websterite, and clinopyroxenite outcrop in a discontinuous belt 25 km long, locally called the Tonsina ultramafic complex. A complex largely of layered hornblende-pyroxene gabbro, leucogabbro, gabbronorite as much as 120 km long and 10 km wide also occurs in the Valdez quadrangle and in the adjacent Anchorage quadrangle north of or within the Border Ranges fault zone. Radiometric age determinations (Winkler and others, 1980; Winkler, 1992) suggest an Early and Middle Jurassic age.

In the Anchorage quadrangle, fault-bounded cumulate ultramafic and mafic rocks of the Wolverine and Eklutna complexes of Winkler (1992) have an inferred age of Middle and Early Jurassic based on correlation with the Tonsina complex of the adjacent Valdez quadrangle and intrusion by Middle and Early Jurassic dikes (Winkler, 1992).

In the southeastern Healy quadrangle, a small discordant pluton of alkali gabbro (monzogabbro) and similar rocks have an inferred age of Late Jurassic (Csejtey and others, 1992). In addition, a small body of dark greenish- or brownish-gray, coarse- to medium-grained ultramafic rock containing olivine and abundant phlogopite, limited to an area between the Denali and Hines Creek strands of the Denali fault system was inferred by Csejtey and others (1992) to be Early Cretaceous or Jurassic in age. It appears to intrude late Triassic calcareous rocks of unit TRcs and been metamorphosed a middle Cretaceous regional event which affected rocks in the eastern Healy quadrangle.

In the McGrath quadrangle, a series of gabbro and diorite sills intrudes late Paleozoic chert and volcaniclastic rocks and late Triassic limestone and have an inferred Early Cretaceous or Jurassic age.

Found throughout the northwestern Gulkana quadrangle, schistose hornblende and clinopyroxene gabbro (Nokleberg and others, in press, units scgb and shgb), even though metamorphosed to greenschist facies is included in this unit

Jtr **Trondhjemite** (latest Jurassic)-- Altered, sheared, and locally faintly foliated trondhjemite in large, structurally discordant, northeast-trending plutons intruding Jurassic quartz-diorite and amphibolite (Winkler, 1992). Plutons crop out in the Talkeetna Mountains and Anchorage quadrangles. K-Ar age determinations range from 129 to 149 Ma, which overlap ages of Cretaceous trondhjemite (unit Ktt) to the south

Ji **Alaska-Aleutian Range and Chitina Valley batholiths, undifferentiated** (Late and Middle Jurassic)-- Includes Jurassic phase of the Alaska-Aleutian Range batholith (Reed and Lanphere, 1972) and the Jurassic Chitina Valley batholith in the Valdez quadrangle (Winkler and others (1980). Ranges from granite through granodiorite to quartz diorite and tonalite. Widely distributed in southern Alaska. Probably the plutonic equivalent of volcanic rocks of Talkeetna Formation, usually 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)

Metamorphic rocks

(All ages quoted for these units are metamorphic ages
and do not necessary reflect the protolith)

Jsch **Greenschist and blueschist** (Jurassic)-- Diverse well-foliated, multiply-deformed metasedimentary and metavolcanic rocks of greenschist and transitional blueschist facies diverse mafic metavolcanic and metasedimentary rocks. Sedimentary protoliths are shale, chert, tuffaceous arenite, and limestone; volcanic protoliths are probably mostly basalt (Winkler, 1992). Outcrop along the northern flank of the Chugach Mountains in the Anchorage and Valdez quadrangles, closely associated with the Border Ranges fault system. In the Valdez quadrangle, includes the schist of Liberty Creek (G.R. Winkler, written commun., 1998). In the Anchorage quadrangle, includes the Knik River schist (unit JPzm of Winkler, 1992 or Knik River terrane of Pavlis, 1983; Pavlis and others, 1988) and is correlative with the other schistose units along the Border Ranges Fault system to the southwest, including the Raspberry Schist of Roeske and others (1989) of the Kodiak Islands and the Seldovia Schist of Roeske (1986, see also Cowan and Boss, 1978). Age control is limited, isotopic ages from metamorphic minerals indicate an Early Jurassic age of metamorphism (see Winkler, 1992; Carden and others, 1977) and Clark (1972, cited in Winkler, 1992) reports a single Permian fossil collection from limestone. The correlative Raspberry Schist of Roeske and others (1989) is intruded by the Triassic Afognak pluton. By analogy with the lithologically similar Strelna (unit PPast, this map), Winkler (1992) suggested some parts of this unit may be as old as middle Paleozoic. Locally, these rocks are included in the McHugh Complex melange. Winkler (1992) suggested that the diverse of protolith lithologies may indicate tectonic mixing prior to metamorphism

Jps **Pelitic schist** (Jurassic?)-- Quartz-muscovite-albite-chlorite schist. Schist remarkably uniform in lithology and has no known correlative rocks (Winkler, 1992). Mineralogy indicates greenschist metamorphism, which Winkler (1992) interpreted probably was retrograded from amphibolite facies metamorphism. Jurassic age inferred for prograde metamorphism based on the age of adjacent amphibolite of unit Jma. K-Ar muscovite ages of 66 to 51 Ma from schist are thought to reflect intrusion of adjacent tonalite and quartz monzonite. Corresponds to unit Jps of Winkler (1992) in Anchorage quadrangle, and unit MzPzs, schist at Willow Creek, of Magoon and others (1976)

JPaur **Uranatina metaplutonic complex** (Jurassic and Pennsylvanian)-- Schistose quartz diorite, quartz monzonite, granodiorite, hornblende diorite, amphibolite, and orthogneiss forming a belt across the northeastern Valdez, Gulkana and northeastern Talkeetna Mountains quadrangle in the southern part of the map area. Unit also forms the core of a tectonic inclusion in the McHugh Complex in the east-central part of the Valdez quadrangle. Mainly of upper greenschist facies metamorphic grade, some parts of unit reach amphibolite facies. Nokleberg and others (in press) report numerous Jurassic K-Ar ages for these metaplutonic rocks and interpret these to indicate the time of metamorphism. In the Valdez quadrangle (Plafker and others, 1992) report a Pennsylvanian U-Pb zircon age of 309+/-11 Ma on blastomylonitic granodiorite, interpreted as an emplacement age for at least part of the complex. However metadiorite yielded a Late Jurassic U-Pb zircon age of 153+/-4 Ma, also thought to indicate emplacement. Includes units sqd, sgd, sqm, and ag in the Gulkana quadrangle of the Metamorphic complex of Gulkana River (Nokleberg and others, in press) and units Jlg and Jag in the Valdez quadrangle (Winkler and others, 1980; G.R. Winkler, written commun., 1998)

JURASSIC AND TRIASSIC
Sedimentary rocks

JTRlm **Limestone and marble** (Early Jurassic or Late Triassic?)-- Light- to dark-gray, fine to medium-grained, massive to poorly bedded, unfossiliferous limestone in discontinuous lenticular bodies within the Talkeetna Formation. Individual lenses as much as 30 m thick. Near intrusions, recrystallized to marble (see unit Jmb)

JTRmc **McCarthy Formation** (Early Jurassic and Late Triassic)-- Upper member dominantly thin-bedded, very fine-grained spiculite, impure chert, impure limestone, and shale; lower member 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 Plensbachian, by inference, the lower unfossiliferous parts of the upper member may be as old as latest Triassic. Fossils, *Monotis sp.*, from the lower part of the lower member indicate a Late Triassic, mainly late Norian, age and MacKevett (1978) suggested that post-Norian Late Triassic and Early Jurassic rocks might be present also. Unit as a whole is marine and the depositional character indicates a restricted environment and possibly starved basin

Igneous rocks

JTRtk **Talkeetna Formation** (Early Jurassic, Late Triassic?)-- Greenstone and tuff first described by Paige and Knopf (1907); the name Talkeetna Formation introduced by Martin (1926), recognized as widespread and an important marker horizon in southern Alaska. Varies from volcanic and volcaniclastic rocks consisting of lava, agglomerate, breccia, tuff, and interbedded sandstone and shale in the Cook Inlet region to volcanic-sourced sedimentary rocks more distal from volcanic sources. Unit is the extrusive product of an early Jurassic island arc, of which the Jurassic phase of the Alaska-Aleutian Range batholith (unit Ji) is the plutonic core. Shallow marine and subaerial deposition for much of the unit is apparent from its fossil content and sedimentary facies (Winkler, 1992). An early Jurassic age is well accepted for the unit, however based on correlation with the Pogibshi unit of Kelley (1984) on the southern Kenai Peninsula, Winkler (1992) inferred a Late Triassic age for the basal part of the unit. Lenticular limestone and marble bodies are interstratified with the volcanic and volcaniclastic rocks and are mapped separately as unit JTRlm and part of Jmb

TRIASSIC
Sedimentary rocks

TRls **Chitistone and Nizina Limestones, undivided** (Late Triassic, Norian to Karnian)-- Carbonate rocks that overlie the Nikolai Greenstone (unit Trn) are generally assigned to these two units (MacKevett, 1978). The Chitistone Limestone at the base is up to 600-m-thick and has a lower part consisting of abundant dolostone, algal-mat chips, stromatolites, and relicts of evaporites, whereas the upper part consists of diverse types of limestone including lime mudstone, wackestone, packstone, and grainstone. The overlying Nizina Limestone is as much as 500-m-thick and consists of various types of limestone that generally contain subordinate chert as nodules, lenses, and coalescing masses; it is gradational lithologically into the overlying McCarthy Formation. Along with the Nikolai Greenstone, these limestone units are critical parts of the Wrangellia terrane as defined (Jones and others, 1977). These limestones, correlative unnamed units in the Mount Hayes and Healy quadrangles, and the Kamishak Formation to the southwest are widespread in southern Alaska

TRsl **Spiculite and sandy limestone** (Late Triassic, Norian)-- Dark-gray banded spiculite and chert, yellowish-orange-weathering sandy fossiliferous limestone and conglomerate and dark-gray shale in the Medfra quadrangle (Patton and others, 1980). Lithologically similar to and correlative with the lower part of the McCarthy Formation (unit JTRmc) in the southeast part of the map area, however it is unlikely that these units were deposited in the same basin

TRcs **Calcareous sedimentary rocks** (Late Triassic, middle? Norian and Late Karnian)-- Thin-bedded, dark- to medium-gray commonly cross-bedded, and carbonaceous intercalated calcareous shale, argillite, sandstone, siltstone, and sandy to silty and argillaceous limestone; generally intensely deformed. Basal beds predominantly fine-grained, gray sandstone and siltstone and subordinate cherty limestone containing 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* as reported in Csejtey and others (1992) and 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 Limestone by turbiditic depositional character, lack of evaporitic or sahbka 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 (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) were tentatively 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

TRcg **Conglomerate and volcanic sandstone** (Late Triassic, Norian)-- Mapped only in a fault bounded(?) exposure at Broad Pass, just south of the Denali fault zone (Csejtey and others, 1992) in the Healy quadrangle. The lower part of this section consists of cobble to boulder conglomerate containing clasts of green volcanic rocks and red radiolarian chert. The chert clasts have yielded Permian radiolaria. Finer grained volcanogenic conglomerate, higher in the section locally contains abundant *Heterastridium* sp., indicating a Late Triassic, late Norian age. The uppermost part of the section is massive volcanic sandstone. No Permian source area is known for the chert of this unit and its overall lithologic character is unique for the Healy quadrangle

TRps **Phosphatic shale and limestone** (Triassic?)-- Thinly bedded, medium- to dark-gray, locally calcareous, phyllitic, and graphitic, phosphatic shale, medium-gray micritic limestone, and medium-dark- to dark-gray packstone having sand- or silt-sized quartz and sparite. These lithologies grade into medium-gray calcareous sandstone and medium-light-gray phosphatic granule conglomerate (Weber and others, 1992). Triassic to Permian microfossils constrain the age and Weber and others (1992) infer a Triassic age because of similarities to the Glenn Shale (Brabb, 1969) of the Charley River quadrangle to the northeast of the map area

TRsc **Black shale and chert** (Triassic)-- 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). Mapped only in Livengood quadrangle. In Tanana quadrangle, equivalent rocks are part of undivided unit TrPs

Igneous rocks

Volcanic rocks

TRn **Nikolai Greenstone and related rocks** (Late and/or 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). Widely distributed and several thousands of meters thick. Commonly associated with Late Triassic carbonate and cherty carbonate rocks. Together with the Chitistone and Nizina Limestones, this unit is one of the diagnostic units of the Wrangellia terrane (Jones and others, 1977). Commonly metamorphosed to lower greenschist facies. Similar or correlative units include the Cottonwood Bay Greenstone of the Lime Hills quadrangle (Reed and Gamble, 1988; Gamble and Reed, 1996) and unnamed Triassic greenstone units in the Talkeetna Mountains (Csejtey and others, 1978), Healy (Csejtey and others, 1992), and Mount McKinley quadrangles (Bela Csejtey, Jr., written commun., 1993) and the Livengood (Weber and others, 1992) and Kantishna River (Chapman and others, 1975) quadrangles

Plutonic rocks

Trc **Carbonatite** (Triassic)-- Intensely magnetic dolomite-calcite-magnetite-apatite-rich rock in two sill-like bodies in the southeastern Tanana quadrangle. $^{40}Ar/^{39}Ar$ age of about 200

Ma reported on contact metamorphic mica reported by Reifenstuhl and others (1998) and interpreted as an intrusion age

TRgb **Gabbro, diabase, and metagabbro** (Late Triassic?)-- Chiefly hornblende-, clinopyroxene-, and hornblende-clinopyroxene-gabbro and sparse quartz gabbro and quartz diorite, along with other mafic and ultramafic rocks. Possible source of flows in the Nikolai Greenstone and related units

Metamorphic rocks

TRnm **Metavolcanic and associated metasedimentary rocks** (Late Triassic)-- Dominantly metabasalt, slate, and other low-grade metasedimentary and metavolcaniclastic rocks; probably derived from the Nikolai Greenstone (Trn unit) of contiguous areas. Corresponds to the TRvs unit of Csejtey and others (1992) in the Healy quadrangle, the TRvs unit of Csejtey and others (1978) in the Talkeetna Mountains quadrangle, and the csv unit of Nokleberg and others (1992a) in the Mount Hayes quadrangle

MESOZOIC AND PALEOZOIC
Assemblages and Sequences

The **Chulitna sequence**, consists of disparate thrust-imbricated sequences or assemblages ranging in age from Cretaceous to Devonian (Csejtey and others, 1992). Gravity measurements by R.L. Morin (Csejtey and others, 1992, p. 31) indicate that these are rootless thrust sheets. The Chulitna sequence crops out in the southwestern part of the Healy quadrangle, southeastern Mount McKinley quadrangle, and the northeastern extreme of the Talkeetna quadrangle. Csejtey and others (1992) indicate that these rocks are dissimilar in lithology, depositional environment, and age from surrounding units and suggest that they are tectonically emplaced remnants of deep oceanic sedimentary units. Units of the Chulitna sequence include the following:

JTRsu **Red and brown sedimentary rocks and basalt** (Early Jurassic and Late Triassic)-- Red-bed sequence of sandstone, siltstone, argillite, and conglomerate grading upward into highly fossiliferous brown sandstone and brownish-gray siltstone. Thickness more than 2,000 m. 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. Mapped only in the Healy quadrangle; on strike southwest of Eldridge Glacier in the Talkeetna quadrangle is replaced by light-green to maroon volcaniclastic rocks of Late Triassic age (see unit JTRct, below)

JTRct **Crystal tuff, argillite, chert, graywacke, and limestone** (Late Jurassic to Late Triassic?)-- 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 fossils of late Sinemurian age (R.W. Imlay, cited in Csejtey and others, 1992). Csejtey and others (1992) indicate that because these fossils were from near the top of the tuffaceous section, that the section may be as old as Late Triassic. Some 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 (Csejtey and others, 1992)

TRlb **Limestone and basalt sequence** (Late Triassic, Norian)-- Interlayered limestone and amygdaloidal basalt flows. Limestone is medium-gray, massive to thick-bedded and locally altered to fine- to medium-grained marble. Fossils including *Monotis subcircularis*, indicate age. Basalt is dark-to greenish-gray, aphanitic and contains numerous amygdules. Character of the unit suggests shallow-water deposition and chemistry of the basalts suggests an ocean island shield volcano (Csejtey and others, 1992). Occurs as thrust slivers in the Chulitna sequence in the Healy quadrangle and extends a short distance into the Talkeetna quadrangle

TRr **Red beds** (Late Triassic?)-- Red sandstone, siltstone, argillite and conglomerate similar to unit JTRsu, distinct from it because of the occurrence of clasts of gabbro, serpentinite, and fossiliferous Permian(?) limestone (Csejtey and others, 1992). Found only in thrust slivers in the southwestern Healy quadrangle. Unconformably overlies volcanogenic and sedimentary rocks of Triassic to Devonian age (unit TRDv)

TRDv **Volcanic and sedimentary rocks** (early Triassic to late Devonian)-- 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 only in the Healy quadrangle. 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. Probably greenschist facies (Csejtey and others, 1992). Considered one of the stratigraphically lower parts of the Chulitna sequence

Dsb **Serpentinite, basalt, chert and gabbro** (Late Devonian)-- 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 (Fammennian). Probably a dismembered ophiolite assemblage, unit is lowest part of the Chulitna sequence. Mapped in the Healy and Mount McKinley quadrangles

End of Chulitna Sequence

Oceanic rocks of the Seventymile, Angayucham, Tozitna, and Innoko assemblages. Possibly correlative assemblages of mafic, ultramafic, and associated, typically chert-rich sedimentary rocks (including the Rampart Group of Brosge and others, 1969, in the Tanana quadrangle) have been assigned to the Tozitna, Angayucham, Innoko, and Seventymile assemblages in the northern part of the compilation area. These assemblages are similar in lithology, age, and allochthonous occurrence. It is well accepted that these are oceanic rock packages (Patton and others, 1994a; Dover, 1994). There is less agreement on the exact nature and original site of deposition, and amount and direction of transport of these sequences. On this map, three lithologic subdivisions are shown in similar colors: 1) ultramafic or dominantly mafic/ultramafic rocks, 2) dominantly sedimentary rocks (with or without greenstone), and 3) mafic, ultramafic, and associated sedimentary rocks, undivided.

Seventymile assemblage

JPsu **Ultramafic rocks** (Jurassic? and/or **Permian**)-- Serpentinized peridotite, harzburgite, and dunite. Not directly dated but age inferred from association with mafic and low-grade metasedimentary rocks of the greenstone and chert unit (JPzsgs). Unit restricted to small areas of outcrop in the Big Delta, Fairbanks, and Circle quadrangles and more extensive exposures to the east of the map area in the Eagle and Tanacross quadrangles (Foster and others, 1994). Corresponds to unit Pu in the Big Delta quadrangle (Weber and others, 1978), unit Dmu in the Fairbanks quadrangle (Pewe and others, 1996) and unit Pzp in the Circle quadrangle (Foster and others, 1983). Unit is structurally infolded with mafic and pelitic schists of unit PzZysa

JPzsgs **Greenstone and chert** (Jurassic? to middle? Paleozoic)-- Massive greenstone, amygdaloidal pillow basalt and metatuff and associated metachert, quartzite, phyllite, silica-carbonate lenses, and other low metamorphic grade sedimentary rocks. Glaucophane-bearing rock associated with greenstone in the northern Eagle quadrangle, east of the map area, yielded a Permian Ar-Ar age (Foster and others, 1992, p. 9). Elsewhere the greenstone is intercalated with chert that yields radiolaria and rare shelly fossils of Mississippian through Triassic age. Mafic rocks locally contain glaucophane. Includes the Pgc and Pq units of Weber and others (1978) in the Big Delta quadrangle, and the Pzg unit of Foster and other (1983) in the Circle quadrangle

Angayucham assemblage

Jaum **Ultramafic rocks (Jurassic?)**-- Serpentinized peridotite, dunite, and harzburgite, having associated layered gabbro and anorthosite, and locally garnet-amphibolite tectonite, possibly derived from eclogite at the base. Forms the upper part of the Angayucham assemblage along the southeast margin of the Yukon-Koyukuk basin and the northwest flack of the Ruby metamorphic complex. Primary igneous minerals and textures are preserved, yet most contacts strongly to cryptically deformed, especially at the structural base of the unit. K-Ar hornblende ages from hornblende gabbro and hornblende-bearing dikes range from 172 to 138 Ma and dates from garnet-amphibolite range from 172 to 155 (Patton and others, 1977; Patton and others, 1994a). All are considered cooling ages related to tectonic emplacement of the ultramafic and mafic rocks. Considered part of a dismembered ophiolite derived from the root of a volcanic arc, rather than a mid-ocean ridge setting (Loney and Himmelberg, 1985; Patton and others, 1994a; see also Patton and others, 1994b). Includes unit JPu in the Melozitna (Patton and others, 1978) and Tanana quadrangles (Chapman and others, 1982), unit Juu in the Nulato quadrangle (W.W. Patton, Jr., written commun., 1977), and unit Ju of Dover (1994)

JMab **Basalt and chert** (Jurassic? to Mississippian)-- Dominantly basalt, greenstone, gabbro, diabase, and chert. 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 recystallized mafic rocks in a low metamorphic grade, blastomylonitic, metasedimentary matrix. Matrix is bedded chert of Triassic age, argillite, slate, limestone of Mississippian age, and andesitic and basaltic tuff. Locally, the metamorphic minerals glaucophane, prehnite, and pumpellyite are present. Unit is thermally metamorphosed along contact with middle Cretaceous (110-120 Ma, unit Kg) plutons in the Melozitna and Tanana quadrangles. Includes unit JPb in the Melozitna (Patton and others, 1978) and Ruby quadrangles (Chapman and Patton, 1978), unit JMms (Chapman and others, 1982) and JMbc (Dover, 1994) in the Tanana quadrangle, and the westernmost part of unit TRMb in the Nulato quadrangle (W.W. Patton, written commun., 1997)

Tozitna assemblage north of the Kaltag Fault

JMtru **Greenstone, chert, and ultramafic rocks, undivided** (Jurassic? to Mississippian?)-- Poorly dated spilitic basalt and diabase largely altered to greenstone. Locally, includes minor sedimentary rocks, generally low metamorphic grade cataclastic assemblage of generally dark gray chert and siliceous argillite. Also includes subordinate volcaniclastic rocks and minor Mississippian limestone. Mafic, ultramafic, and associated metasedimentary rocks of the Tozitna terrane of Silberling and Jones (1984; see fig.2, herein) in the Tanana and Circle quadrangles are part of this unit. Similar rocks occur on strike to the northeast in the Bettles quadrangle (Patton and Miller, 1973). Includes unit TRPv in the Tanana (Chapman and others, 1975) quadrangle, unit TRMru in the Tanana quadrangle (Reifenstuhl and others, 1997), and unit MzPzc, the Circle Volcanics, in the Circle quadrangle (Foster and others, 1983). The origin, original setting, and tectonic emplacement of these rocks are discussed by Churkin and others (1982), Coney and Jones (1985), Gemuts and others (1983), Dover (1994), Foster and others, 1994, and Patton and others, 1994a

