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Geologic Map of the Yukon-Koyukuk Basin, Alaska

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Pamphlet to accompany

Scientific Investigations Map 2909

Pinnacles of Cretaceous conglomerate (map unit Kmc) in Waring Mountains on northern margin of the Yukon-Koyukuk Basin.

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Contents

Introduction

This map and accompanying digital files represent part of a systematic effort to release geologic data for the United States in a uniform manner. All the geologic data in this series will be published as parts of the U.S. Geological Survey Data Series. The geologic data in this series have been compiled from a wide variety of sources, ranging from state and regional geologic maps to large-scale field mapping. The data are presented for use at a nominal scale of 1:500,000, although individual datasets may contain data suitable for use at larger scales. The metadata associated with each release will provide more detailed information on sources and appropriate scales for use. Associated attribute databases accompany the spatial database of the geology and are uniformly structured for ease in developing regional- and national-scale maps.

The 1:500,000-scale geologic map of the Yukon-Koyukuk Basin, Alaska, covers more than 200,000 square kilometers of western Alaska or nearly 15 percent of the total land area of the state (fig. 1). It stretches from the Brooks Range on the north to the Kuskokwim River and lower reaches of the Yukon River on the south and from Kotzebue Sound, Seward Peninsula, and Norton Sound on the west to the Yukon-Tanana Uplands and Tanana-Kuskokwim Lowlands on the east. It includes not only the northern and central part of the basin, but also the lands that border the basin. The area is characterized by isolated clusters of hills and low mountain ranges separated by broad alluviated interior and coastal lowlands. Most of the lowlands, except those bordering Kotzebue Sound and Norton Sound, support a heavy vegetation cover. Exposures of bedrock are generally limited to rubble-strewn ridgetops and to cutbanks along the rivers.

The map of the Yukon-Koyukuk Basin was prepared largely from geologic field data collected between 1953 and 1988 by the U.S. Geological Survey and published as 1:250,000-scale geologic quadrangle maps. Additional data for parts of the Wiseman, Ruby, Medfra, and Ophir quadrangles came from 1:63,360-scale quadrangle maps published by the Alaska Division of Geological and Geophysical Surveys. The map also incorporates some unpublished field data for the Ruby quadrangle collected by R.M. Chapman between 1944 and 1977 and for parts of the Tanana, Bettles, Norton Bay, and Candle quadrangles collected by W.W. Patton, Jr. and others between 1954 and 1985. Sources of geologic map data for each of the eighteen 1:250,000-scale quadrangles used in compiling this 1:500,000-scale map of the Yukon-Koyukuk Basin as well as sources of general geologic information pertaining to the entire map area are provided in the "Sources of Information" section.

Geology

The map units are divided into overlap assemblages and lithotectonic terranes. The overlap assemblages are composed of undeformed to highly deformed sedimentary, volcanic, and plutonic rocks that range in age from late Early Cretaceous to Holocene and unconformably overlie or intrude the lithotectonic terranes. The lithotectonic terranes range in age from Proterozoic to Early Cretaceous and consist of complexly deformed displaced fragments of an ancient continental margin (Seward, Arctic Alaska, Ruby, Nixon Fork, and Minchumina terranes) and displaced fragments of island-arc and oceanic rocks (Koyukuk, Angayucham-Tozitna, and Innoko terranes) that were accreted to the continental margin by the Early Cretaceous (Patton and others, 1994).

Overlap Assemblages

Sedimentary Rocks

Surficial Deposits

Coastal and interior lowlands occupy more than half the map area and are mantled by thick deposits of water-laid and windblown silt, fine sand, and gravel (units Qf, Qua, and Qs). The heavy cover of surficial deposits in the Koyukuk Flats and Nowitna and Innoko Lowlands appears to have been transported into the area during the Pleistocene and Holocene along the valleys of the Yukon and Koyukuk Rivers from glaciated areas in the Brooks Range and Alaska Range (Wahrhaftig, 1965). Discontinuous areas of glacial drift (unit QTgl), which were deposited by piedmont glaciers that emanated from the Brooks Range during the Pliocene(?) and Pleistocene, extend as much as 160 kilometers south of the range front. The surficial deposits include two fields of active and recently stabilized sand dunes (unit Qsa): the Great Kobuk Sand Dunes and the Little Kobuk Sand Dunes in the Ambler River and Baird Mountains quadrangles and the Nogahabara Sand Dunes in the Kateel River quadrangle. Included in the list of surficial deposits are high-level quartz gravels (unit QTgr) in the southeastern corner of the Bettles quadrangle and northeastern corner of the Tanana quadrangle. Also included are a few very small poorly consolidated nonmarine deposits of Tertiary age (unit Ts) scattered along the Kaltag Fault in the Unalakleet, Norton Bay, and Melozitna quadrangles, in the Tozitna River Valley in the Tanana quadrangle, and along an unnamed east-trending fault in the southern Selawik quadrangle.

Yukon-Koyukuk Basin

The Cretaceous sedimentary rocks filling the Yukon-Koyukuk Basin are divided into three broad groups based on their depositional environment: deltaic, submarine fan, and marginal shelf and slope deposits (Patton and others, 1994) (fig. 2, sheet 2).

The deltaic deposits consist of nonmarine fluvial and delta-plain deposits (units Ks and Kms) that grade downward and northwestward into shallow-marine deposits. On the northwest these nonmarine and shallow water deposits are faulted against deeper water prodelta deposits (unit Kcs), which in turn are in thrust contact on the northwest with the submarine fan deposits.

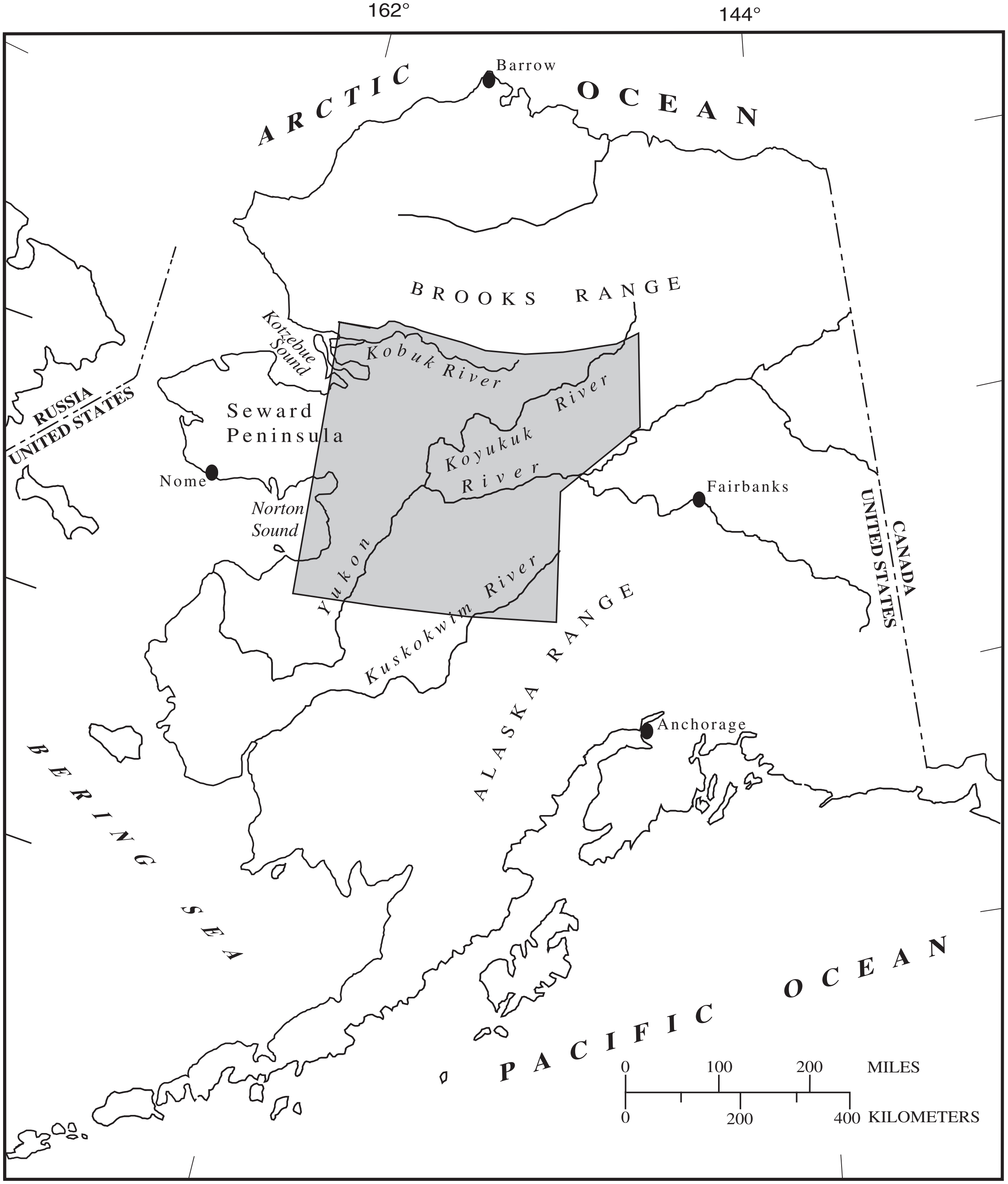

Figure 1. Index map showing location of Yukon-Koyukuk Basin map area, Alaska. Gray area denotes location of map.

The submarine fan deposits (units Kcg. Kcvg, and, Kvg) consist of midfan channel, midfan lobe, and outer fan to basin plain turbidites. Volcanic-clast turbidite deposits (unit Kvg) extend over much of the basin and are composed predominately of mafic and intermediate volcanic and chert debris derived from the volcanic-arc rocks of the Koyukuk terrane that underlie the basin and from the oceanic rocks of the Angayucham-Tozitna terrane that rim the basin. On the west side of the basin, in the Selawik, Candle, and Norton Bay quadrangles, the submarine fan deposits of units Kcg, and Kcvg contain, in addition to volcanic and chert debris, notable amounts of carbonate rock and schist detritus derived from the Seward and western Arctic Alaska terranes.

The marginal shelf and slope deposits (units Kcc, Kvc, Kqc, and Kmc) are scattered around the rim of the basin and had their source in the rocks of the adjoining Seward, Arctic Alaska, Ruby, Angayucham-Tozitna, and Koyukuk terranes. In the Candle and Norton Bay quadrangles at the western edge of the basin they consist of (1) a lower unit (Kvc) of debris flow and alluvial fan coarse clastic deposits containing volcanic rock debris from the underlying Koyukuk terrane and granitic rock debris from the plutons that intrude the Koyukuk terrane and, (2) an upper unit (Kcc) of nonmarine and shallow-water coarse clastic deposits dominated by carbonate rock debris derived from the adjoining Seward terrane. Along the northern and southeastern margins of the basin, the marginal shelf and slope deposits consist of (1) a lower coarse conglomerate (unit Kmc) composed of poorly sorted clasts of mafic volcanic and intrusive rocks and chert derived chiefly from the Angayucham-Tozitna terrane and, (2) an upper coarse conglomerate (unit Kqc) containing abundant quartz and metagraywacke debris eroded from the Arctic Alaska and Ruby terranes.

Kuskokwim Basin

Cretaceous sedimentary rocks in the Ophir and Medfra quadrangles represent the northeastern tip of the Kuskokwim Basin, a large sedimentary trough that extends southwestward to Bristol Bay. Most of these basinal deposits are poorly exposed and assigned to an undivided unit (Ksu) of shale, siltstone, and sandstone. An exception occurs in the southwestern Medfra quadrangle where a broad open syncline exposes a shallow-marine fossiliferous sandstone and shale unit (Kss) that grades upward into a fluvial sandstone and conglomerate unit (Ksc) that contains abundant plant fossils and freshwater mollusks.

