EXPLANATION OF MAP UNITS: BEDROCK-GEOLOGIC MAP, ALASKA HIGHWAY CORRIDOR, DOT LAKE TO TETLIN JUNCTION, ALASKA

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EXPLANATION OF MAP UNITS: BEDROCK-GEOLOGIC MAP, ALASKA HIGHWAY CORRIDOR, DOT LAKE TO TETLIN JUNCTION, ALASKA

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DESCRIPTION OF GEOLOGIC MAP UNITS

(All map units may not appear on both map sheets)

The accompanying map shows the distribution of bedrock units exposed at or near the surface in the corridor along the Alaska Highway in parts of the Tanacross A-4, B-4, B-5, B-6, and C-6 quadrangles. It is the central of three bedrock-geologic maps along the Alaska Highway corridor (Werdon and others, 2019; Solie and others, 2019), and is part of a multi-year project conducted by the Alaska Division of Geological & Geophysical Surveys (DGGS) between 2006 and 2013. The project focused on investigating and reporting the geology and geologic hazards of the corridor. Bedrock units were mapped and structural elements were measured in the field; where bedrock units are covered by surficial units and vegetation, units were interpreted using airborne magnetic and electromagnetic surveys published by DGGS (Burns and others, 2006). Rock names were assigned based on field and petrographic observations, modal-mineral percentages, and interpretations of geochemical data (Werdon and others, 2014). Surficial-geologic map units are shown in Reger and others (2011). Active faults in the map area are described in Carver and others (2010). Ages correlate with International Commission on Stratigraphy Chart (2018). Where bedrock map units are shown with a pattern and queried label, unit designation is interpreted based on nearby geology and geophysical characteristics.

BEDROCK MAP UNITS

buk — BEDROCK, UNKNOWN (Tertiary and older)—Identity of bedrock was not interpreted in areas of thick and widespread unconsolidated Quaternary and Recent fluvial, colluvial, and glacial deposits. Although geophysical data were acquired over the entire map area, field observations of exposed bedrock in buk areas were insufficient for reasonable interpretation of bedrock character. The extent of interpreted bedrock underlying the Quaternary is subjectively located and does not indicate a geologic contact. Overlying surficial-geologic units are shown in Reger and others (2011).

b — UNMAPPED BEDROCK (Tertiary and older)—Identifiable bedrock is present at or near surface but was not mapped because no field visits were possible during the course of this project.

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IGNEOUS DIKES

GRANITE DIKES (Tertiary to Cretaceous)—Granite dikes are texturally variable, ranging from fine-grained, porphyritic with aphanitic to finely granular groundmass, to medium- to coarse-grained and equigranular. Dikes are typically less than 4 m thick and intrude both metamorphic and earlier igneous units. Granite is pale gray to orange-pink on weathered surfaces, greenish to pinkish-white on fresh surfaces. Modal mineralogy includes quartz, alkali feldspar, plagioclase, biotite (<5%), and rarely white mica and possible garnet. Minor disseminated pyrite is generally replaced by iron oxide. Magnetic susceptibility varies from 0.01×10^{-3} SI to 0.23×10^{-3} SI (Système International) with an average of 0.15×10^{-3} SI. Granite dikes throughout the map area are likely comagmatic with nearby Cretaceous plutons based on spatial proximity, but could be as young as Tertiary in age.

GRANITE PORPHYRY DIKES (Tertiary to Cretaceous)—Granite porphyry dikes have an aphanitic, light-colored, quartz-rich groundmass with phenocrysts up to 3 mm including biotite, plagioclase, alkali feldspar, hornblende, and quartz. Several dikes have relatively coarse (>0.8 mm) alkali feldspar and euhedral smoky quartz phenocrysts. Chlorite is relatively common as an alteration product of biotite. Magnetic susceptibility varies from 0.02×10^{-3} SI to 3.8×10^{-3} SI with an average value of 0.7×10^{-3} SI. Larger bodies of similar lithology and likely equivalent age are shown as granite porphyry (TKp) on this map.

APLITE DIKES (Tertiary to Cretaceous)—Felsic aplite dikes crop out within or near Cretaceous plutonic rocks through most of the study area. Aplite dikes range in width from 2 cm to 4.5 m. They are commonly light pink, also ranging from cream to light pinkish-orange; fine-grained; equigranular; with some trace biotite up to 5 percent. Minor to trace amounts of disseminated pyrite are mostly oxidized. Trace amounts of magnetite are present rarely. Several felsic pegmatitic dikes with centimeter-scale alkali feldspar crystals are included in this unit. The magnetic susceptibility varies from 0.01×10^{-3} SI to 5.3×10^{-3} SI, averaging 1.15×10^{-3} SI. The aplite dikes may be comagmatic with Cretaceous intrusions but genetic relationships are uncertain, therefore they are assigned Cretaceous to Tertiary age.

GRANODIORITE DIKES (Tertiary to Cretaceous)—A minor number of intermediate dikes were identified, intruding metamorphic and Cretaceous granitic units. Dikes are aphanitic to fine-grained, variably porphyritic with phenocrysts including biotite, hornblende, and feldspar, and are up to 4 m wide. Magnetic susceptibility is moderately low, averaging 0.25×10^{-3} SI. Assigned Cretaceous to Tertiary age based on intrusive relationship with Kg; granodiorite dikes may be of different ages.