JTRtmu **Mafic and ultramafic rocks** (Jurassic? to Triassic)-- Diabase, gabbro, leucogabbro, and greenstone; ultramafic rocks include serpentinized peridotite, harzburgite, and werhlite. Locally, may include minor associated sedimentary rocks. Tentative age range based on K-Ar age of 210+/-6 Ma reported by Brosge and others (1969; age recalculated using constants of Steiger and Jager, 1977) on gabbro in Rampart Group, and stratigraphic and/or intrusive relationship with rocks as young as Triassic. Includes unit TRMrg in the Tanana B-1 quadrangle (Reifenstuhl and others, 1997), unit TRMrv in the Livengood quadrangle (Weber and others, 1992) (Foster and others, 1983)

TRMts **Sedimentary rocks** (Triassic to Mississippian)-- Chert, metachert, metatuff, quartzite, phyllite, and other associated incipiently metamorphosed sedimentary rocks; includes basalt and amygdaloidal pillow basalt in places. Corresponds to the Rampart Group of Brosge 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, and the TRMrs unit of Weber and others (1992) in the Livengood quadrangle and unit PaMc of Foster and others in the Circle quadrangle

Tozitna assemblage south of the Kaltag Fault

JMtu Mafic, ultramafic, and sedimentary rocks, undivided (Jurassic to Mississippian)-- Basalt, gabbro, diabase, basaltic tuff, and chert. May include minor ultramafic rocks and other associated low metamorphic grade metasedimentary rocks in the Nulato, Ophir, and Ruby quadrangles that resemble the Tozitna assemblage north of the Kaltag fault interpreted as an offset equivalent. Poorly dated. Corresponds to the eastern parts of unit TRMb of Patton (written commun., 1997) in the Nulato quadrangle, unit TrMb in the Ophir quadrangle (Chapman and others, 1985), and parts of units mc and mi in the Ruby quadrangle (Cass, 1959). A large area in the northwest part of the Ruby quadrangle is shown as this unit; however, we believe on the basis of information from R.M. Chapman (oral commun., 1998) that unit JMtu primarily occurs capping ridges and that rocks of the Ruby metamorphic complex occur at lower elevations. Further mapping will be necessary to resolve the geology of this area

Jtu Ultramafic rocks, undivided (Jurassic)-- Cumulate ultramafic rocks, harzburgite tectonite, and other ultramafic rocks, undivided; K-Ar ages on hornblende of 151+/-4.5, 172+/-5.2 and 269+/-8 Ma reported by Patton and others (1984), the Permian age is considered spurious. Corresponds to unit Ju of Patton and others (1984) and the informal Jcu, Jht, and Juu units of Patton (written commun., 1997) in the Nulato quadrangle

JPztm Mafic and ultramafic rocks, undivided (Jurassic? and/or Paleozoic?)-- Gabbro sills and subordinate quartz diorite, quartz monzonite, and pyroxenite. Undated; age and assignment to the Tozitna assemblage based on lithologic associations and regional comparisons. Corresponds to informal Pzmi unit of Puchner (1984) in western Ruby quadrangle

TRMtqp Quartzite and phyllite (Triassic? to Mississippian?)-- Quartzite, phyllitic quartzite, phyllite, and subordinate limestone. Occupies a position structurally between the Tozitna assemblage and the Ruby metamorphic complex south of the Kaltag fault. Originally assigned to the Slate Creek thrust panel of the Angayucham terrane (see fig. 2) by Patton and others (1994a) and to the Ruby metamorphic complex by Puchner (1984), we have provisionally assigned it to the Tozitna assemblage herein based on lithologic compatibility, map distribution and its distinctly lower metamorphic grade than the underlying Ruby metamorphic complex. Poorly dated and of controversial age; Dillon and others (1986) assigned similar rocks in the Wiseman quadrangle a Triassic to Mississippian age on the basis of radiolaria from intercalated chert layers whereas Patton and others (1994a) prefer a Devonian age, based on palynflora also in the Wiseman and, additionally, the Christian quadrangles. Corresponds to the TRMq unit of Patton (written commun., 1997) in the Nulato quadrangle and unit Pzrp of Puchner (1984) in the western Ruby quadrangle. A similar, but more highly metamorphosed quartzite unit in the Melozitna quadrangle (unit PzpCq, Patton and others, 1978) is here shown within unit PzZrpg of the Ruby metamorphic complex; W.W. Patton, Jr. (personal commun., 1998) suggest these may represent the same unit

TRMtsu Sedimentary rocks, undivided (Triassic? to Mississippian?)-- Rocks tentatively correlated with the Rampart Group of the Tanana quadrangle, including chert, slate, siltstone, meta-graywacke, basalt, greenstone, and minor limestone. Corresponds to informal Pzrg unit and its' subdivisions of Puchner (1984) in western Ruby quadrangle

Innoko assemblage

Jium Ultramafic and mafic rocks, undivided (Jurassic to Mississippian?)-- Peridotite, dunite, serpentinite, harzburgite tectonite, and cumulate ultramafic rocks of the Mt Hurst area, and subordinate gabbro, diorite, and basalt. Age based on dating of correlative rocks in the Tozitna sequence of the Nulato quadrangle. Includes ph and pc units of Chapman and others (1985) in the Ophir quadrangle. In the Iditarod quadrangle, gabbronorite, gabbro and diabase and associated serpentinized harzburgite, minor dunite and rare pyroxenite of the Dishna River mafic and ultramafic rocks (Miller and Bundtzen, 1994) occur as fault-bounded slivers along the Dishna River fault zone

JTRta Cherty tuff, crystal and lithic tuffs, and volcanic breccia (Early Jurassic? and Triassic)-- Dark greenish, very fine-grained cherty tuff grading into greenish-gray radiolarian chert. Also fine- to coarse-grained crystal and lithic tuffs. Volcanic breccia and conglomerate composed of poorly sorted clasts of mafic volcanic rocks and cherty tuff in a crystal and lithic tuff matrix. Age assignment is from widespread radiolaria and conodonts from the cherty beds. Mapped only in the Medfra quadrangle (unit JTRt, Patton and others, 1980). Unit assigned to the Innoko terrane (see fig. 2, herein) by Patton and others (1980); however unit is unique in the Rampart Group related terranes (Innoko, Tozitna, and Angayucham) because of its young age relative to other units and its tuffaceous character. Unit outcrops in a distinctive band east of the more typical Innoko terrane rocks. Very similar in age and lithology to unit JTRct of the Chulitna sequence, but there is little reason to believe that these are the same unit

TRMis **Sandstone, grit, and argillite** (Triassic to Mississippian)-- Calcareous graywacke, grit, chert-argillite-clast pebble conglomerate, and subordinate interbedded argillite, tuff, and volcaniclastic rocks. Poorly dated but may overlie TRMica unit. Corresponds to the TRMs unit of Chapman and others (1985) in the Ophir quadrangle

TRMica **Chert, argillite, and volcaniclastic rocks** (Triassic to Mississippian)-- Dominantly medium-dark- to dark-gray, thin-banded, bedded radiolarian-bearing chert having thin interbeds of slaty argillaceous rocks, including argillite, slate, and phyllite. Also includes subordinate intermediate to basaltic volcanic and volcaniclastic rocks including lithic and waterlaid tuff, fossiliferous shallow-water limestone, grit, and arkosic sandstone lenses. Age range based on radiolaria of Mississippian age, conodonts, and foraminifera of Mississippian age 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 unequivocal Innoko assemblage rocks; however Patton and others (1994a) report Devonian palynflora from the Wiseman and Christian quadrangles in the similar Angayucham assemblage. A K-Ar age of 302+/-9 Ma on amphibole from tuff indicates a Pennsylvanian age (Miller and Bundtzen, 1994). This unit originally described by Chapman and Patton (1979) and redefines part of the Cretaceous chert and argillite unit of Cass (1959, unit Kc). Corresponds to the TRMc unit of Chapman and others (1985) in the Ophir quadrangle and Miller and Bundtzen (1994) in the Iditarod quadrangle. Includes the PaMc unit of Patton and others (1980) in the Medfra quadrangle. Corresponds to the informal MDc unit of Puchner (1984) in the western Ruby quadrangle

Pig **Graywacke** (Permian)-- Fine- to medium-grained, medium-gray to dark-greenish-gray, locally calcareous, graywacke and grit to small-pebble graywacke conglomerate, and greenish-gray to medium-dark gray mudstone and shale. Originally described by Chapman and Patton (1978); unit redefines part of the Cretaceous chert and argillite unit of Cass (1959, unit Kc). Probable Permian microfossils and bryozoan and echinoderm fragments were collected from the northern of two localities (Chapman and Patton, 1978) are basis of unit age. Mertie and Harrington (1924) reported a possible ammonite fragment of indeterminate age in the southern outcrop area, which Cass (1959) used to infer a Cretaceous age. Known only from the Ruby quadrangle, mapped as unit Pg of Chapman and Patton (1978) and Puchner (1984) in southwestern Ruby quadrangle, which Chapman and Patton (1978) correlated with the Rampart Group

MDl **Fine-grained limestone** (Mississippian? to Devonian?)-- Light- to medium-dark-gray, fine-grained, slightly recrystallized, conodont-bearing limestone containing minor calcite veinlets and lenses. Includes minor chert granules and mafic rock fragments, chiefly concentrated in thin layers, and rare thin layers containing poorly preserved stromatoporoids, crinoid fragments, and shelly debris including an unidentified brachiopod. Found in small outcrop exposures and lenses within unit TrMica of this map in the Ophir (unit MDl, Chapman and others, 1985) and Medfra (unit PaMcl, Patton and others, 1980) quadrangles Includes the PaMc and PaMcl units of Patton and others (1980) in the Medfra quadrangle and MDl unit of Chapman and others in the Ophir quadrangle.

End of Oceanic rocks group

Stratigraphic sequences

Mystic sequence

JDm **Mystic stratigraphic sequence, undivided** (Jurassic to Devonian)-- Mapped only in reconnaissance, but presumed to consist of some of the rock types listed below under descriptions of the Tatina River Volcanics, Sheep Creek, and St. John Hill Formations: basalt, limestone, siltstone, sandstone, and various other minor rock types. Locally subdivided into:

JTRtv **Tatina River Volcanic and equivalent units** (Early Jurassic, Sinemurian? and Triassic)-- Where best studied in the McGrath quadrangle (Bundtzen and others, 1997a), consist of three members.

Upper member (unit lJs of Bundtzen and others, 1997a) consists chiefly of green medium-grained, concretion-rich volcaniclastic sandstone, subordinate medium- to very dark-gray, phosphatic shale, and minor tan chert-pebble conglomerate. Lower Jurassic ammonite-bearing phosphatic shale beds in the western Talkeetna quadrangle, which Reed and Nelson (1980) assigned to their unit KJs are reassigned to this member.

A lower volcanic member (unit TRab of Bundtzen and others, 1997a) consists of dark-greenish-gray elongate bodies of pillow basalt. Includes interbeds and lenses of mudstone, shale, and siltstone. Locally, gabbro bodies, interpreted 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. Each of these units has similar reported major element oxide contents and also show similar copper content between 200 to 500 ppm. Age control is lacking; assignment based on association with other members. Laterally gradational with the volcanic member is a volcaniclastic member (unit TRs of Bundtzen and others, 1997a), which consists of brown silty shale and light-gray, green, and black chert associated with coarse volcanic sandstone and conglomerate. Bundtzen and others (1997a) reported the occurrence of *Monotis subcircularis*, indicating a Late Triassic (Norian) age

PMl **Younger limestone** (Permian to Mississippian)-- Brown to gray, layered to nodular limestone, calcareous siltstone, varicolored chert, and limestone-chert conglomerate. Conglomerate contains rounded clasts of silty sandstone, chert, and limestone. Conodonts indicate a Late Mississippian age (Bundtzen and others, 1994). Shown separately only in western Lime Hills quadrangle

PDsc **Sheep Creek Formation and correlative siliciclastic units** (Permian to Devonian)-- Clastic-dominated, but heterogeneous, middle third of the Mystic stratigraphic sequence. Consists of sandstone, conglomerate, siltstone, and argillite, and lesser chert and limestone. Age control is provided by conodonts, fusilinids, brachiopods, corals, and plants. Depositional environments are dominantly fluvial, but carbonate-platform and deep marine environments are also represented by the subordinate rock types in this grouping of units. Includes Sheep Creek Formation of eastern and western McGrath and western Lime Hills quadrangles, units Pacg and uPzac of eastern McGrath quadrangle (Bundtzen, unpublished data, 1997; 1998; Bundtzen and others, 1997a), the conglomerate of Mt. Dall (unit Pag) in the Talkeetna quadrangle (Reed and Nelson, 1980), and unit Ps of Medfra quadrangle (Patton and others, 1980). The Conglomerate of Mt. Dall, which has yielded a Permian plant assemblage of Siberian affinity (Mamay and Reed, 1984), contains clasts of Devonian limestone of the Mystic stratigraphic sequence, and chert, chert-pebble conglomerate, and graded sandstone, presumably derived from the Dillinger stratigraphic succession. Conglomerate of unit Ps in Medfra quadrangle (Patton and others, 1980) contains clasts of limestone of the subjacent Nixon Fork sequence

Dsc **Shale and chert** (Devonian)-- Occurs in limited area in eastern Lime Hills quadrangle. Important because unit hosts Gargaryah bedded-barite deposit. Age Middle to Late Devonian (Givetian to Frasnian)

Dml **Older limestone** (Devonian)-- Chiefly algal-laminated limestone and dolostone of shallow-marine origin. In eastern McGrath quadrangle, includes members Dls (consisting of limestone, mudstone, siltstone, and lithic sandstone) and uDl of the St. John Hill Formation, and members lDl and lDd of the Sheep Creek Formation (Bundtzen and others, 1997a). In the western McGrath and western Lime Hills quadrangles, includes unit uDl. Age, constrained by conodonts, corals, and brachiopods, is chiefly Late Devonian (Frasnian)

End of Mystic sequence

Mystic and Dillinger stratigraphic sequences, undivided

JCmd **Mystic and Dillinger stratigraphic sequences, undivided** (Jurassic to Cambrian)-- Includes rocks in the Healy, Mount McKinley, and Talkeetna quadrangles, which appear to correlate with the Dillinger and Mystic sequences of the eastern McGrath quadrangle, but which have only been studied in reconnaissance. Jurassic to Cambrian quoted encompasses the entire age range of the Mystic and Dillinger sequences where they are better studied; fossils within the area mapped as undivided Mystic and Dillinger range from Permian to Silurian. In the Talkeetna quadrangle (Reed and Nelson, 1980), unit Pzus (the original Mystic terrane of Jones and Siberling (1979) consists of a structurally complex assemblage of deep marine facies (siliciclastic turbidites, cherty pelagite, pillow basalt, and wildflysch), slope and shelf facies (chert, shale, and reefoid limestone), and nonmarine facies (conglomerate and sandstone). Fossil ages range from Early Devonian to Permian; strata below the Devonian limestone in this belt belong to the Dillinger sequence. In the Healy quadrangle (Csejtey and others, 1992) and Mount McKinley quadrangle (Bela Csejtey, Jr., written commun., 1993), units DOs and DOls, respectively, consist of a complexly folded assemblage of (1) fine-grained, calcareous, siliceous, and siliciclastic strata, (2) calcareous siliciclastic turbidites containing a Late Silurian to possibly Early Devonian conodont fauna (corresponding to the Terra Cotta Mountains Sandstone of Bundtzen and others, 1997a), and (3) calcareous turbidites and debris flows that have yielded Early Silurian conodonts (Dumoulin and others, in press). Separately mapped carbonate bodies within the outcrop belt of undivided Dillinger and Mystic strata are here assigned to unit DSmdl:

DSmdl **Unnamed limestone** (Devonian and Silurian)-- Limestone bodies within the outcrop area of the undivided Dillinger and Mystic stratigraphic sequences. In the Talkeetna quadrangle, includes Silurian and Devonian limestones that were mapped as separate units by Reed and Nelson (1980). Silurian unit (unit Sl, Reed and Nelson, 1980) consists of light-gray to light-brown massive-weathering meta-limestone and local thin-bedded to laminated limestone; age based on graptolites, *dasclydacean* algae, and corals. Fossil content suggests, at face value, both shallow and deep marine environments. Devonian limestone (unit Dl, Reed and Nelson, 1980) contains locally abundant corals and stromatoporoids, and brachiopods (of Siberian affinity, Blodgett and Brease, 1997), indicative of shallow marine deposition. Corals, brachiopods, and conodonts indicate Early to Late Devonian (Emsian to Frasnian) age. In the Mount McKinley and Healy quadrangles, includes limestone bodies within units DOs and DOls (Bela Csejtey, Jr., written commun., 1993; Csejtey and others, 1992), respectively. Recent work by Dumoulin and others (in press) using conodonts for age control showed that the previously mapped limestone unit [(ls)DOs] in the Healy quadrangle includes both Silurian deep-water limestone and Late Devonian shallow-water limestone

End of Dillinger and Mystic sequences, undivided

Sedimentary rocks

TRPs **Sedimentary rocks, undivided** (Triassic to Permian)-- Dominantly dark gray, typically phyllitic, siliceous to carbonaceous argillite and shale, with subordinate but characteristic clast-supported chert-rich conglomerate, greenish-gray chert, tuffaceous volcaniclastic rocks, yellowish- to reddish-brown highly calcareous argillite or limestone, and minor intrusive rocks; locally may include older (Mississippian? or Devonian?) or younger (Cretaceous) rocks (Dover, unpublished data, 1997). Mapped in Tanana quadrangle. In Livengood quadrangle, equivalent rocks have been subdivided into two units, Trsc and Ps

TRPas **Flysch-like sedimentary rocks** (Late Triassic to Pennsylvanian)-- Intensely folded sequence of dark-gray to black, massive to thin-bedded marine flysch-like rocks including conglomerate, sandstone, siltstone, and argillite, a few thin interbeds of limestone, and thin interbeds of chert in the upper part (Csejtey and others, 1992). Age based on Triassic radiolaria and conodonts from cherts and calcareous units and on a reported collection of Pennsylvanian brachiopods (see Csejtey and others, 1992, p. 28). Thought at least several hundred meters thick. Overlain by and locally interbedded with late Triassic pillow basalt, herein assigned to the Nikolai Greenstone (unit TRn) of this map. However, Csejtey and others (1992) did not assign either of these units to known packages or assemblages because of the discontinuous and fault-bounded nature of their occurrence

Igneous rocks

MzPzi **Intrusive and volcanic rocks, undivided** (Mesozoic or Paleozoic)-- Granodiorite of Rainbow Mountain in the Mount Hayes quadrangle (unit grrm, Nokleberg and others, 1992a), diorite in the Circle and Bid Delta quadrangles (unit MzPzd, Foster and others, 1983; unit Pzd, Weber and others, 1978), and gabbro and quartz diorite in the Talkeetna, Tyonek, and McGrath quadrangles (unit MzPzg, Reed and Nelson, 1980; unit MzPzm, Magoon and others, 1976; unit MzPzi, Bundtzen and others, 1997a, T.K. Bundtzen, written commun., 1997). Also dark-gray to greenish-gray dikes ranging from basalt to granodiorite in the Talkeetna quadrangle (unit MzPzi, Reed and Nelson, 1980) and volcanic rocks of unknown age in the Nulato and the Lime Hills quadrangles (unit vr, W.W. Patton, Jr., written commun., 1997; unit MzPzi, Reed and Gamble, 1988)

MzZum **Ultramafic and mafic rocks, undivided** (Mesozoic?, Paleozoic?, and (or) Late Proterozoic?)-- Serpentinite, peridotite, dunite, gabbro, diorite, metabasite, and minor talc schist and roddingite are widespread throughout map area. These exhibit a broad range of intrusive and (or) metamorphic textures and fabrics. Age control is generally poor and inferred ages range from Mesozoic to late Proterozoic. $^{40}Ar/^{39}Ar$ dating of hornblende from gabbro in the Tanana quadrangle yielded an apparent 540 Ma age and similar dates in the Livengood quadrangle yielded ages ranging from 465 to 536+/-2.6 Ma (Reifenstuhl and others, 1998). In the Talkeetna quadrangle, includes serpentinite and minor talc schist that Reed and Nelson (unit MzPzu, 1980) interpreted was derived from peridotite. Includes unit MzPzum in the Tyonek quadrangle (Magoon and others, 1976), units Pzd and Pzu in the Big Delta quadrangle (Weber and others, 1978), units PzZm and CZum in the Livengood quadrangle (Weber and others, 1992), unit PzpCm in the Nulato quadrangle (Patton, written commun., 1997), and unit Pzum of Reifenstuhl and others (in press) in the Tanana A-1 (1:63,360-scale) quadrangle. In the Healy quadrangle, includes two metagabbro intrusions north of the Denali fault system of inferred Devonian age (unit Dmg, Csejtey and others, 1992)

Metamorphic rocks

JPzk **Kakhonak Complex** (Jurassic, Triassic and older?)-- Within map area, consists of poorly described metasedimentary, and metavolcanic rocks tentatively correlated with the Kakhonak Complex. Best described by Detterman and Reed (1980) in the Iliamna quadrangle to the south of the map area, the unit is a heterogeneous assemblage of largely greenschist facies metamorphic rocks. However, the rocks are most commonly exposed as roof pendants within the Alaska-Aleutian Range batholith (Reed and Lanphere, 1969; 1972; 1973) and therefore locally display contact metamorphic effects. Lithologies listed by Detterman and Reed include argillite and slaty argillite, marble, quartz- mica schist, and quartzite and there is mention but no description of metavolcanic and metaplutonic rocks. In our map area, we have included a variety of metamorphic rocks exposed in associated with the Alaska-Aleutian Range batholith in the Tyonek and Lime Hills quadrangle within this unit. The rocks include units Mzs, Mzv, and Mzu of Reed and Elliott (1970) in the Tyonek and Lime Hills quadrangles, JPu of Magoon and others (1976) and MzPzs of Gamble and Reed (1996)

PALEOZOIC
Assemblages and sequences
Skolai Group

This assemblage of rocks comprises a lower(?) unit of gabbro and gneiss (Pennsylvanian?), a middle volcanic and volcaniclastic sequence (Permian and Pennsylvanian) and a carbonate unit (Permian). The upper units are known under various names such as the Skolai arc, Skolai Group, Mankomen Group, Strelna metamorphic assemblage, and the Metamorphic Complex of Gulkana River and are regarded by many workers, as the basement of the Wrangellia terrane of Jones and others (1977). Although not originally defined as part of Wrangellia, they are now commonly included in it.

Rock units and assemblages similar to these are widespread in southern Alaska, ranging from Puale Bay on the Alaska Peninsula (Wilson and others, in press) to southeast Alaska.

