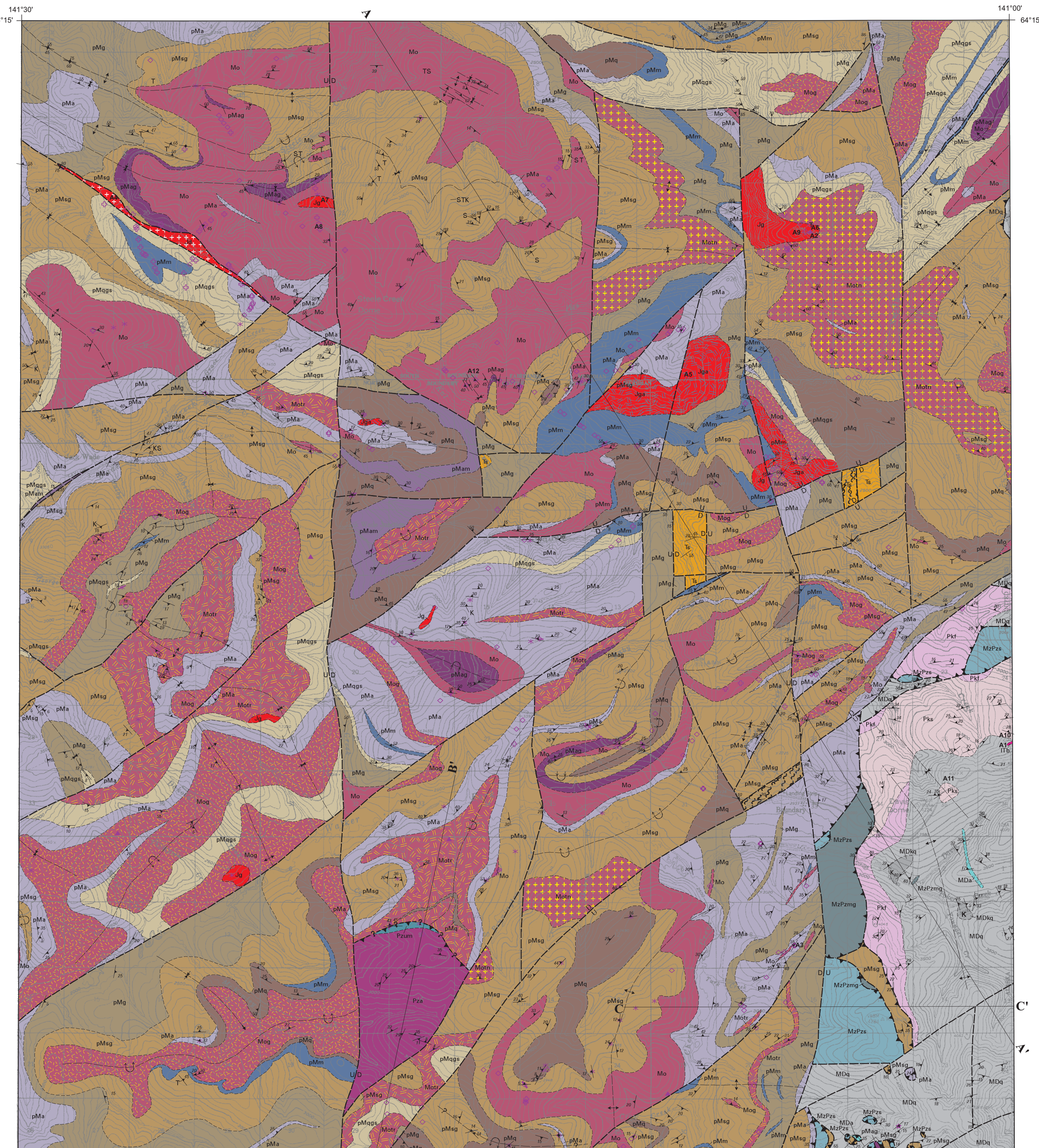
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

PRELIMINARY INTERPRETIVE REPORT 2002-1b
Szumigala and others (2002)



Base map from:
Eagle A-1 Quadrangle, U.S. Geological Survey digital raster graphic image, 1997.
Map projection: UTM zone 7
Datum: NAD 27

SCALE 1:63,360

CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

Bedrock geologic field investigations by: D.J. Szumigala (1999-2001), R.J. Newberry (1999-2001), M.B. Werdon (1999-2001), J.E. Athey (2001), K.H. Clautice (2001), J.C. Grady (2000), W.C. Munley (2000), R.L. Flynn (1999-2001), and M.R. Johnson (2001).