MAFIC SILLS AND DIKES (Late Cretaceous)—Includes biotite gabbro, diorite, quartz monzodiorite, and trachyandesite sills and dikes. Textures are variably porphyritic with groundmass ranging from aphanitic to fine-grained to medium-grained. Mafic dikes intrude both metamorphic and igneous units. Those in metamorphic rocks are generally less than 3 m wide; typically porphyritic with common biotite and plagioclase and local hornblende or clinopyroxene phenocrysts; groundmass aphanitic to medium-grained; ranging from dark gray to very dark green on fresh surfaces; weathers to dull brown or pale green-brown.

Alteration products include chlorite, epidote, and iron oxide. Mafic dikes that intruded earlier igneous phases range from a few cm up to approximately 2 m wide; commonly not porphyritic; aphanitic to medium grained. Where present, phenocrysts include biotite, plagioclase, and hornblende. Color ranges from dark green to dark blue-gray; alteration minerals include chlorite, epidote, and iron oxide; vesicles observed rarely. A trachyandesite dike from the volcanic unit (lKv) is black to pale maroon with phenocrysts of biotite, feldspar, and altered hornblende in a very-fine-grained groundmass. Overall, the magnetic susceptibility of the mafic dikes is generally high, ranging from 0.25 x 10^{-3} SI to 17 x 10^{-3} SI, with an average of 5.6 x 10^{-3} SI. A $^{40}Ar/^{39}Ar$ plateau age of 68.8 ± 0.6 Ma was measured from biotite in this dike (map location A1; table 1; Solie and others, 2013).

IGNEOUS MAP UNITS

TKp FELSIC PORPHYRY (Tertiary to Cretaceous)—Felsic porphyry crops out in granite (Kg) in the northern map area and in granite and metamorphic rocks in the eastern map area. This unit is similar to, and likely equivalent to, the granite porphyry dikes described above. However, based on map distribution it appears to comprise more extensive bodies, interpreted as hypabyssal intrusive rocks. Extrusive volcanic textures have not been identified. Felsic porphyry is variably porphyritic with phenocrysts of smoky quartz, feldspar, and biotite comprising up to 60 percent of rock volume in an aphanitic, silicic, light tan or gray matrix. Quartz phenocrysts are common and up to 6 mm in diameter. Biotite phenocrysts are less common, up to 5 percent of the phenocrysts, and generally form small brown to black flakes (<0.5–2 mm across). Alkali feldspar or plagioclase feldspar phenocrysts are present mostly in the eastern exposures, as subhedral crystals up to 6 mm long, locally altered to clay. The groundmass commonly weathers an orange coloration due to iron-oxide staining. Remnants of oxidized pyrite are uncommon. The magnetic susceptibility of the bodies in the eastern map area is generally low, from 0.01 x 10^{-3} to 2.9 x 10^{-3} SI, with an average value of 0.5 x 10^{-3} SI. The magnetic susceptibility of the northern bodies is higher, with an average of 3.2 x 10^{-3} SI. The unit correlates with the granite porphyry unit (Tp) of Foster (1970), which is assigned a probable Tertiary age. A high-silica rhyolite from the Taylor Highway just north of the study area has an Eocene age of 54.6 ± 1.2 Ma based on K-Ar analysis of sanidine (Bacon and others, 1990). Mid-Cretaceous felsic volcanic rocks of the Sixtymile Butte caldera just north of the study area may also be coeval with some TKp bodies. The age of the Sixtymile Butte caldera is based on a K-Ar age of 92.1 Ma for hornblende (Bacon and others, 1990). Other Cretaceous and Tertiary porphyritic felsic rocks are found in nearby areas of the western Yukon (for example, Tempelman-Kluit, 1974; Ryan and others, 2003; Lowey and others, 1986).

lKv INTERMEDIATE VOLCANIC ROCKS (Late Cretaceous)—Volcanic rocks are exposed at an isolated hill in the Tok basin. There are two observed rock types included in this unit, but they are not well enough exposed to map separately: (1) Trachyandesite, which is dark green, fine grained, occasionally porphyritic with plagioclase phenocrysts, and locally with clinopyroxene (reacted to hornblende or biotite). The trachyandesite occurs as massive lava flows, dikes and, locally, autobreccia. These rocks are strongly weathered and/or altered, with hematite Liesegang banding, chloritized mafic silicates, and local pyrite. The groundmass weathers maroon-pink to dark green, and the fresh surface is dark green/gray to black. Magnetic susceptibility is high, averaging 7 x 10^{-3} SI and ranging from 2.5 x 10^{-3} to 16 x 10^{-3} SI. (2) Tan-colored, fine-grained, locally porphyritic dacite. Quartz, feldspar and biotite phenocrysts are approximately 0.7 mm across and the matrix consists of fine, intergrown feldspar laths in a pale gray siliceous matrix. Preserved textures resemble massive brecciated volcanic rocks. The breccias have a few percent of exotic lithic clasts and amygdules filled with serpentine, or chlorite with calcite. Weathering/alteration gives these rocks an orange coloration due to disseminated iron oxide, and manganese oxide dendrites coat fracture surfaces. Magnetic susceptibility is variable, with mean values from two samples of 0.6 x 10^{-3} SI and 5.6 x 10^{-3} SI. A sample of a trachyandesite dike in this unit has an age of 68.8 ± 0.6 Ma as described in "mafic sills and dikes" above.