Volcanic and Hypabyssal Rocks

Volcanic and associated hypabyssal rocks are widely distributed in the map area. They are divided into four age groups—late Tertiary and Quaternary, early Tertiary, Late Cretaceous and early Tertiary, and Late Cretaceous. Where possible, they are further divided by composition into units composed predominately of basalt, andesite and basalt, or dacite and rhyolite. The late Tertiary and Quaternary age group (units Qtb, Qab, and QTb) includes two large basalt fields along the west side of the map area in the Unalakleet, Candle, and Selawik quadrangles. The two fields are part of the Bering Sea basalt province, which extends westward and southward across the Seward Peninsula and Yukon River Delta to the islands of the Bering Sea (Moll-Stalcup and others, 1994). The early Tertiary age group (units Tb, Ta, Td, Tad, Thr, and Tt) is exposed in several large volcanic fields west of the Yukon River in the Unalakleet, Norton Bay, and Nulato quadrangles and along a northeast-trending belt that stretches from the southwestern Melozitna quadrangle to the southern Bettles quadrangle. The Late Cretaceous and early Tertiary age group (units TKa, TKd, TKad, TKi, and TKvc) forms several large volcanic fields and numerous smaller bodies that are widely distributed throughout the southern part of the map area. Also assigned to this group in the Unalakleet, Norton Bay, Nulato, and Ruby quadrangles are domal complexes (unit TKic) composed of a network of small closely spaced subvolcanic bodies that have intruded and altered Cretaceous sedimentary rocks of the Yukon-Koyukuk Basin. The Late Cretaceous age group of volcanic rocks (unit Krd) is confined to the south-central and southwestern parts of the Shungnak quadrangle.

Plutonic Rocks

The plutonic rocks are divided by age into five groups: early Tertiary, Late Cretaceous and early Tertiary, Late Cretaceous, Early Cretaceous, and Cretaceous(?) (fig. 3, sheet 2). Where possible they are further subdivided compositionally into three units composed chiefly of granite; granite and granodiorite; and syenite, monzonite, and nepheline syenite. The early Tertiary group (unit Tg) is represented by a single stock in the Blackburn Hills in the Unalakleet quadrangle (fig. 3, sheet 2). The Late Cretaceous and early Tertiary group (units TKg and TKm) is confined to the Ophir, Medfra, and Ruby quadrangles. The Late Cretaceous group forms several large plutons (units Kgd and Ksm) in the Shungnak, Hughes, and Melozitna quadrangles and a small stock at Christmas Mountain in the Norton Bay quadrangle (fig. 3, sheet 2). The Early Cretaceous group (units Kgr, Ksy, and Knsy) is distributed in two widely separated belts—an eastern belt that extends along the southeast margin of the Yukon-Koyukuk Basin from the northeastern Bettles quadrangle to the southwestern Nulato quadrangle and a western belt that can be traced from the Shungnak quadrangle westward through the Selawik quadrangle and southward into the Candle quadrangle. The plutons of the eastern belt are composed predominantly of granite and granodiorite (unit Kgr). By contrast, the plutons of the western belt, many of which are composite bodies, consist of granite and granodiorite (unit Kgr), syenite and monzonite (unit Ksy) and locally small bodies of nepheline syenite (unit Knsy). Kgu, the last on the list of plutonic rock units, is represented by two small plutons of uncertain but probable Cretaceous age—one in the north-central Hughes quadrangle and the other in the northwestern Kateel River quadrangle (fig. 3, sheet 2).

Lithotectonic Terranes

Koyukuk Terrane

The Koyukuk terrane underlies a large part of the Yukon-Koyukuk Basin and is widely exposed on a broad structural high that separates the Lower Yukon subbasin from the Kobuk-Koyukuk subbasin (figs. 4, 5*A*, sheet 2). The terrane is composed of three different lithologic assemblages from top to bottom: (1) intermediate and mafic volcanic rocks (units Kft, Ktg, Kbd, and Kv), (2) trondhjemite-tonalite plutonic rocks (unit Jgt), and (3) mafic-ultramafic complexes (unit MzPzum). The three lithologic assemblages probably represent different levels of an ancient volcanic arc (Patton, 1993). While most exposures of the Koyukuk terrane lie within the borders of the Yukon-Koyukuk Basin, allochthonous bodies composed chiefly of the mafic-ultramafic complex unit occur outside the basin in the Ambler River, Bettles, Tanana, and Nulato, quadrangles and one tiny body in the southwestern Candle quadrangle (fig. 5*A*, sheet 2). Also, assigned to this unit is a mafic-ultramafic complex spatially associated with units Pzcr and PzⱣsr of the Ruby terrane in the south-central part of the Ophir quadrangle. This complex is presumed to occupy a structural window within the overthrust Innoko terrane.

Mélange

A mélange (unit KJm) is mapped locally along the faulted contact between the Angayucham-Tozitna terrane and the Arctic Alaska and Ruby terranes. It probably formed during the Jurassic or Early Cretaceous and consists of randomly oriented blocks of carbonate rocks, chert, metagraywacke, and altered mafic igneous rocks in a phyllite matrix.

Angayucham-Tozitna Terrane

The Angayucham-Tozitna terrane is an assemblage of rocks that range in age from Devonian to Jurassic. The terrane is widely exposed around the rim of the Yukon-Koyukuk Basin where it dips inward beneath the basin sedimentary rocks and is faulted outward against the continental margin rocks of the Arctic Alaska, Ruby, and Seward terranes (fig. 5*B*, sheet 2). It also occurs within the Ruby terrane as large synformal klippen and on a structural high within the Yukon-Koyukuk Basin in the south-central part of the Unalakleet quadrangle. The terrane is made up of two separate thrust fault panels: a structurally higher panel (unit JDv) composed of altered basalt, gabbro, chert, argillaceous rocks, tuff, graywacke and carbonate rocks and a structurally lower panel (unit MzPzq) composed of quartzite (metachert), carbonate rocks, and phyllite.

Innoko Terrane

The Innoko terrane lies south of the Poorman Fault and consists of a poorly exposed belt of late Paleozoic to Early Cretaceous(?) oceanic and volcanic-arc rocks that extends from the southwestern corner of the Ruby quadrangle through northwestern Medfra quadrangle, eastern Ophir quadrangle, and into the adjoining Iditarod quadrangle south of the map area (fig. 5*C*, sheet 2). The Innoko terrane consists of five map units: two (Kgc and JMc) are arc-related and composed of clastic rocks made up chiefly of first- and second-cycle volcanic rock debris, and three (TRMbc, TRMg, and TRDc) are composed of a mixture of arc and oceanic deposits including radiolarian chert, limestone, volcanic-rich sedimentary rocks, and basalt flows.

Nixon Fork Terrane

The Nixon Fork terrane, a continental margin assemblage, is confined to the southeastern part of the map area south of the Poorman Fault in the Ruby and Medfra quadrangles (fig. 5*C*, sheet 2). It consists of nine map units divided into three stratigraphic packages separated by unconformities: (1) an upper package (units Kqs, TRs, and Ps) composed of terrigenous shallow-marine sedimentary rocks consisting largely of quartz and carbonate debris eroded from the underlying carbonate and metamorphic rocks, (2) a middle package (units DSw, DSp, and Ont) of shelf carbonate rocks, and (3) a lower package (units Ᵽv, Ᵽc, and Ᵽs) consisting of a greenschist metamorphic facies assemblage of pelitic- and calc-schists, greenstone, and minor felsic plutonic rocks locally capped by felsic metavolcanic rocks. The Nixon Fork terrane is distiguished from the continental margin assemblages of the Ruby, Arctic Alaska, and Seward terranes by its lack of a Jurassic and Early Cretaceous metamorphic overprint.

Minchumina Terrane

The Minchumina terrane occupies a small area in the eastern part of the Medfra quadrangle and the southeastern corner of the Ruby quadrangle (fig. 5*C*, sheet 2). It is composed of two subterranes, the East Fork and the Telida. The East Fork subterrane is made up entirely of the East Fork Formation, a Cambrian to Devonian limestone turbidite assemblage (unit D€ef) representing a deep-water facies of the shelf carbonate rocks in the Nixon Fork terrane. The Telida subterrane consists of an Ordovician unit (Oc) of turbiditic deep-water chert, argillite, limestone, and dolomite and a Proterozoic(?) and early Paleozoic unit (PzⱣq) of quartzite, grit, argillite, and quartz-mica schist. Most of the Minchumina terrane lies south of the Iditarod Fault but several small exposures are found north of the fault (fig. 5*C*, sheet 2). Emplacement of these small fragments within the Nixon Fork terrane may be the result of strike-slip and (or) thrust faulting along splays of the Iditarod Fault (Dumoulin and others, 1997).

Ruby, Seward, and Arctic Alaska Terranes

The Ruby, Seward, and Arctic Alaska terranes form the borderlands of the Yukon-Koyukuk Basin (fig. 5*D*, sheet 2).

Gross similarities in their composition suggest that prior to the late Mesozoic they formed aligned segments of the North American(?) continental margin. Their present configuration probably is the result of severe deformation by oroclinal bending and strike-slip and extensional faulting in the late Mesozoic and Cenozoic (Patton and others, 1994). All three terranes within the map area are composed of similar pelitic schist, calc-schist, and quartzite units (PzPsr, PzPss, and PzPsa), carbonate rock units (Pzcr, Pzcs, and Pzca), and metabasite units (MzPzmr, MzPzms, and MzPzma). The Ruby and Arctic Alaska terranes also include similar granite gneiss units (Dgnr and Dgna) and phyllite units (Pzpr, and Pzpa). All of the pre-Late Cretaceous rocks in these three terrane were regionally metamorphosed in late Mesozoic time to greenschist-facies assemblages and locally to high-pressure greenschist-blueschist- and amphibolite-facies assemblages.

The Ruby terrane forms the core of a broad pre-mid-Cretaceous uplift that trends diagonally across the map area along the southeast side of the Yukon-Koyukuk Basin (Silberling and others, 1994) (fig. 5*D*, sheet 2). The terrane is cut off at the northeast end by the Kobuk Fault and at the southwest end by the Poorman Fault. Three small bodies, tentatively assigned to the Ruby terrane, lying south of the Poorman Fault in the Ophir quadrangle are interpreted to occupy structural windows in an overlying thrust sheet of Innoko terrane. The rocks of the Ruby terrane are widely intruded and thermally altered by Cretaceous granitic plutons of unit Kgr.

The Seward terrane borders the west side of the Yukon-Koyukuk Basin and extends westward beyond the map area to include much of the Seward Peninsula (Silberling and others, 1994). Only a narrow slice of this terrane stretching from Norton Bay north to Eschscholtz Bay occurs within in map area (fig. 5*D*, sheet 2).

The Arctic Alaska terrane extends along the northern edge of the Yukon-Koyukuk Basin from the west edge of the map area to the upper reaches of the Koyukuk River (fig. 5*D*, sheet 2). The terrane forms a broad band that encompasses most of the Brooks Range (Silberling and others, 1994), but only the southernmost edge is included in the map area. The Arctic Alaska terrane is separated from the Yukon-Koyukuk Basin by a complex zone of east-west high-angle faults including the Kobuk Fault, a strike-slip fault of probable large-scale dextral displacement (fig. 5*D*, sheet 2).

Structure

Yukon-Koyukuk Basin

More than half the map area is occupied by the Yukon-Koyukuk Basin, a large wedge-shaped depression filled with mid- and Late Cretaceous sedimentary rocks that are divided into the Kobuk-Koyukuk and the Lower Yukon subbasins (fig. 4, sheet 2) (Patton and others, 1994). The two subbasins are separated by a structural high that exposes Middle Jurassic to Early Cretaceous volcanic-arc rocks of the Koyukuk terrane. The volcanic-arc rocks are also exposed on smaller structural highs within the two subbasins.