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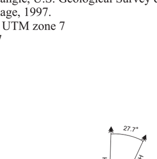
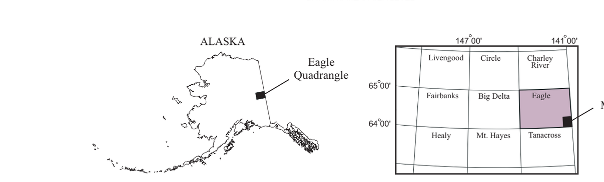
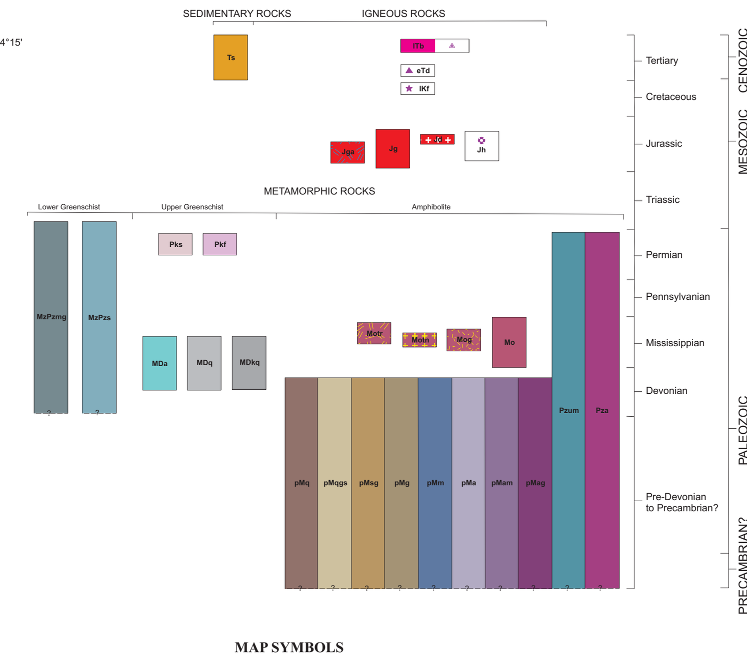