Cathedral Bluffs Granite

Kc CATHEDRAL BLUFFS MONZOGRANITE (Cretaceous)—Crops out on north side of Tanana River, forming hills above Cathedral Bluffs and Tower Bluffs. Local tors are up to approximately 12 m high. Monzogranite is predominantly porphyritic with fine- to coarse-grained groundmass, pink to light gray/tan in color. Euhedral alkali feldspar megacrysts are abundant, up to 12 cm long, averaging 2–5 cm. Rapakivi texture occurs locally as composite quartz and plagioclase surrounding alkali feldspar megacrysts. Magmatic flow alignment of crystals can be observed locally. Quartz phenocrysts are translucent to smoky gray, euhedral and 0.5–1.5 cm in diameter. Plagioclase is white, subhedral, and present as early inclusions in alkali feldspar megacrysts and in the groundmass. Biotite is the main mafic silicate mineral, generally 0.2–0.4 cm in diameter. Hornblende is present locally, generally less abundant than biotite, up to 0.4 cm long. The unit also includes medium- to coarse-grained, equigranular to seriate, biotite ± hornblende monzogranite to syenogranite, and is cut by aplite dikes. Intrusive relationship with mapped Kgd areas within Cathedral Bluffs monzogranite is uncertain. Brittle-ductile shear zones cut the unit downstream of Cathedral Bluffs along the Tanana River. Joints and fractures are abundant throughout. Magnetic susceptibility ranges from low to high: 0.02 x 10^{-3} to 22 x 10^{-3} SI with an average value of 4.7 x 10^{-3} SI. The least magnetic samples are generally highly weathered, altered, or fractured. Of the fresh samples, the highest magnetic susceptibilities are generally associated with hornblende-bearing rocks. There is an unpublished U-Pb zircon age for this unit of approximately 95 Ma (sample CBGC-1 of Mortensen, pers. commun., 2008).

Mansfield Granodiorite

Kmgd MANSFIELD GRANODIORITE (Cretaceous)—The Mansfield granodiorite crops out on the hill south of Lake Mansfield. It is a distinctive medium gray, equigranular to slightly porphyritic, medium- to coarse-grained rock ranging in composition from granodiorite to monzogranite. The rock is mafic silicate rich, with 15–25 percent biotite, and hornblende in varying relative abundance. Alkali feldspar is present as late interstitial grains between plagioclase, biotite, hornblende, and quartz; it rarely occurs as sparse (≤15 percent) megacrysts (1.5 cm in length). Coarse biotite and plagioclase are locally slightly porphyritic with grain size up to 6 mm across. The magnetic susceptibility for this unit ranges from 3.7 x 10^{-3} SI to 12 x 10^{-3} SI with an average magnetic susceptibility of 5.5 x 10^{-3} SI. Cretaceous age is assigned based on overall similarities with nearby Cretaceous plutonic bodies.

Round Lake Granodiorite

Kr ROUND LAKE GRANODIORITE (Cretaceous)—The Round Lake granodiorite crops out on the ridge east of Round Lake. The granodiorite is fine to medium grained, light colored, tan to gray, and equigranular to slightly porphyritic. The composition varies from granodiorite to monzodiorite; field identification is difficult because both feldspars are light colored (white). Quartz and plagioclase are early, slightly porphyritic, euhedral to subhedral, and generally less than 0.3 cm across. Alkali feldspar is generally subhedral to anhedral, 0.6 cm long, and less abundant than plagioclase. Biotite and hornblende are fine grained and relatively abundant (10–15 percent). Biotite locally defines a weak foliation in the north portion of the unit. The magnetic susceptibilities of the granodiorite average 1.3 x 10^{-3} SI; the values range from 0.06 x 10^{-3} SI to 3.2 x 10^{-3} SI. Unit is assigned Cretaceous age based on prevalence of Cretaceous plutonism in the area; age is uncertain.

Tower Bluffs Granite

Kt TOWER BLUFFS MONZOGRANITE (Cretaceous)—The Tower Bluffs monzogranite crops out on the hills above Tower Bluffs, east of Tower Bluff Rapids in the Tanana River. The monzogranite is pink to tan colored, and generally equigranular, ranging from fine to medium grained in the southern portion of the unit, to medium to coarse grained in the northern portion. Biotite is approximately 5–15 percent of the rock and locally forms a subtle foliation in the southern portion of the unit. Hornblende (~2–7 percent) is present in some of the coarse-grained rocks. Mafic enclaves locally comprise up to 10 percent of the outcrop. The magnetic susceptibility is variable, with an average value of 1.2 x 10^{-3} SI. The magnetic susceptibility values range from 0.01 x 10^{-3} SI to 11.7 x 10^{-3} SI. Some of the low values may be related to weathering and oxidation, or proximity to major brittle structures in the area. The Tower Bluffs monzogranite (unit Kc) is spatially associated with the Mansfield granodiorite (unit Kmgd) and the Cathedral Bluffs monzogranite and these may be part of the same intrusive suite. A Cretaceous age is assigned based on this spatial association; age is uncertain.