The structure of the Cretaceous sedimentary rocks is exceedingly complex as a result of strong compression at the end of the Cretaceous. Tightly appressed folds and numerous closely spaced high-angle faults are characteristic throughout the basin. In addition, juxtaposition of belts of dissimilar sedimentary facies suggests that large-scale horizontal foreshortening by thrust faulting occurred as an early phase of the deformation and was later overprinted by the pervasive high-angle faulting. The intense phase of deformation was completed by the beginning of the Tertiary and thereafter deformation was confined to broad open-folding and regional strike-slip faulting.

Borderland Terranes

The Yukon-Koyukuk Basin is bordered by the Ruby, Seward, and Arctic Alaska terranes, which in the Jurassic and Early Cretaceous were overthrust by the Angayucham-Tozitna and Koyukuk terranes and subjected to greenschist-, blueschist-greenschist-, and amphibolite-facies metamorphism. The three borderland terranes are interpreted to represent parts of the former North American? continental margin that were subducted beneath the oceanic and volcanic arc rocks of the Angayucham-Tozitna and Koyukuk terranes in the Jurassic and Early Cretaceous (Patton and others, 1994). Following subduction, the borderland terranes underwent a complex structural history of uplift, extensional faulting, and, in the Ruby terrane, widespread intrusion by late Early Cretaceous plutonic rocks.

Terranes South of Poorman Fault

The three terranes south of the Poorman Fault (Innoko, Nixon Fork, and Minchumina) and the overlapping Cretaceous sedimentary rocks of the Kuskokwim Basin were complexly folded and faulted by the same Late Cretaceous deformation that affected the rocks north of the Poorman Fault. However, none of these three terranes appears to have undergone the Jurassic and Early Cretaceous metamorphic event that occurred in the terranes bordering the Yukon-Koyukuk Basin. The Proterozoic strata at the base of the Nixon Fork terrane were regionally metamorphosed to a greenschist-facies assemblage, presumably in latest Proterozoic or earliest Paleozoic. It is uncertain if any of the terranes north of the Poorman Fault were affected by the same metamorphic event.

Strike-slip Faults

The map area is transected by four major strike-slip fault systems: Kobuk, Kaltag, Iditarod, and Poorman (figs. 2, 3, 4, and 5, sheet 2). Field evidence suggests that dominant movement on the first three faults was right-lateral; the direction of displacement on the Poorman Fault is uncertain.

The Kobuk Fault extends across the northern tier of quadrangles from the Kobuk River Delta to beyond the eastern edge of the map area. In places it is represented by a broad zone as much as 32 kilometers wide of parallel strands and splays. At the western end, the fault appears to dextrally offset the margin of the Yukon-Koyukuk Basin a minimum of 32 kilometers. To the east the course of the fault along the Kobuk River Valley is marked by prominent lineaments cutting the Quaternary glacial and alluvial deposits. At the eastern border of the map area, the fault forms the structural boundary between the northeast-trending Ruby terrane and the east-trending Arctic Alaska terrane. East of the map area, Avé Lallemant and others (1998) found evidence of possibly as much as 80 kilometers of dextral offset on the fault.

The Kaltag Fault can be traced from Norton Sound to near the eastern edge of the map area. Profound lithologic and structural discontinuites in the bedrock are evident along its entire length (Patton and Hoare, 1968). Where the fault traverses the Koyukuk Flats its course is marked by prominent lineaments cutting the Quaternary surficial deposits. Dextral strike-slip movement of approximately 130 kilometers is indicated by offset of the eastern boundary of the Yukon-Koyukuk Basin and by offset of the Kobuk-Koyukuk and Lower Yukon subbasins (fig. 4, sheet 2).

The Iditarod Fault traces southwesterly across the Medfra quadrangle and into the adjoining McGrath and Iditarod quadrangles south of the map area. In the Medfra quadrangle it consists of several parallel strands that for most of their lengths separate the deep-water deposits of the Minchumina terrane from the shallow-water deposits of the Nixon Fork terrane. Evidence of strike-slip displacement in the Medfra quadrangle is ambiguous, but to the southwest in the Iditarod quadrangle, Miller and Bundtzen (1988) documented approximately 88 kilometers of dextral offset based on lateral separation of similar sections of Late Cretaceous and early Tertiary volcanic rocks.

The Poorman Fault has been mapped from the eastern border of the map area southwest across the Ruby quadrangle and the northwest corner of the Medfra quadrangle to the Innoko Lowlands in the central Ophir quadrangle. Its presence is inferred largely from the juxtaposition of Angayucham-Tozitna and Ruby terranes on the northwest with Innoko and Nixon Fork terranes on the southeast. A notable difference across the fault is the presence of a Jurassic and Early Cretaceous regional greenschist-facies metamorphic overprint in the Angayucham-Tozitna and Ruby terranes and its absence in the Innoko and Nixon Fork terranes.

DESCRIPTION OF MAP UNITS

OVERLAP ASSEMBLAGES

SEDIMENTARY ROCKS

Surficial Deposits

Qf **Floodplain and tidal flat deposits (Holocene)**

Location and physiographic expression—Deposits occur along floodplains of major drainages and on tidal flats bordering the shores of Selawik Lake, Hotham Inlet, Eschscholtz Bay, Norton Sound, and Norton Bay. Floodplain deposits characterized physiographically by bars, oxbow lakes, meander scrolls, abandoned channels, and other evidence of recent floodplain building

Description—Gravel, sand, silt, and peat. Floodplain deposits in Koyukuk Flats and along Yukon River composed mainly of light gray micaceous silt

Qsa **Actively drifting and recently stabilized dune fields (Holocene)**

Location and physiogrphic expression—Great Kobuk and Little Kobuk Sand Dunes in the southwestern Ambler River and southeastern Baird Mountains quadrangles, and Nogahabara Sand Dunes in the Kateel River quadrangle. The Great Kobuk and Little Kobuk dune fields covering 65 square kilometers and 8 square kilometers, respectively, are composed of parabolic or U-shaped dunes and large transverse dune ridges that locally develop into barchan-like dunes. Wind direction varies from northeast to southeast. The Nogahabara Sand Dunes are characterized by a circular field 8 kilometers in diameter consisting of transverse dunes that migrate outward in wavelike fashion from a deflationary area in the central and western part of the field. The main field is surrounded by smaller circular and elliptical fields of wavelike transverse dunes that have been recently stabilized or partially stabilized by a thin cover of vegetation

Description—Fine- to coarse-grained sand

Qs **Eolian and water-laid sand and silt sheets and stabilized dune fields (Holocene and Pleistocene)**

Location and physiographic expression—Extensive sheets of windblown and associated water-laid deposits are present in three separate locations:

Baird Mountains, Ambler River, Selawik, and Shungnak quadrangles: Modified and partly dissected sheets of mixed windblown and water-laid deposits bordering the south edge of the Brooks Range.

Kateel River and Melozitna quadrangles: Sheet-like dune fields of windblown sand mantling alluvial silt deposits of the Koyukuk Flats. Dunes are much modified and locally dissected by stream erosion. Orientation of parabolic dunes suggest deposition by prevailing northeast winds.

Ruby quadrangle: A broad sheet of wind-blown silt and sand that extends over a wide area in the Nowitna Lowland south of the Yukon River. The sheet is much modified by stream erosion, but parabolic and longitudinal dune forms can be recognized in aerial photographs and on 1:63.360-scale topographic maps. The dune forms have a strong northeast-southwest orientation and suggest deposition by prevailing northeast winds. Small isolated sand sheets also occur in Bettles, Hughes, and Medfra quadrangles.

Description—Sand and coarse silt

Qua **Alluvial, colluvial, glacial, and windblown terrace and slope deposits, undivided (Holocene and Pleistocene)**

Location—Widespread in lowland areas throughout the central and southern parts of the map area

Desciption—Chiefly silt and very fine sand including thick deposits of micaeous silt in the Koyukuk Flats and Nowitna and Innoko Lowlands. Local deposits of alluvial fan and glacial outwash gravels

QTgl **Glacial and glaciolacustrine deposits (Pleistocene and Pliocene?)**

Location—Glacial drift deposits bordering the southern edge of the Brooks Range and extending to the southern edge of the Selawik, Shungnak, Hughes, and Bettles quadrangles. Also includes drift from small Pleistocene alpine glaciers in the Melozitna, Tanana, and Medfra quadrangles

Lithology and physiographic expression—Includes unsorted to poorly sorted till, outwash sand and gravel, alluvium, and eolian deposits. Along the southern edge of Brooks Range, unit is characterized by little-modified middle and late Pleistocene drift including prominent morainal ridges (shown by hachured lines), ice-contact features, and glaciolacustrine deposits. Further south, in Bettles, Hughes, Shungnak, and Selawik quadrangles, unit is composed of discontinuous areas of highly modified drift of Pliocene(?) and early Pleistocene age interspersed with alluvium and eolian deposits. Glacial erratics occur in hilly parts of the central Shungnak and Hughes quadrangles to an elevation of 600 meters. In the Bettles quadrangle the southern margin of the unit consists chiefly of lacustrine sediments deposited from a large proglacial lake

QTgr **Quartz gravel deposits (Quaternary or Tertiary)**

Location—Southeast corner of Bettles quadrangle and northeast corner of Tanana quadrangle

Description—High-level deposits of quartz pebble gravel; overlies basalt flows of unit Tb

Ts **Small deposits of nonmarine conglomerate, sandstone, shale, and coal (Tertiary)**

Location and description—Poorly consolidated nonmarine deposits occur in five areas listed below; the first three are located close to the Kaltag Fault. Pollen samples from these five areas range in age from Oligocene to Pliocene

Unalakleet quadrangle: Clay shale, lignite, and volcanic ash exposed on Norton Sound coast

Norton Bay quadrangle: Small body of coaly mudstone, lignite, poorly consolidated quartz gravel and sandstone exposed on north side of Unalakleet River Valley

Melozitna and Tanana quadrangles: Sandstone, claystone, conglomerate, and lignite exposed on south bank of Yukon River near the border of the Melozitna and Tanana quadrangles and small outcrops on the north side of the Yukon River in the Tanana quadrangle

Tanana quadrangle: Sandstone, shale, coal, and lignite exposed on the Tozitna River and its tributaries in central part of Tanana quadrangle

Selawik quadrangle: Tiny body of gravel and sand along an east-trending fault in southern part of Selawik quadrangle

YUKON-KOYUKUK BASIN

Deltaic deposits (fig. 2, sheet 2)

Ks **Fluvial and shallow marine sandstone and shale, undivided (Cretaceous)**

Location—Unit is widely distributed in the Lower Yukon subbasin (fig. 4, sheet 2). In the Kobuk-Koyukuk subbasin, unit is limited to the northeastern corner of Nulato quadrangle, the northwestern corner of Ruby quadrangle, and the southwestern corner of Melozitna quadrangle

Description—Nonmarine, fluvial, delta-plain deposits that grade downward into marine delta-front deposits. Fluvial deposits are characterized by fine-grained, locally cross-bedded quartzose sandstone interbedded with micaeous shale and siltstone. Near the base, the fluvial beds are composed of fine- to coarse-grained, lenticular, crossbedded, friable sandstone and conglomerate containing pebble- to grit-size clasts of quartz and chert and lesser amounts of mafic intrusive and extrusive rocks, and schist. Contains bituminous coal seams as much as 90 centimeters in thickness. Sandstone composed of quartz, chert, metamorphic detritus, and subordinate amounts of volcanic rock fragments. The quartzose nature of the lithic clasts (including polycrystalline quartz), as well as the relatively high proportions of potassium feldspar and micas suggest a mixed metamorphic and granitic provenance. These data, when combined with limited paleocurrent data, indicate that the unit prograded westward from a source area in the Ruby terrane bordering the southeastern margin of the Yukon-Koyukuk Basin. Nonmarine fluvial deposits contain abundant fresh- and brackish-water mollusks and well-preserved plant remains of Late Cretaceous (Cenomanian and Turonian?) age. Shallow-marine deposits contain abundant molluscan fauna of late Early (Albian) and early Late (Cenomanian) Cretaceous age