Maps Showing Location of Study Area

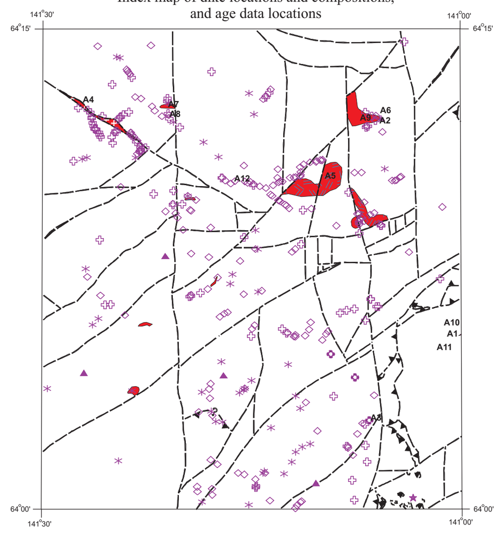
CORRELATION OF MAP UNITS



MAP SYMBOLS

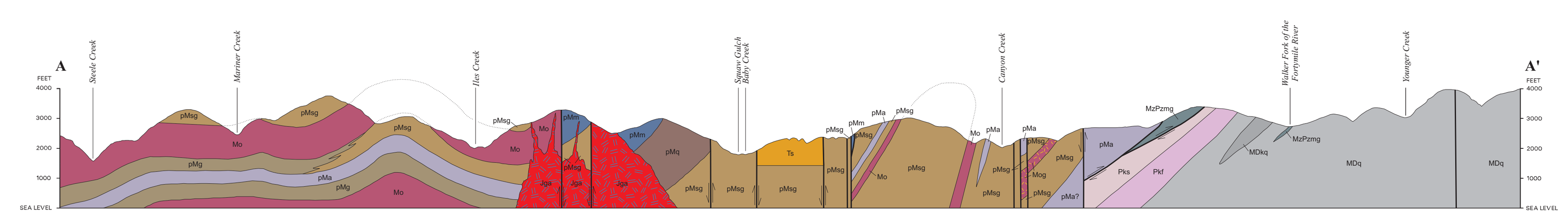
- **Contact** - Dashed where approximately located or inferred
- **Fault** - Dashed where approximately located or inferred. Arrows indicate apparent direction of relative movement; U, upthrown block; D downthrown block
- **Low angle or thrust fault** - Dashed where approximately located or inferred, queried where relationship uncertain; Barbs on upper plate
- **Shear zone**
- **Fold** - Showing trace of axial surface; arrows located on the axial trace indicate direction of plunge; queried where location or orientation uncertain
  - Antiform
  - Overturned antiform, showing direction of dip of limbs
  - Synform
  - Overturned synform, showing direction of dip of limbs
- **Strike and dip of bedding**
- **Strike and dip of foliation**
- **Horizontal foliation**
- **Strike of vertical foliation**
- K **Kyanite locality** - shown on map; identified by thin section petrography
- S **Staurolite locality** - shown on map; identified by thin section petrography
- T **Tourmaline locality** - shown on map; identified by thin section petrography
- A1 **^{40}Ar/^{39}Ar and U-Pb localities** - numbers refer to map and table 1

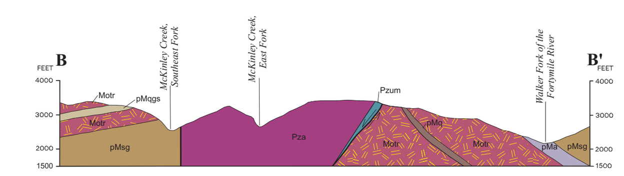
Index map of dike locations and compositions, and age data locations

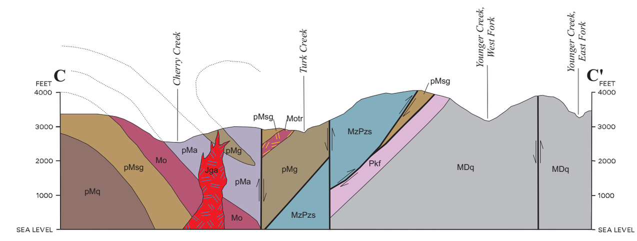


DIKE SYMBOLS

- Dikes shown on geologic map as lines where orientation was recorded
- Basalt; equivalent to lTb (Tertiary)
- Diabase; equivalent to eTd (Tertiary)
- Rhyolite; equivalent to lKf (Cretaceous)
- Hornblendite; equivalent to Jh (Jurassic)
- Aplitic to pegmatitic; interpreted to be the latest phase of Jurassic intrusions (Jurassic)
- Felsic to intermediate granitic; equivalent to Jurassic intrusions (Jurassic)
- Foliated; may either be syn-Jurassic deformation, or part of the pre-Mississippian amphibolite-facies metamorphic rocks





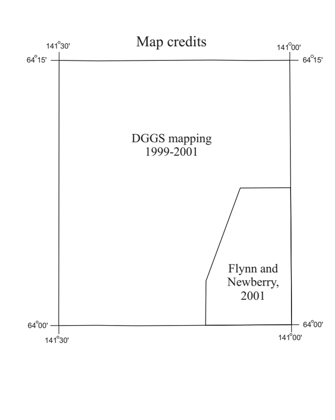


2X VERTICAL EXAGGERATION IN SCHEMATIC CROSS SECTIONS

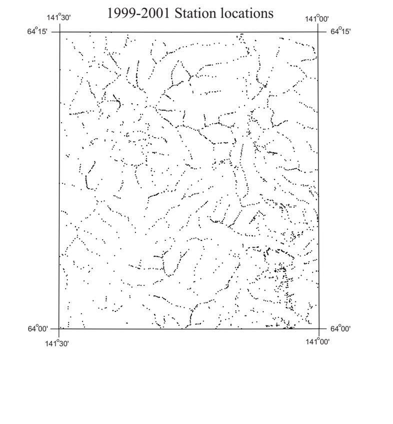
Table 1. Interpreted ^{40}Ar/^{39}Ar and U-Pb ages for selected samples from the Eagle A-1 Quadrangle, Alaska