Yerrick Creek Granitic Suite

Ky YERRICK CREEK PORPHYRITIC MONZOGRANITE (Cretaceous)—The Yerrick Creek porphyritic monzogranite crops out on the ridges east of Yerrick Creek, south of the Tanana River. The porphyritic monzogranite has a pale gray to pink, fine- to medium-grained groundmass with pink megacrystic (1–4 cm) alkali feldspar phenocrysts. Alkali feldspar phenocrysts are euhedral and generally compose 10–20 percent of the rock, although phenocryst abundance ranges from 0 to 30 percent. Some exhibit Carlsbad twinning; some have composite quartz–plagioclase mantles (rapakivi texture in the broadest sense). Plagioclase can also be porphyritic, but with smaller crystals (<1 cm). Biotite is typical, generally about 3–10 percent but up to approximately 20 percent in the groundmass; hornblende is locally present in about equal or less abundance than biotite. Euhedral titanite up to 2 mm in length is present locally in trace amounts. Rounded black dioritic enclaves up to 20 cm across occur locally. The magnetic susceptibility is generally high with an average value of 9 x 10^{-3} SI, but the magnetic susceptibility ranges from 1 x 10^{-3} SI to 28 x 10^{-3} SI. Where bedrock is obscured by vegetative and soil cover on ridges, the map area of this unit is characterized by high total magnetic field values (Burns and others, 2006). However, additional areas of Kyq and Kgd are likely within the mapped Ky unit. The aeromagnetic high extends eastward under thick surficial deposits for about 13 km, suggesting that bedrock associated with the Yerrick Creek granitic suite may be present at depth. A K-Ar age of 88 ± 3 Ma on biotite was determined from a quartz monzonite within Ky (map location A5; table 1; Foster and others, 1976).

Kyq YERRICK CREEK PORPHYRITIC QUARTZ MONZONITE (Cretaceous)—The Yerrick Creek porphyritic quartz monzonite is porphyritic, coarse-grained, with abundant (25–30 percent) pink alkali feldspar megacrysts (up to 3 cm long). This unit is relatively mafic rich (25–30 percent) with hornblende more abundant than biotite. Plagioclase is locally porphyritic, medium grained, and predominantly interstitial. Quartz is noticeably less abundant than in other Yerrick Creek plutonic rocks. The magnetic susceptibility varies, with an average value of 10.5 x 10^{-3} SI, ranging from 0.04 x 10^{-3} to 33.3 x 10^{-3} SI. Generally the lower magnetic susceptibilities of less than 1 x 10^{-3} SI are weathered, or at or near the contact zone with paragneiss country rocks. The quartz monzonite appears to be genetically related to the Yerrick Creek porphyritic monzogranite as a more mafic border phase and is therefore assigned a Cretaceous age.

Other Igneous Rocks

Kgd GRANODIORITE (Cretaceous)—Granodiorite crops out in small bodies throughout the map area, and may comprise phases related to surrounding or nearby plutons, though intrusive and magmatic relationships are unknown. The granodiorites are described in five groups based on location: (1) Kgd bodies near the Round Lake granodiorite (Kr) are generally fine- to medium-grained granodiorite, with 5–20 percent biotite and average magnetic susceptibility of 1.2 x 10^{-3} SI; (2) Kgd in the Tower Bluffs monzogranite (Kt) is generally medium- to coarse-grained granodiorite, with up to 15 percent mafic minerals including both biotite and hornblende, and average magnetic susceptibility of 3.1 x 10^{-3} SI; (3) Kgd in the Cathedral Bluffs monzogranite (Kc) includes granodiorite, quartz monzodiorite, quartz diorite, and quartz monzonite. The rocks are generally medium grained, slightly feldspar porphyritic with either alkali feldspar or plagioclase phenocrysts up to 2 cm in lengtj, with 5–15 percent mafic minerals (biotite ≥ hornblende), and magnetic susceptibility averaging 13.1 x 10^{-3} SI; (4) Kgd in the Yerrick Creek porphyritic monzogranite (Ky) appears similar to surrounding rock but with lower quartz and alkali feldspar content. Average magnetic susceptibility for these granodiorites is 8.8 x 10^{-3} SI; and (5) Kgd bodies near the eastern edge of the map area are generally slightly plagioclase ± quartz porphyritic, fine- to medium-grained granodiorite with 15–25 percent mafic minerals (biotite > hornblende). Magnetic susceptibility of these bodies averages 6.7 x 10^{-3} SI. Kgd is assigned a Cretaceous age based on its close association, and apparent comagmatic relationship, with surrounding Cretaceous plutonic rocks.