Kms **Shallow marine sandstone and shale (Cretaceous)**—Mapped separately along the Yukon River and in a belt to the west extending from the southern edge of the Norton Bay quadrangle to the western Kateel River quadrangle. These deposits compose a marine tongue that underlies the nonmarine fluvial deposits and thickens westward. On the Yukon River, the marine deposits consist of fine- to coarse-grained, crossbedded, lenticular sandstone grading down into fine-grained sandstone and interbedded dark-gray siltstone and shale. In the belt to the west, the marine deposits are composed predominantly of siltstone and shale

Kcs **Offshore calcareous sandstone, siltstone, and shale (Cretaceous)**

Location—Unit extends in an arcuate belt from the southern edge of the Norton Bay quadrangle to the western part of the Kateel River quadrangle

Description—Fine- to coarse-grained, moderately to highly calcareous, turbiditic sandstone interbedded with dark-gray shale and siltstone. The sandstone occurs in beds 50 to 100 centimeters thick grading upward into finely cross-laminated, muscovite-rich siltstone and shale. The bases of sandstone beds commonly are marked by flute casts, ripple marks and rip-up clasts of underlying shale layers along with grit-size grains of quartz and chert. The siltstone and fine-grained sandstone generally contain thin layers of finely comminuted, carbonized plant debris. Calcareous discoidal concretions as much 20 centimeters in diameter are common. The sandstone typically consists of poorly sorted clasts of quartz, chert, feldspar (chiefly plagioclase), muscovite, and carbonate rocks in a carbonate-rich matrix. Carbonate composes as much as 50 percent of the sandstone. Unit contains sparsely distributed ammonites of late Early Cretaceous (Albian) age and is interpreted as a prodelta facies approximately correlative in age with the marine sandstone, siltstone, and shale deltaic deposits of unit Kms

Submarine fan deposits (fig. 2, sheet 2)

Kcg **Carbonate-clast graywacke and mudstone (Cretaceous)**

Location—Central parts of the Norton Bay and Candle quadrangles

Description—Fine-grained to gritty graywacke and laminated micaceous mudstone turbidite deposits composed largely of carbonate detritus and lesser amounts of quartz, chert, volcanic rock, and mica clasts. Contains abundant carbonized plant debris. The mudstone intervals typically display fine convolute cross laminations and current rippled partings. Unit grades from a high graywacke/mudstone ratio on the southwest to a low graywacke/mudstone ratio on the northeast; paleocurrent directions are to the northeast. The abundance of detrital carbonate, quartz, and mica fragments suggest that the unit was derived largely from carbonate rocks and schist units (Pzcs and PzPss) of the Seward terrane. Unit interpreted to represent submarine mid- to outer-fan deposits. A single collection of palynomorphs from the Norton Bay quadrangle is Cretaceous in age, possibly late Early or early Late Cretaceous (Albian or Cenomanian)

Kcvg **Carbonate- and volcanic-clast graywacke and mudstone (Cretaceous)**

Location—Unit forms an arcuate belt extending from the northern edge of the Unalakleet quadrangle to the central part of the Candle quadrangle and underlies a large part of the Waring Mountains in the Selawik and Shungnak quadrangles. Fault-bounded blocks of this unit, altered to calc-silicate and pelitic hornfels, are enclosed in granitic rock units Kgr and Ksy in southern part of the Selawik quadrangle

Description—Cyclically interbedded fine- to coarse-grained highly calcareous graywacke; hard, fine- to medium-grained, carbonaceous, volcanic graywacke; and dark carbonaceous mudstone. Graywacke is typically graded and sole-marked. Carbonized plant debris is abundant. Graywacke/mudstone ratios are generally high. The unit is interpreted to represent middle and outer submarine fan lobe deposits; some locally thick sections of mudstone probably represent basin plain deposits. Paleocurrents are generally to the northeast. Unit appears to be transitional between the carbonate-rich deposits of map unit Kcg and the volcanic-rich deposits of map unit Kvg. Poorly preserved marine mollusks of late Early Cretaceous(?) age are present in this unit in the Selawik quadrangle

Kvg **Volcanic-clast graywacke and mudstone (Cretaceous)**

Location—Unit widely distributed throughout the Yukon-Koyukuk Basin

Description—Hard, fine-grained to conglomeratic, locally tuffaceous, graywacke and dark-gray finely laminated mudstone. The graywacke is composed of matrix-supported clasts of intermediate and mafic volcanic and intrusive rocks and chert. Clasts of quartz and of metamorphic and granitic rocks are present in subordinate amounts. Some of the graywacke beds are characterized by a distinctly mottled appearance owing to the presence of laumontite, most commonly in fine-grained tuffaceous-rich layers. Metamorphic detritus becomes increasingly abundant in upper part of the unit. The graywacke beds display a typical "Bouma" sequence grading from massive at the base to laminated in the middle to cross laminated at the top. Mudstone rip-up clasts are common at the base of the graywacke beds. The unit has a high graywacke/mudstone ratio and is interpreted to represent middle and outer submarine fan deposits. Marine mollusks of late Early Cretaceous (Albian) age were identified in this unit in the Bettles, Hughes, and Kateel River quadrangles

Marginal shelf and slope deposits (fig. 2, sheet 2)

Kcc **Carbonate-clast conglomerate, sandstone, and shale (Cretaceous)**

Location—Unit extensively exposed in western parts of Norton Bay and Candle quadrangles and in a small area in northwestern part of Selawik quadrangle south of Kobuk River

Description—Poorly sorted nonmarine and shallow-water shelf deposits consisting of carbonate-rich conglomerate (calcirudite), sandstone (calcarenite), and shale (calcilutite). Unit contains abundant plant debris and thin seams of bituminous coal. Clast-supported cobble to boulder conglomerate, composed almost entirely of carbonate rocks, grades eastward into trough cross-bedded, medium- to coarse-grained sandstone and pebble conglomerate fan-delta deposits, which in turn grade eastward into cross-bedded, fine- to coarse-grained, inner and outer shelf sandstone and shale. Chert, volcanic rock, quartz, and schist detritus present in subordinate amounts. Unit derived in large part from Paleozoic carbonate rocks (Pzcs) of the Seward terrane. Unit contains sparse palynomorphs of Cretaceous(?) age in the Norton Bay quadrangle

Kvc **Volcanic-clast conglomerate, sandstone, and shale (Cretaceous)**

Location—Unit crops out in the western and central parts of Candle and Norton Bay quadrangles

Description—Massive, poorly stratified pebble to boulder conglomerate, interbedded with dark graywacke and dark finely laminated mudstone. Unit composed of debris flows and alluvial fan deposits. Consists chiefly of andesitic volcanic rock detritus, but locally includes notable amounts of granitic and fine-grained tuffaceous material. Unit overlies volcanic breccia and agglomerate of unit Kv of the Koyukuk terrane and underlies unit Kcc. A granitic clast from conglomerate yielded a K/Ar cooling age of 113 Ma

Kqc **Quartz- and metagraywacke-clast conglomerate, sandstone, and shale (Cretaceous)**

Location—Unit exposed along the northern and southeastern margin of the Yukon-Koyukuk Basin from Baird Mountains and Selawik quadrangles eastward to Wiseman and Bettles quadrangles and southwestward to Melozitna quadrangle

Description—Composed chiefly of well-sorted and well-rounded clasts of white quartz and (or) metagraywacke in a quartzose and micaceous matrix; schist, chert, greenstone, and limestone clasts occur in subordinate amounts. Conglomerate is interbedded with quartzose, cross-bedded sandstone and carbonaceous and micaceous mudstone. Contains rare interbeds of ashy tuff. Plant fossils and thin bituminous coal seams are locally abundant. Unit composed chiefly of debris eroded from the Arctic Alaska and Ruby terranes. Grades downward into unit (Kmc) reflecting the progressive unroofing of the Arctic Alaska and Ruby terranes beneath the Angayucham-Tozitna terrane. Unit is regionally metamorposed to stretched-pebble conglomerate, semischist, and phyllite in northeastern part of Shungak quadrangle and in adjoining parts of Ambler River and Hughes quadrangles. Sparse plant fossil collections from this unit range in age from late Early Cretaceous to Late Cretaceous. A K/Ar isotopic cooling age of 86 Ma was obtained from interbedded ash-fall tuff in Selawik quadrangle

Kmc **Mafic igneous-clast conglomerate, sandstone, and mudstone (Cretaceous)**

Location—Occurs at scattered localities along the northern and southeastern margin of the Yukon-Koyukuk Basin from Baird Mountains and Selawik quadrangles eastward to Wiseman and Bettles quadrangles and then southwestward to Ruby quadrangle

Description—Consists of massive poorly stratified and poorly sorted conglomerate composed of pebble- to cobble-size clasts in a graywacke and mudstone matrix. Clasts predominately mafic intrusive and extrusive rocks, varied colored chert, and locally metagraywacke. Limestone, quartz, and granitic rock clasts present in subordinate amounts. Conglomerate is interbedded with mafic- and calcareous-clast graywacke and mudstone. Unit composed chiefly of debris eroded from the Angayucham-Tozitna terrane. Unit stratigraphically underlies unit Kqc. Contains marine mollusks of Early Cretaceous(?) age in the Selawik quadrangle

KUSKOKWIM BASIN

Ksc **Fluvial and shallow-marine sandstone and conglomerate (Late Cretaceous)**

Location—West-central part of Medfra quadrangle and adjoining parts of Ophir quadrangle

Description—Fine- to coarse-grained, thinly cross-bedded sandstone and quartz-chert pebble conglomerate interbedded with dark shale and siltstone. Sandstone consist of as much as 45 percent quartz and chert clasts, 25 to 60 percent metamorphic and sedimentary rock fragments, and less than 10 percent argillaceous matrix. Non-diagnostic plant fossils and freshwater mollusks are present in abundance. Unit probably represents a prograding delta, which grades upward from nearshore marine deposits of unit Kss into subaerial standline, lagoonal, and coastal plain deposits. Unit stratigraphically overlies unit Kss and is overlain and intruded by Late Cretaceous and early Tertiary volcano-plutonic complexes of unit TKvc

Kss **Shallow-marine sandstone, siltstone, and shale (Late Cretaceous)**

Location—West-central part of Medfra quadrangle and adjoining parts of Ophir quadrangle

Description—Fine- to medium-grained, thinly cross-bedded, fossiliferous sandstone and poorly exposed dark siltstone and shale. Clasts composed of 40 to 45 percent quartz, 45 to 50 percent volcanic and sedimentary lithic fragments, and 5 to 15 percent feldspar, chiefly plagioclase. Clasts set in a finely divided calcareous and argillaceous matrix. Unit deposited in a nearshore marine environment. Unit contains abundant early Late Cretaceous (Cenomanian) species of *Inoceramus*

Ksu **Shale, siltstone, and sandstone, undivided (Cretaceous)**

Location—Central Medfra quadrangle and adjoining parts of southeastern Ophir quadrangle