Pe **Eagle Creek Formation** (Early Permian)-- Alternating marine argillite and limestone disconformably overlying the Slana Spur Formation (Nokleberg and others, 1992a). Limestone is fine- to medium-grained, thin- to medium-bedded and was deposited in shallow water at or near wave base. Abundant fossils include a heterogeneous assemblage of coral, bryozoan, brachiopod, echinoid, crinoid, fusulinid, and algal(?) fragments. Argillite member is chiefly thin-bedded and dark-gray and has thin lenses and laminae of gray siltstone and minor bioclastic limestone, calcareous siltstone and pyritic sandstone. Thin units of radiolarian chert, shale, and limestone occur within the Formation. May be as much as 1,000-m-thick. Disconformably overlain by the Nikolai Greenstone (unit TRn) and conformably overlies the Slana Spur Formation (equivalent to Station Creek Formation, in part). Stratigraphically and lithologically correlative with the Hasen Creek Formation of the McCarthy quadrangle (MacKevett, 1978). Metamorphosed to lower greenschist facies

PPasc **Station Creek and Slana Spur Formations, and equivalent rocks** (Early Permian and Pennsylvanian)-- Divided into two informal units: Lower volcanic member consists chiefly of submarine andesite and basalt flows, locally pillowed and brecciated; upper volcaniclastic member generally grades upward from coarse volcanic breccia, to abundant volcanic graywacke, and finally to volcanilutite. No fossils are known in the type area. Age assignment is relative to overlying Hasen Creek Formation (Early Permian, MacKevett, 1978) and stratigraphic and lithologic correlation with the Slana Spur Formation (Nokleberg and others, 1992a). As here mapped, includes unit Pzt of Nokleberg and others (1992a) consisting of aquagene tuff, argillite, limestone, chert, andesitic tuff, and greenstone which have yielded fragments of late Paleozoic bryozoans. In the Talkeetna Mountains quadrangle, Early through Late Permian conodonts were collected from unit Pzv (Csejtey and others, 1978)

Pat **Tetelna Volcanics** (Pennsylvanian)-- Chiefly greenish volcanic flows, mud and debris avalanches, and lapilli-pumice tuff interbedded with fine- to coarse-grained volcaniclastic rocks (Nokleberg and others, 1992a). Flows are mainly andesitic and are correlative with volcanic flows member of the Station Creek Formation. Metamorphosed to lower greenschist facies. As here mapped, unit also includes greenstone of the Skolai Group in the Valdez quadrangle (Winkler and others, 1980) and Early Permian(?) and Pennsylvanian andesitic volcanic rocks in the Healy quadrangle (Csejtey and others, 1992)

Pmi **Shallow stocks, dikes, and sills** (Early Permian?)-- Sparse to locally abundant andesite, and subordinate dacite and rhyolite stocks, dikes, and sills (Nokleberg and others, 1992a). Intrudes Slana Formation and Tetelna Volcanics but not the Eagle Creek Formation (Nokleberg and others, 1992a). Age inferred from intrusive relations. Metamorphosed to lower greenschist facies. Locally intense hydrothermal alteration and associated sulfide mineralization

PPagi **Ahtell pluton** (Permian and Pennsylvanian)-- Fine- to coarse-grained granite, quartz monzonite, granodiorite, tonalite, and minor quartz diorite. Crops out in the northeastern Gulkana quadrangle. Intrudes Tetelna Volcanics. U-Pb age of 311 Ma (Nokleberg and others, in press). Locally metamorphosed to lower greenschist facies. Consists of units PPaf, PPap, and PPag of the Gulkana quadrangle (Nokleberg and others, in press) and unit PPag of Mount Hayes quadrangle (Nokleberg and others, 1992a)

PPad **Diorite complex** (Permian to Pennsylvanian)-- Diorite, granodiorite, and altered diabase and gabbronorite. Crops out in the northeastern Gulkana quadrangle. Intrudes Tetelna Volcanics. U-Pb ages of 295 to 319 Ma (Nokleberg and others, in press). Locally metamorphosed to greenschist facies. Units PPaa, and PPad of the Gulkana quadrangle (Nokleberg and others, in press)

Pagb **Gabbro and orthogneiss** (Pennsylvanian?)-- Thick complex of layered gabbro or locally, interlayered gneiss and gabbro conformably overlain by the Skolai Group in the Valdez quadrangle (Winkler and others, 1980). Gabbroic parts of the unit are interpreted as part of the oceanic crust that underlies the Skolai arc; the significance and origin of the gneiss is uncertain, it has affinities to members of the charnokite series

PPast **Strelna metamorphic complex** (Early Permian to Middle Pennsylvanian)-- Variably metamorphosed but largely lower greenschist facies metasedimentary and metavolcanic rocks of the Skolai Group. Includes quartzofeldspathic and quartz-mica schist, locally having compositional layering reflecting original bedding, greenstone derived from mafic to intermediate volcanic rocks, and locally abundant marble interbeds and tectonic lenses and metachert and orthogneiss. Metamorphic grade generally increases to amphibolite facies near contacts with the Uranatina River metaplutonic complex (unit JPaur, herein). 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). Included here is the Strelna metamorphic assemblage of the Valdez quadrangle (G.R. Winkler, written commun., 1998) and the metamorphic complex of Gulkana River units ds, mmp, am, mha, mcb of the Gulkana quadrangle (Nokleberg and others, in press), the nonplutonic older part of the Haley Creek terrane of Winkler and others (1980), units Jgs and Jam of Csejtey and others (1978) in the Talkeetna Mountains quadrangle, and unit Jma in the Anchorage quadrangle (Winkler, 1992). Also includes migmatitic border rocks (unit Jpmu) of the Jurassic plutons and undifferentiated metamorphic and plutonic rocks (unit Jgdm) in the Talkeetna Mountains quadrangle (Csejtey and others, 1978)

PPaskm **Marble** (Early Permian? and Pennsylvanian?)-- White, medium- to coarse-grained marble occurring as massive lenticular interbeds, as much as 30-m-thick in the Strelna metamorphic complex in the Talkeetna Mountains quadrangle (units Jmrb, Jmb, and Pls Csejtey and others, 1978) and marble within the Skolai Group in the Valdez quadrangle (unit Pzm, Winkler and others, 1980; unit ma, G.R. Winkler, written commun., 1998). In the Talkeetna Mountains quadrangle, the protolith may have been limestone within the Talkeetna Formation (unit Jtk) or within the Late Paleozoic volcanogenic rocks (unit PPasc)

End of Skolai Group

Dillinger and Nixon Fork sequences

The term Dillinger has been widely used in Alaska for a Cambrian to Devonian succession of mostly deep-marine strata, which outcrop in the southwestern part of the present map area. These rocks have been assigned to the Dillinger terrane (Silberling and others, 1994; see fig. 2, herein), Dillinger subterrane of the Farewell terrane (Bundtzen and others, 1997), and Dillinger sequence of the present compilation. On the present map, the Dillinger sequence is broken out into constituent formations in parts of its outcrop belt, but is left undivided in the Sleetmute, Lime Hills, and Talkeetna quadrangles. The term Nixon Fork has been widely used in Alaska for a late Proterozoic to Devonian succession of mostly shallow-marine carbonate rocks, which also outcrop in the southwestern part of the present map area. These rocks have been assigned to the Nixon Fork terrane (Silberling and others, 1994; see fig. 2, herein), Nixon Fork subterrane of the Farewell terrane (Bundtzen and others, 1997), and Nixon Fork sequence of the present compilation. On the present map, the Nixon Fork sequence is broken out into constituent formations in most of its outcrop belt, but is left undivided where mapped in reconnaissance in the Sleetmute and Lime Hills quadrangles and in a limited part of the Medfra quadrangle. Decker and others (1994) showed that the Nixon Fork and Dillinger sequences are laterally equivalent shallow- and deep-water facies of what they termed the White Mountain sequence.

Dillinger sequence

DCd **Dillinger sequence, undivided** (Devonian to Cambrian)-- Consists of the rock types listed below under descriptions of Post River and Lyman Hills Formations, Terra Cotta Mountains Sandstone, and Barren Ridge Limestone -- all interpreted as slope or basinal deposits. Age control is from conodonts and graptolites. Includes units Pzd in Talkeetna quadrangle (Reed and Nelson, 1980), Pzu in eastern Lime Hills quadrangle (Gamble and Reed, 1996), Pzdu in western Lime Hills quadrangle (T.K. Bundtzen, unpublished data, 1998), East Fork Hills Formation (Dutro and Patton, 1982) DOsl (age extended by conodonts to include Cambrian, Dumoulin and others, in press) in Medfra quadrangle (Patton and others, 1980, now East Fork Hills Formation of Dutro and Patton, 1982). In the northwestern Mount McKinley quadrangle, includes unit Pzc, which consists of chert and slate that has yielded Ordovician graptolites, quartz-rich turbiditic sandstones and minor interbedded limestone yielding Early Silurian (Llandoverian) conodonts (Dumoulin and others, in press), and quartzite that has yielded Silurian to Devonian corals (W. Oliver, written commun., 1997). Where subdivided, includes the following units:

Dsbr **Barren Ridge Limestone and correlative units** (Late Devonian to Late Silurian)-- Thin- to thick-bedded, buff to orange-weathered, light- to medium-gray, phyllitic calcarenite, thin-bedded orange to buff siltstone, and light-gray silty limestone. Age based on conodonts. Deposited in a basinal and (or) slope setting. Includes Barren Ridge Limestone in eastern McGrath and western Lime Hills quadrangles Bundtzen, unpublished data, 1997; 1998). Is the upper third of the Dillinger stratigraphic succession

Stc **Terra Cotta Mountains Sandstone and correlative units** (Late and middle Silurian)-- Chiefly calcareous sandstone and interbedded graptolitic shale. Mappable members include silty limestone, volcaniclastic sandstone, micaceous calc-sandstone, chert, and argillaceous graptolitic limestone. Sedimentary structures such as graded bedding, flute casts, and cross-lamination indicate deposition by turbidity currents in a deep-marine setting. Age based on graptolites. Includes various subdivisions of the Terra Cotta Mountains Sandstone of Bundtzen and others (1997a) (units mSs, mSl, mSvs, uSsl) in the eastern McGrath quadrangle (Bundtzen and others, 1997a), unit mSs in western McGrath (Bundtzen, unpublished data, 1997), and unit mSs in western Lime Hills quadrangles (Bundtzen, unpublished data, 1998). Is the middle third of the Dillinger stratigraphic succession

SCpl **Post River Sandstone, Lyman Hills Formation, and correlative units** (middle Silurian (Wenlockian) to Late Cambrian)-- Post River Formation (Churkin and Carter, 1996) consists of graptolitic shale, siltstone, and chert; Lyman Hills Formation of Bundtzen and others (1997a) consists of silty limestone and shale, commonly cross-laminated, locally containing Bouma 'cde' intervals. Age constrained by uppermost Cambrian conodonts and Ordovician and Silurian graptolites. Deposited in a basinal and(or) slope setting, in part by turbidity currents. Includes the Lyman Hills and Post River Formations in their type areas in the eastern McGrath quadrangle (Bundtzen and others, 1997a; Bundtzen, unpublished data, 1997), unit OCls, which intertongues with the Nixon Fork sequence in the western McGrath quadrangle (Bundtzen, unpublished data, 1997), unit Oc in the Talkeetna quadrangle (Reed and Nelson, 1980), and part of unit mcb in the Ruby quadrangle (Cass, 1959). This combined unit forms the lower third of the Dillinger stratigraphic sequence

End of Dillinger sequence

Nixon Fork sequence

DZn **Shallow-marine carbonate units of Holitna basin area, undivided** (Devonian to Late Proterozoic)-- shallow-marine limestone and dolostone facies having reported algal reefs. Middle Devonian to Middle Cambrian age range indicated by trilobites, conodonts, corals, stromatoporoids, and brachiopods; an unfossiliferous dolostone unit below Middle Cambrian strata has been assigned to Late Proterozoic (St. John and Babcock, 1997). Map distribution compiled from Miller and others (1989), Bundtzen (unpublished data, 1998), and Decker and others (1994). Locally includes the following units:

DSwc **Whirlwind Creek Formation and unnamed correlative units** (Late Devonian, Frasnian through middle Silurian, Wenlockian)-- Shallow-marine limestone and dolostone comprises the upper third of the Nixon Fork stratigraphic sequence in its type area in the Medfra quadrangle. Age range is based on conodonts, stromatoporoids, corals, and ostracodes. Depositional setting interpreted as shallow marine. Includes Whirlwind Creek Formation in Medfra quadrangle (Patton and others, 1980; Dutro and Patton, 1982), unit DSl in the Mt. McKinley quadrangle (Bela Csejtey, Jr., written commun., 1993), units lDl, lDd, mDl, SLa, and SDlw in the western McGrath quadrangle (Bundtzen, unpublished data, 1997), and unit SDlw(h) in the western Lime Hills quadrangle (Bundtzen, unpublished data, 1998)

Spf **Paradise Fork Formation and unnamed correlative rocks** (middle Silurian, late Llandoverian to Wenlockian)-- Dark, platy limestone and limy shale. Is the middle third of the Nixon Fork sequence in its type area in the Medfra quadrangle. Age based on conodonts and graptolites. Depositional setting interpreted as deeper water, off-platform.

Includes the type Paradise Fork Formation in Medfra quadrangle (Patton and others, 1980; Dutro and Patton, 1982) and unit Ssh in the western McGrath quadrangle (Bundtzen, unpublished data, 1997)

Ont **Novi Mountain and Telsitna Formations, and unnamed correlative rocks** (Ordovician and late Cambrian?)-- Novi Mountain Formation consists of variably argillaceous limestone, distinctively orange weathering in places, and locally oolitic. The overlying Telsitna Formation is mainly peloidal lime micrite and lesser dolostone. Age is based on conodonts, corals, and brachiopods. Depositional setting interpreted as shelf, locally very shallow. 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. Includes Novi Mountain Formation (unit Od of Patton and others, 1980; Dutro and Patton, 1982) and Telsitna Formation (unit Osl of Patton and others, 1980; Dutro and Patton, 1982) in their type areas in the Medfra quadrangle (Dutro and Patton, 1982). Also includes unit Ol in the Ruby quadrangle (Cass, 1959), and units Ol, lOlb, mOl, uOl, uOll, and Om in western McGrath quadrangle (Gilbert, 1981; Bundtzen, unpublished data, 1997). Also includes somewhat problematic dolostones that rest on crystalline basement in the northernmost Medfra quadrangle, which Dutro and Patton (1982) assigned to the Telsitna Formation. These strata have yielded the gastropod *steinkerns* that allow the possibility of an age as old as Late Cambrian

CZds **Unnamed dolostone, sandstone, siltstone** (Early Cambrian to Proterozoic)-- Alternating intervals of 1) yellow, brown, and maroon siltstone and cross-bedded quartzose sandstone, and 2) dolostone, consisting of packstone and grainstone having coated grains and fenestral fabric. The siliciclastic rocks probably accumulated in a marginal-marine environment; the dolostone in a shallow marine shelf or platform. Devoid of fossils, unit is assigned a pre-Middle Cambrian age because similar strata underlie Middle Cambrian trilobite-bearing rocks in the Sleetmute quadrangle (Miller and others, 1989). Includes units Xmso, Xcd, and Xcl in western McGrath quadrangle (T.K. Bundtzen, unpublished data, 1997)

End of Nixon Fork sequence

Sedimentary rocks

Pzlc **Limestone and chert** (Paleozoic)-- Light- to dark-gray lime mudstone, locally argillaceous in eastern exposures and interbedded with chert in western exposures. Occurs only between strands of the Tintina fault in the Circle quadrangle in the so-called "Preacher Block" of Foster and others (1983). No fossils are known from unit and Foster and others (1983) suggest rocks in the eastern and western exposures may be of significantly different ages. Unit is at least 350 m thick

Ps **Argillite, siltstone, sandstone, and minor conglomerate** (Permian)-- 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. Foraminifera, conodonts, and brachiopods indicate a Permian age (Weber and others, 1992). Mapped in the Livengood quadrangle. In the Tanana quadrangle, equivalent rocks are part of unit TRPs

PDms **Sedimentary rocks** (Permian? to Devonian?)-- Indeterminate or poorly identified units in Livengood quadrangle. Black and greenish-gray siliceous slate, thinly interbedded gray chert, shaly chert, and minor breccia, siliceous, locally sandy siltstone displaying turbiditic sedimentary structures, red and greenish-gray, or dark-gray, locally calcareous shale, phyllite, minor quartz- sandstone, argillite, greenstone, lime mudstone to packstone, and limestone debris flows. Conodonts from a limestone clast in one debris flow indicate a Late Devonian (Famennian) age (Weber and others, 1992). Includes units PDms and Pzs in the Livengood quadrangle (Weber and others, 1992)

Mgq **Globe quartzite** (Mississippian)-- Light gray, massive or thinly laminated quartzite and medium- to dark-gray slate, phyllite, and laminated claystone. Unfossiliferous; age inferred on the basis of intrusion by Triassic rocks and by lithologic and stratigraphic similarity with the Keno Hill quartzite of Yukon Territory, Canada (Dover, 1994).

Associated with gabbroic dikes and sills. Occurs in the White Mountains and Schwatka stratigraphic belts in Livengood and Tanana quadrangles and has limited exposure in the Circle quadrangle (F.R. Weber, unpublished mapping, 1998)

Dps **Phyllite, slate, siliceous siltstone, and argillite** (Devonian)-- Light- and medium-gray to silvery gray phyllite, slate, siliceous siltstone, and argillite. Includes some thin limestone and calcareous siltstone. Unfossiliferous; Devonian age assigned on the basis of two equivocal observations: 1) unit Dps appears to overlie limestone (unit DSl of the present compilation) which locally has yielded Late Devonian (Frasnian) corals, but 2), unit Dps is also possibly gradational with unit DSl (Chapman and others, 1975). Mapped only in the Kantishna River quadrangle

Dcb **Cascaden Ridge, Beaver Bend, and correlative rocks** (Devonian?)-- Various Devonian siliciclastic units in the Livengood and Circle quadrangles. Cascaden Ridge unit of Weber and others (1992), exposed in Livengood quadrangle, is chiefly rhythmically interbedded gray and olive-gray shale, gray siltstone, and graywacke. Less abundant components are gray limestone and polymictic granule- and pebble conglomerate having a graywacke matrix. Conglomerate clasts include mafic/ultramafic rocks, chert, dolomite, and shale (Weber and others, 1992). Limestone contains Middle Devonian conodonts, brachiopods, and corals. 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. Unit has yielded unidentifiable plant fragments; however, it is assigned a probable Devonian age. In the western Circle quadrangle, unfossiliferous chert-pebble conglomerate mapped as unit part of MzPzat by Foster and others (1983) is assigned to Beaver Bend unit (F.R. Weber, unpublished mapping, 1998). In 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. Combined unit correlates with the Nation River Formation of the Charley River quadrangle (Brabb and Churkin, 1969)

Dq **Quail unit** (Devonian)-- Gray and green phyllite interlaminated with calcareous siltstone, quartzose sandstone, graywacke, and granule- to boulder conglomerate constitute the Quail unit of 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). Slightly higher metamorphic grade than age and lithologically similar Cascaden Ridge unit of Weber and others (1992), here mapped as part of unit Dcb. Correlates with the Nation River Formation of the Charley River quadrangle (Brabb and Churkin, 1969)

Dtr **Troublesome unit and possibly correlative rocks** (Devonian?)-- Rhythmically interbedded dark-gray to black cherty argillite to chert, and thin beds of black to gray, siliceous slate as mapped in the Livengood quadrangle. Associated with extensive mafic intrusive and extrusive rocks. Unidentified radiolaria are only reported fossils (Weber and others, 1992). Depositionally overlain by Frasnian carbonate buildups at base of Quail unit, hence Middle Devonian or older. Also includes unit Pzc 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 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. May correlate with the McCann Hill Chert of the Charley River quadrangle (Brabb and Churkin, 1969)

Ds **Schwatka limestone unit** (Middle to Early Devonian)-- 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 Dsv. Mapped only in northeastern Livengood and northwestern Circle quadrangles. Depositional environment interpreted as shallow marine

Dsv **Volcanic part of Schwatka unit** (Middle to Early Devonian)-- 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 (Weber and others, 1992) interbedded with limestone of unit Ds. Metamorphosed to greenschist facies. Mapped in Livengood and Circle quadrangles

DSlc **Lost Creek unit** (Devonian and Silurian?)-- Light-gray, massively bedded, lime mudstone and wackestone. Limestone occurs as debris flows 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 (mapped here within unit Oc). Channels and debris flows together indicate a deep-water depositional setting. Brachiopods, corals, and trilobites indicate a Late to middle Silurian age (Wenlockian to Ludlovian). 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)

DSl **Limestone** (Late Devonian to middle Silurian)-- Various shallow-marine, carbonate-dominated rocks of Silurian to Devonian age in the Circle, Tanana, Kantishna River, and Livengood quadrangles, except the Tolovana and Schwatka units, which are shown by their own symbols. In the Circle quadrangle, includes unit Dl of Foster and others (1983), medium-gray, generally massive, locally recrystallized limestone which is found in scattered outcrop belts north of the Tintina fault. It has yielded Early Devonian conodonts from several localities (Foster and others, 1983). In the Tanana quadrangle, includes the following units of Dover (unpublished mapping, 1997): 1) unit Dld, which consists of light- to medium-gray or tan sandy, platy limestone and massive-bedded silicified limestone and dolostone, of Late Devonian (Famennian) age; 2) "unit Ml", gray, bioclastic limestone of Famennian in age; and 3) the limestone of Raven Ridge, which consists of gray micritic limestone and brecciated limestone, of Late Devonian(?) age. In the Kantishna River quadrangle, includes unit Dls of Chapman and others (1975), which is chiefly medium- to dark-gray limestone, dolomitic in part, and medium-gray shaly to phyllitic siltstone. This unit has yielded Late Devonian (Frasnian) corals from one locality (Chapman and others, 1975). In the Livengood quadrangle, consists of light- to medium-gray lime mudstone or wackestone. Locally corals and stromatoporoids are common and conodonts at several localities suggest a Frasnian (Late Devonian) age (A.G. Harris, written commun., 1984-1988; cited in Weber and others, 1992). "These bodies, as thick as 30 m have a lateral extent of several hundred meters in the basal Quail unit, were deposited as local biogenic buildups on the Troublesome unit (Weber and others, 1992)"

DSt **Tolovana Limestone** (Middle Devonian to Early Silurian)-- Lower part of alternating green and maroon lime mudstone, succeeded by yellowish-brown weathering, silty to shaly lime mudstone and wackestone, and a main, upper part of light-weathering peloid- and ooid-rich lime packstone and grainstone and rare dolostone in the White Mountains of east-central Livengood quadrangle. Conodonts, brachiopods, and corals indicate an Early Silurian age. 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. Rocks formerly assigned to the Tolovana Limestone in northwesternmost Circle quadrangle are herein assigned to the Schwatka unit (unit Ds); rocks formerly assigned to the Tolovana Limestone in north-central and northeastern Circle quadrangle are herein to unit DSl. Depositional environment interpreted as shallow marine