Kg GRANITE (Cretaceous)—Granitic rocks crop out in much of the map area north and east of the Tanana River and in the Tanana River valley. This unit includes undifferentiated granitic phases including monzogranite, porphyritic monzogranite, and leucogranite, as well as minor quartz monzonite, quartz diorite, monzodiorite, and quartz diorite. In general, the monzogranite is fine- to medium-grained, equigranular, commonly poikilitic with alkali feldspar crystals up to 2 cm in diameter. Monzogranite is tan to light orange colored. Modal mineralogy includes quartz, alkali feldspar, plagioclase, biotite, and minor hornblende.

The fine-grained monzogranite is fine to medium grained with subhedral quartz phenocrysts (0.1–0.5 cm in diameter), subhedral alkali feldspar and plagioclase (≤0.4 cm in length), and a few percent of fine-grained biotite (1 mm in diameter). Many samples have a weak foliation defined by roughly aligned zones of feldspar and quartz. Thus, at least some of the fine-grained granite may be part of the Mississippian–Devonian-age orthogneiss suite (MDlo).

The coarse-grained monzogranite is similar to the Tower Bluffs monzogranite but not as coarse grained or as quartz rich. Quartz crystals average about 6 mm across and often occur as glomerocrysts. Alkali feldspar is occasionally megacrystic (1.5 cm long), less abundant than plagioclase, and generally occurs as interstitial grains between plagioclase and quartz.

Porphyritic monzogranite is medium to coarse grained with porphyritic subhedral alkali feldspar crystals up to 2 cm long. Plagioclase is subhedral and occasionally megacrystic (1.2 cm long). The matrix is dominated by interstitial alkali feldspar, quartz, and biotite.

Leucocratic monzogranite is very light colored, white to pale pink, fine grained, equigranular, with abundant fine- to medium-grained quartz phenocrysts. Both plagioclase and alkali feldspar are white, with alkali feldspar much more abundant than plagioclase. Biotite is the sole mafic silicate, fine grained, and generally composing less than 2 percent of the rock.

Quartz diorite is gray to tan, medium to coarse grained, and locally porphyritic. Biotite and hornblende are both present in roughly equal amounts. Hornblende occasionally occurs as euhedral elongate prisms up to 2 cm long. Compositions vary from diorite to quartz monzonite to monzodiorite.

The magnetic susceptibility of the map unit is variable, though overall tends to be fairly low, between 0.05×10^{-3} SI and 1.0×10^{-3} SI. The coarse-grained and porphyritic phases have higher average magnetic susceptibilities, around 3×10^{-3} SI. Within a granitic phase lower values are commonly more altered, weathered, or sheared samples; higher values are fresher, less deformed, or may be in close proximity to the margins of more mafic intrusions.

A similar monzogranite crops out to the west, near Dot Lake (Werdon and others, 2019), and yields an $^{40}Ar/^{39}Ar$ age of 89.7 ± 1.1 Ma (Solie and others, 2013). Based on the similarity of lithology and geologic relationships, Kg is assigned a Cretaceous age.

Kgb BIOTITE GABBRO, CLINOPYROXENITE, AND WEHRLITE (Cretaceous)—Three spatially separate areas of mafic to ultramafic rocks are present in the study area:

1. Biotite gabbro is exposed between two ultramafic sill-like bodies on the north side of Sheep Creek. Two other mafic ± ultramafic intrusions are inferred along the south ridge of Sheep Creek based on high aeromagnetic signatures similar to the mapped unit. The observed northern ultramafic contact is interpreted as a fault based on the lack of contact metamorphism, chill zones, and continuity despite good cliff-side exposures. The southern part of the exposure is subparallel to foliation of the metamorphic country rock and has a distinctive orange coloration in the contact aureole; it is therefore interpreted as an intrusive contact. The biotite gabbro is medium to coarse grained with phenocrysts of olivine, plagioclase, clinopyroxene, biotite, and minor orthopyroxene. Intercumulate textures are common in some exposures where olivine is early and plagioclase or clinopyroxene are late. The magnetic susceptibility of relatively unaltered gabbro is high, up to 26×10^{-3} SI. Magnetic susceptibility of altered gabbro averages 5×10^{-3} SI, but can be as low as 0.2×10^{-3} SI. A K-Ar age of 65.0 ± 2 Ma has been reported on biotite from an olivine gabbro in this area (Foster and others, 1976). The ultramafic bodies associated with the biotite gabbro are biotite wehrlite and clinopyroxenite. The biotite wehrlite is medium to coarse grained, dominated by coarse olivine phenocrysts that are partially altered to talc. Also present are abundant clinopyroxene, biotite, minor orthopyroxene, and opaque minerals. Calcite and white mica are alteration products. The magnetic susceptibility of the biotite wehrlite is moderately high, averaging 5×10^{-3} SI with a range from of 2×10^{-3} SI to 10×10^{-3} SI. One exposure near the bottom contact has strong iron-oxide weathering with red-colored carbonate and disseminated mica. The magnetic susceptibility of this altered unit is low, averaging 0.2×10^{-3} SI with a range from of 0.1×10^{-3} to 0.4×10^{-3} SI. The biotite clinopyroxenite (2008RN645A) has an age of 68.1 ± 0.3 Ma, based on $^{40}Ar/^{39}Ar$ plateau step-heating analyses of biotite (map location A2; table 1; Solie and others, 2013). K-Ar analysis of biotite from an olivine gabbro near this locality yielded an age of 65 ± 2 Ma (map location A7; table 1; Foster and others, 1976).