Description—Chiefly dark carbonaceous, generally nonfossilferous shale, siltstone and fine-grained sandstone. Poorly exposed except where altered to a dark slaty hornfels in the vicinity of plutonic and hypabyssal intrusive rocks. Locally includes a limestone-clast conglomerate in central Medfra quadrangle and several volcaniclastic horizons in Ophir quadrangle. Unit probably correlative in part with unit Kss of Late Cretaceous age, but some beds may be as old as late Early Cretaceous

VOLCANIC AND HYPABYSSAL ROCKS

Qtb **Tholeiitic basalt cones and flows (Holocene? and Pleistocene)**

Location—One large and one small body within large volcanic flow field of unit QTb in the western part of Unalakleet quadrangle

Description—Black glassy olivine tholeiitic basalt flows erupted from two small craters. Flows show well-developed pahoehoe crusts and lack vegetative cover. One K/Ar isotopic determination from this unit gave a cooling age of 0.19 Ma

Qab **Alkalic basalt cones and flows (Pleistocene)**

Location—Widely distributed bodies within large volcanic flow field of unit QTb in western part of Unalakleet quadrangle

Description—Unit comprises numerous alkali basalt, basanite, and hawaiite cones, short flows, and maar craters. Cones and flows have little or no vegetative cover and still preserve some primary flow structures. Locally contains peridotite and pyroxenite xenoliths. Unit was erupted through and stratigraphically overlies unit QTb

QTb **Basalt flows (Pleistocene and Pliocene)**

Location—Large volcanic flow fields in western part of Unalakleet quadrangle and in Candle, Selawik, and Kateel River quadrangles

Description—Vesicular tholeiitic and alkali basalt flows. In Candle and Selawik quadrangles unit includes several alkali basalt cones and flows that contain abundant peridotite inclusions. K/Ar isotopic cooling ages from the volcanic field in western part of Unalakleet quadrangle range from 3.25 Ma to 1.39 Ma

Tb **Basalt flows (Oligocene)**

Location—Small area in southeastern corner of Bettles quadrangle and extending into northeastern Tanana quadrangle

Description—Vesicular and columnar-jointed basalt flows and lahar deposits. Unit yielded a K/Ar cooling age of 32 Ma

Ta **Andesite and basalt lava flows and volcaniclastic rocks (Eocene and Paleocene)**

Location—Forms large volcanic fields on west side of the Yukon River in Unalakleet, Nulato, and Norton Bay quadrangles. Also included in this unit are undated basalt flows scattered along the Koyukuk River in central part of the Kateel River quadrangle

Description—Subaerial, columnar-jointed, andesite and basalt lava flows that locally contain interbedded tuffs, breccias, and agglomerates. Lava flows composed chiefly of pyroxene andesite and less commonly of hornblende-bearing high-silica andesite, olivine-bearing basaltic andesite, and basalt. Upper part of unit locally underlies and is intruded by dacite and rhyolite of unit Td. K/Ar isotopic cooling ages range from 65 to 52 Ma

Td **Dacite and rhyolite lava flows, domes, and volcaniclastic rocks (Eocene and Paleocene)**

Location—Forms large volcanic fields in a belt extending from central part of Bettles quadrangle to southwestern part of Melozitna quadrangle. Elsewhere unit is limited to small widely distributed bodies, some of which overlie or intrude unit Ta

Description—Finely banded dacitic and rhyolitic lava flows, basal breccia, tuffs, obsidian, and hypabyssal domal intrusive bodies. Forms a compositionally continuous suite with unit Ta. K/Ar isotopic cooling ages from this unit range from 60 to 40 Ma

Tad **Andesite and basalt lava flows and volcaniclastic rocks (Ta) and dacite and rhyolite lava flows, domes, and volcaniclastic rock (Td), undivided (Eocene and Paleocene)**

Location—Confined to west-central part of Melozitna quadrangle where field data are insufficient to map units Ta and Td separately

Thr **Rhyolite hypabyssal bodies (Eocene or Paleocene)**

Location—Confined to east-central part of Unalakleet quadrangle

Description—Fine-grained porphyritic rhyolite composed of phenocrysts of plagioclase rimmed by orthoclase in a groundmass of plagioclase, orthoclase, quartz, and altered mafic minerals. Unit probably correlates and forms a compositional continuum with a nearby granite stock (unit Tg), which yielded an isotopic K/Ar cooling age of 56 Ma

Tt **Tuff and tuff breccia (Eocene or Paleocene)**

Location—Confined to east-central part of Unalakleet quadrangle

Description—Tuff and breccia are composed of abundant lithic fragments of flow–banded rhyolite and partially welded pumice in a matrix of devitrified glass shards, altered plagioclase, quartz, and mafic minerals. Unit contains subordinate altered andesite and dacite lava flows. Unit appears to cut through unit Ta and is intruded by unit Tg

TKa **Andesite and basalt lava flows and volcaniclastic rocks (early Tertiary and Late Cretaceous)**

Location—Forms a large volcanic field in northwestern part of Medfra quadrangle and south-central part of Ruby quadrangle. Also occurs as small widely scattered bodies in the central and eastern part of Unalakleet quadrangle. Unit is locally interlayered with unit TKd

Description—Columnar-jointed andesite, basaltic andesite, and basalt lava flows. Composed of phenocrysts of plagioclase and pyroxene in a fine-grained groundmass of plagioclase microlites, granular pyroxene, and dark glass. K/Ar isotopic cooling ages range from 64 to 54 Ma

TKd **Dacite and rhyolite lava flows, domes, and volcaniclastic and hypabyssal rocks (early Tertiary and Late Cretaceous)**

Location—Forms a large volcanic field and small domal bodies in Medfra and Ruby quadrangles. Also is sparsely distributed as small flow fields in Unalakleet quadrangle and as small domal bodies in eastern Bettles quadrangle. Unit locally interlayered with unit TKa

Description—Dacite, rhyolite, and trachyandesite lava flows, domes, sills, dikes, and interlayered breccias and tuffs. Composed of phenocrysts of plagioclase, quartz, sanidine, and biotite in a groundmass of quartz and feldspar. Locally in Unalakleet and Medfra quadrangles, tuffs at the base of unit contain interbeds of quartz- chert-pebble conglomerate, sandstone, siltstone, and thin coaly layers with abundant plant fossils. K/Ar isotopic cooling ages for this unit range from 71 to 53 Ma. Palynoflora collected from coaly layers at the base of the unit in Medfra quadrangle are latest Cretaceous (Campanian or Maastrichtian) in age

TKad **Andesite and basalt lava flows and volcaniclastic rocks (TKa) and dacite and rhyolite lava flows, domes, and volcaniclastic and hypabyssal rocks (TKd), undivided (early Tertiary and Late Cretaceous)**

Location—Unalakleet, Ophir, and Medfra quadrangles where field data are insufficient to map units TKa and TKd separately

TKi **Shallow intrusive rocks of silicic and intermediate composition (Tertiary and Late Cretaceous)**

Location—Small bodies scattered throughout map area

Description—Includes a wide variety of shallow intrusive rocks including rhyolite, dacite, trachyte, and andesite plugs, domes, sills, and dikes and larger more coarsely crystalline bodies of granite, granodiorite, tonalite, and monzonite porphyry

TKvc **Volcano-plutonic complexes (early Tertiary and Late Cretaceous)**

Location—Unit forms prominent nearly circular topographic features in southwestern part of Medfra quadrangle and southeastern part of Ophir quadrangle

Description—Complexes composed primarily of altered basalt, andesite, and trachyandesite porphyry lava flows and hypabyssal intrusive bodies. The complexes also contain altered mafic and intermediate crystal and lithic tuffs and subordinate olivine basalt and dacite flows. The flows and hypabyssal rocks are composed of plagioclase and clinopyroxene phenocrysts in a groundmass of fine-grained plagioclase laths, granular pyroxene and dark glass. K/Ar isotopic cooling ages from the unit range from 77 to 65 Ma

TKic **Complexes of shallow intrusive rocks and altered Cretaceous sedimentary rocks of the Yukon-Koyukuk Basin, undivided (early Tertiary and Cretaceous)**

Location—Complexes form broad domal topographic features in Unalakleet quadrangle, in northeastern part of Nulato quadrangle and adjoining parts of the Ruby quadrangle, and in the western part of Norton Bay quadrangle.

Description—Complexes are composed of small, closely spaced rhyolite, dacite, andesite, granite, granodiorite, tonalite, and monzonite porphyry bodies, which intrude Cretaceous sedimentary deposits of the Yukon-Koyukuk Basin. Intrusive bodies are too small and too numerous to be mapped separately. Sedimentary host rocks are altered to an erosion-resistant hornfels. A felsic hypabyssal body belonging to the complex in southwestern part of Unalakleet quadrangle yielded a single K/Ar isotopic cooling age of 69 Ma

Krd **Rhyolite, dacite, and trachyte lava flows and volcaniclastic rocks (Late Cretaceous)**

Location—Unit confined to southwestern and south-central parts of Shungnak quadrangle

Description—Rhyolite, dacite, and trachyte flows and crystal and lithic tuffs, felsic ash-fall tuffs, tuffaceous graywacke, and volcanic conglomerate. One K/Ar isotopic determination from this unit gave a cooling age of 87 Ma

PLUTONIC ROCKS (FIG. 3, SHEET 2)

Tg **Granite (Eocene or Paleocene)**

Location—Forms a stock intruding units Ta and Tt in a large volcanic field in the east-central part of Unalakleet quadrangle

Description—Fine-grained equigranular to sparsely porphyritic granite characterized by plagioclase laths mantled by orthoclase. One K/Ar isotopic determination from this unit yielded a cooling age of 56 Ma

TKg **Granite and granodiorite (early Tertiary and Late Cretaceous)**

Location—Forms small plutonic bodies in Medfra and Ruby quadrangles

Description—Fine- to coarse–grained, equigranular to porphyritic biotite granite and rarely muscovite-biotite granite. K/Ar isotopic cooling ages for this unit range from 71 to 63 Ma

TKm **Monzonite (early Tertiary and Late Cretaceous)**

Location—Forms small plutonic bodies in Medfra and Ophir quadrangles

Description—Medium- to coarse-grained, equigranular biotite and hornblende monzonite, quartz monzonite, monzodiorite, and quartz diorite. Subordinate monzogabbro and gabbro. K/Ar isotopic cooling ages from this unit range from 70 to 66 Ma

Kgd **Granodiorite and granite (Late Cretaceous)**

Location—Forms three large plutons and numerous small plutons in the southern parts of Shungnak and Hughes quadrangles and along a belt that extends diagonally southwestward across the central part of Melozitna quadrangle

Description—Generally fine- to medium-grained equigranular, but locally porphyritic, hornblende-biotite granodiorite, and alaskitic biotite granite. Locally includes tonalite and quartz monzodiorite. K/Ar isotopic cooling ages range from 89 to 78 Ma

Ksm **Syenite and monzonite (Late Cretaceous)**

Location—Confined to one tiny stock in the core of Christmas Mountain in the west-central part of Norton Bay quadrangle

Description—Consists chiefly of hornblende syenite, biotite-hornblende monzonite, and monzodiorite, and lesser amounts of biotite diorite and biotite quartz monzonite. One K/Ar isotopic determination yielded a cooling age of 76 Ma

Kgr **Granite and granodiorite (Early Cretaceous)**

Location—Unit occurs in two separate Early Cretaceous plutonic belts (fig. 3, sheet 2): an eastern belt that extends from northeastern Bettles quadrangle to the southwestern part of Nulato quadrangle and a western belt that can be traced from Shungnak quadrangle westward through Selawik quadrangle and then southward into Candle quadrangle

Description—Unit consists chiefly of biotite and muscovite-biotite granite and granodiorite. K/Ar isotopic cooling ages range from 112 to 96 Ma and two U/Pb zircon analyses give crystallization ages of 112 and 109 Ma