SZa **Amy Creek unit** (Silurian to Late Proterozoic)-- In Livengood quadrangle were described by Weber and others (1992), consists chiefly of medium-grained gray dolostone, and light-gray, yellow-gray, or buff dolomitic mudstone, packstone, and wackestone. Coarser-grained rocks show abundant peloids and crossbedding; laminations present in mudstone; solution breccia and algal coatings present. Other interbedded rock types include chert, black argillite, lime mudstone, basaltic greenstone, tuff, tuffaceous siltstone, shale, and minor volcaniclastic graywacke (Weber and others, 1992). In the Tanana quadrangle, consists of white, massive, locally laminated cherty dolostone having gray limestone at top and bottom of section (Dover, unpublished mapping, 1997). In the Circle quadrangle, consists of yellow-gray dolomite and gray to dark-gray and black argillite, shale, and siltstone, interlayered with light- and dark-gray chert, gray marble, and gray, fine-grained quartzite (Foster and others, 1983). Age poorly constrained; age range given here is from Weber and others (1992). Must be older than the fossiliferous Middle Devonian strata that overlie it, and at least in part Cambrian or younger because it has yielded sponge spicules and unidentifiable radiolaria

Oc **Chert** (Ordovician)-- Dark gray and black chert, siliceous slate, argillite, and less abundant greenstone, impure limestone, and dolostone. Age assigned on basis of graptolites. Includes the Livengood Dome Chert in the Livengood, Circle, and Tanana quadrangles, unit Pzlc in Tanana quadrangle (Dover, unpublished mapping, 1997), the Nilkoka Group in Fairbanks quadrangle (Pewe and others, 1966), and unit DOc in Mount McKinley and Kantishna River quadrangles (Bela Csejtey, Jr., written commun., 1993; Chapman and others, 1975)

Ocl **Limestone** (Paleozoic?)-- Distinctive marker bed of lime mudstone within chert unit, locally characterized by coated ooids. Thickness varies from 10 to several ten's of meters, probably in part due structural thickening and repetition. Only mapped locally. Corresponds to unit Pzl, in part, of Chapman and others (1982) in the Tanana quadrangle

Igneous rocks

Pzvs **Volcanic and sedimentary rocks** (late or middle Paleozoic)-- Dark-greenish-gray mafic volcanic rocks and interbeds of black phyllite, chert-pebble conglomerate, light-green tuff, and graywacke (Reed and Nelson, 1980). Volcanic rocks include pillow basalt, breccia agglomerate, tuff, and massive basalt flows. Distinguished from unit Trpb (this map, unit Pzbs, Reed and Nelson, 1980) by presence of massive basalt flows

Ofc **Fossil Creek Volcanics** (Ordovician)-- Two members, one largely volcanic, one largely sedimentary. 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 which are intruded by gabbro. Late Ordovician brachiopods, trilobites, gastropods, and conodonts have been recovered from sedimentary rocks in the volcanic member; Early Ordovician conodonts and trilobites have been recovered from the sedimentary member (Weber and others, 1992). Mapped in the White Mountains stratigraphic belt of Livengood, Circle, and Tanana quadrangles (Dover, 1994). Laterally equivalent to Livengood Dome Chert

Metamorphic rocks

PMpc **Phyllite and chert** (Permian to Mississippian)-- Two map units of Bundtzen and others (1997a) in eastern McGrath quadrangle are included in this unit: (1) unit uPzs, composed of dark gray-green to distinctly maroon, pyrite-rich volcanogenic phyllite, and (2) unit uPzc, white-weathered, gray-green, banded phyllitic ribbon chert. The latter has yielded Permian through Pennsylvanian radiolaria and Permian through Mississippian conodonts (Bundtzen and others, 1997a). Assigned by Bundtzen and others (1997a) to Yukon-Tanana terrane

Dy **Yanert Fork sequence and correlative rocks** (Devonian and older)-- Metasedimentary and metavolcanic rocks having variable degrees of penetrative fabric and metamorphic grade, found between the Hines Creek strand and main Denali faults, in the Healy, Mount McKinley, and Mount Hayes quadrangles. Includes argillite, slate, phyllite, phyllonite, semischist, impure quartzite, schistose stretched-pebble conglomerate, banded metachert, felsic metatuff, and metabasalt, all intruded by Mesozoic(?) diabase and gabbro. Sedimentary textures and pillow structure preserved in places. Grade dominantly greenschist facies but ranges to amphibolite facies eastward into the Mount Hayes quadrangle. Conodonts from a marble interbed indicate a Late Devonian age (Csejtey and others, 1992). Protolith interpreted to represent a volcanic-bearing continentally derived turbiditic marine sequence deposits on the continental slope. Considered part of the Yukon-Tanana terrane by Csejtey and others (1992) and depositionally overlain by the TRcs unit; tentatively correlated with rocks of similar age and lithology (units hgs and hgv) in the Hayes Glacier subterrane of Nokleberg and others (1992a) in the Mount Hayes quadrangle, which they also consider part of the Yukon-Tanana terrane. Includes unit Dy in the Healy quadrangle (Csejtey and others, 1992) and is correlated with units hgs and hgv of the Hayes Glacier sub-terrane in the Mount Hayes quadrangle (Nokleberg and others, 1992a). Subdivided in the Mount Hayes quadrangle as:

Dys **Fine-grained schistose sedimentary rocks** (Devonian and older)-- Fine-grained schistose sedimentary rocks of unit hgs of the Hayes Glacier sub-terrane in the Mount Hayes quadrangle (Nokleberg and others, 1992a)

Dyv **Fine-grained schistose volcanic rocks** (Devonian and older)-- Chiefly fine-grained metavolcanic and metasedimentary phyllonites and blastomylonites of unit hgv of the Hayes Glacier sub-terrane in the Mount Hayes quadrangle (Nokleberg and others, 1992a)

Pzsc **Spruce Creek sequence and correlative rocks** (Paleozoic)-- Mainly mafic to felsic metavolcanic rocks and minor greenstone sills, mappable as separate metavolcanic units in most places. Consists of two mappable units, a mafic metavolcanic and a felsic metavolcanic unit. Mafic unit consists predominantly of dark, massive to schistose metabasalt, metamorphosed andesite, and amphibolite, containing intercalated quartz- to mafic schist, pelitic schist, phyllite, metasiltstone, metatuff, and minor chert and marble. Distinctive felsic unit consists mostly of blastoporphyritic metarhyolite and felsic schist. Agglomeratic and pillow structures, and relict phenocrysts of quartz, orthoclase, and plagioclase are preserved locally. Underwent amphibolite facies metamorphism and later greenschist facies retrogression. Metarhyolite from the northeast Mount McKinley quadrangle yields U-Pb zircon dates of 368 and 371 Ma (T.K. Bundtzen, unpublished data, 1998) and metarhyolite in the vicinity of Fairbanks yields a U-Pb zircon age of 369 Ma (Aleinikoff and Nokleberg, 1989). U-Pb zircon ages of 364, 372, and 375 Ma on metavolcanic layers in unit jcv in the Mount Hayes quadrangle are interpreted to date extrusion of the now metamorphosed volcanic rocks (Nokleberg and others, 1992a). In the Healy quadrangle, conodonts of Late Devonian age have been collected (Csejtey and others, 1992). Unit consists of the Spruce Creek sequence of Bundtzen (1981) in the northeast Mount McKinley quadrangle, the Muskox sequence of Newberry and others (1996) in the Fairbanks Mining District, and units Dmf, Dmb, and Dms in the Healy quadrangle (Csejtey and others, 1992), unit jcv in the Mount Hayes quadrangle (Nokleberg and others, 1992a), and tentatively, unit DSu in the eastern Mount McKinley quadrangle (Bela Csejtey, Jr., written commun., 1993). May be correlative with the Yanert Fork sequence of Csejtey and others (1992)

Pzlsl **Schist, phyllite, limestone, and greenstone** (Early Paleozoic)-- Light- to medium-green chloritic schist, light- to medium-gray with silvery sheen phyllite, light- to medium-gray and greenish-gray, sandy in part, largely recrystallized limestone, and light- to medium-green greenstone. Schist and phyllite are partly calcareous, intensely folded and interbedded with thin limestone beds. Greenstone is basaltic, less common than other rock types. Unfossiliferous; probably older than the adjacent Frasnian limestone (unit DSl). Mapped only in the western Kantishna River quadrangle (Chapman and others, 1975)

PALEOZOIC AND PRECAMBRIAN
Sequences and Complexes

Yukon-Tanana, Alaska Range, and Ruby metamorphic complexes

Metamorphic rocks of the Yukon-Tanana Upland, Alaska Range, and Ruby Geanticline (for areas, see figure 2, sheet 3) areas have complex histories of polyphase deformation and crystallization. Differences in details of metamorphic, thermal, uplift, and plutonic histories between the Yukon-Tanana and Ruby areas are discussed in regional studies (Dusel-Bacon, 1994; Mortensen, 1992; Foster and others, 1994; Dover, 1994; Roeske and others, 1995) prevent confident correlation of the metamorphic sequences between them. On the other hand, gross similarities in the composition, lithic content, and inferred protoliths of these two complexes, and local similarities in at least some aspects of their crystallization-deformation histories, are consistent with the possible development of both complexes in a continental arc setting along the Late Proterozoic to Middle Paleozoic North American continental margin (Nokleberg and others, 1992a, p. 7; Dover, 1994; Roeske and others, 1995). This compilation attempts to accommodate contrasting interpretations by assigning the same or similar map colors to similar crystalline packages in all areas north of the Denali fault, while preserving differences previously recognized in local studies by use of patterns that in part reflect original unit assignments.

Yukon-Tanana and northern Alaska Range metamorphic complex

Pzydm **Dolostone and marble** (Paleozoic)-- Represents two discrete units. In the western Circle quadrangle, an isolated mass consists of massive gray to cream-colored dolostone and gray to greenish-gray marble interlayered with calcareous greenish-gray and gray quartzite, phyllite, and calc-silicate. Unit is in fault contact with unit PzZyqs. In the southeastern Circle, white or cream-colored marble interbeds(?) as much as 20-m-thick occur in unit PzZysa (Foster and others, 1983)

Pze **Eclogite-bearing schist** (Paleozoic)-- Garnet and omphacite bearing biotite-muscovite schist, micaceous marble, black quartzite, and amphibolite. Protolith predominantly quartz- and pelitic to calcareous pelitic sediments, impure limestone, and associated mafic volcanic and volcaniclastic rocks. Mapped as a distinct allochthon by previous workers cited below However, the high-pressure eclogite facies mineral assemblage is restricted to thin interlayers within a metamorphic sequence that has at least some lithologic similarities with the structurally underlying quartz- and pelitic schist unit (PzZyqs). P/T conditions of 11 Kb and 600 to 700°C cited by Newberry and others (1996) for the eclogite facies assemblage. A Mississippian to Devonian protolith age inferred from Ar-Ar, K-Ar, and Pb-Pb studies cited in Newberry and others (1996); a questionable K-Ar Ordovician protolith age of 478+/-35 Ma on low-K amphibole and K-Ar mica ages ranging from 166.+=/-2.2 to 103.5+/-3.4 Ma attributed to Mesozoic metamorphism were reported by Forbes (1982). Includes units Pce and Pcu of the Chatanika assemblage of Robinson and others (1990), unit PDe of Newberry and others (1996), unit Pzc in the Livengood quadrangle (Weber and others, 1992), and unit PzpCms in the Circle quadrangle (Foster and others, 1983)

MDyao **Augen orthogneiss** (Mississippian and(or) Devonian?)-- Peraluminous granitic gneiss containing augen of potassium feldspar generally interpreted to represent a blastoporphyritic texture. U-Pb zircon data indicate a 341+/-3 Ma crystallization age for augen gneiss in the Big Delta quadrangle (Aleinikoff and others, 1986); similar augen gneiss in the Tanacross quadrangle east of map area yielded U-Pb ages of 353+/-4 and 356+/-2 Ma (Dusel-Bacon and Aleinikoff, 1996). Comprised of unit PzpCa in the Big Delta quadrangle (Weber and others, 1978), and unit Da in the Circle quadrangle (Foster and others, 1983), and tentatively includes units lga, lgr, mg, and jcg assigned by Nokleberg and others (1992a) to the Lake George, Macomb, and Jarvis Creek Glacier subterranes of the Yukon-Tanana terrane in the Mount Hayes quadrangle. Rb-Sr biotite, K-feldspar, plagioclase, and whole-rock isochron ages of about 110 Ma on some of these rocks are interpreted by Wilson and others (1985) and Nokleberg and others (1992a) as the age of metamorphism

MDt **Totatlanika Schist** (Early Mississippian to Middle Devonian)-- Low-grade, multiply-deformed, locally mylonitic assemblage of gritty semischist containing 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. Age poorly defined, from one marble interbed Middle Devonian to Early Mississippian conodonts, and less precisely dated crinoids, corals, and gastropods were collected (Wahrhaftig, 1968). Meta-andesite from the northeastern Big Delta quadrangle yields a U-Pb zircon age of 375 Ma that is interpreted as an extrusive age of protolith (Dusel-Bacon and others, 1993, p. C-14). Comprised of the Totatlanika Schist of the Fairbanks (Pewe and others, 1966) and Healy quadrangles (Csejtey and others, 1992), various units of the Totatlanika Schist in the Chena River area (Smith and others, 1994), and the Pzsg unit of Weber and others (1978) in the Big Delta quadrangle

MDtm **Mylonitic Totatlanika Schist** (middle Paleozoic?)-- Blastomylonitic quartzofeldspathic schist, gneiss, and augen gneiss. Probably derived from the Totatlanika Schist (MDt). Mapped only in the Big Delta quadrangle where shown as unit Pzc by Weber and others (1978)

Pzk **Keevy Peak Formation** (Early Mississippian? to Devonian?)-- Siliceous and carbonaceous assemblage of phyllite, meta-argillite, quartzite, metachert(?), and lesser amounts of interlayered calcareous phyllite, marble, and mafic and felsic metavolcanic rocks. Contains minor stretched pebble conglomerate in the Healy and Mount McKinley quadrangles. Locally, calcareous phyllite and semischist at the base of the unit it is mapped separately and shown as unit Pzkcp. Multiply deformed; metamorphic grade ranges from lower to upper greenschist facies. In the Big Delta quadrangle, a 346+/-1 Ma U-Pb zircon age from a felsic metatuff interlayer indicates an early Mississippian extrusion age and therefore a depositional age for at least part of the sequence; Pb-isotope data for syngenetic galena in carbonaceous phyllite-hosted stratiform zinc-lead deposit also indicates a Mississippian or Devonian age for mineralization (Dusel-Bacon and others, 1998). Late and Middle Devonian fossils have been reported in the Mount McKinley quadrangle (Gilbert and Redman, 1977). Unit appears to occupy regional stratigraphic position between the Totatlanika Schist and unit PzZyqs of this map. As mapped, includes the Keevy Peak as originally defined by Wahrhaftig (1968) in the Healy and Mount McKinley quadrangles; new age data support extension of the unit to the Big Delta, Circle, and Fairbanks quadrangles, and correlation with the Nasina assemblage in Yukon Territory proposed by Weber and others (1978). Includes unit Pzq in the Big Delta (Weber and others, 1978) and quadrangles (Foster and others, 1983), unit Pzk in the Healy (Csejtey and others, 1992) and Mount McKinley (Bela Csejtey, written commun., 1993) quadrangles, and the upper part of the Birch Hill Sequence (unit Dbs, Newberry and others, 1996) in the Fairbanks Mining District of the southeastern Livengood and northeastern Fairbanks quadrangles

Pzkcp Calcareous and phyllitic rocks (Devonian or older)-- Calc-phyllite, marble, and phyllite; lower to upper greenschist facies. Age unknown. Distributed discontinuously along the basal contact of the Keevy Peak Formation, and interpreted here as a calcareous, basal part of the Keevy Peak. Corresponds to the lower part of the Birch Hill Sequence (Dbcs unit) of Newberry and others (1996) in the southeastern Livengood and northeastern Fairbanks quadrangles, and unit Pzm in the Big Delta (Weber and others, 1978) and in the Circle quadrangles (Foster and others, 1983)

PzZym Mafic schist (Paleozoic and(or) Late? Proterozoic)-- 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 PzZyqs. Outside of the map extent shown, these rocks also occur as interbeds in unit PzZyqs in the Circle quadrangle. Includes unit PzpCm of Foster and others (1983) and unit Pzcl of Wiltse and others (1995)

PzZyqs Quartz- and pelitic schist of the Yukon-Tanana Upland (middle to early Paleozoic and(or) Late? Proterozoic)-- Dominantly polymetamorphic quartzite, schistose quartzite, and quartz-mica schist, containing subordinate gritty quartzite, chlorite schist, calc-silicate schist, marble, magnetite-biotite schist, amphibolite, and greenstone. Ranges from amphibolite to greenschist facies. Protolith age at least as old as the augen gneiss unit (MDyao) that intrudes it; U-Pb zircon age of 365 Ma reported from an interlayer interpreted as meta-tuff in the Big Delta quadrangle (Aleinikoff and others, 1986). K-Ar dating in much of the Yukon-Tanana Upland has shown that Cretaceous pluton yield ages distinctly younger than metamorphic ages, that in general there is no indication of thermal resetting by these plutons, and that therefore many of the K-Ar ages, typically between 105 and 120 Ma indicate the timing of metamorphism (Wilson and others, 1985). To the south in the Mount Hayes quadrangle, Nokleberg and others (1992a) interpreted K-Ar white mica ages between 106 and 118 Ma on their unit jcs as metamorphic crystallization rather than cooling ages. Unit PzZyqs corresponds to the Fairbanks Schist of the Fairbanks Mining District and surrounding areas of the southeastern Livengood and northeastern Fairbanks quadrangles of Robinson and others (1990, unit PzPfs) and Newberry and others (1996, units Zf, Zfa, Zfm, Zfc, Zfg, and Zfw), units Zf and Zfc in the Livengood quadrangle (Weber and others, 1992), units Pzs, PzpCs, and PzpCsq (Weber and others, 1978) in the Big Delta quadrangle, unit PzpCq in the Circle quadrangle (Foster and others, 1983), and pCcq, pCu, pCcm, and pCm units of the quartz- "basement" of Smith and others (1994) in the Chena River area. Also includes some rocks distinguished by Robinson and others (1990) in the Fairbanks Mining district as the Chena River Sequence based on inferred differences in grade, but reassigned to the Fairbanks Schist by Newberry and others (1996) because their study shows the Chena River rocks formed under similar T/P conditions and contain chemically identical amphiboles as the Fairbanks Schist. Devonian metavolcanic rocks of the Cleary sequence, originally included in the Fairbanks Schist of Robinson and others (1990), were reassigned by Newberry and others (1996) to their distinctly younger Muskox Sequence, which is herein assigned to unit Pzsc

PzZaqs Pelitic and quartzose schist of the Alaska Range-- Dominantly pelitic and quartz-rich schist in the Healy and Mount McKinley quadrangles; includes subordinate calc-schist and feldspathic schist. Generally underwent greenschist to amphibolite facies metamorphism, with or without greenschist facies retrogression. Corresponds to unit PzpCp in the Healy (Csejtey and others, 1992) and Mount McKinley quadrangles (Bela Csejtey, Jr., written commun., 1993), the PzpCq unit in the southeast Medfra quadrangle (Patton and others, 1980) and unit Pzsv in the Talkeetna quadrangle (Reed and Nelson, 1980). Also, for this compilation, tentatively includes the jcs unit of the Jarvis Creek Glacier subterrane of the Yukon-Tanana terrane in the Mount Hayes quadrangle (Nokleberg and others, 1992a)

PzZysa Schist and amphibolite (middle to early Paleozoic and(or) Late? Proterozoic)-- Medium- to high-grade pelitic schist containing subordinate quartzite, quartz- schist, calc-silicate rocks and calc-schist, marble, amphibolite, graphitic schist, and augen gneiss interbeds. Contains less quartzite and quartz- schist, and more marble interbeds, and is of generally higher grade than the PzZyqs unit. May grade in lithology, polymetamorphic history, and metamorphic grade with the Fairbanks Schist in the Fairbanks Mining District (Newberry and others, 1996) of the southeastern Livengood and northeastern Fairbanks quadrangles. The contact with our unit PzZyqs is interpreted as a thrust by Foster and others (1983) in the Circle quadrangle. The augen gneiss in the Chena River area was interpreted by Smith and others (1994) to have a felsic volcanic protolith, and yields K-Ar ages of 76.7+/-1.5 Ma on biotite, and 82.3+/-3.5 Ma on muscovite (DuBois and others, 1986) which are considered reset by nearby Latest Cretaceous or Earliest Tertiary plutonism (Wilson and others, 1984). Foster and others (1992) inferred the augen gneiss is of Mississippian age by correlation with augen gneiss of plutonic origin in the adjoining Big Delta quadrangle. One gneiss body in this area has yielded a concordant Cretaceous (110 Ma) U-Pb zircon age (Dusel-Bacon and others, 1998), however, we do not have the data at hand to determine the impact this date has on the unit as a whole. Corresponds to the PzpCs unit (including the sillimanite gneiss subunit) of Foster and others (1983) in the Circle quadrangle, and rocks included in the Chena River Sequence of Robinson and others (1990) and includes the lgs, and ms units of the Lake George and Macomb subterranes of the Yukon-Tanana terrane in the Mount Hayes quadrangle (Nokleberg and others, 1992a)

PzZyg Gneiss (Early Paleozoic to Proterozoic)-- Gray, medium-grained, mylonitic, quartzofeldspathic biotite-sillimanite gneiss; associated with unit PzZygs, gneiss, schist, and quartzite. Forms core of a gneiss dome in the central Big Delta quadrangle (Dusel-Bacon and Foster, 1983). Age uncertain. Corresponds with Pzg unit of Weber and others (1978) in the Big Delta quadrangle

PzZygs Gneiss, schist, and quartzite (Early Paleozoic to Proterozoic)-- Quartzofeldspathic orthogneiss, pelitic schist and paragneiss, quartzite, and marble. Corresponds to PzpCg unit of Weber and others (1978) in the Big Delta quadrangle, the quartzite subunit of unit PzpCs of Foster and others (1983) in the Circle quadrangle, and includes the pCwo, pCwp, and pCwm units of Smith and others (1994) in their West Point complex of the Chena River area. Granitic orthogneiss mapped as part of this unit by Smith and others (1994) yielded and inferred preCambrian age on the basis of multi-grain U-Pb zircon dating. However, resampling and redating by Dusel-Bacon and others (1998) using single grain ion microprobe analysis of zircon from this orthogneiss yielded a mid-Cretaceous (110 Ma) concordant U-Pb zircon age, interpreted as an igneous crystallization age synchronous with high-grade metamorphism, extensional deformation, and exhumation in a gneiss dome. It is not clear how this new date may impact the inferred age of the other parts of this unit