2. Biotite gabbro/microgabbro is exposed on a knob on the eastern edge of the study area. The biotite gabbro is medium to fine grained, porphyritic to slightly porphyritic, with biotite and plagioclase up to 2 mm across. The primary minerals consist of plagioclase laths, clinopyroxene, and olivine remnants surrounded by rims of talc alteration ± biotite. There are local pegmatitic pods of plagioclase and biotite with or without chalcopyrite. The magnetic susceptibility is high, averaging 20×10^{-3} SI. This gabbro has an age of 70.0 ± 0.3 Ma based on $^{40}Ar/^{39}Ar$ plateau step-heating analyses of biotite (map location A4; table 1; Solie and others, 2013).

3. Gabbro is exposed in two map areas near Tetlin Junction. The western map area contains dark green, aphanitic to medium-grained, roughly equigranular hornblende gabbro. The larger area of Kgb includes gabbro and possible clinopyroxenite with pervasive mylonitic textures throughout the exposure. The rock is dark green to green and white. A few samples preserve relict crystalline igneous textures, predominantly medium-grained plagioclase and clinopyroxene. The gabbro is strongly sheared and altered; plagioclase is commonly turbid and locally replaced by white mica in patches. Talc is a common alteration product and epidote is common as veins in pervasively sheared samples. Minor fine-grained quartz and serpentine can

be found as secondary and alteration mineral products. The magnetic susceptibility is low, averaging 0.4 x 10^{-3} SI with a maximum of 0.8 x 10^{-3} SI. Hornblende from gabbro approximately located near the mapped hornblende gabbro body yielded a K-Ar age of 133 ± 4 Ma (map location A6; table 1; Foster and others, 1976).

eKm MUSCOVITE GRANITE (Early Cretaceous)—Monzogranite is medium to coarse grained, equigranular, light colored, with muscovite, lesser garnet, and trace biotite. Garnet crystals are interstitial between quartz and alkali feldspar. The magnetic susceptibility is low, averaging 0.04 x 10^{-3} SI. Muscovite from this rock unit has a $^{40}Ar/^{39}Ar$ plateau age of 102.9 ± 0.4 Ma (map location A3; table 1; Solie and others, 2013).

METAMORPHIC MAP UNITS

Amphibolite-Facies Metaigneous and Metasedimentary Rocks — Lake George assemblage of parautochthonous North America

Amphibolite-facies rocks are correlated to the Lake George assemblage of the parautochthonous North American assemblage as defined by Dusel-Bacon and others (2006).

MDlo UNDIFFERENTIATED ORTHOGNEISS (Mississippian to Devonian)—Unit includes granite orthogneiss, granite augen orthogneiss, granodiorite orthogneiss, and tonalite orthogneiss. Orthogneisses crop out throughout the map area, on both sides of the Tanana River valley. The outcrop patterns of this unit are as thin sill-like bodies a few meters thick within older metasedimentary rocks, as larger irregular and slightly elongate bodies, and as orthogneiss zones gradational into older metasedimentary rocks. Contact-metamorphic recrystallization appears to be related to nearby Cretaceous plutonism. Where orthogneiss is mapped in one of the Cretaceous plutonic bodies, it may be a pendant of host rock enclosed by the pluton.

Granite orthogneiss is light gray, medium to fine grained, with faint to obvious gneissic banding. Modal mineralogy includes quartz, alkali feldspar (microcline and orthoclase), plagioclase, biotite, and hornblende. Accessory minerals include chlorite (after biotite and amphibole), muscovite, apatite, allanite, opaque minerals (magnetite), and zircon. Amphibolite-grade metamorphic reactions are preserved in the samples closest to exposed or buried contacts with the middle Cretaceous Cathedral Bluffs monzogranite (unit Kc). These high-grade gneisses contain garnet and epidote. The garnets occur as very fine crystals in subparallel clumps associated with biotite or muscovite foliation relicts. Some samples have undergone late high-temperature deformation evidenced in thin section by quartz with undulatory extinction, core and mantle structures, and embayed grain boundaries. A few brittle shears of cataclasite, epidote mineralized shear zones, and microfaults have been observed. Associated with this granitic orthogneiss are amphibolite bodies that have apparent dike-like relationships with the enclosing gneiss. These amphibolite bodies do not occur in large enough bodies to be mapped separately. They have relict or weakly preserved foliation overprinted by strong hornfels recrystallization so that most of the hornblende and plagioclase do not have a preferred orientation. These may be related to amphibolite bodies in the older metasedimentary sequence rocks.

Granite augen orthogneiss has similar mineralogy, textural history, and outcrop relationships to the granitic orthogneiss, but with coarse alkali feldspar augen (≤5 cm long) and often coarser grain sizes. Some samples have undergone progressive deformation under more brittle–ductile conditions where feldspars are fractured and rotated. The interstitial matrix comprises finer-grained, often elongate, quartz and biotite. This brittle–ductile shear records top-to–the-east shear sense.