Ksy **Syenite, monzonite, and nepheline syenite (Early Cretaceous)**

Location—Unit occurs in two separate Early Cretaceous plutonic belts (fig. 3, sheet 2): a western belt that can be traced from Shungnak quadrangle westward through Selawik quadrangle and southward into the Candle quadrangle and an eastern belt that extends from the northeastern part of Bettles quadrangle to southwestern part of the Nulato quadrangle. Unit is widespread in the western belt, but is confined to a single composite pluton at the northeastern end of the eastern belt

Description—Unit composed of syenite, monzonite, and subordinate quartz monzonite, monzodiorite, quartz syenite, and nepheline syenite and related mafic alkaline rocks including malignite, ijolite, shonkinite, and pyroxenite. K/Ar isotopic cooling ages from units Ksy and Knsy range from 113 to 99 Ma

Knsy **Bodies of nepheline syenite and related rocks** large enough to be shown separately on the map

Kgu **Granitic rocks of uncertain affinity (Cretaceous?)**

Location—Small bodies in the central part of the Hughes quadrangle and northwestern part of Kateel River quadrangle (fig. 3, sheet 2)

Description—Medium- to coarse-grained granitic intrusive and hypabyssal rocks

LITHOTECTONIC TERRANES

KOYUKUK TERRANE (FIG. 5*A*, SHEET 2)

Kft **Shoshonitic tuffs and lava flows (Early Cretaceous)**

Location—Unit confined to a small area in south-central part of Unalakleet quadrangle

Description—Lithic tuffs, pillowed andesite flows, diabase, and volcanic conglomerate of shoshonitic composition, characterized chemically by very high K_2O, Rb, and Ba contents and low TiO_2 content. Tuffs consist of coarse-grained volcanic rock fragments, crystals of plagioclase and clinopyroxene, and pumice. Flows consist of plagioclase and clinopyroxene phenocrysts in a groundmass of plagioclase laths and devitrified glass. The diabase is compositionally similar to the shoshonitic flows but has a diabasic texture. The conglomerate consists of well-rounded cobbles of shoshonitic andesite porphyry in a tuffaceous matrix. Unit also locally includes fine-grained syenite intrusive rocks composed of 5 to 15 percent coarse-grained phenocrysts of twinned potassium feldspar in a groundmass of potassium feldspar laths and interstitial quartz. Two K/Ar isotopic analyses from this unit gave cooling ages of 118 and 117 Ma

Ktg **Tuff, volcanic graywacke, and mudstone (Early Cretaceous)**

Location—Confined to small area in south-central Hughes and north-central Melozitna quadrangles

Description—Chiefly crystal and lithic tuffs and volcanic graywacke interbedded with laminated mudstone. Tuffs and graywacke characterized by abundant potassium feldspar crystals and potassium-rich volcanic rock fragments; rare mafic and intermediate lava flows. Unit contains dinoflagellates of late Early Cretaceous (Hauterivian, Barremian, and possibly Aptian) age. Unit conformably overlies and is transitional into unit Kv

Kbd **Spilitic basalt and diabase (Early Cretaceous?)**

Location—Southwestern corner of Shungnak quadrangle and adjoining parts of Kateel River quadrangle

Description—Fine-grained, amygdaloidal, spilitic pillow basalt flows and medium- to coarse-grained spilitic diabase intrusive rocks. Contains subordinate andesitic and basaltic tuffs Appears to overlie unit Kv and to underlie unit Krd

Kv **Andesite and basalt lava flows and volcaniclastic rocks (Early Cretaceous)**

Location—Widely exposed in Hughes, Shungnak, Selawik, Candle, Kateel River, and Melozitna quadrangles, and in the central part of Unalakleet quadrangle

Description—Flows of andesite and basalt, interbedded with tuff, tuff breccia, agglomerate, volcanic conglomerate, and volcanic graywacke. Flows typically have phenocrysts of plagioclase and pyroxene set in a matrix of devitrified glass, altered plagioclase microlites, pyroxene, chlorite, and opaque oxides. Rhyolite and dacite flows are present locally. Tuffs are composed chiefly of fine-grained basalt and andesite clasts, plagioclase crystals, and mafic minerals in an altered matrix of devitrified glass. In upper part of unit, the tuffs are highly calcareous and contain abundant shelly debris, including species of *Buchia*. Tuffs commonly occur in cyclically repeated sequences that grade upward from coarse tuff breccia and lapilli tuff to very finegrained cherty tuff and blue-green radiolarian chert. Massive agglomerate, breccia, and volcanic conglomerate are present locally. Unit contains abundant marine mollusks of early Early Cretaceous (Berriasian and Valanginian) age. K/Ar isotopic ages range from 137 to 120 Ma

Jgt **Trondhjemite and tonalite (Late and Middle Jurassic)**

Location—Unit forms a long narrow partly fault bounded pluton extending northward across the central part of Unalakleet quadrangle

Description—Trondhjemite, tonalite, and subordinate quartz diorite, diorite, and gabbro. Trondhjemite consists of 50 to 60 percent plagioclase, 25 to 45 percent quartz, 4 to 8 percent mafic minerals (chiefly biotite and subordinate amphibole). Tonalite has 50 to 55 percent plagioclase, about 20 percent quartz, 5 to 10 percent biotite, and 15 to 25 percent amphibole. Diorite and gabbro have as much as 30 percent mafic minerals, usually amphibole cored by minor clinopyroxene. Much of the western part of the pluton has been metasomatized by potassium-rich fluids to a pink granite and granodiorite. In these altered rocks potassium feldspar forms rims on plagioclase grains and occurs as patches or veins replacing plagioclase. The pluton locally has been cataclastically deformed. Unit is unconformably overlain by andesitic volcaniclastic rocks of unit Kv. K/Ar isotopic cooling ages range from 173 to 130 Ma

MzPzum **Mafic-ultramfic complexes (Mesozoic and Paleozoic?)**

Location—Unit exposed along southeastern and northern borders of Yukon-Koyukuk Basin, in the south-central part of Unalakleet quadrangle where it is spatially associated with the trondjhemite and tonalite unit Jgt, and in one small area along the western border of the basin in southern Candle quadrangle. Also included in this unit is a small complex exposed in a window(?) through the Innoko terrane in the south-central part of Ophir quadrangle

Description—The complexes consist of: (1) a cumulate magmatic suite composed of interlayered dunite, wehrlite, olivine clinopyroxenite, and gabbro, (2) a mantle suite composed of harzburgite, dunite, and minor clinopyoxenite, and (3) a metamorphic sole consisting of a highly tectonized layer of amphibolite, garnet amphibolite, and pyroxene granulite. The harzburgite in the mantle suite typically is partly to mostly serpentinized. Chromite is generally restricted to centimeter-scale layers in dunite and as an accessory mineral. The complexes are intruded by narrow dikes of fresh clinopyroxenite, hornblendite, gabbro, and gabbro pegmatite

The complexes appear to form the roots of the Koyukuk volcanic arc that was active from Jurassic to late Early Cretaceous. The protolith age of the mantle suite is uncertain and may be as old as Paleozoic. K/Ar isotopic cooling ages from the magmatic suite average 159 Ma and two 40Ar/39Ar determinations yielded a plateau age of 162 Ma. K/Ar isotopic cooling ages from the metamorphic sole at the base of the complexes range from 172 to 155 Ma and one 40Ar /39Ar determination from the metamorphic sole yielded a plateau age of 161 Ma

MÉLANGE

KJm **Mélange (Early Cretaceous? and Jurassic)**

Location—Along the faulted contact between Angayucham-Tozitna and Arctic Alaska terranes from Baird Mountains quadrangle eastward to Survey Pass quadrangle and along the faulted contact between Angayucham-Tozitna and Ruby terranes in the Bettles and Tanana quadrangles

Description—Mélange consists of blocks of carbonate rocks, chert, metagraywacke, and altered mafic volcanic and intrusive rocks in a matrix of phyllite. Within the mélange unit, large blocks of carbonate rocks from units Pzca and Pzcr and altered basalt, diabase, and gabbro from unit JDv are mapped separately. Mélange probably formed during time of tectonic emplacement of Angayucham-Tozitna terrane structurally above Arctic Alaska and Ruby terranes

ANGAYUCHAM-TOZITNA TERRANE (FIG. 5*B*, SHEET 2)

JDv **Altered basalt, gabbro, chert, argillaceous rocks, tuff, graywacke, and carbonate rocks (Jurassic to Devonian)**

Location—Exposed in a nearly continuous belt along the margins of Yukon-Koyukuk Basin from the Yukon River northeast to Wiseman quadrangle and then westward to Baird Mountains quadrangle. The unit is also exposed in several large klippen resting on the Ruby terrane in Nulato, Ophir, Ruby, and Tanana quadrangles and on a north-trending structural high in the central part of Unalakleet quadrangle

Description—Variably altered and metamorphosed flows and shallow intrusives of basalt, diabase, and gabbro interbedded with varying proportions of chert, argillite, slate, phyllite, volcaniclastic rocks, graywacke, and carbonate rocks. The basalt, diabase, and gabbro are weakly metamorphosed to prehnite-pumpellyite facies and generally increase in metamorphic grade structurally downward. Greenschist-facies metamorphism and locally high-pressure blueschist metamorphism, as indicated by the presence of glaucophane and lawsonite, occur near the base of the terrane where it strucurally overlies the Ruby terrane. The chert includes both interpillow and bedded varieties and ranges from pure radiolarian and spiculitic chert to cherty tuff. In the southeastern part of Nulato quadrangle and adjoining parts of Ruby quadrangle, the unit is characterized by sill-like bodies of diabase and gabbro, argillaceous rocks, fine-grained to conglomeritic graywacke, and chert

Radiolaria from chert in this unit range in age from Devonian to Jurassic. Sparse megafossils from the carbonate rocks range in age from Devonian to Permian. The carbonate rocks in the lower part of the unit contain redeposited shallow-water conodont faunas that range in age from Ordovician to Late Mississippian

MzPzq **Quartzite (metachert), carbonate rocks, and phyllite (Mesozoic? and Paleozoic)**

Location—Confined to small scattered areas in Nulato, Ophir, Ruby, and Melozitna quadrangles. Unit appears to form a separate thrust panel that structurally overlies the Ruby terrane and structurally underlies unit JDv

Description—Interbedded white to light-gray banded quartzite, dark phyllite, and gray laminated limestone. Thin sections show the quartzite to be composed of as much as 99 percent interlocking quartz grains. Thin layers of white mica folia give the quartzite a faint foliation. The white and light-gray banding, the purity of the quartzites, and the even texture of the quartz grains suggest that the quartzite is a recrystallized chert (metachert). The quartzite is locally interlayered with dark-gray, finely laminated, slightly foliated siliceous argillite, dark phyllite, and a talcy chloritic schist. In central Ruby quadrangle, unit is composed chiefly of phyllite and fine-grained quartz-muscovite-chlorite schist interbedded with metagraywacke, recrystallized chert, greenstone, and rare marble. In the Nulato quadrangle the limestone is partly recrystallyzed and silicified and locally contains unidentifiable coral and crinoid fragments. In Melozitna quadrangle, thin marble beds contain conodonts and crinoids of Devonian age (Harris, written commun., 1983). Some of the metachert may be as young as Mesozoic and correlative with the Mesozoic chert in unit JDv

INNOKO TERRANE (FIG. 5*C*, SHEET 2)

Kgc **Volcanic graywacke and conglomerate (Early Cretaceous?)**

Location—Exposed along border between Ophir and Medfra quadrangles and in two small areas in southern part of Ophir quadrangle