End of Yukon-Tanana and northern Alaska Range metamorphic complex

---

Ruby metamorphic complex

Pzrm Marble (Paleozoic)-- Massive light- to dark-gray marble and recrystallized limestone, having sedimentary structures preserved locally. Age inferred as Devonian and(or) Ordovician by Cass (1959). Includes the mcl unit of Cass (1959) and the Pzrm and Pztbl units of Puchner (1984) in the Ruby quadrangle. In the Nulato quadrangle, drill core at the Illinois Creek prospect yielded Ordovician conodonts (Steve Teller and Anita Harris, written commun., 1984). Tentatively includes unit Pzc of Chapman and others (1985) in the Ophir quadrangle which overlies or maybe gradationally interbedded with quartzite and phyllite here assigned to unit PzZrqs

Pzrmi **Metamorphosed mafic igneous rocks** (Paleozoic?)-- Metamorphosed mafic igneous rocks, ranging from metagabbro and metadiabase to greenstone, amphibolite, and garnet amphibolite. Variable intensity of sheared within unit. Unit Pzm of Dover (unpublished mapping, 1997), not mapped separately by Chapman and others (1982)

MDrao **Augen orthogneiss** (Mississippian and(or) Devonian?)-- Peraluminous granitic gneiss containing augen of potassium feldspar generally interpreted to represent blastoporphyritic texture. U-Pb zircon age of 390+/-12 Ma reported from Ray Mountains area of the (north-central) Tanana quadrangle (Patton and others, 1987); Dillon and others (1979; 1980 report Middle Devonian to Early Mississippian Rb/Sr whole-rock and U-Pb zircon ages on similar rocks elsewhere in the Ruby metamorphic complex. Corresponds to unit MDao of Dover (1994) in the Tanana quadrangle and some rocks that were included in unit Km of Patton and others (1978) in the Melozitna quadrangle, which have since been recognized as augen orthogneiss and included in unit Pzgn of Roeske and others (1995)

Dm **Marble** (Late Devonian)-- Calcitic to dolomitic marble in distinctive marker beds intercalated with greenschist and amphibolite facies rocks of the pelitic and quartz- schist unit (PzZrqs). Age assignment based on conodonts (Anita Harris, written commun., 1984). Corresponds to unit Dl of Dover (1994) in the Tanana quadrangle and unit Pzm of Patton and others (1978) in the Melozitna quadrangle

PzZrqs **Pelitic and quartzitic schist** (middle to early Paleozoic and(or) Late? Proterozoic)-- Mainly muscovite- and quartz-rich schist, and subordinate calc-schist, quartzofeldspathic schist, gneiss, amphibolite, and quartzite. Locally mappable marble interbeds are shown as unit Dm north of the Kaltag fault and unit Pzrm south of the Kaltag fault. In the Ray Mountains of the north-central Tanana quadrangle, underwent polymetamorphic history of synkinematic greenschist, local blueschist, and amphibolite facies metamorphism that 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). Blueschist facies metamorphism largely obliterated by greenschist to granulite facies overprint in the Kokrines Hills (Roeske and others, 1995). Includes the Pzs and associated Pzm and MzPzm units of Dover (1994) in the Tanana quadrangle, the unit PzpCs of Patton and others (1978), the PzpCm unit of Chapman and Patton (1978), and the Pzs unit of Roeske and others (1995), in the Melozitna quadrangle. South of the Kaltag fault, these rocks are even more poorly exposed and especially little studied rocks. Corresponds to the mc and mca units of Cass (1959), and the informal PzpCsg and PzpCs units of Puchner (1984) in the Ruby quadrangle, the PzpCs and PzpCc units of Patton (written commun., 1997) in the Nulato quadrangle, and the PzpCs unit of Chapman and others (1986) in the Ophir quadrangle. Unit shown using a vertical line overprint pattern north of the Kaltag fault and horizontal line pattern south of the Kaltag fault

PzZrpg **Quartzofeldspathic paragneiss and quartzite** (Early Paleozoic to Proterozoic)-- Dominantly quartz-rich and quartzofeldspathic paragneiss, quartzite, and subordinate thinly interlayered quartz-mica schist, but also contains lenses and layers of augen orthogneiss. In the Ray Mountains area of the north-central Tanana quadrangle, the unit is typically well-foliated, and texture ranges from compositionally banded to massive, depending on composition and grainsize of the protolith (Dover, 1994). Metamorphosed to amphibolite facies. Undated; appears to stratigraphically and/or structurally underlie schistose units inferred as Paleozoic to Late Proterozoic in age. Corresponds to the CZg unit of Dover (1994) in the Ray Mountains area, part of the PzpCsq unit of Chapman and others (1982) in the Tanana quadrangle, the PzpCn and PzpCq units of Patton and others (1978) in the Melozitna quadrangle, and tentatively, unit Pzpgn of Roeske and others (1995) in the Melozitna quadrangle and unit PzpCg of Chapman and Patton (1978) in the northwest Ruby quadrangle. Also tentatively included here, from the western Ruby quadrangle, Puchner (1984) mapped a pelitic schist and gneiss unit (PzpCsg) consisting of quartz-muscovite-chlorite-biotite-graphite-garnet-staurolite schist, quartzofeldspathic orthogneiss, and foliated greenstone all retrograded from amphibolite facies. Unit PzpCq of Patton and others (1978) can alternatively be correlated with unit TRMtqp of this map

End of Ruby metamorphic complex

Sedimentary rocks

CZw **Wickersham grit, undivided** (Cambrian? and Late Proterozoic)-- Dominantly clastic sequence of poorly sorted quartzite, feldspathic quartzite, grit, calcareous siltstone and fine-grained sandstone, and subordinate dark limestone and chert. Variable cataclasis and generally low-grade recrystallization, and locally structurally dismembered and imbricated. Age poorly constrained. Interpreted by F.R. Weber as protolith of at least part of the quartz- and pelitic schist (PzZyqs) and schist and amphibolite (PzZysa) units. Includes the CZwg unit of Weber and others (1992) in the Livengood quadrangle, some rocks of the PzpCa? and PzpCgq units of Foster and others (1983) in the Circle quadrangle, the PzPws and PzPwg units of Reifenstuhl and others (1997) in the Tanana B-1 quadrangle, and rocks tentatively assigned to this unit in the Kantishna River, Mount McKinley, McGrath, and Medfra quadrangles (F.R. Weber and T.K. Bundtzen, unpublished data, 1998). Locally divided into:

CZwl **Wickersham limestone**-- Medium- to very dark-gray, dense to very finely crystalline, nonfossiliferous limestone and medium-gray, fine-grained, non-siliceous dolostone. Dolostone contains nondiagnostic stromatolites. Interbedded in Wickersham unit. Consists of units Cwl, CZwl, and CZwad of Weber and others (1992) in the Livengood quadrangle

CZwa **Argillaceous upper unit**-- Dominantly argillaceous, containing distinctive tan-weathering gray calcareous siltstone and fine-grained sandstone, subordinate quartzite and chert, and locally, a few black clastic limestone interbeds. Corresponds to the CZwa unit of Weber and others (1992) in the Livengood quadrangle, unit ng of Pewe and others (1966) in the Fairbanks quadrangle, and the PzpCa unit of Foster and others (1983) in the Circle quadrangle

Zwg **Gritty lower unit** (Late Proterozoic?)-- Dominantly poorly sorted to bimodal quartzite and gritty quartzite, and granule conglomerate characteristically containing sparse, single-crystal milky white to blue quartz granules ("eyes") in a slightly cherty quartzofeldspathic-wacke matrix. Lithologically gradational with argillaceous upper unit (Czwa). Corresponds to the Zwg unit of Weber and others (1992) in the Livengood quadrangle, and the PzpCqg unit of Foster and others (1983) in the Circle quadrangle

PRECAMBRIAN
Metamorphic rocks

ZYnm **Metamorphic basement rocks of the Nixon Fork sequence, undivided** (Late and(or) Middle Proterozoic)-- Dominantly greenschist facies quartz- and pelitic schist, with subordinate calc-schist, quartzofeldspathic schist, marble, schistose felsic metavolcanic rocks, greenstone, and gneissic and schistose plutonic rocks. Depositionally overlain by unmetamorphosed Ordovician and latest Cambrian carbonate rocks of the Nixon Fork sequence in the Medfra quadrangle (Eakins, 1918; Patton and others, 1980; J.A. Dumoulin and D.C. Bradley, unpublished data, 1998) and by Permian conglomerate elsewhere (Patton and Dutro, 1979). Kyanite has been reported locally (Grant Abbott and T.K. Bundtzen, written commun., 1997). Resembles quartz- and pelitic units (PzZyqs, PzZaqs, and PzZrqs) in the Yukon-Tanana and Ruby crystalline complexes in the predominance of quartz-mica schist and micaceous quartzite, but differs from those units in lacking evidence of Cretaceous or Jurassic metamorphism and in its clear evidence of pre-Ordovician metamorphism and probable Proterozoic protolith age (Dillon and others, 1985). K-Ar mica ages ranging from 296-921 Ma are reported by Silberman and others (1979). Discordant U-Pb zircon ages from metaplutonic rocks having upper intercepts as old as 1,250+/-50 Ma and additional K-Ar ages are reported Dillon and others (1985). Corresponds to one area of the mca unit and the mcb unit of Cass (1959) in the Ruby quadrangle and a slight extension into the Medfra quadrangle based on mapping of Eakin (1918). Locally (primarily the Medfra quadrangle), subdivided into:

ZYns **Pelitic schist**-- Chiefly greenschist facies pelitic schist and quartzose metasedimentary rocks, with subordinate calc-schist, marble, and locally, greenstone (Patton and others, 1980). Includes a small granitic gneiss body in the Medfra quadrangle. Stratigraphic evidence indicates a pre-Ordovician age; K-Ar mica minimum ages range between 274 and

514 Ma (Silberman and others, 1979). Corresponds to unit PzpCp of Patton and others (1980)

ZYnc Calc-schist-- Dominantly light- to medium-gray calc-schist and thin-bedded schistose marble, and subordinate quartz-mica schist. Gradational into pelitic schist unit (ZYns). Distinguished from pelitic schist in poorly exposed areas by relatively smooth aeromagnetic signature in contrast to rugged, steep-gradient profiles over pelitic schist unit (Patton and others, 1980). Corresponds to PzpCc unit of Patton and others (1980)

ZYnv Metavolcanic rocks-- Tan, light-gray, pink, and green banded fine-grained blastoporphyritic felsic metavolcanic rocks having a well-developed foliation. Subordinate quartzofeldspathic rocks thought to represent recrystallized felsic flows and tuffs (Patton and others, 1980). Corresponds to the PzpCv unit of Patton and others (1980)

Ynqd Meta-quartz diorite (middle Proterozoic?)-- Sheared metamorphosed porphyritic quartz diorite. Contains biotite phenocrysts as large as 1 cm and numerous micro-veinlets of quartz (Silberman and others, 1979). K-Ar age on biotite yielded an age of 921+/-25 Ma and muscovite from mylonite along border yielded 663+/-20 Ma (Silberman and others, 1979). Intrudes quartz-mica schist of unit ZYnm in the southwest Ruby quadrangle. Corresponds to unit pCm of Silberman and others (1979)

Xi **Idono metamorphic complex** (Early Proterozoic)-- Foliated augen gneiss, amphibolite, and minor metasedimentary rocks, all of amphibolite facies. Protolith age 2.06 Ga based on U-Pb zircon and Sm-Nd isotopic dating of Miller and others (1991); K-Ar ages range from 120 to 1230 Ma. Corresponds to unit Xi of Miller and Bundtzen (1994)

References cited

Aleinikoff, J.N., Dusel-Bacon, C., and Foster, H.L.., 1986, Geochronology of augen gneiss and related rocks, Yukon-Tanana terrane, east-central Alaska: Geological Society of America Bulletin v. 97, p. 626-637.

Aleinikoff, J.N., Moore, T.E., Nokleberg, W.J., and Koch, R.D., 1995, Preliminary U-Pb ages from detrital zircons from the Arctic Alaska and Yukon-Tanana terranes, Alaska: Geological Society of America Abstracts with Programs v 27, p. 2

Aleinikoff, J.N., and Nokleberg, W.J., 1989, Age of deposition and provenance of the Fairbanks Schist unit, Yukon-Tanana terrane, east-central Alaska: U.S. Geological Survey Bulletin 1903, p. 75-83.

Berg, H.C., Jones, D.L., and Richter, D.H., 1972, Gravina-Notzutin belt -- Tectonic significance of an upper Mesozoic sedimentary and volcanic sequence in southern and southeastern Alaska, *in* Geological Survey research 1972: U.S. Geological Survey Professional Paper 800-D, p. D1-D24.

Blodgett, R.B., and Brease, P.F., 1997, Essian (late Early Devonian) brachiopods from Shellabarger Pass, Talkeetna C-6 quadrangle, Denali National Park, Alaska indicate Siberian origin for Farewell terrane [abs.]: Geological Society of America Abstracts with Program, v. 29, no. 5, p. 5.

Box, S.E., Moll-Stalcup, E.J., Frost, T.P., and Murphy, J.M., 1993, Preliminary geologic map of the Bethel and southern Russian Mission quadrangles, southwestern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-2226-A, scale 1:250,000.

Brabb, E.E., 1969, Six new Paleozoic and Mesozoic Formations in east-central Alaska: U.S. Geological Survey Bulletin 1274-I, p. I1-I26.

Brabb, E.E., and Churkin, Michael, Jr., 1969, Geologic map of the Charley River quadrangle, east-central Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-573, scale 1:250,000.

Brosge, W.P., Lanphere, M.A., Reiser, H.N., and Chapman, R.M., 1969, Probable Permian age of the Rampart Group, central Alaska: U.S. Geological Survey Bulletin 1294-B, 18 p.

Bundtzen, T.K., 1981, Geology and mineral deposits of the Kantishna Hills, Mount McKinley quadrangle, Alaska: Fairbanks, University of Alaska, M.S. Thesis, 237 p., 1 sheet, scale 1:63,360.

Bundtzen, T.K., and Laird, G.M., 1980, Preliminary geology of the McGrath-upper Innoko River area, western Interior Alaska: Alaska Division of Geological and Geophysical Surveys, Open-File Report 134, 36 p., 3 plates.

Bundtzen, T.K., and Laird, G.M., 1982, Geologic map of the Iditarod D-2 and western D-3 quadrangles, Alaska: Alaska Division of Geological and Geophysical Surveys, Professional Report 72, 1 plate.

Bundtzen, T.K., Harris, E.E., and Gilbert, W.G., 1997a, Geologic map of the eastern half of the McGrath quadrangle, Alaska: Alaska Division Geological and Geophysical Surveys Report of Investigations 97-14a, scale 1:125,000, 34 p.

Bundtzen, T.K., Pinney, D.S., and Laird, G.M., 1997b, Preliminary geologic map and data table from the Ophir C-1 and western Medfra C-6 quadrangles, Alaska: Alaska Division Geological and Geophysical Surveys Public Data File 97-46, scale 1:63,360, 10 p.

Bundtzen, T.K., Laird, G.M., Clautice, K.H., and Harris, E.E., 1994, Geologic map of the Gagaryah River area, Lime Hills C-5 and C-6 quadrangles, southwest Alaska: Alaska Division Geological and Geophysical Surveys Public Data File 94-40, scale 1:63,360.

Calderwood, K.W., and Fackler, W.C., 1972, Proposed stratigraphic nomenclature for Kenai Group, Cook Inlet basin, Alaska, American Association of Petroleum Geologists Bulletin, v. 56, no. 4, p. 739-754.

Carden, J.R., Connelly, W., Forbes, R.B., and Turner, D.L., 1977, Blueschists of the Kodiak Islands, Alaska: An extension of the Seldovia schist terrane: Geology, v. 5, p. 529-533.

Cass, J.T., 1959, Reconnaissance geologic map of the Ruby quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigation Map I-289, 1 sheet, scale 1:250:000.

Chapman, R.M., and Patton, W.W., Jr., 1978, Preliminary summary of the geology in the northwest part of the Ruby quadrangle, *in* Johnson, K.M., ed., The United States Geological Survey in Alaska: Accomplishments during 1977: U.S. Geological Survey Circular 772-B, p. B39-B41.

Chapman, R.M., and Patton, W.W., Jr., 1979, Two upper Paleozoic rock units identified in southwestern part of the Ruby quadrangle, *in* Johnson, K.M., and Williams, J.R., eds., The United States Geological Survey in Alaska: Accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B59-B61.

Chapman, R.M., Patton, W.W., Jr., and Moll, E.J., 1985, Reconnaissance geology of the Ophir quadrangle, Alaska: U.S. Geological Survey Open-File Report 85-203, 17 p., 1 sheet, scale 1:250,000.

Chapman, R.M., Yeend, W.E., Brosge, W.P, and Reiser, H.N., 1975, Preliminary geologic map of the Tanana and northeast part of the Kantishna River quadrangles, Alaska: U.S. Geological Survey Open File Report 75-337, scale 1:250,000.

Chapman, R. M., Patton, W. W. Jr., and Moll, E. J., 1985, Reconnaissance geologic map of the Ophir quadrangle, Alaska: U.S. Geological Survey Open-File Report 85-203, 1 sheet, scale 1:250,000.

Chapman, R.M., Yeend, W.E., Patton, W.W., Jr., 1975, Preliminary reconnaissance geologic map of the western half of Kantishna River quadrangle, Alaska: U.S. Geological Survey Open File Report 75-351, scale 1:250,000.

Chapman, R.M., Yeend, Warren, Brosge, W.P., and Reiser, H.N., 1982, Reconnaissance geologic map of the Tanana quadrangle, Alaska: U.S. Geological Survey Open-File Report 82-734, scale 1:250,000, 18 p.

Churkin, Michael, Jr., and Carter, Claire, 1996, Stratigraphy, structure, and graptolites of an Ordovician and Silurian sequence in the Terra Cotta Mountains, Alaska Range, Alaska: U.S. Geological Survey Professional Paper 1555, 84 p.

Churkin, M., Jr., Foster, H.L., Chapman, R.M., and Weber, F.R., 1982, Terranes and suture zones in east-central Alaska: Journal of Geophysical Research, v. 87, no. B5, p. 3718-3730.

Clark, S.H.B., 1972, Reconnaissance bedrock geologic map of the Chugach Mountain near Anchorage, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-350, 1 sheet, scale 1:250,000.

Coney, P.J., and Jones, D.L., 1985, Accretion tectonics and crustal structure in Alaska: Tectonophysics, v. 119, p. 265-283.

Cowan, D.S., and Boss, R.F., 1978, Tectonic framework of the southwestern Kenai Peninsula, Alaska: Geological Society of America Bulletin, v. 89, p. 155-158.

Csejtey, Bela, Jr., Mullen, M.W., Cox, D.P., and Stricker, G.D., 1992, Geology and geochronology of the Healy quadrangle, south-central Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1961, scale 1:250,000, 63 p.

Csejtey, Bela, Jr., Nelson, W.H., Eberlein, G.D., Lanphere, M.A., and Smith, J.G., 1977, New data concerning age of the Arkose Ridge Formation, south-central Alaska in Blean, K.M., ed., The United States Geological Survey in Alaska: Accomplishments during 1976: U.S. Geological Survey Circular 751-B, p. B62-B64.

Csejtey, Bela, Jr., Nelson, W.H., Jones, D.L., Silberling, N.J., Dean, R.M., Morris, M.S., Lanphere, M.A., Smith, J.G., and Silberman, M.L., 1978, Reconnaissance geologic map and geochronology, Talkeetna Mountains quadrangle, northern part of Anchorage quadrangle, and southwest corner Healy quadrangle, Alaska: U.S. Geological Survey Open-file Report 78-558A, scale 1:250,000, 60 p.

Decker, John, Bergman, S.C., Blodgett, R.B., Box, S.E., Bundtzen, T.K., Clough, J.G., Coonrad, W.L., Gilbert, W.G., Miller, M.L., Murphy, J.M., Robinson, M.S., and Wallace, W.K., 1994, Geology of southwestern Alaska, *in* Plafker, George and Berg, H.C., eds., The Geology of Alaska, volume G-1, The Geology of North America: Geological Society of America, Decade of North American Geology, p. 285-310.

Detterman, R.L., and Reed, B.L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, 86 p., 1 sheet, scale 1:250,000.

Detterman, R.L., Case, J.E., Miller, J.W., Wilson, F.H., and Yount, M.E., 1996, Stratigraphic Framework of the Alaska Peninsula, *in* Geologic Studies on the Alaska Peninsula: U.S. Geological Survey Bulletin 1969-A, 74 p.

Dillon, J.T., Pessel, G.H., Chen, J.H., and Veach, N.C., 1979, Tectonic and economic significance of Late Devonian and late Proterozoic U-Pb zircon ages from the Brooks Range, Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 61, p. 36-43.

Dillon, J.T., Pessel, G.H., Chen, J.H., and Veach, N.C., 1980, Middle Paleozoic magmatism and orogenesis in the Brooks Range, Alaska: Geology, v. 8, p. 338-343.

Dillon, J.T., Patton, W.W., Jr., Mukasa, S.B., Tilton, J.B., and Moll, E.J., 1985, New radiometric evidence for the age and thermal history of the metamorphic rocks of the Ruby and Nixon Fork terranes, west-central Alaska, *in* Bartsch-Winkler, S., and Reed, K.M., eds., The United States Geological Survey in Alaska: Accomplishments during 1983: U.S. Geological Survey Circular 945, p. 13-18.

Dillon, J.T., Brosge, W.P., and Dutro, J.T., Jr., 1986, Generalized geologic map of the Wiseman quadrangle, Akaska: U.S. Geological Survey Open-File Report 86-219, scale 1:250,000.

Dover, J.H., 1994, Geology of part of east-central Alaska, *in* Plafker, George and Berg, H.C., eds., The Geology of Alaska, volume G-1, The Geology of North America: Boulder, Colorado, Geological Society of America, Decade of North American Geology, p. 153-204.

Dover, J.H., and Miyaoka, R.T., 1988, Reinterpreted geologic map and fossil data, Charley River quadrangle, east-central, Alaska:: U.S. Geological Survey Miscellaneous Field Studies Map MF-2004, scale 1:250,000.

DuBois, G.D., Wilson, F.H., and Shew, Nora, 1986, Map and table showing potassium-argon age determinations and selected major-element chemical analyses from the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 86-392, scale 1:250,000.

Dumoulin, J.A., Bradley, D.C., and Harris, A.G., in press, Sedimentology, conodonts, structure, and correlation of Silurian and Devonian metasedimentary rocks in Denali National Park, Alaska *in* Gray, J. and Riehle, J.R. , eds., Geologic studies in Alaska by the U.S. Geological Survey in 1996, U.S. Geological Survey Professional Paper, 50 MS pp, 12 figs.

Dusel-Bacon, Cynthia, 1994, Metamorphic history of Alaska, *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Boulder, Colorado, Geological Society of America, The Geology of North America v G-1, p. 495-533.