No.	Sample No.	Mineral Analyzed	Location/Unit	Rock Type	Unit Label	Best Interpreted Age (Ma)	Age Type	Reference
A1	00RF547B	Whole rock	Dike cutting MDq	vesicular olivine alkali basalt	lTb	13.8 +/- 0.4	p	1
A2	01Z158A	Whole rock	VABM Canyon basalt	vesicular alkali basalt	lTb	18.0 +/- 0.2	ap	2
A3	00RF222A	Hornblende	Hornblendite	plagioclase-bearing hornblendite	Jh	191.4 +/- 1.6	p	1
A4	99RN41	Hornblende	The Great Dike	biotite granodiorite	Jd	189.6 +/- 1.0	p	2
A5	01RN146A	White mica	Granite pegmatite and aplite	granite	Jga	181.3 +/- 1.5	p	2
A6	01Z158C	Hornblende	VABM Canyon dike	hornblende latite	Jg	183.7 +/- 1.2	p	2
A7	01MBW381B	Biotite	Granodiorite	hornblende-biotite granodiorite	Jg	184.8 +/- 1.4	p	2
A8	01MBW377B	Biotite	Granodiorite dike	hornblende biotite granodiorite	Jg	204.1 +/- 1.5	ap	2
A9	01Z160A	Biotite	Granodiorite	biotite hornblende granodiorite	Jg	178.7 +/- 1.3	ma	2
A10	00RF549A	Phengite	Klondike series	mica-quartz schist	Pks	157.5 +/- 1.2	p	1
A11	00RF015B	Phengite	Nasina series	white mica-quartz schist	MDq	106.3+/- 0.6	p	
						116.3 +/-0.9	p	1
A12	98Ad174	Zircon	Orthogneiss	orthogneiss	Mo	343 +/- 4	*	3

Age type: ^{40}Ar/^{39}Ar laser step-heating (p = plateau age, ap = weighted average of plateau ages from two runs of the same sample, ma = minimum age) and SHRIMP U-Pb (* = weighted average of ^{206}Pb/^{238}U ages and uncertainties from 13 grains).
References: (1) Flynn and Newberry, 2001, (2) Layer and others, in prep., (3) Day and others, in press.



1999-2001 Station locations



BEDROCK GEOLOGIC MAP OF THE EAGLE A-1 QUADRANGLE, FORTYMILE MINING DISTRICT, ALASKA

by
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2002

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DESCRIPTION OF MAP UNITS

SEDIMENTARY ROCKS

Ts SEDIMENTARY ROCKS (Tertiary) — Poorly- to well-indurated, nonmarine sedimentary rocks of Tertiary age, as established by pollen (Foster, 1976; Foster and Igarashi, 1990). The unit typically consists of conglomerate, with lesser sandstone, shale, siltstone, and graywacke. Magnetic susceptibility is very low, <0.1 x 10^{-3} SI (Système International). Spatial association with placer-gold-bearing gravels in the Baby Creek area suggests that this unit may be gold-bearing as well. The unit is truncated by high-angle faults; unconformable contacts with older units are not observed.

IGNEOUS ROCKS

lTb ALKALI BASALT (late Tertiary) — Dark gray, variably vesicular, alkali basalt containing phenocrysts of olivine + augite, in an aphanitic groundmass of augite + plagioclase + magnetite, with calcite-filled amygdules. Magnetic susceptibility is high, typically ~5 x 10^{-3} SI. Major and minor oxide analysis indicates alkali basalt composition; minor oxide and trace element analysis is consistent with within-plate basalt geochemistry. The unit occurs as dikes that are finer grained and contain higher incompatible element concentrations than the early Tertiary mafic dikes seen in the Eagle A-2 and A-3 quadrangles. Two alkali basalt samples yielded whole-rock ^{40}Ar/^{39}Ar plateau ages of 13.8 ± 0.4 Ma (sample A1; table 1) and 18.0 ± 0.2 Ma (sample A2; table 1). Alkali olivine basalt about 15 km southeast of the Eagle A-1 Quadrangle gave a K–Ar biotite age of 17.2 ± 0.3 Ma (Hunt and Roddick, 1991). Late Tertiary alkali olivine basalt is mapped at several locations to the east in Yukon Territory, including near the head of Moose Creek, about 5 km east of the Eagle A-1 Quadrangle (Mortensen, 1988a). The occurrence of these extension-related basalt dikes suggest late-Tertiary high-angle normal faulting.