Description—Poorly sorted fine- to coarse-grained graywacke sandstone, grit, and pebble to cobble conglomerate composed chiefly of volcanic rock and chert detritus. Interbedded dark mudstone. Unit tentatively assigned an Early Cretaceous age. It locally contains abundant shell prisms probably derived from large-shelled Early Cretaceous species of *Inoceramus*

JMc **Chert, cherty tuff, argillite, crystal-lithic tuff, volcanic breccia, and conglomerate (Jurassic? to Mississippian)**

Location—Exposed along a belt extending from southern Ruby quadrangle through northwestern Medfra quadrangle and into eastern Ophir quadrangle

Description—Chiefly banded radiolarian chert interbedded with argillite, cherty tuff, fine- to coarse-grained crystal and lithic tuff, and volcanic breccia and conglomerate. Breccia and conglomerate are composed of poorly sorted clasts of mafic volcanic rocks and cherty tuff in a matrix of crystal and lithic tuff. Unit also includes several small bodies of slightly recrystallized limestone and a few small intrusive bodies of gabbro and diabase. Unit contains abundant radiolaria ranging in age from Mississippian to possibly as young as Jurassic

ŦMbc **Pillow basalt, chert, and minor agglomerate (Triassic? to Mississippian?)**

Location—Forms narrow northeast-trending belt extending across boundary between Ophir and Medfra quadrangles

Description—Altered aphanitic and porphyritic pillow basalt. Phenocrysts in the porphyritic basalt are composed chiefly of olivine and pyroxene. Basalt is interlayered with chert and subordinate beds of agglomerate containing clasts of basalt and chert. Chert contains bryozoans and radiolaria of late Paleozoic and possibly Triassic age

ŦMg **Graywacke, grit, and argillite (Triassic? to Mississippian?)**

Location—Scattered exposures along a belt extending from southwestern Ruby quadrangle to south-central part of Ophir quadrangle

Description—Fine- to medium-grained, commonly calcareous graywacke and granule conglomerate, which contain clasts of chert, shale, argillite, and volcanic rocks. Graywacke and conglomerate are interbedded with argillite. Unit contains microfossils and bryozoan and echinoids fragments assigned to a Permian(?) age in the Ruby quadrangle and assigned more generally to a late Paleozoic age in the Ophir quadrangle. Unit appears to interfinger locally with unit ŦDc

ŦDc **Chert, argillite, and limestone (Triassic? to Devonian)**

Location—Extends from southwestern corner of Ruby quadrangle through the northwestern part of Medfra quadrangle and into the eastern part of Ophir quadrangle

Description—Varicolored radiolarian chert, lenticular beds of fossiliferous limestone, and interbedded argillite. Subordinate beds of sandy limestone, grit, and arkosic sandstone. Unit contains abundant radiolaria, condonts, and foraminifera that range in age from latest Devonian to possibly as young as Triassic

NIXON FORK TERRANE (FIG. 5*C*, SHEET 2)

Kqs **Quartz-carbonate sandstone (Early Cretaceous)**

Location—Confined to several small areas in central part of Medfra quadrangle

Description—Fine- to coarse-grained quartz-carbonate sandstone and conglomerate, quartzose limestone, and pebbly mudstone and siltstone. Sandstone clasts composed chiefly of quartz, carbonate rock, and quartz-mica schist debris. Unit contains abundant marine mollusks and belemnites of Early Cretaceous (Valanginian, Hauterivian, and Barremian) age

Ŧs **Spiculite and sandy limestone (Late Triassic)**

Location—Confined to several small areas in central part of Medfra quadrangle

Description—Composed of quartz-carbonate sandstone and conglomerate in lower part of unit and spiculitic chert in upper part. Sandstone and conglomerate consist of detrital carbonate, quartz, and chert clasts, and calcareous fossil debris. Spiculite is composed of chert, fine quartz grains, and as much as 60 percent sponge spicules. Unit contains marine mollusks of Late Triassic (Norian) age in lower part and radiolaria of probable Triassic age in upper part

Ps **Sandstone, sandy limestone, and conglomerate (Permian)**

Location—Confined to several small areas in central part of Medfra quadrangle

Description—Fine- to coarse-grained sandstone, limy sandstone, sandy limestone, siltstone, and shale. Sandstone ranges from clean quartz arenite to a lithic arenite containing as much as 25 percent muscovite and metamorphic rock fragments. Where unit unconformably overlies units Ᵽs and Ᵽc, it contains a basal conglomerate that has large clasts of calc schist, quartz-mica schist, and chlorite schist in a micaceous and sandy matrix. Unit locally contains an abundant Permian brachiopod fauna

DSw **Whirlwind Creek Formation (Devonian and Late Silurian)**

Location—Eastern part of Medfra quadrangle and a small area in southeastern part of Ruby quadrangle

Description—Shallow-water deposits consisting of several repeated cycles. In lower part of formation the cycles grade from algal laminated dolomite into pelletoidal limestone and then into silty limestone and siltstone. In upper part the cycles grade from thick-bedded reefy limestone into thin-bedded limestone. The formation contains an abundant Late Silurian and Devonian conodont, brachiopod, coral, and ostracod fauna

DSp **Paradise Fork Formation (Early Devonian and Silurian)**

Location—Eastern part of Medfra quadrangle

Description—Deep-water turbiditic and hemipelagic deposits of dark, thin-bedded, fissile to laminated limestone, limy shale, and siltstone. The formation has an abundant graptolite, conodont, and ostracod fauna. It was originally assigned an Early to Late Silurian age by Dutro and Patton (1982), but subsequent investigations by Dumoulin and others (1997) indicate that it ranges from Silurian to Early Devonian

Ont **Novi Mountain and Telsitna Formations, undivided (Ordovician)**

Location—Eastern part of Medfra quadrangle and southeastern corner of Ruby quadrangle

Description—Unit consists of:

Novi Mountain Formation: Shallow-water deposits. Lower part composed predominately of calcareous siltstone and shale. Upper part characterized by cycles beginning with massive limestone commonly containing flat carbonate pebbles at the base and grading upward through thin irregularly bedded shaly limestone into calcareous siltstone or shale at the top. The formation contains a sparse Early Ordovician conodont fauna

Telsitna Formation: Chiefly shallow-water limestone and dolomite. The lower part is dominated by highly fossiliferous thin-bedded fine-grained limestone containing silty interbeds. Middle part consists chiefly of nonfossiliferous dolomite. The upper part is composed mainly of limestone that ranges from thick bedded and fine-grained to thin-bedded and silty. Stringers and nodules of black chert occur near the top. The upper part locally is characterized by platy dark limestone containing conodonts indicative of deep-water deposition. The formation contains an abundant conodont, brachiopod, and coral fauna. It was originally assigned a Middle and Late Ordovician age by Dutro and Patton (1982), but subsequent investigations by Dumoulin and others (1997) indicate that it ranges from Early to Late Ordovician

Ᵽv **Metavolcanic rocks (Late Proterozoic)**

Location—Unit confined to several small areas in north-central part of Medfra quadrangle.

Description—Banded fine-grained, foliated, felsic volcanic rocks. Chiefly porphyry composed of large phenocrysts of embayed quartz and plagioclase in a very fine grained quartz and feldspar groundmass that has a distinct micaceous overprint. Subordinate fine-grained quartzofeldspathic rocks, which probably represent recrystallized felsic flows and tuffs. Zircon fractions from two samples of a foliated quartz porphyry flow give a crystallization age of approximately 850 Ma

Ᵽc **Calc schist, quartz-mica schist, and greenstone (Proterozoic)**

Location—North-central Medfra quadrangle and southeast Ruby quadrangle

Description—Calc schist, thin-bedded schistose impure marble, and fine-grained massive sandy marble. Contains subordinate quartz-mica schist and small bodies of greenstone. Unit underlies unit Ont and gradationally overlies unit Ᵽs

Ᵽs **Pelitic schist, quartzite, quartzo-feldspathic gneiss, and greenstone (Proterozoic)**

Locaton—North-central Medfra quadrangle and southeast Ruby quadrangle

Description—Chiefly pelitic and quartzose metasedimentary rocks of greenschist metamorphic facies. Micaeous quartzite and quartz-chlorite schist grade into quartz-muscovite-biotite-garnet schist. Subordinate calc schist and marble. Unit locally includes small bodies of greenstone and greenschist metabasite, granitic gneiss, and metamorphosed quartz porphyry. Zircon fractions from two samples of metamorphosed quartz porphyry indicate a crystallization age of 1,265±50 Ma. Metamorphic minerals from the schist yield K/Ar isotopic cooling ages that range from 921 to 296 Ma

MINCHUMINA TERRANE (FIG. 5*C*, SHEET 2)

East Fork subterrane

D€ef **East Fork Hills Formation (Devonian to Cambrian)**

Location—Southeastern part of Medfra quadrangle

Description—Deep-water deposits of finely laminated limestone and dolomitic limestone. Subordinate chert and siliceous siltstone. Formation was originally assigned an Ordovician to Devonian age on the basis of a sparse conodont fauna (Dutro and Patton, 1982). More recent work, however, indicates that it also contains conodonts of Cambrian age (Dumoulin and others, 1997)

Telida subterrane

Oc **Chert and argillite (Ordovician)**

Location—Eastern part of Medfra quadrangle and southeastern corner of Ruby quadrangle

Description—Banded chert, argillite, fine-grained thin-bedded limestone, and silty dolomite. Beds separated by carbonaceous partings. Unit interpreted to be a deep-water sequence composed of turbiditic and hemipelagic deposits. Unit locally contains conodonts and graptolites of Early and Middle Ordovician age in Medfra quadrangle and in adjoining parts of Mt. McKinley quadrangle east of the map area

PzPq **Quartzite, grit, argillite, and quartz-mica schist (early Paleozoic and Proterozoic?)**

Location—Eastern margin of Medfra quadrangle

Description—Mixed assemblage of laminated fine- to coarse-grained quartzite, grit, and argillite grading upward into very fine grained quartzite, argillite, phyllite, and chert. In southeast corner of Medfra quadrangle unit is metamorphosed to greenschist facies composed of sheared and foliated grit, quartzite, quartz-muscovite schist, and subordinate thin carbonate rocks and metachert. No fossils found in this unit in Medfra quadrangle, but to the east in adjoining Mt. McKinley quadrangle unit contains fossils of Silurian and Devonian age (Dumoulin and others, 1997). In the southeastern part of Medfra quadrangle unit is interlayered with mafic igneous rocks that yielded a K/Ar isotopic cooling age of 421 Ma. Unit may include rocks as old as Proterozoic

RUBY TERRANE (FIG. 5*D*, SHEET 2)

MzPkc **Complex of Kokrines Hills (Mesozoic to Proterozoic?)**

Location—South-central Melozitna and north-central Ruby quadrangles

Description—Undivided assemblage of (1) biotite granite and granite gneiss, including augen gneiss, (2) quartzofeldspathic schist, quartzite, pelitic schist, and amphibolite metamorphosed to upper amphibolite to lower granulite facies, and (3) marble and calc-silicate rocks. Field data are insufficient to map separately the complexly interrelated lithologic components of this unit. The granite and granite gneiss yielded a Cretaceous U/Pb isotopic zircon crystallization age of 118 Ma and Cretaceous K/Ar isotopic cooling ages of 120 to 110 Ma. The schist, quartzite, and carbonate rocks probably are correlative with units PzPsr and Pzcr of Paleozoic and Proterozoic(?) age

MzPzmr **Metabasite (Mesozoic? to Proterozoic?)**

Location—Small widely scattered bodies in the Bettles, Tanana, and Nulato quadrangles

Description—Massive greenstone to thinly layered greenschist bodies that probably represent metamorphosed mafic to ultramafic intrusive rocks and mafic to intermediate flows and tuffs. Unit is intercalated with units PzPsr, Pzcr, and Dgnr