Dusel-Bacon, Cynthia, and Aleinikoff, J.N., 1985, Petrology and tectonic significance of augen gneiss from a belt of Mississippian granitoids in the Yukon-Tanana terrane, east-central Alaska: Geological Society of America Bulletin, v. 96, p. 411-425.

Dusel-Bacon, Cynthia, and Aleinikoff, J.N., 1996, U-Pb zircon and titanite ages for augen gneiss from the Divide Mountain area, eastern Yukon-Tanana upland, Alaska, and evidence for the composite nature of the Fiftymile batholith, *in* Moore, T.E., and Dumoulin, J.A., eds. Geologic Studies in Alaska by the U.S. Geological Survey during 1994: U.S. Geological Survey Bulletin 2152, p. 131-141.

Dusel-Bacon, Cynthia, and Foster, H.L., 1983, A sillimanite gneiss dome in the Yukon crystalline terrane, east-central Alaska; petrography and garnet-biotite thermometry: U.S. Geological Survey Professional Paper 1179-E, 25 p.

Dusel-Bacon, Cynthia, Brosge, W.P., Till, A.B., Doyle, E.O., Mayfield, C.F., Reiser, H.N., and Miller, T.P., 1989, Distribution, facies, ages, and proposed tectonic associations of regionally metamorphosed rocks in northern Alaska: U.S. Geological Survey Professional Paper 1497-A, 44 p., 2 plates., 1:1,000,000-scale.

Dusel-Bacon, Cynthia, Csejtey, B., Jr., Foster, H.L., Doyle, E.O., Nokleberg, W.J., and Plafker, George, 1993, Distribution, facies, ages, and proposed tectonic associations of regionally metamorphosed rocks in east- and south-central Alaska: U.S. Geological Survey Professional Paper 1497-C, 73 p., 2 plates., 1:1,000,000-scale.

Dusel-Bacon, Cynthia, Wooden, J.L., Mortensen, J.K., Bressler, J.R., Takaoka, Hidetoshi, Oliver, D.H., Newberry, Rainer, and Bundtzen, T.K., 1998, Metamorphic-hosted mineralization in the Yukon-Tanana Upland, Alaska [extended abs.]: Alaska Miners Association, Extended abstracts of the 16th Biennial Conference on Alaskan Mining, "Second Rush of 98", p. 16-18.

Dutro, J.T., Jr., and Patton, W.W., Jr., 1982, New Paleozoic formations in the northern Kuskokwim Mountains, west-central Alaska, *in* Stratigraphic notes, 1980-1982: U.S. Geological Survey Bulletin 1529-H, p. H13-H22.

Eakin, H.M., 1918, The Cosna-Nowitna region, Alaska: U.S. Geological Survey Bulletin 667, map, scale 1:250,000, 54 p.

Forbes, R.B., 1982, with contributions from F.R. Weber, R.C. Swainbank, J.M. Britton, and J.M. Brown, Bedrock geology and petrology of the Fairbanks Mining District: Alaska Division of Geological and Geophysical Surveys Open-file Report AOF-169, 68 p.

Foster, H.L., Laird, Jo, Keith, T.E.C., Cushing, G.W., and Menzie, W.D., 1983, Preliminary geologic map of the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report, 83-170-A, scale 1:250,000.

Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1994, Geology of the Yukon-Tanana area of east-central Alaska, *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Boulder, Colorado, Geological Survey of America, The Geology of North America, v. G-1, p. 205-240.

Galloway, J.P., and Laney, Jim, 1994, Status of geologic mapping in Alaska -- A digital bibliography: U.S. Geological Survey Open-File Report OFR 94-675-A, 96 p., 4 plates, scale 1:7,500,000.

Gamble, B.M., and Reed, B.L., 1996, Preliminary geologic map of the eastern half of the Lime Hills quadrangle, Alaska: unpublished U.S. Geological Survey map compilation, scale 1:250,000.

Gemuts, I., Puchner, C.C., and Steffel, C.I., 1983, Regional geology and tectonic history of western Alaska *in* Proceedings of the 1982 Symposium on Western Alaska Geology and Resource Potential: Journal of the Alaska Geological Society v. 3, p. 67-85.

Gilbert, W.G., 1979, A geologic guide to Mount McKinley National Park: Alaska Natural History Association, in cooperation with the National Park Service, U.S. Dept. of the Interior, 52 p., 1 plate, scale 1:250,000.

Gilbert, W.G., 1981, Preliminary geologic map of Cheeneetuk River area, Alaska: Alaska Division of Geological and Geophysical Survey Open File Report AOF-153, scale 1:63,360.

Gilbert, W.G., and Redman, E.R., 1977, Metamorphic rocks of the Toklat-Teklanika River area, Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 50, 30 p., 1 sheet, scale 1:63,360.

Grantz, Arthur, 1960, Geologic map of the Talkeetna A-2 quadrangle, Alaska and contiguous area to the north and northwest: U.S. Geological Survey Miscellaneous Investigations Series Map I-313, scale 1:48,000.

Hoare, J.M., and Coonrad, W.L., 1959a, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-285, scale 1:250,000.

Hoare, J.M., and Coonrad, W.L., 1959b, Geology of the Russian Mission quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-292, scale 1:250,000.

Imlay, R.W., and Reeside, J.B., Jr., 1954, Correlation of the Cretaceous formations of Greenland and Alaska: Geological Society of America Bulletin, v. 65, p. 223-246.

Jones, D.L., and Silberling, N.J., 1979, Mesozoic stratigraphy: The key to tectonic analysis of southern and central Alaska: U.S. Geological Survey Open-File Report 79-2100, 41 p.

Jones, D.L., Silberling, N.J., and Hillhouse, John, 1977, Wrangellia -- a displaced terrane in northwestern North America: Canadian Journal of Earth Sciences, v. 14, no. 11, p. 2565-2577.

Jones, D.L., Silberling, N.J., Gilbert, W.G., and Coney, P.J.,, 1982, Character, distribution, and tectonic significance of accretionary terranes in the central Alaska Range: Journal of Geophysical Research, v. 87, no. B5, p. 3709-3717.

Kelley, J.S., 1984, Geologic map and sections of the southwestern Kenai Peninsula west of the Port Graham fault: U.S. Geological Survey Open-File Report 84-152, scale 1:63,360.

Layer, P.W. and Solie, D.N., 1991, Timing of igneous activity and basin formation, southern Alaska Range, as constrained by $^{40}Ar/^{39}Ar$ dating: EOS, v. 72, no. 44, p. 503.

Loney, R.A., and Himmelberg, G.R., 1985, Distribution and character of the peridotite-layered gabbro complex of the southeastern Yukon-Koyukuk ophiolite belt, Alaska, *in* Bartsch-Winkler, S., and Reed, K.M., eds., U.S. Geological Survey in Alaska; Accomplishments during 1983: U.S. Geological Survey Circular 945, p. 46-48

MacKevett, Jr., E.M., 1978, Geologic map of the McCarthy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1032, scale 1:250,000.

MacKevett, E.M., Jr., and Plafker, George, 1974, The Border Ranges fault in south-central Alaska: U.S. Geological Survey Journal of Research, v. 2, no. 3, p. 323-329.

Magoon, L.B. Adkison, W.L., and Egbert, R.M, 1976, Map showing geology, wildcat wells, Tertiary plant localities, K/Ar age dates, and petroleum operations, Cook Inlet area, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1019, scale 1:250,000, 3 sheets.

Mamay, S.H., and Reed, B.L., 1984, Permian plant megafossils from the conglomerate of Mt. Dall, central Alaska Range, *in* Coonrad, W.L., and Elliott, R.L., eds., United States Geological Survey in Alaska; Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 98-102.

Martin, G.C., 1926, The Mesozoic stratigraphy of Alaska: U.S. Geological Survey Bulletin 776, 493 p.

Mertie, J.B., Jr., and Harrington, G.L., 1924, The Ruby-Kuskokwim region, Alaska: U.S. Geological Survey Bulletin 754, 129 p.

Meyer, J.F., Jr., and Saltus, R.W., 1995, Merged aeromagnetic map of Interior Alaska: U.S. Geological Survey Geophysical Investigations Map GP-1014, 2 sheets, scale 1:500,000.

Meyer, J.F., Jr., Saltus, R.W., Barnes, D.F., and Morin, R.F., 1996, Bouguer gravity map of Interior Alaska: U.S. Geological Survey Geophysical Investigations Map GP-1016, 2 sheets, scale 1:500,000.

Miller, M.L, and Bundtzen, T.K., 1994, Generalized geologic map of the Iditarod quadrangle, Alaska, showing potassium-argon, major-oxide, trace-element, fossil, paleocurrent, and archaeological sample localities: U.S. Geological Survey Miscellaneous Field Studies Map MF-2219A, scale 1:250,000, 48 p.

Miller, M.L., Belkin, H.E., Blodgett, R.B., Bundtzen, T.K., Cady, J.W., Goldfarb, R.J., Gray, J.E., McGimsey, R.G., and Simpson, S.L., 1989, Pre-field study and mineral resource assessment of the Sleetmute quadrangle, southwestern Alaska: U.S. Geological Survey Open-File Report 89-363, 115 p., 1 map, scale 1:250,000.

Miller, M.L., Bradshaw, J.Y., Kimbrough, D.L., Stern, T.W., and Bundtzen, T.K., 1991, Isotopic evidence for Early Proterozoic age of the Idono Complex, west-central Alaska: Journal of Geology, v. 99, no. 2, p. 209-223.

Miller, T.P., and Smith, R.L., 1976, "New" volcanoes in the Aleutian volcanic arc, *in* Cobb, E.H., ed., The United States Geological Survey in Alaska: Accomplishments during 1975: U.S. Geological survey Circular 733, p. 11.

Miyaoka, R.T., and Dover, J.H., 1990, Shear sense in mylonites, and implications for transport of the Rampart assemblage (Tozitna terrane), Tanana quadrangle, east-central Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1989: U.S. Geological Survey Bulletin 1946, p. 51-64.

Moll-Stalcup, Elizabeth, Brew, D.A., and Vallier, T.L., 1994, Latest Cretaceous and Cenozoic magmatic rocks of Alaska, Plate 5, in Plafker, George and Berg, H.C., eds., The Geology of Alaska, The Geology of North America, Volume G-1: Geological Society of America Decade of North America Geology Project, 1 sheet, scale 1:2,500,000.

Mortensen, J.K., 1992, Pre-mid-Mesozoic tectonic evolution of the Yukon-Tanana terrane, Yukon and Alaska: Tectonics v. 11, p. 836-853.

Newberry, R.J., Bundtzen, T.K, Clautice, K.H., Combellick, R.A., Douglas, T., Laird, G.M., Liss, S.A., Pinney, D.S., Reifenstuhl, R.R., and Solie, D.N., 1996, Preliminary geologic map of the Fairbanks Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 96-16, scale ?, ? p.

Nokleberg, W.J., Aleinikoff, J.N., Lange, I.M., Silva, S.R., Miyaoka, R.T., Schwab, C.E., and Zehner, R.E., with contribution for selected areas from Bond, G.C., Richter, D.H., Smith, T.E., and Stout, J.H., 1992a, Preliminary geologic map of the Mount Hayes quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Open-File Report 92-594, scale 1:250,000.

Nokleberg, W.J., Aleinikoff, J.N., Dutro, J.T., Jr., Lanphere, M.A., Silberling, N.J., Silva, S.R., Smith, T.E., and Turner, D.L., 1992b, Map, tables, and summary of fossil and isotopic age data, Mount Hayes quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Map MF-1996-D, scale 1:250,000, 43 p.

Nokleberg, W.J., Moll-Stalcup, E.J., Miller, T.P., Brew, D.A., Grantz, Arthur, Reed, J.C., Jr., Plafker, George, Moore, T.E., Silva, S.R., and Patton, W.W., Jr., 1994, Tectonostratigraphic terrane and overlap assemblage map of Alaska: U.S. Geological Survey Open-File Report 94-194, 45 p., scale 1:2,500,000.

Nokleberg, W.J., Richter, D.H., Ferrians, O.J., Lange, I.M., Campbell, D.L., Aleinikoff, J.N., Smith, T.E., and Koch, R.D., in press, Introduction, previous studies, acknowledgements, detailed description of map units, geologic and tectonic summary, and references cited for preliminary geologic map of the Gulkana quadrangle, eastern Alaska Range and northern Copper River Basin, Alaska: U.S. Geological Survey Open-File Report, scale 1:250,000, text 32 p.

Paige, Sidney, and Knopf, Adolph, 1907, Stratigraphic succession in the region northeast of Cook Inlet, Alaska: Geological Society of America Bulletin, v. 18, p. 327-328.

Patton, W.W., Jr., 1966, Regional geology of the Kateel River quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-437, scale 1:250,000.

Patton, W.W., Jr., 1973, Reconnaissance geology of the northern Yukon-Koyukuk province, Alaska: U.S. Geological Survey Professional Paper 774-A, p. A1-A17.

Patton, W.W., Jr., and Dutro, J.T., Jr., 1979, Age of the metamorphic complex in the northern Kuskokwim Mountains, west-central Alaska, *in* Johnson, K.M., and Williams, J.R., eds., The United States Geological Survey in Alaska: Accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B61-B63

Patton, W.W., Jr., and Miller, T.P., 1973, Bedrock geologic map of Bettles and southern part of Wiseman quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-492, scale 1:250,000.

Patton, W.W., Jr., and Moll-Stalcup, E.J., 1996, Geologic map of the Unalakleet quadrangle, west-central Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-2559, scale 1:250,000, 39 p.

Patton, W.W., Jr., Box, S.E., Moll-Stalcup, E.J., and Miller, T.P., 1994a, Geology of west-central Alaska *in* Plafker, George, and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, Boulder, Colorado, v. G-1, p. 241-269.

Patton, W.W., Jr., Box, S.E., and Grybeck, D.J.,, 1994b, Ophiolites and other mafic-ultramafic complexes in Alaska *in* Plafker, George, and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, Boulder, Colorado, v. G-1, p. 671-686.

Patton, W.W., Miller, T.P., Chapman, R.M., and Yeend, Warren, 1978, Geologic map of the Melozitna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1071, scale 1:250,000.

Patton, W.W., Jr., Moll, E.J., Dutro, J.T., Jr., Silberman, M.L., and Chapman, R.M., 1980, Preliminary geologic map of the Medfra quadrangle, Alaska: U.S. Geological Survey Open-File Report 80-811A, 1 sheet, scale 1:250,000.

Patton, W.W., Jr., Stern, T.W., Arth, J.G., and Carlson, C., 1987, New U/Pb ages from granite and granite gneiss in the Ruby geanticline and southern Brooks Range, Alaska: Journal of Geology v. 95, p. 118-126.

Patton, W.W., Jr., Tailleur, I.L., Brosge, W.P., and Lanphere, M.A., 1977, Preliminary report on the ophiolites of northern and western Alaska, *in* Coleman, R.G., and Irwin, W.P., North American Ophiolites: Oregon Department of Geology and mineral Industries, Bulletin 95, p. 51-57.

Patton, W.W., Jr., Moll, E.J., Lanphere, M.A., and Jones, D.L., 1984, New age data for the Kaiyuh Mountains, west-central Alaska, *in* Coonrad, W.L., and Elliott, R.L., eds., United States Geological Survey in Alaska; Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 30-32.

Pewe, T.L., Wahrhaftig, C., and Weber, F., 1966, Geologic map of the Fairbanks quadrangle, Alaska: U.S. Geological Survey, Miscellaneous Investigations I-455, 5 pages, 1 sheet, scale 1:250,000.

Plafker, George, Lull, J.S., Nokleberg, W.J., Pessel, G.H., Wallace, W.K., and Winkler, G.R., 1992, Geologic map of the Valdez A-4, B-3, B-4, C-3, C-4, D-4 quadrangles, northern Chugach Mountains and southern Copper River basin: U.S. Geological Survey Miscellaneous Investigations Series Map I-2164, 1 sheet, scale 1:125,000.

Puchner, C.C., 1984, Geologic map of the Ruby/Poorman area: Unpublished Anaconda Mining Company Report, scale 1:250,000

Reed, B.L., and Gamble, B.M., 1988, Preliminary geologic map of the Lime Hills quadrangle, Alaska, *in* Gamble, B.M., Allen, M.S., McCammon, R.B., Root, D.H., Scott, W.A., Griscom, Andrew, Krohn, M.D., Ehmann, W.J., and Southworth, S.C., Lime Hills quadrangle, Alaska -- An AMRAP planning document: U.S. Geological Survey Administrative report, 167 p., 22 plates.

Reed, B.L, and Elliott, R.L., 1970, Reconnaissance geologic map, analyses of bedrock and stream sediment samples, and an aeromagnetic map of parts of the southern Alaska Range: U.S. Geological Survey Open File Report 70-271, scale 1:63,360, 24 p.

Reed, B.L., and Lanphere, M.A., 1969, Age and chemistry of Mesozoic and Tertiary plutonic rocks in south-central Alaska: Geological Society of America Bulletin, v. 80, p. 23-44.

Reed, B.L., and Lanphere, M.A., 1972, Generalized geologic map of the Alaska-Aleutian Range batholith showing potassium-argon age of the plutonic rocks: U.S. Geological Survey Miscellaneous Field Studies Map MF-372, 2 sheets, scale 1:1,000,000.

Reed, B.L., and Lanphere, M.A., 1973, Alaska-Aleutian Range batholith -- Geochronology, chemistry, and relation to circum-Pacific plutonism: Geological Society of America Bulletin, v. 84, p. 2583-2610.

Reed, B.L., and Nelson, S.W., 1980, Geologic map of the Talkeetna quadrangle, Alaska: U.S. Geological Survey, Miscellaneous Investigation Series Map I-1174, 15 pages, 1 plate, scale 1:250,000.

Reifenstuhl, R.R., Dover, J.H., Pinney, D.S., Newberry, R.J., Clautice, K.H., Liss, S.A., Blodgett, R.B., Bundtzen, T.K., and Weber, F.R., 1997, Geologic map of the Tanana B-1 quadrangle, central Alaska: Alaska Department of Geological and Geophysical Surveys Report of Investigations 97-15a, scale 1:63,360, 17 p.

Reifenstuhl, R.R., Dover, J.H., Newberry, R.J., Clautice, K.H., Liss, S.A., Blodgett, R.B., and Weber, F.R., 1998, Geologic map of the Tanana A-1 and A-2, central Alaska: Alaska Department of Geological and Geophysical Surveys Public Data File 98-37a, scale 1:63,360.

Ridgeway, K.D, Trop, J.M., and Sweet, A.R., 1994, Depositional systems, age, and provenance of the Cantwell Formation, Cantwell basin, Alaska Range [abs]: Geological Society of America Abstracts with Programs, v. 26, p. 492.

Riehle, J.R., Fleming, M.D., Molnia, B.F., Dover, J.H., Kelley, J.S., Miller, M.L., Nokleberg, W.J., Plafker, George, and Till, A.B., 1997, Digital shaded-relief image of Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-2585, scale 1:2,500,000.

Robinson, M.S., Smith, T.E., and Metz, P.A., 1990, Bedrock geology of the Fairbanks Mining District: Alaska Division of Geological and Geophysical Surveys Professional Report 106, scale 1:63,360.

Roeske, S.M., 1986, Field relations and metamorphism of the Raspberry Schist, Kodiak Island, Alaska, *in* Evans, B.W., and Brown, E.H., eds., Blueschist and ecologites: Geological Society of America Memoir 164, p. 169-184.

Roeske, S.M., Mattinson, J.M., and Armstrong, R.L., 1989, Isotopic ages of glaucophane schists on the Kodiak Islands, southern Alaska, and their implications for Mesozoic tectonic history of the Border Ranges Fault system: Geological Society of America Bulletin, v. 101, p. 1021-1037.

Roeske, S.M., Dusel-Bacon , C., Aleinikoff, J.N., Snee, L.W., and Lanphere, M.A., 1995, Metamorphic and structural history of continental crust at a Mesozoic collisional margin, the Ruby terrane, central Alaska: Journal of Metamorphic Geology v. 13, p. 25-40.

St. John, J.M., and Babcock, L.E., 1997, Middle Cambrian trilobites of Siberian aspect from the Farewell terrane, southwestern Alaska: U.S. Geological Survey Professional Paper 1574, p. 269-281.

Silberling, N.J., and Jones, D.L., eds., 1984, Lithotectonic terrane maps of the North American Cordillera: U.S. Geological Survey Open-File Report 84-523, Scale 1:2,500,000

Silberling, N.J., Jones, D.L., Monger, J.W.H., Coney, P.J., Berg, H.C., and Plafker, George, 1994, Lithotectonic terrane map of Alaska and adjacent parts of Canada, *in* Plafker, George, and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, Boulder, Colorado, plate 3, scale 1:2,500,000.

Silberman, M.L., Moll, E.J., Patton, W.W., Jr., Chapman, R.M., and Conner, C.L., 1979, PreCambrian age of metamorphic rocks from the Ruby province, Medfra and Ruby quadrangles--preliminary evidence from radiometric age data, *in* Johnson, K.M., and Williams, J.R., eds., The United States Geological Survey in Alaska: Accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B64, B66-B68.

Solie, D.N., Gilbert, W.G., Harris, E.E., Kline, J.T., Liss, S.A., and Robinson, M.S., 1991, Preliminary geologic map of Tyonek D-6 and eastern Tyonek D-7 quadrangles, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data File 91-10, scale 1:63,360, 15 p., not paginated.

Smith, T.E., 1981, Geology of the Clearwater Mountains, south-central Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 60, 1 sheet, scale 1:63,360, 73 p.

Smith, T.E., Albanese, M.D., and Kline, G.L., 1984, Geologic map of the Healy A-2 quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 95, 1 sheet, scale 1:63,360.

Smith, T.E., Robinson, M.S., Weber, F.R., Waythomas, C.W., and Reifenstuhl, R.R., 1994, Geologic map of the Upper Chena River area, eastern interior Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 115, scale 1:63,360, 19 p.

Spurr, J.E., 1900, A reconnaissance in southwestern Alaska in 1898: U.S. Geological Survey 20th Annual Report, Part 7, p. 31-264.

Steiger, R.H., and Jager, E., 1977, Subcommission on Geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Turner, D.L., and Smith, T.E., 1974, Geochronology and generalized geology of the central Alaska Range, Clearwater Mountains, and northern Talkeetna Mountains: Alaska Division of Geological and Geophysical Surveys Open-File Report AOF-72, 11 p., 1 sheet.

Wahrhaftig, Clyde, 1968, Schists of the central Alaska Range: U.S. Geological Survey Bulletin 1254-E, p. E1-E22.

Weber, F.R., Foster, H.L., Keith, T.E.C., and Dusel-Bacon, Cynthia, 1978, Preliminary geologic map of the Big Delta quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-529A, scale 1:250,000.

Weber, F.R., Wheeler, K.L., Rinehart, C.D., Chapman, R.M., and Blodgett, R.B., 1992, Geologic map of the Livengood quadrangle, Alaska: U.S. Geological Survey Open-File Report 92-562, scale 1:250,000, 19 p.