Granodiorite orthogneiss is dark green to gray, medium grained with abundant mafic minerals (20–30 percent). Plagioclase is the dominant mineral with minor quartz and alkali feldspar (microcline). Biotite and hornblende occur in glomerocrysts in earlier relict gneissic foliation.

Tonalite orthogneiss is light to dark gray, medium grained, equigranular, with variable preservation of gneissic layering. Modal mineralogy includes quartz, plagioclase, and minor alkali feldspar (microcline) with hornblende, biotite, and accessory titanite, opaque minerals (magnetite), apatite, and allanite. Foliation is well preserved, except where localized hornfels recrystallization from nearby Early to middle Cretaceous plutonism has occurred. The mafic domains best preserve the earlier foliation, where hornblende is still aligned along the foliation planes and biotite has recrystallized without a preferred orientation.

The magnetic susceptibility of the orthogneiss unit is generally moderately low, averaging 0.7 x 10^{-3} SI overall. Higher magnetic susceptibilities of up to 19 x 10^{-3} SI in a few localities appear to be an effect of contact metamorphism.

Orthogneiss unit MDlo is assigned Early Mississippian to Late Devonian age based on dated orthogneiss bodies elsewhere in the Lake George assemblage. Four SHRIMP (sensitive high-resolution ion microprobe) U-Pb ages from orthogneiss in the Tanacross Quadrangle northeast of the map area range from 347.4 ± 5.1 to 370.5 ± 5.9 Ma (Dusel-Bacon and Williams, 2009). Orthogneiss from the Goodpaster River area northwest of the map area yields SHRIMP U-Pb ages of 362 ± 4 to 371 ± 3 Ma (Dusel-Bacon and others, 2004). One Laser-Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) U-Pb age from orthogneiss in the Tanacross Quadrangle southeast of the map area (Solie and others, 2018) has an age of 370.5 ± 5.9 Ma (Solie and others, 2014).

pMlp PARAGNEISS AND SCHIST (pre-Mississippian)—Paragneiss is the dominant metasedimentary rock in the map area, interlayered with lesser amounts of schist. The unit crops out on both sides of the Tanana River valley. Paragneiss is distinguished from schist by having lower modal mica content; from quartzite by having less modal quartz; and from gneiss or orthogneiss by having less modal feldspar. The map unit (pMlp) includes interlayered paragneiss, schist, quartzite, amphibolite, and calc-silicate schist. Only where the latter three lithologies were observed in exposures extensive enough to map are they shown as pMlq, MDla, and pMlc, respectively, on the map. Contacts between the lithologies can be sharp or gradational; individual lithologic layers range in thickness from centimeters to many meters.

Paragneiss is interpreted as having a sedimentary, generally pelitic, protolith. Paragneiss occurs in several compositions with variable gray, brown, or green colors depending on the mineral content. Two main compositions are apparent: (1) Darker, greenish paragneiss is rich in hornblende and albite and may have biotite and chlorite, predominantly as reaction products of hornblende. Epidote-group minerals are common in hornblende-rich paragneiss in the form of epidote, clinozoisite, and zoisite. Titanite, calcite, and opaque minerals (mostly magnetite) are relatively abundant; (2) Lighter-colored paragneiss has more quartz, muscovite, and biotite. This composition locally grades into micaceous quartzite. Garnet and albite, both occurring as porphyroblasts, are common in all of the paragneiss compositions. Other mineral constituents observed in paragneiss are tourmaline, cordierite, rutile, zircon, and andalusite. The rocks have experienced amphibolite facies dynamic metamorphism and many preserve evidence of a later retrograde thermal event. Magnetic susceptibility of the paragneiss unit overall is quite low, averaging about 0.5×10^{-3} SI. Measured values range from 0.01×10^{-3} SI to 8.8×10^{-3} SI; high values may be effects of contact metamorphism.

Schists are most prevalent in the southwestern part of the map area. They are typically interlayered with and less abundant than the less micaceous paragneiss. Most schist is muscovite- and quartz-bearing with variable amounts of biotite. Some schist is biotite- and chlorite-rich with small amounts of amphibole, quartz, and plagioclase feldspar. The schists have various colors, but most are shades of light tan, brown, and gray. Porphyroblasts of albite and garnet up to 5 mm in diameter are common in many localities. Most of these porphyroblasts have undergone ductile shear along foliation and exhibit textures like ‘S’-shaped inclusion trails, synthetic microfaults, asymmetrical pressure shadows, and delta-clast shear textures. Tourmaline-bearing schists are common west of southern Yerrick Creek, where needle-like crystals up to 1.5 cm long grow along foliation, but are not oriented into a lineation. Cordierite is present in many of the more aluminous schist samples. Remnants of kyanite blades are rare, partly replaced by fibrous sillimanite, growing across foliation without a preferred orientation. Andalusite is the most common aluminosilicate; post-deformational andalusite crystals form porphyroblasts up to 3 cm long. Other observed minerals include staurolite, hornblende, rutile, zircon, graphite, titanite, clinozoisite, epidote, actinolite, calcite, pyrite, and magnetite. Magnetic susceptibility of schist averages 0.15×10^{-3} SI.