Dgnr **Granitic gneiss (Devonian)**

Location—Tanana quadrangle and southeastern part of Melozitna quadrangle

Description—Strongly foliated quartzofeldspathic gneiss. Consists of a coarse- to medium-grained porphyroclastic biotite-quartz-feldspar±muscovite mylonite gneiss containing resistant augen of K-feldspar in a ductile matrix of mica, quartz, and feldspar. A U/Pb zircon determination from unit in Tanana quadrangle yielded a crystallization age of 390 Ma, which suggests that this unit is approximately the same age as unit Dgna in the Arctic Alaska terrane

Pzpr **Phyllite (Paleozoic?)**

Location—Eastern Bettles quadrangle and northern Tanana quadrangle. Unit appears to form a thrust sheet lying structurally above unit PzPsr of the Ruby terrane and below unit JDv of Angayucham-Tozitna terrane

Description—Phyllite and subordinate fine-grained metagraywacke cut by abundant vein quartz. The phyllite and metagraywacke are overprinted by a low-grade penetrative metamorphic fabric, but turbidite features, such as sole marks and graded bedding, are locally discernible. Age of unit is uncertain, probably Devonian or late Paleozoic and correlative with unit Pzpa in the Arctic Alaska terrane

Pzcr **Carbonate rocks (Paleozoic)**

Location—Scattered small bodies within schistose rocks of unit PzPsr in Nulato, Ruby, Melozitna, Tanana, and Bettles quadrangles. Map shows only the larger of these bodies that were observed in the field or on aerial photographs. Undoubtedly many additional unrecognized bodies exist in areas mapped as unit PzPsr. Also included in this unit is a small area of metacarbonate rocks exposed in a window(?) within the thrust-faulted Innoko terrane in east-central Ophir quadrangle

Description—Gray to white, partly to wholly recrystallized limestone, marble, dark-gray dolomitic marble, and impure schistose limestone. Unit occurs in layers as much as 25m thick intercalated with quartz-mica schist, mica schist, graphitic schist, metabasite, and quartzite. Some contacts are gradational; others are sharp and may be faulted. Unit contains conodonts of Middle Ordovician age in the Nulato quadrangle and poorly preserved corals of Ordovician to Late Mississippian age in Ruby quadrangle

PzPsr **Pelitic schist, calc schist, and quartzite (Paleozoic and Proterozoic?)**

Location—Widely exposed along southeast side of the Yukon-Koyukuk Basin from Ophir quadrangle to the northeast corner of Bettles quadrangle. Also included in this unit are two small areas of schist exposed in windows(?) within the Innoko terrane in the east-central Ophir quadrangle

Description—Quartz-mica schist, chlorite schist, quartzofeldspathic schist, quartzite, and micaceous and graphitic schist. Regionally metamorphosed to greenschist facies, but also locally includes high-pressure greenschist-blueschist-facies (distinguished by the presence of glaucophane) and amphibolite facies (distinguished by the presence of sillimanite and kyanite). Andalusite-cordierite hornfels and contact schist occur in broad bands around Cretaceous granitic bodies of units Kgr and Ksy. Unit is locally interlayered with carbonate rocks of unit Pzcr and therefore is, at least in part, Paleozoic in age. However, some of the unit may be as old as Proterozoic. The regional metamorphism clearly pre-dates the widespread intrusion of the Early Cretaceous granitic bodies of units Kgr and Ksy. Metamorphic minerals in this unit in the Nulato quadrangle yielded K/Ar isotopic cooling ages of 136 and 134 Ma

SEWARD TERRANE (FIG. 5*D*, SHEET 2)

MzPrc **Complex of the Reindeer Hills (Mesozoic to Proterozoic?)**

Location—West-central Norton Bay quadrangle

Description—Undivided assemblage of interlayered impure marble, quartz-mica schist, and quartzite intruded by aplite and amphibolite dikes. Includes some ductily deformed metasomatized contact marble with biotite- and epidote-rich bands. Field data are insufficient to map separately the complexly interrelated lithologic components of this assemblage. Marble, schist, and quartzite probably are correlative with units Pzcs and PzPss exposed in northwestern part of Norton Bay quadrangle. An aplite dike in the complex yielded a K/Ar isotopic cooling age of 120 Ma

MzPms **Metabasite (Mesozoic? to Proterozoic?)**

Location—Several small bodies intruding unit PzPus along the shores of Spafarief Bay in Selawik quadrangle

Description—Greenstone and greenschist bodies representing altered mafic and intermediate volcanic and intrusive rocks

Pzcs **Carbonate rocks (Paleozoic)**

Location—Scattered exposures along the western edge of map area extending from Norton Bay quadrangle to the southwestern part of Selawik quadrangle

Description—Chiefly massively bedded light gray to tan dolomitic and calcareous marble. Locally interbedded black to dark gray calcareous marble and subordinate impure marble and calcareous schist. Unit locally contains an abundant conodont fauna of Ordovician to Devonian age

PzPss **Pelitic schist, calc schist, and quartzite (Paleozoic and Proterozoic?)**

Location—Exposed in northwestern part of Norton Bay and southwestern part of Candle quadrangle

Description—Quartz-muscovite-graphite schist, calc schist, quartzofeldspathic schist, phyllite, and quartzite. Unit is locally interlayered with unit Pzcs and is, at least in part, Paleozoic in age. Some of the unit may be as old as Proterozoic. Samples of the schist yielded a metamorphic mineral K/Ar isotopic cooling age of 124 Ma

PzPus **Pelitic schist, calc schist, and quartzite (PzPss) and carbonate rocks (Pzcs), undivided (Paleozoic and Proterozoic?)**

Location—Scattered exposures along the western edge of the map area extending from Norton Bay quadrangle to southwestern part of Selawik quadrangle

ARCTIC ALASKA TERRANE (FIG. 5*D*, SHEET 2)

MzPma **Metabasite (Mesozoic? to Proterozoic?)**

Location—Small scattered bodies in Wiseman, Survey Pass, Ambler River, Baird Mountains, and Selawik quadrangles

Description—Varies from thinly layered greenschist to more massively layered greenstone bodies representing altered mafic and intermediate volcanic and shallow intrusive rocks. The characteristic minerals are chlorite, albite, actinolite, and epidote. Unit may include rocks of several different ages. Some of the bodies are interlayered with the Devonian felsic schist of unit Df and are part of a bimodal volcanic assemblage. Other bodies are interlayered with carbonate rocks (unit Pzca) that contain fossils of probable Devonian and Mississippian age. Still other bodies may represent tectonically emplaced slices of unit JDv of the Angayucham-Tozitna terrane

Df **Felsic schist (Devonian)**

Location—Occurs as thin layers in pelitic schist, calc schist, quartzite, and carbonate rocks in Wiseman and Survey Pass quadrangles

Description—Schistose felsic volcanic rocks, including flows, tuffs, and porphyritic hypabyssal? rocks, interlayered with metasedimentary rocks belonging to units PzPsa and Pzca. An important component of this unit is the widely recognized "button schist"—a porphyritic rhyolite composed of quartz megacrysts and albite porphyroblasts in a groundmass of quartz, potassium feldspar, and muscovite. Unit yielded Devonian U/Pb and Pb/Pb zircon crystallization ages and is interlayered with carbonate rocks containing fossils of probable middle Paleozoic age

MzPfm **Metabasite (MzPma) and felsic schist (Df), undivided (Mesozoic? to Proterozoic?)**

Location—Wiseman quadrangle

Dgna **Granitic gneiss (Devonian)**

Location—Small pluton intruding unit PzPsa on northern edge of Shungnak quadrangle in the Cosmos Hills

Description—Foliated gneissic granite composed of albite, potassium feldspar, quartz, muscovite, and biotite. Intruded by aplite dikes. The pluton yielded a probable Devonian U/Pb zircon crystallization age and appears to be approximately correlative in age with unit Dgnr in the Ruby terrane

Pzpa **Phyllite and subordinate metagraywacke (Paleozoic?)**

Location—Forms a belt extending along northern edge of the map area from Baird Mountains quadrangle to Wiseman quadrangle

Description—Dark phyllite and minor metagraywacke that have a penetrative fabric ranging from slaty cleavage to weakly schistose. Unit locally contains slices of little deformed shallow-water Devonian carbonate rocks that are enveloped in basalt flows and debris-flow(?) breccias composed of blocks of vesicular basalt in a matrix of volcanic and carbonate debris. Age of unit is probably middle or late Paleozoic and correlative with Pzpr unit in the Ruby terrane

Pzg **Metagraywacke and subordinate phyllite (Paleozoic?)**

Location—Distributed along the belt of unit Pzpa in Hughes, Survey Pass, and Wiseman quadrangles

Description—Fine- to medium-grained metagraywacke and metasiltstone composed chiefly of quartz and chert clasts, but in places containing a significant component of volcanic rock and feldspar clasts. Overprinted by low-grade penetrative metamorphic fabric, but turbidite features, such as graded bedding and sole marks, are locally discernible. Interbedded with subordinate amounts of phyllite

Pzca **Carbonate rocks (Paleozoic)**

Location—Distributed along northern edge of map area from Baird Mountains and Selawik quadrangle on the west to Wiseman quadrangle on the east. Occurs as scattered bodies within schistose and phyllitic rocks of units PzPsa, PzPua, and Pzpa and as tectonic blocks in the mélange unit KJm

Description—Ranges from light gray to white partly recrystallized limestone to coarsely crystalline marble. Dark finely crystalline dolomitic marble. Interbedded calc schist, chloritic schist, and quartzite in subordinate amounts. Unit ranges in age from Ordovician to Mississippian and may locally include rocks as old as Cambrian. Contains scattered fossils, chiefly conodonts, from map area and from exposures of unit in contiguous parts of the Arctic Alaska terrane north of map area

PzPsa **Pelitic schist, calc schist, and quartzite (Paleozoic and Proterozoic)**

Location—Forms a continuous band along northern edge of map area

Description—Quartz-mica schist and lesser amounts of calc schist, quartzite, graphitic schist, chlorite schist, and quartzofeldspathic schist. Polydeformed greenschist-blueschist facies characterized by quartz-muscovite-chlorite-albite±glaucophane assemblages. A relict epidote-amphibolite metamorphic assemblage suggests that, at least locally, the unit underwent a pre-mid Devonian metamorphic event. Unit is interbedded with carbonate rocks of unit Pzca and therefore is, in part, Paleozoic in age. In Baird Mountains quadrangle, the unit is intruded by Proterozoic granitic rocks of unit PzPi, and is, at least locally, as old as Proterozoic. K/Ar isotopic analyses of the schist yielded Early Cretaceous metamorphic mineral cooling ages

PzPua **Pelitic schist, calc schist, and quartzite (PzPsa) and carbonate rocks (Pzca), undivided (Paleozoic and Proterozoic)**

Location—Baird Mountains and Selawik quadrangles

PzPi **Granitic gneiss (Paleozoic? and Proterozoic)**

Location—Two small bodies in Baird Mountains quadrangle

Description—Granite, granodiorite, diorite, and gabbro that have a slight to moderate gneissic fabric. The northwesternmost of the two bodies is Proterozoic and has yielded a U/Pb zircon crystallization age of 705 Ma. The southeasternmost body is of uncertain age; it may also be Proterozoic or it may be Devonian and correlative with unit Dgna

ROCKS OF UNCERTAIN AFFINITY

TDg **Gabbro and diabase (Tertiary? to Devonian?)**

Location—Small scattered bodies in Medfra, Ophir, Ruby, and Hughes quadrangles

Description—Fresh to altered gabbroic and diabasic intrusive bodies. Unit intrudes rocks as old as middle Paleozoic and as young as Cretaceous. May represent a wide range of ages

Sources of Map Information

General

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