Wilson, F.H., Smith, J.G., and Shew, Nora, 1985, Review of radiometric data from the Yukon Crystalline terrane, Alaska and Yukon Territory: Canadian Journal of Earth Sciences, v. 22, no. 4, p. 525-537.

Wilson, F.H., Weber, F.R., and Angeloni, Linda, 1984, Late Cretaceous thermal overprint and metamorphism, southeast Circle quadrangle, Alaska [abs.]: Geological society of America Abstracts with Programs, v. 16, no. 5, p. 340.

Wiltse, M.A., Reger, R.D., Newberry, R.J., Pessel, G.H., Pinney, D.S., Robinson, M.S., and Solie, D.N., 1995, Geologic map of the Circle Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 95-2a, scale 1:63,360.

Winkler, G.R., Silberman, M.L., Grantz, Arthur, Miller, R.J., and MacKevett, E.M., Jr., 1980, Geologic map and summary geochronology of the Valdez quadrangle, southern Alaska: U.S. Geological Survey Open-File Report 80-892-A, scale 1:250,000, 2 sheets.

Winkler, G.R., compiler, 1992, Geologic map and summary geochronology of the Anchorage 1° x 3° quadrangle, southern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-2283, scale 1:250,000.

List of Map Sources

Anchorage:

AN1: Winkler, G.R., compiler, 1992, Geologic map and summary geochronology of the Anchorage 1° x 3° quadrangle, southern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-2283,, scale 1:250,000.

Big Delta:

BD1: Weber, F.R., Foster, H.L., Keith, T.E.C., and Dusel-Bacon, Cynthia, 1978, Preliminary geologic map of the Big Delta quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-529A, scale 1:250,000.

BDCI1: Smith, T.E., Robinson, M.S., Weber, F.R., Waythomas, C.W., and Reifenstuhl, R.R., 1994, Geologic map of the Upper Chena River area, eastern interior Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 115, scale 1:63,360, 19 p.

Circle:

CI1: Foster, H.L., Laird, Jo, Keith, T.E.C., Cushing, G.W., and Menzie, D.W., 1983, Preliminary geologic map of the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report, 83-170-A, scale 1:250,000.

CI2: Wiltse, M.A., Reger, R.D., Newberry, R.J., Pessel, G.H., Pinney, D.S., Robinson, M.S., and Solie, D.N., 1995, Geologic map of the Circle Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 95-2a, scale 1:63,360.

CI3: Weber, F.R, Unpublished mapping, 1997, scale 1:250,000.

BDCI1: Smith, T.E., Robinson, M.S., Weber, F.R., Waythomas, C.W., and Reifenstuhl, R.R., 1994, Geologic map of the Upper Chena River area, eastern interior Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 115, scale 1:63,360, 19 p.

FMD1: Robinson, M.S., Smith, T.E., and Metz, P.A., 1990, Bedrock geology of the Fairbanks Mining District: Alaska Division of Geological and Geophysical Surveys Professional Report 106, scale 1:63,360.

FMD1: Newberry, R.J., Bundtzen, T.K, Clautice, K.H., Combellick, R.A., Douglas, T., Laird, G.M., Liss, S.A., Pinney, D.S., Reifenstuhl, R.R., and Solie, D.N., 1996, Preliminary geologic map of the Fairbanks Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 96-16, scale 1:63,360.

Fairbanks:

FB1: Pewe, T.L., Wahrhaftig, C., and Weber, F., 1966, Geologic map of the Fairbanks quadrangle, Alaska: U.S. Geological Survey, Miscellaneous Investigations I-455, scale 1:250,000, 5 p.

FMD1: Newberry, R.J., Bundtzen, T.K, Clautice, K.H., Combellick, R.A., Douglas, T., Laird, G.M., Liss, S.A., Pinney, D.S., Reifenstuhl, R.R., and Solie, D.N., 1996, Preliminary geologic map of the Fairbanks Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 96-16, scale 1:63,360.

FMD1: Robinson, M.S., Smith, T.E., and Metz, P.A., 1990, Bedrock geology of the Fairbanks Mining District: Alaska Division of Geological and Geophysical Surveys Professional Report 106, scale 1:63,360.

Gulkana:

GU1: Nokleberg, W.J., Richter, D.H., Ferrians, O.J., Lange, I.M., Campbell, D.L., Aleinikoff, J.N., Smith, T.E., and Koch, R.D., in press, Introduction, previous studies, acknowledgements, detailed description of map units, geologic and tectonic summary, and references cited for preliminary geologic map of the Gulkana quadrangle, eastern Alaska Range and northern Copper River basin, Alaska: U.S. Geological Survey Open-File Report, in press [CAD coverage 1997]

Healy:

HE1: Csejtey, Bela, Jr., Mullen, M.W., Cox, D.P., and Stricker, G.D., 1992, Geology and geochronology of the Healy quadrangle, south-central Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1961, scale 1:250,000, 63 p.

HE2: Smith, T.E., 1981, Geology of the Clearwater Mountains, south-central Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 60, 1 sheet, scale 1:63,360, 73 p.

HE3: Smith, T.E., Albanese, M.D., and Kline, G.L., 1984, Geologic map of the Healy A-2 quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 95, 1 sheet, scale 1:63,360.

Iditarod:

ID1: Miller, M.L, and Bundtzen, T.K., 1994, Generalized geologic map of the Iditarod quadrangle, Alaska, showing potassium-argon, major-oxide, trace-element, fossil, paleocurrent, and archaeological sample localities: U.S. Geological Survey Miscellaneous Field Studies Map MF-2219A, scale 1:250,000, 48 p. (With revisions from unpublished data, M.L. Miller and T.K. Bundtzen, 1997)

Kantishna River:

KH1: Chapman, R.M., Yeend, W.E., Patton, W.W., Jr., 1975, Preliminary reconnaissance geologic map of the western half of Kantishna River quadrangle, Alaska: U.S. Geological Survey Open File Report 75-351, scale 1:250,000.

KH2: Chapman, R.M., and Yeend, Warren, 1981, Geologic reconnaissance of the east half of Kantishna River quadrangle and adjacent areas, in Albert, N.R.D., and Hudson, Travis, ed., The United States Geological Survey in Alaska: Accomplishments during 1979: U.S. Geological Survey Circular 823-B, p. B30-B32.

KH3: Weber, F.R, Unpublished mapping, 1997, scale 1:250,000.

Kateel River:

KT1: Patton, W.W., Jr., 1966, Regional geology of the Kateel River quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-437, 1 sheet, 1:250,000. (With revisions from unpublished data, W.W. Patton, Jr., 1997)

Lime Hills:

LH1: Gamble, B.M., and Reed, B.L., 1996, Preliminary geologic map of the eastern half of the Lime Hills quadrangle, Alaska: unpublished U.S. Geological Survey map compilation, scale 1:250,000.

LH2: Bundtzen, T.K., West half of the Lime Hills quadrangle, Alaska: Unpublished mapping, 1997.

LH2: Reed, B.L., and Gamble, B.M., 1988, Preliminary geologic map of the Lime Hills quadrangle, Alaska, *in* Gamble, B.M., Allen, M.S., McCammon, R.B., Root, D.H., Scott, W.A., Griscom, Andrew, Krohn, M.D., Ehmann, W.J., and Southworth, S.C., Lime Hills quadrangle, Alaska -- An AMRAP planning document: U.S. Geological Survey Administrative report, 167 p., 22 plates. (*Used only the west half of this map, see above.*)

Livengood:

LG1: Weber, F.R., Wheeler, K.L., Rinehart, C.D., Chapman, R.M., and Blodgett, R.B., 1992, Geologic map of the Livengood quadrangle, Alaska: U.S. Geological Survey Open-File Report 92-562, 19 p., scale 1:250,000. (With revisions from unpublished data, F.R. Weber, 1997)

FMD1: Newberry, R.J., Bundtzen, T.K, Clautice, K.H., Combellick, R.A., Douglas, T., Laird, G.M., Liss, S.A., Pinney, D.S., Reifenstuhl, R.R., and Solie, D.N., 1996, Preliminary geologic map of the Fairbanks Mining District, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 96-16, scale 1:63,360.

FMD1: Robinson, M.S., Smith, T.E., and Metz, P.A., 1990, Bedrock geology of the Fairbanks Mining District: Alaska Division of Geological and Geophysical Surveys Professional Report 106, scale 1:63,360.

McGrath:

MG1: Bundtzen, T.K., Harris, E.E., and Gilbert, W.G., 1997, Geologic map of the eastern half of the McGrath quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 97-14a, scale 1:125,000, 34 p.

MG2: Bundtzen, T.K., 1997, Unpublished draft compilation of the western half of the McGrath quadrangle, Alaska, Cited references include:

Babcock, L.E., Blodgett, R.B., and St. John, J., 1994, New Late(?) Proterozoic age formations in the vicinity of Lone Mountain, McGrath quadrangle, west-central Alaska: U.S. Geological Survey Bulletin 2107, p. 143-156.

Blodgett, R.B. and Gilbert, W.G., The Cheeneetuk Limestone -- a new Early(?) to Middle Devonian Formation in the McGrath A-4 and A-5 quadrangles, Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 85, 6 p., 1 sheet, scale 1:63,360.

Bundtzen, T.K., 1986, Geology and prospect examination of the Vinasale Mt.-Alder Creek area, McGrath C-6 quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data 86-15, 10 p., 1 figure, scale 1:63,360.

Bundtzen, T.K., and Laird, G.M., 1983, Geologic map of the McGrath D-6 quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 79, scale 1:63,360.

Dutro, J.T., Jr., and Patton, W.W., Jr., 1982, New Paleozoic formations in the northern Kuskokwim Mountains, west-central Alaska: U.S. Geological Survey Bulletin 1529-H, p. H13-H22.

Medfra:

MD1: Patton, W.W., Jr., Moll, E.J., Dutro, J.T., Jr., Silberman, M.L., and Chapman, R.M., 1980, Preliminary geologic map of the Medfra quadrangle, Alaska: U.S. Geological Survey Open-File Report 80-811A, 1 sheet, scale 1:250,000.

OPMD1: Bundtzen, T.K., Pinney, D.S., and Laird, G.M., 1997b, Preliminary geologic map and data table from the Ophir C-1 and western Medfra C-6 quadrangles, Alaska: Alaska Division Geological and Geophysical Surveys Public Data File 97-46, scale 1:63,360, 10 p.

Mount Hayes:

MH1: Nokleberg, W.J., Aleinikoff, J.N., Lange, I.M., Silva, S.R., Miyaoka, R.T., Schwab, C.E., and Zehner, R.E., with contribution for selected areas from Bond, G.C., Richter, D.H., Smith, T.E., and Stout, J.H., 1992, Preliminary geologic map of the Mount Hayes quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Open File Report 92-594, scale 1:250,000.

Mount McKinley:

MM1: Csejtey, Bela, Jr., 1993, Unpublished draft compilation of the Mount McKinley quadrangle, Alaska

MM1: Gilbert, W.G., 1979, A geologic guide to Mount McKinley National Park: Alaska Natural History Association, in cooperation with the National Park Service, U.S. Dept. of the Interior, 52 p., 1 plate, scale 1:250,000.

MM1: Reed, J.C., Jr., 1961, Geology of the Mount McKinley quadrangle, Alaska: U.S. Geological Survey Bulletin 1108-A, 36 p., 1 map, scale 1:250,000.

Melozitna:

MZ1: Patton, W.W., Miller, T.P., Chapman, R.M., and Yeend, Warren, 1978, Geologic map of the Melozitna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1071, scale 1:250,000.

MZ2: Roeske, S.M., Dusel-Bacon , C., Aleinikoff, J.N., Snee, L.W., and Lanphere, M.A., 1995, Metamorphic and structural history of continental crust at a Mesozoic collisional margin, the Ruby terrane, central Alaska: Journal of Metamorphic Geology v. 13, p. 25-40.

Nulato:

NL1: Patton, W.W., Jr., 1994, Unpublished draft compilation of the Nulato quadrangle, Alaska.

Ophir:

OP1: Chapman, R. M., Patton, W. W. Jr., and Moll, E. J., 1985, Reconnaissance geologic map of the Ophir quadrangle, Alaska: U.S. Geological Survey Open-File Report 85-203, 1 sheet, scale 1:250,000.

OP1: Chapman, R.M., Patton, W.W. Jr., and Moll, E.J., 1982, Preliminary summary of geology in eastern part of Ophir quadrangle, in Coonrad, W.L., ed., The United States Geological Survey in Alaska: Accomplishments during 1980: U.S. Geological Survey Circular 844, p. 70-73.

OPMD1: Bundtzen, T.K., Pinney, D.S., and Laird, G.M., 1997b, Preliminary geologic map and data table from the Ophir C-1 and western Medfra C-6 quadrangles, Alaska: Alaska Division Geological and Geophysical Surveys Public Data File 97-46, scale 1:63,360, 10 p.

Ruby:

RB1: Cass, J.T., 1959, Reconnaissance geologic map of the Ruby quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigation Map I-289, 1 sheet, scale 1:250:000 [Geologic linework transcribed by David Dempsey, 1996, to fit modern topographic base].

RB2: Chapman, R.M., and Patton, W.W., Jr., 1978, Preliminary summary of the geology in the northwest part of the Ruby quadrangle, *in* Johnson, K.M., ed., The United States Geological Survey in Alaska: Accomplishments during 1977: U.S. Geological Survey Circular 772-B, p. B39-B41.

RB3: Chapman, R.M., and Patton, W.W., Jr., 1979, Two upper Paleozoic rock units identified in southwestern part of the Ruby quadrangle, *in* Johnson, K.M., and Williams, J.R., eds., The United States Geological Survey in Alaska: Accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B59-B61.

RB4: Puchner, C.C., 1984, Geologic map of the Ruby/Poorman area: Unpublished Anaconda Mining Company Report, scale 1:250,000, written commun., 1997.

RB5: Dusel-Bacon, Cynthia, Brosge, W.P., Till, A.B., Doyle, E.O., Mayfield, C.F., Reiser, H.N., and Miller, T.P., 1989, Distribution, facies, ages, and proposed tectonic associations of regionally metamorphosed rocks in northern Alaska: U.S. Geological Survey Professional Paper 1497-A, 44 p., 2 plates., 1:1,000,000-scale.

Sleetmute:

SM1: Miller, M.L., Belkin, H.E., Blodgett, R.B., Bundtzen, T.K., Cady, J.W., Goldfarb, R.J., Gray, J.E., McGimsey, R.G., and Simpson, S.L., 1989, Pre-field study and mineral resource assessment of the Sleetmute quadrangle, southwestern Alaska: U.S. Geological Survey Open-File Report 89-363, 115 p., 1 map, scale 1:250,000.

SM2: Bundtzen, T.K., Laird, G.M., Harris, E.E., Kline, J.T., and Miller, M.L., 1993, Geologic map of the Sleetmute C-7, D-7, C-8, and D-8 Quadrangles, Horn Mountains area, southwest Alaska: Alaska Division of Geological and Geophysical Surveys Public-Data File 93-47, 15 p., 2 sheets, scale 1:63,360.

Talkeetna:

TL1: Reed, B.L., and Nelson, S.W., 1980, Geologic map of the Talkeetna quadrangle, Alaska: U.S. Geological Survey, Miscellaneous Investigation Series Map I-1174, 15 pages, 1 plate, scale 1:250,000.

Talkeetna Mountains:

TK1: Csejtey, Bela, Jr., Nelson, W.H., Jones, D.L., Silberling, N.J., Dean, R.M., Morris, M.S., Lanphere, M.A., Smith, J.G., and Silberman, M.L., 1978, Reconnaissance geologic map and geochronology, Talkeetna Mountains quadrangle, northern part of Anchorage quadrangle, and southwest corner Healy quadrangle, Alaska: U.S. Geological Survey Open-file Report 78-558A, scale 1:250,000, 60 p.

TK2: Kline, J.T., Bundtzen, T.K., and Smith, T.E., 1990, Preliminary bedrock geologic map of the Talkeetna Mountains D-2 quadrangle, Alaska: Alaska Division Geological and Geophysical Surveys Public Data File 90-24, scale 1:63,360, not paginated.

Tanana:

TN1: Dover, J.H., 1997, Unpublished draft compilation of the Tanana quadrangle, Alaska, scale 1:250,000.

TN1: Chapman, R.M., Yeend, Warren, Brosge, W.P., and Reiser, H.N., 1982, Reconnaissance geologic map of the Tanana quadrangle, Alaska: U.S. Geological Survey Open-File Report 82-734, scale 1:250,000, 18 p.

TN2: Reifenstuhl, R.R., Dover, J.H., Pinney, D.S., Newberry, R.J., Clautice, K.H., Liss, S.A., Blodgett, R.B., Bundtzen, T.K., and Weber, F.R., 1997, Geologic map of the Tanana B-1 quadrangle, central Alaska: Alaska Department of Geological and Geophysical Surveys Report of Investigations 97-15a, scale 1:63,360, 17 p.

TN3: Reifenstuhl, R.R., Dover, J.H., Newberry, R.J., Clautice, K.H., Liss, S.A., Blodgett, R.B., and Weber, F.R., 1998, Geologic map of the Tanana A-1 and A-2, central Alaska: Alaska Department of Geological and Geophysical Surveys Public Data File 98-37a, scale 1:63,360.

Tyonek:

TY1: Haeussler, P.J., 1997, Unpublished draft compilation of the Tyonek quadrangle, Alaska, scale 1:250,000.

TY1: Magoon, L.B. Adkison, W.L., and Egbert, R.M, 1976, Map showing geology, wildcat wells, Tertiary plant localities, K/Ar age dates, and petroleum operations, Cook Inlet area, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1019, scale 1:250,000, 3 sheets.

TY2: Reed, B.L, and Elliott, R.L., 1970, Reconnaissance geologic map, analyses of bedrock and stream sediment samples, and an aeromagnetic map of parts of the southern Alaska Range: U.S. Geological Survey Open File Report 70-271, scale 1:63,360, 24 p.

TY3: Solie, D.N., Gilbert, W.G., Harris, E.E., Kline, J.T., Liss, S.A., and Robinson, M.S., 1991, Preliminary geologic map of Tyonek D-6 and eastern Tyonek D-7 quadrangles, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data File 91-10, scale 1:63,360, 15 p., not paginated.

Valdez:

VA1: Winkler, G.R., Silberman, M.L., Grantz, Arthur, Miller, R.J., and MacKevett, E.M., Jr., 1980, Geologic map and summary geochronology of the Valdez quadrangle, southern Alaska: U.S. Geological Survey Open-File Report 80-892-A, scale 1:250,000, 2 sheets. (With revisions from unpublished data, G.R. Winkler, 1997)

VA2: Plafker, George, Lull, J.S., Nokleberg, W.J., Pessel, G.A., Wallace, W.K., and Winkler, G.R., 1992, Geologic map of the Valdez A-4, B-3, B-4, C-3, C-4, D-4 quadrangles, northern Chugach Mountains and southern Copper River basin, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-2164.

Index of map units

Appendix A. Exploratory drillholes in Central (Interior) Alaska

The data in the following table on exploratory drillholes in the map area was provided by the Alaska Division of Oil and Gas (DOG). A map showing the distribution of these wells in the map area is shown on sheet 3 as figures 5a and 5b. This data set has been abstracted from a database of drill holes in Alaska maintained by DOG. Explanation for coded entries in columns of the table is as below:

Column	Entries
Map Number	Shown on figures 5a and 5b , sheet 3
API number	--
Well name	--
Operator name	--
Status	P&A, plugged and abandoned; P&A-G, plugged and abandoned, gas show(s); P&A-O, plugged and abandoned, oil show(s); P&A-OC, plugged and abandoned, "significant" oil show; P&A-OG, plugged and abandoned, oil and gas show(s); GAS, gas producer; SUSP-O, suspended, oil show(s); SUSP-G, suspended, gas show(s)
Completion date	--
Permit number	--
Area	KOYK - Koyukuk; MTAN - Middle Tanana; COPR - Copper River; SUSIT - Susitna; CI - Cook Inlet
Latitude	At surface, decimal degress, N
Longitude	At surface, decimal degrees, W
Township	Number and direction, at surface
Range	Number and direction, at surface
Section	Section number
Meridian	At surface
Bottonhole latitude	Decimal degrees
Bottomhole longitude	Decimal degrees
Bottomhole township	Number and direction
Bottomhole range	Number and direction
Bottomhole section	Section number
Total depth	Feet

Exploratory drillholes in Central (Interior) Alaska

Map Number	API Number	Well Name	Well Number	Operator Name	Status	Completion Date
1	50193100010000	NULATO	1	BENEDUM P G	P&A	5/25/60
2	50083100010000	NENANA	1	UNOCAL	P&A	3/6/62
3	50083200010000	TOTEK HILLS	1	ARCO	P&A	10/8/84
4	50099100050000	RAINBOW FED	2	ATLANTIC	P&A	1/26/66
5	50099100040000	RAINBOW	1	ATLANTIC	P&A	12/21/65
6	50099200030000	AHTNA	1	AMOCO	P&A	4/16/80
7	50099100030000	SALMON BERRY	1	MOBIL	P&A	3/18/64
8	50099200040000	AHTNA	A1	AMOCO	P&A	8/6/80
9	50099100020000	TAZLINA	1	UNOCAL	P&A	10/24/62
10	50099200020000	ALICIA	1	COPPER VALLEY	P&A	1/15/83
11	50099200010000	TAWAWE	1	CONSOLIDATED	P&A	1/19/70
12	50099100010000	MOOSE CK	1	AMOCO	P&A	7/17/63
13	50267100010000	PURE KAHILTNA UNIT	1	UNION TEXAS	P&A	3/11/64
14	50009100210000	EUREKA	2	ALEDO OIL	P&A	5/6/63
15	50009100200000	EUREKA	1	ALEDO OIL	P&A	6/1/57
16	50283200650000	TRAIL RIDGE UNIT	1	UNOCAL	P&A	12/13/80
17	50009100190000	CHICKALOON	1	PETERSON	P&A-G	9/17/30
18	50009200020000	FISH HOOK	1	HILL	P&A	5/7/69
19	50009009990000	HERSHEY WATER WELL	1	HERSHEY	P&A-G	12/5/86
20	50009100240000	HOUSTON CORE HOLE	3	U S D O M	P&A	1/1/52
21	50283200190000	RED SHIRT LAKE	1	FARMS (HILL?)	P&A	12/14/68
22	50009100150000	ROSETTA	2	ANCHORAGE O&G	P&A	5/21/56
23	50009100230000	HOUSTON CORE HOLE	2	U S D O M	P&A-G	1/1/52
24	50009100140000	ROSETTA	1	ANCHORAGE O&G	P&A-G	6/30/59
25	50009100220000	HOUSTON CORE HOLE	1	U S D O M	P&A-G	1/1/51
26	50009100170000	ROSETTA	4	ANCHORAGE O&G	P&A-G	10/7/61
27	50009100180000	ROSETTA	4A	ANCHORAGE O&G	P&A-G	9/24/62
28	50009100160000	ROSETTA	3	ANCHORAGE O&G	P&A-G	9/1/63
29	50009200030000	BEAVER LAKES	1	HARBINGER	P&A-G	9/18/75
30	50009100130000	PITTMAN	1	UNOCAL	P&A-G	5/27/62
31	50009200080000	AK94CBM	1	ALASKA DNR	P&A	5/24/94
32	50009200050000	HORSESHOE LAKE	1	GREAT PLAINS AMER	P&A	5/15/73