eTd DIABASE (early Tertiary) — Fine- to medium-grained (1–5 mm) tholeiitic diabase. Typically contains 50–70 percent felted plagioclase laths, 30–50 percent altered clinopyroxene + olivine, 3–5 percent magnetite + ilmenite, and 0–1 percent biotite. Age based on ^{40}Ar/^{39}Ar biotite plateau age of 57.5 Ma for a dike of indistinguishable major and minor element content from the Eagle A-2 Quadrangle (Werdon and others, 2001). Probably correlates with Tertiary basalts of similar major- and trace-element compositions (within-plate) throughout Interior Alaska. Relatively unaltered mafic dikes (too small to be shown at map scale) are sporadically present elsewhere in the map area and probably represent the same early Tertiary magmatism. Magnetic susceptibility of the unit is moderate to high, usually 1–11 x 10^{-3} SI. In the Eagle A-2 and A-1 quadrangles this mafic rock occurs along or is cut by north–northeast-trending high-angle faults, indicating a change in structural regime following Late Cretaceous magmatism and faulting.

lKf FELSIC PORPHYRY (Late Cretaceous) — Brownish-gray porphyritic rock with quartz phenocrysts and altered sanidine phenocrysts in an aphanitic groundmass of sericite + quartz + calcite + iron oxides, occurring as rare dikes in the northeast and southeast parts of the quadrangle. Magnetic susceptibility is low: 0.01–0.1 x 10^{-3} SI. Major oxide analysis indicates rhyolite to rhyodacite composition. Whole-rock ^{40}Ar/^{39}Ar dating (Flynn and Newberry, 2001) of a rhyolite from 3 km south of the Eagle A-1 Quadrangle yielded a plateau age of 64.7 ± 0.4 Ma, which most likely represents latest Cretaceous igneous crystallization. Late Cretaceous volcanic and plutonic rocks occur just to the east in Yukon Territory, up to within 6 km of the U.S. border (Mortensen, 1988a). A rhyolite porphyry pluton 15 km to the east has a U–Pb (zircon) age of 68.7 ± 0.3 Ma; the Moosehide Hills rhyolite, 45 km to the east, has a U–Pb (zircon) age of 68.1 ± 0.6 Ma (Mortensen, 1999). The small felsic porphyry dikes in the Eagle A-1 Quadrangle most likely represent the distal fringes of latest Cretaceous magmatism abundantly exposed in the western Yukon Territory. Latest Cretaceous mafic and alkalic igneous rocks are temporally and spatially associated with the felsic rocks just south of the Eagle A-1 Quadrangle (Flynn and Newberry, 2001) and especially to the east, in Yukon Territory (Mortensen, 1988b; 1999). The magmatic associations indicate an extensional tectonic environment; these igneous bodies are characteristically within (Flynn and Newberry, 2001) or bounded (Mortensen, 1988a) by high-angle, northeast-trending faults of likely similar age.

Jh HORNBLENDITE (Jurassic) — Black, unfoliated, very coarse-grained rock containing more than 85 percent subequant hornblende (0.5–2 cm), with minor plagioclase ± biotite ± sphene, and minor secondary epidote + calcite + sericite. Magnetic susceptibility is moderate to very high, 0.2–22 x 10^{-3} SI. Numerous biotite clinopyroxenite dikes with up to 50 percent amphibole are found in the northwest Eagle A-2 Quadrangle (Werdon and others, 2001). Biotite hornblendite is also noted in the Eagle C-3 (Newberry and others, 1998) and B-1 (Foster and Keith, 1968) quadrangles. In the east-central Eagle Quadrangle such dikes contain anomalous concentrations of platinum (Pt) and palladium (Pd); however, none of the dikes sampled in the Eagle A-1 Quadrangle contained detectable gold, palladium, or platinum. ^{40}Ar/^{39}Ar dating of hornblende from hornblendite yielded a plateau age of 191.4 ± 1.6 (sample A3; table 1). Hornblende from a hornblende dike just south of the Eagle A-1 Quadrangle gave a ^{40}Ar/^{39}Ar age of 175.8 ± 2.2 (Flynn and Newberry, 2001). Hornblende in biotite hornblendite from the Eagle C-3 Quadrangle yielded a plateau age of 184 ± 0.6 Ma (Newberry and others, 1998). While clearly Jurassic in age, the hornblendite dikes apparently represent a protracted magmatic episode.