The age of this unit is poorly constrained. The unit (pMlp) is intruded by, and therefore older than, metaigneous orthogneiss unit (MDlo) which is assigned Early Mississippian to Late Devonian age. Unit could include rocks as old as Precambrian (Foster, 1970).

pMlq QUARTZITE (pre-Mississippian)—Quartzite is fine to medium grained, massive, light gray with faint banding (interpreted as relict bedding), and locally interlayered with lenses of paragneiss, schist, and amphibolite. Most quartzite layers are thin or have indistinct gradations into paragneiss and schist layers. Graphite and magnetite are notable minerals present in darker gray quartzite. Only a few quartzite exposures are of mappable scale. Quartzite may have minor components of muscovite and biotite (≤20 percent), and many of the micaceous compositions show strong isoclinal folding. Calc-silicate and metacarbonate layers are often interlayered or in close proximity with quartzite. These calcic rocks, where associated with quartzite, occur as thin alternating bands between 0.5 and 3 mm thick. One quartzite associated with calcium-rich units has 4-cm-diameter garnets with distinctive sigmoidal inclusion trails. Magnetic susceptibility is generally low, averaging about 0.2 x 10^{-3} SI. Locally, these rocks have magnetic susceptibilities up to 3.5 x 10^{-3} SI due to effects of contact metamorphism. Age is assigned based on interpreted depositional relationship with Devonian or older metasedimentary unit pMlp.

MDIa AMPHIBOLITE (Mississippian to Devonian)—Amphibolite is fine to medium grained, with lesser amphibole-plagioclase gneiss in thin lenses, layers, and localized outcrops. Amphibolite modal mineralogy consists of hornblende (~90 percent) and plagioclase (~10 percent). Amphibole-plagioclase gneiss is finely banded with modal mineralogy consisting of hornblende (60–90 percent), plagioclase (10–40 percent), and quartz (<10 percent), with minor amounts of biotite clinozoisite, epidote, chlorite, titanite, and garnet. Trace-element analyses of amphibolite units throughout the map area, assuming a basaltic protolith, indicate variable tectonic settings including within-plate, island arc, and mid-ocean ridge affinities (Werdon and others, 2014). Most samples preserve a strong fabric of aligned amphiboles, while others have weak foliation with evidence of post-foliation hornfels recrystallization. Some layers have coarse albite and hornblende porphyroblasts. Garnets commonly show evidence of retrograde reaction to biotite and/or chlorite. Some samples show subsequent brittle–ductile deformation under lower greenschist conditions with abundant fine-grained white mica and zoisite. A few percent of disseminated pyrite (and oxidized remnants) occur in several localities. The magnetic susceptibilities for amphibolite occur in two distinctive subsets: (1) average magnetic susceptibilities of 0.3 x 10^{-3} SI, and (2) average magnetic susceptibilities of 5.3 x 10^{-3} SI. Samples from the higher group appear to contain more Fe-rich minerals; some may be a result of contact metamorphism. Age is assigned based on interpreted pre-metamorphic intrusive and/or depositional relationship with Devonian or older metasedimentary unit pMlp. An orthoamphibolite from the Lake George assemblage northwest of the map area yielded a Late Devonian SHRIMP U-Pb zircon crystallization age of 369 ± 3 Ma (Dusel-Bacon and others, 2004). No older amphibolites are currently known; we therefore assign a Devonian to Mississippian age.

pMlc CALC-SILCATE AND MARBLE (pre-Mississippian)—Calc-silicate rocks are typically a minor component of the metasedimentary rocks in the map area. The most prevalent association is for very thin (<1–2 mm) calc-silicate layers in or near quartzites, often associated with garnet-bearing metacarbonate. Only one body of marble and associated calc-silicate skarn is mapped, along the Tanana River east of Jan Lake. These skarn rocks locally have diopside, wollastonite, garnet, and epidote with granofels in contact with granitic orthogneiss. The magnetic susceptibilities range from 0.5 x 10^{-3} to 5.8 x 10^{-3} SI. Age is assigned based on interpreted depositional relationship with Devonian or older metasedimentary unit pMlp.

Greenschist-Facies Metaigneous and Metasedimentary Rocks — Jarvis belt

DЄtp TUSHTENA PASS SCHIST, QUARTZITE, AND CARBONATE (Devonian or older)—The area south of the Elting Creek and Robertson River fault included only two stations during the DGGS field season. The unit was recognized as distinct from rocks to the north; the unit name and description are from Dashevsky and others (2003). They report the Tushtena Pass unit includes quartz–sericite–chlorite schist, quartz-rich, and calcareous layers. Quartz-carbonate veins are common. Protoliths include calc-arenite, limestone and siltstone sedimentary rocks, and trachyandesite–andesite to rhyodacite volcanic rocks. The unit is typically intruded by gabbroic sills and dikes. The Elting Creek fault is the basal contact of the unit. Age is based on a Devonian 372 ± 6 Ma SHRIMP U-Pb age ascribed to the overlying Lagoon unit with which it is in transitional contact (Dashevsky and others, 2003).

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