Exploratory drillholes in Central (Interior) Alaska

Map Number	Permit Number	Area	Latitude	Longitude	Township		Range		Section number	Meridian	Bottomhole latitude
					No.	Direc-tion	No.	Direc-tion			
1		KOYK	64.6332	158.5668	10	S	1	E	12	KATEEL RIVER	
2		MTAN	64.5807	149.6385	4	S	10	W	7	FAIRBANKS	
3	840100	MTAN	64.2619	149.8437	7	S	12	W	36	FAIRBANKS	
4		COPR	62.5089	146.0708	8	N	5	W	1	COPPER RIVER	
5		COPR	62.4309	146.2338	8	N	5	W	31	COPPER RIVER	
6		COPR	62.3002	145.4921	6	N	1	W	18	COPPER RIVER	62.3000
7		COPR	62.2918	146.2649	6	N	6	W	24	COPPER RIVER	62.2800
8		COPR	62.1896	145.4105	5	N	1	W	28	COPPER RIVER	62.1894
9		COPR	62.1382	146.4930	4	N	7	W	10	COPPER RIVER	
10		COPR	62.1132	145.9116	4	N	4	W	23	COPPER RIVER	
11		COPR	62.1087	146.6074	4	N	8	W	24	COPPER RIVER	
12		COPR	62.1060	145.8105	4	N	3	W	29	COPPER RIVER	
13		SUSIT	62.0405	150.7555	23	N	8	W	33	SEWARD	
14		COPR	61.9525	147.1345	2	N	10	W	18	COPPER RIVER	
15		COPR	61.9250	147.2632	21	N	12	E	9	SEWARD	
16	790072	SUSIT	61.8427	151.0833	20	N	10	W	9	SEWARD	61.8481
17		CI	61.7969	148.5075	20	N	5	E	26	SEWARD	
18		CI	61.6752	149.2631	18	N	1	E	3	SEWARD	
19		CI	61.6593	149.4079	18	N	1	W	11	SEWARD	
20		SUSIT	61.6459	149.8733	18	N	3	W	18	SEWARD	
21		SUSIT	61.6416	150.0942	18	N	5	W	24	SEWARD	
22		SUSIT	61.6416	149.8591	18	N	3	W	20	SEWARD	
23		SUSIT	61.6415	149.8594	18	N	3	W	20	SEWARD	
24		SUSIT	61.6415	149.8594	18	N	3	W	20	SEWARD	
25		SUSIT	61.6389	149.8538	18	N	3	W	20	SEWARD	
26	590008	SUSIT	61.6383	149.8382	18	N	3	W	21	SEWARD	
27		SUSIT	61.6383	149.8386	18	N	3	W	21	SEWARD	
28		SUSIT	61.6350	149.8388	18	N	3	W	21	SEWARD	
29	690011	CI	61.6127	149.8526	18	N	3	W	32	SEWARD	
30		CI	61.6056	149.6382	18	N	2	W	33	SEWARD	
31	940069	CI	61.6009	149.5098	18	N	1	W	31	SEWARD	
32		CI	61.5892	149.9148	17	N	4	W	1	SEWARD	

Map Number	**Bottomhole longitude**	**Bottomhole Township**		**Bottomhole Range**		**Bh. Section**	**Total depth**
		No.	**Direc-tion**	**No.**	**Direc-tion**		
1							12015
2							3062
3							3590
4							2793
5							3000
6	145.4913	6	N	1	W	18	7928
7	146.2369	6	N	6	W	24	7913
8	145.4091	5	N	1	W	28	5677
9							8837
10							1050
11							6721
12							7869
13							7265
14							8546
15							4818
16	151.0580	20	N	10	W	3	13708
17							1362
18							2375
19							285
20							386
21							2074
22							1100
23							1142
24							4260
25							481
26							1627
27							2407
28							6109
29							8474
30							6136
31							1245
32							8230

Map Number	API Number	Well Name	Well Number	Operator Name	Status	Completion Date
33	50009100090000	NEEDHAM	1	AUSTRAL	P&A	5/7/66
34	50283200240000	FISH CK	1	ARCO (INLET OIL)	P&A	3/29/69
35	50009200040000	BIG LAKE AM QUASAR	1	AMER QUASAR PET	P&A	1/6/72
36	50009200060000	BIG LAKE (BLT)	1	ARCO	P&A-OG	3/24/92
37	50009100110000	WALLACE KNUTSON	1-A	WALLACE MINING	P&A	4/30/66
38	50009100100000	WALLACE-KNUTSON	1	WALLACE MINING	P&A	6/18/65
39	50009100120000	WASILLA STATE	1	BP	P&A-O	2/25/63
40	50009100060000	KNIK ARM	2	UNOCAL	P&A	10/22/60
41	50009100080000	KNIK ARM	1	UNOCAL	P&A	10/8/60
42	50009100070000	FISH CK	12-8	UNOCAL	P&A	10/2/61
43	50009100050000	ALASKA GULF	1	ALASKA GULF	P&A-G	9/6/55
44	50009200010000	BIG LAKE	1	AMOCO	P&A	10/21/68
45	50283100110000	BELL ISL	1	BRITISH AMER	P&A	5/31/62
46	50283200440000	FIGURE EIGHT	1	UNOCAL	P&A	3/15/76
47	50283100100000	SUSITNA STATE	1	HUMBLE	P&A	3/12/64
48	50283200210000	MIDDLE LAKE UNIT	1	GULF	P&A	4/3/69
49	50283200680000	LEWIS RIVER UNIT	D-1	CITIES SERVICE	P&A-G	10/3/81
50	50283200460000	ISLA GRANDE UNIT	1	AMAREX INC	P&A	4/9/75
51	50283200470000	LEWIS RIVER	1	CITIES SERVICE	GAS	10/1/75
52	50283200110000	LEWIS RIVER	13-2	SOCAL	P&A-G	4/18/68
53	50009100030000	KNIK ARM STATE	1	UNOCAL	P&A	8/31/63
54	50283200430000	PRETTY CREEK	1	TEXAS INTL	P&A	2/19/75
55	50283200480000	E LEWIS RIV	1	CITIES SERVICE	P&A	12/6/75
56	50009100040000	LORRAINE	1	ATLANTIC	P&A	2/28/66
57	50283200550000	STUMP LAKE UNIT	41-33	CHEVRON	GAS	5/14/78
58	50283200220000	PRETTY CREEK UNIT	2	CHEVRON	P&A-G	7/28/69
59	50283200220001	PRETTY CREEK UNIT	2	CHEVRON	GAS	2/26/79
60	50283200880000	IVAN RIVER UNIT	41-1	UNOCAL	GAS	1/26/93
61	50283100090000	IVAN RIVER	23-12	SOCAL	P&A-G	1/24/67
62	50283100080000	IVAN RIVER	44-1	SOCAL	GAS	10/8/66
63	50283200570000	PRETTY CREEK	1	UNOCAL	P&A	10/14/77
64	50283200500000	BURGLIN	X33-12	ALASKA ENERGY	P&A	1/23/77

Exploratory drillholes in Central (Interior) Alaska

Map Number	Permit Number	Area	Latitude	Longitude	Township		Range		Section number	Meridian	Bottomhole latitude
					No.	Direc-tion	No.	Direc-tion			
33		CI	61.5842	149.3310	17	N	1	E	7	SEWARD	
34		SUSIT	61.5620	150.2713	17	N	6	W	13	SEWARD	
35		CI	61.5550	149.8010	17	N	3	W	22	SEWARD	
36	910130	CI	61.5546	149.8031	17	N	3	W	22	SEWARD	
37		CI	61.5443	149.4140	17	N	1	W	23	SEWARD	
38		CI	61.5442	149.4140	17	N	1	W	23	SEWARD	
39		CI	61.5246	149.4514	17	N	1	W	33	SEWARD	
40		CI	61.5115	149.8455	16	N	3	W	5	SEWARD	
41		CI	61.5114	149.9399	16	N	4	W	2	SEWARD	
42		CI	61.4949	149.8665	16	N	3	W	8	SEWARD	
43		CI	61.4214	149.8102	15	N	3	W	4	SEWARD	
44	680081	CI	61.4178	149.9142	15	N	4	W	1	SEWARD	
45		CI	61.4018	150.4632	15	N	7	W	12	SEWARD	
46		CI	61.3947	150.3179	15	N	6	W	15	SEWARD	
47		CI	61.3853	150.0496	15	N	4	W	18	SEWARD	0.0000
48		CI	61.3782	150.1586	15	N	5	W	22	SEWARD	
49		CI	61.3488	150.8406	15	N	9	W	35	SEWARD	
50		CI	61.3430	150.6190	15	N	8	W	36	SEWARD	
51		CI	61.3355	150.8434	14	N	9	W	2	SEWARD	
52		CI	61.3311	150.8487	14	N	9	W	2	SEWARD	
53		CI	61.3288	149.9159	14	N	4	W	1	SEWARD	61.3280
54		CI	61.3266	151.0057	14	N	10	W	2	SEWARD	
55		CI	61.3022	150.7814	14	N	8	W	18	SEWARD	
56		CI	61.2953	149.9947	14	N	4	W	21	SEWARD	
57		CI	61.2658	150.7057	14	N	8	W	33	SEWARD	
58		CI	61.2636	150.8945	14	N	9	W	33	SEWARD	
59		CI	61.2636	150.8945	14	N	9	W	33	SEWARD	
60	920109	CI	61.2410	150.7966	13	N	9	W	1	SEWARD	61.2505
61		CI	61.2409	150.7963	13	N	9	W	1	SEWARD	61.2286
62		CI	61.2409	150.7962	13	N	9	W	1	SEWARD	
63		CI	61.2330	150.9436	13	N	9	W	7	SEWARD	61.2236
64	750064	CI	61.2287	150.9834	13	N	10	W	12	SEWARD	61.2296

Map Number	Bottomhole longitude	Bottomhole Township		Bottomhole Range		Bh. Section	Total depth
		No.	Direc-tion	No.	Direc-tion		
33							6004
34							2035
35							6307
36							6200
37							6146
38							560
39							4849
40							3215
41							3013
42							6418
43							3855
44							6026
45							11364
46							10660
47	0.0000	15	N	4	W	18	12550
48							9742
49							8025
50							11801
51							
52							11625
53	149.9100	14	N	4	W	1	6106
54							6570
55							11636
56							8010
57							11650
58							12025
59							4750
60	150.7964	13	N	9	W	1	9170
61	150.8166	13	N	9	W	12	11288
62							15269
63	150.9257	13	N	9	W	17	8506
64	150.9851	13	N	10	W	12	6730

Exploratory drillholes in Central (Interior) Alaska

Map Number	API Number	Well Name	Well Number	Operator Name	Status	Completion Date
65	50283100240000	BELUGA RIVER UNIT	14-19	SOCAL	P&A	5/15/64
66	50283200400000	NO TYONEK ST	1	PHILLIPS	P&A	8/12/73
67	50283200380000	BELUGA RIV U	241-34	SOCAL	GAS	8/10/72
68	50283100270000	BELUGA RIV U 212-35	1	SOCAL	GAS	12/18/62
69	50283200140000	CAMPBELL PT	1	YUKON SERVICES	P&A	7/26/68
70	50283200040000	THREE-MILE CREEK	1	SUPERIOR	P&A	10/24/67
71	50009100020000	OLD WILDCAT	1	ANCHORAGE O&G	P&A	1/1/21
72	50283100050000	CHUIT ST	1	SUPERIOR	P&A	5/10/62
73	50283100040000	CHUIT ST	2	SUPERIOR	P&A	9/4/62
74	50009100010000	ROMIG PARK	1	AMOCO	P&A	3/12/64
75	50283100060000	CHUITNA RIVER	1	AMOCO	P&A	2/25/67
76	50883100180000	NORTH COOK INLET	1	SHELL	GAS	9/13/64
77	50883200710000	FIRE ISLAND	1	ARCO	P&A	6/8/84
78	50283100070000	STEDATNA CREEK	1	AMOCO	P&A	5/12/62
79	50283200630000	SIMPCO E MOQUAWKIE	1	SIMASKO	P&A	9/13/79
80	50283200350000	WEST MOQUAWKIE	1	MOBIL	P&A	12/6/70
81	50283200390000	LONG LAKE UNT	1	TEXACO	P&A	5/18/73
82	50283200600000	SIMPCO MOQUAWKIE	1	SIMASKO	GAS	10/28/78
83	50883200870000	SUNFISH (NCI A-13)	2	PHILLIPS	GAS	11/15/93
84	50883200900000	SUNFISH	3	ARCO	SUSP-O	4/2/94
85	50883200930000	N COOK INLET UNIT	B1-01	PHILLIPS	SUSP-O	10/17/97
86	50883200320000	N COOK INLET UNIT	A-12	PHILLIPS	GAS-O	5/11/70
87	50283100010000	TYONEK RESERVE	1	HUMBLE	P&A	4/21/65
88	50283100190000	MOQUAWKIE	1	MOBIL	P&A-G	11/28/65
89	50283200150000	MOQUAWKIE	2	MOBIL	P&A	10/31/68
90	50883100130000	COOK INLET ST 17589	1A	PAN AM	GAS	7/8/64
91	50283200620000	SIMPCO MOQUAWKIE	2	SIMASKO	GAS	2/25/79
92	50883100120000	COOK INLET ST 17589	1	AMOCO	P&A-G	9/14/64
93	50883100160000	COOK INLET ST 17591	1	AMOCO	P&A	8/22/67
94	50883100170000	COOK INLET ST 18740	1	AMOCO	P&A-G	11/10/65
95	50883200840000	SUNFISH	1	ARCO	P&A-OC	11/5/91
96	50883100150000	COOK INLET ST 18741	2	AMOCO	P&A-G	7/8/66

Exploratory drillholes in Central (Interior) Alaska

Map Number	Permit Number	Area	Latitude	Longitude	Township		Range		Section number	Meridian	Bottomhole latitude
					No.	Direc-tion	No.	Direc-tion			
65		CI	61.1975	150.9681	13	N	9	W	19	SEWARD	
66		CI	61.1859	151.1772	13	N	11	W	25	SEWARD	
67	720016	CI	61.1788	151.0395	13	N	10	W	34	SEWARD	
68		CI	61.1770	151.0281	13	N	10	W	35	SEWARD	
69		CI	61.1702	150.0514	13	N	4	W	31	SEWARD	
70		CI	61.1632	151.2133	12	N	11	W	3	SEWARD	
71		CI	61.1452	149.9941	13	N	3	W	0	SEWARD	
72		CI	61.1448	151.2763	12	N	11	W	8	SEWARD	
73		CI	61.1433	151.2894	12	N	11	W	7	SEWARD	
74		CI	61.1395	149.9830	12	N	4	W	9	SEWARD	61.1380
75		CI	61.1364	151.3734	12	N	12	W	15	SEWARD	
76		CI	61.1037	150.9148	12	N	9	W	29	SEWARD	0.0000
77		CI	61.0980	150.3882	12	N	6	W	29	SEWARD	
78		CI	61.0967	151.4752	12	N	12	W	30	SEWARD	
79	790020	CI	61.0846	151.2864	12	N	11	W	31	SEWARD	
80		CI	61.0835	151.3227	12	N	12	W	36	SEWARD	
81		CI	61.0831	151.4307	12	N	12	W	32	SEWARD	61.0829
82		CI	61.0814	151.3163	12	N	12	W	36	SEWARD	
83	920106	CI	61.0768	150.9491	11	N	9	W	6	SEWARD	61.0861
84	930203	CI	61.0768	150.9490	11	N	9	W	6	SEWARD	61.0921
85	970115	CI	61.0768	150.9490	11	N	9	W	6	SEWARD	61.0555
86		CI	61.0768	150.9493	11	N	9	W	6	SEWARD	61.0691
87		CI	61.0745	151.2534	11	N	11	W	5	SEWARD	
88		CI	61.0737	151.3188	11	N	12	W	1	SEWARD	61.0743
89		CI	61.0710	151.3064	11	N	11	W	6	SEWARD	61.0705
90		CI	61.0692	150.9434	11	N	9	W	6	SEWARD	
91		CI	61.0679	151.3208	11	N	12	W	1	SEWARD	
92		CI	61.0677	150.9522	11	N	9	W	6	SEWARD	
93		CI	61.0666	151.0176	11	N	10	W	3	SEWARD	61.0800
94		CI	61.0641	150.9878	11	N	10	W	11	SEWARD	
95	910055	CI	61.0622	150.9723	11	N	10	W	12	SEWARD	61.0628
96		CI	61.0613	150.9165	11	N	9	W	8	SEWARD	

Map Number	Bottomhole longitude	Bottomhole Township		Bottomhole Range		Bh. Section	Total depth
		No.	Direc-tion	No.	Direc-tion		
65							14948
66							6063
67							6505
68							16428
69							4744
70							13773
71							300
72							12500
73							9152
74	149.9751	12	N	4	W	10	11566
75							10717
76	0.0000	12	N	9	W	29	14850
77							14237
78							7459
79							10852
80							8015
81	151.4340	12	N	12	W	32	11097
82							6166
83	150.9882	12	N	10	W	35	17318
84	150.9468	12	N	9	W	31	14705
85	150.9357	11	N	9	W	7	15500
86	150.9473	11	N	9	W	6	14910
87							13600
88	151.3162	11	N	12	W	1	11364
89	151.3127	11	N	12	W	1	13115
90							12676
91							6727
92							12237
93	151.0420	11	N	10	W	3	14000
94							6182
95	150.9699	11	N	10	W	12	13285
96							6015

Exploratory drillholes in Central (Interior) Alaska

Map Number	API Number	Well Name	Well Number	Operator Name	Status	Completion Date
97	50883200050000	TURNAGAIN ARM	1	AMOCO	P&A	7/17/67
98	50283200340000	WEST TYONEK	1	MOBIL	P&A	1/1/71
99	50883100140000	COOK INLET ST 18741	1	AMOCO	P&A-G	11/21/65
100	50283200170000	MOQUAWKIE	44-8	SOCAL	P&A-O	2/19/69
101	50283200070000	TYONEK RESERVE-B	1	HUMBLE	P&A	1/30/68
102	50883200850000	N FORELAND STATE	1	ARCO	P&A-OC	11/20/92
103	50283200660000	SIMPCO KALDACHABUNA	1	SIMASKO	P&A	11/30/80
104	50283200010000	COTTONWOOD	1	SHELL	P&A	2/10/67
105	50283100290000	TYONEK	1	AMOCO	P&A-G	7/25/63
106	50283200030000	NICOLAI CREEK	3	TEXACO	SUSP-G	5/4/67
107	50283200360000	NICOLAI CREEK	5	TEXACO	P&A-G	3/7/72
108	50283200060000	ALBERT KALOA	1	PAN AM	P&A-G	1/4/68
109	50283100280000	TYONEK	2	AMOCO	P&A	6/24/64
110	50283200580000	SIMPCO KALOA	1	SIMASKO	SUSP-G	7/21/78
111	50283200330101	NICOLAI CREEK UNIT	4	UNOCAL	P&A	9/9/91
112	50283200330000	NICOLAI CREEK	4	TEXACO	P&A-O	12/7/70
113	50283200640000	NICOLAI CREEK	6	TEXACO	P&A-G	2/7/80
114	50283100200000	NICOLAI CREEK	1	TEXACO	P&A-G	3/11/66
115	50283100200101	NICOLAI CREEK	1A	TEXACO	SUSP-G	5/2/66
116	50883100300000	TYONEK	2	AMOCO	P&A-OG	10/17/65
117	50883100020000	TYONEK ST 17588	1	PAN AM	P&A-OG	8/10/66

Exploratory drillholes in Central (Interior) Alaska

Map Number	Permit Number	Area	Latitude	Longitude	Township		Range		Section number	Meridian	Bottomhole latitude
					No.	Direc-tion	No.	Direc-tion			
97		CI	61.0569	150.1682	11	N	5	W	9	SEWARD	
98		CI	61.0546	151.4706	11	N	12	W	7	SEWARD	
99		CI	61.0533	150.9075	11	N	9	W	8	SEWARD	
100		CI	61.0527	151.2569	11	N	11	W	8	SEWARD	
101		CI	61.0479	151.2874	11	N	11	W	18	SEWARD	
102	920025	CI	61.0452	150.9771	11	N	10	W	13	SEWARD	
103		CI	61.0415	151.2721	11	N	11	W	17	SEWARD	61.0393
104		CI	61.0407	151.6752	11	N	14	W	13	SEWARD	
105		CI	61.0399	151.2696	11	N	11	W	17	SEWARD	61.0338
106		CI	61.0316	151.4486	11	N	12	W	20	SEWARD	
107	710030	CI	61.0309	151.4668	11	N	12	W	19	SEWARD	
108		CI	61.0197	151.3484	11	N	12	W	26	SEWARD	61.0184
109		CI	61.0178	151.3284	11	N	12	W	25	SEWARD	61.0170
110		CI	61.0159	151.3502	11	N	12	W	26	SEWARD	61.0161
111	910100	CI	61.0140	151.4299	11	N	12	W	29	SEWARD	61.0054
112		CI	61.0140	151.4299	11	N	12	W	29	SEWARD	61.0054
113	790061	CI	61.0136	151.4563	11	N	12	W	29	SEWARD	61.0047
114	650027	CI	61.0135	151.4568	11	N	12	W	29	SEWARD	61.0082
115	660008	CI	61.0135	151.4568	11	N	12	W	29	SEWARD	61.0109
116		CI	61.0135	151.2842	11	N	11	W	30	SEWARD	
117		CI	61.0099	151.2469	11	N	11	W	28	SEWARD	61.0198

Map Number	Bottomhole longitude	Bottomhole Township		Bottomhole Range		Bh. Section	Total depth
		No.	Direc-tion	No.	Direc-tion		
97							6325
98							6646
99							6030
100							12505
101							15600
102							17770
103	151.2701	11	N	11	W	17	12976
104							4268
105	151.2647	11	N	11	W	20	13079
106							8841
107							8578
108	151.3464	11	N	12	W	26	13600
109	151.3153	11	N	12	W	25	12588
110	151.3416	11	N	12	W	26	10281
111	151.4450	11	N	12	W	32	12744
112	151.4451	11	N	12	W	32	12744
113	151.4588	11	N	12	W	31	11776
114	151.4627	11	N	12	W	30	8338
115	151.4595	11	N	12	W	30	9302
116							12335
117	151.2501	11	N	11	W	28	13523