Jd THE GREAT DIKE (Jurassic) — Sub-equigranular, medium-grained, locally foliated to nonfoliated biotite granodiorite to hornblende–biotite granodiorite, present in a body 7 km long and 50–400 m wide, herein called the Great Dike. Typical modal mineralogy is 15–30 percent quartz, 35–45 percent plagioclase, 7–15 percent K-feldspar, 20 percent mafics, 1 percent each of sphene, myrmekite, and magnetite, and trace apatite and allanite. Relative mafic mineral abundance ranges from nearly all biotite to hornblende slightly greater than biotite. K-feldspars are up to 8 mm in length, other major minerals typically are 1–5 mm. Alteration is usually minor, with some chloritization of mafic minerals and sericitic dusting of plagioclase. Trace and major element characteristics indicate the body is of I-type, arc-related affinity. No obvious hornfels alteration is seen in metamorphic rocks surrounding the body; the dissimilar rock types on opposite sides of the dike suggest it was intruded along a Jurassic west–northwest-trending fault that was subsequently reactivated. Magnetic susceptibility is moderate (0.3–1.4 x 10^{-3} SI), similar to Jurassic plutons in the Eagle A-2 Quadrangle (Werdon and others, 2001). ^{40}Ar/^{39}Ar hornblende plateau age of 189.6 ± 1.0 Ma (sample A4; table 1) is similar to that of mildly foliated Jurassic plutons in the adjacent Eagle A-2 Quadrangle (Werdon and others, 2001).

Jga GRANITE PEGMATITE AND APLITE (Jurassic) — Unfoliated, leucocratic granite with mixed pegmatite, aplite, and rare seriate textures. Grain size varies between >1 cm and ~1 mm, typically either coarse- or fine-grained. Variations in texture and grain size occur at the outcrop and hand-specimen scale. Typical modal mineralogy is 5 percent mafics (biotite and/or muscovite), 25–35 percent quartz, 25–30 percent K-feldspar, and 30–35 percent plagioclase. Muscovite occurs both as a replacement of biotite and as apparently primary grains. Trace and major element compositions suggest that these are highly fractionated I-type granites of arc affinities, which occur both as kilometer-scale bodies and as dikes. Magnetic susceptibility is low, typically ~0.1 x 10^{-3} SI. Muscovite from a large aplite-granite body yielded a ^{40}Ar/^{39}Ar plateau age of 181.3 ± 1.5 Ma (sample A5; table 1). Similar-appearing granite pegmatite–aplite bodies about 10 km east of the Eagle A-1 Quadrangle yield U–Pb (zircon) ages of 190–191 Ma (Mortensen, 1999). ^{40}Ar/^{39}Ar muscovite plateau age for similar-appearing granite in the Eagle A-2 Quadrangle is ~186 Ma (Werdon and others, 2001). These bodies may have been intruded over a protracted period in the early Jurassic.

Jg GRANODIORITIC PLUTONS (Jurassic?) — Numerous small to moderate-sized, commonly elongate Jurassic(?) plutons scattered throughout the quadrangle. These bodies texturally resemble the Jurassic Uhler pluton of the Eagle A-2 Quadrangle (Werdon and others, 2001) and the Great Dike. Rocks of these plutons may display a slight foliation; they are commonly porphyritic to sub-equigranular, medium- to fine-grained. Compositions are largely granodiorite, but include lesser granite, tonalite, and quartz diorite. Trace and major element compositions indicate I-type, arc affinity. Typically contain 15–30 percent quartz, 15–35 percent K-feldspar, 35–45 percent plagioclase, 0–15 percent hornblende, 2–10 percent biotite, and minor sphene, magnetite, and allanite. Epidote and chlorite are variably present as alteration products of the mafic minerals. Magnetic susceptibilities vary from 0.1 to 0.6 x 10^{-3} SI. ^{40}Ar/^{39}Ar plateau ages for granodioritic dikes and plutons in the Eagle A-1 Quadrangle include 183.7 ± 1.2 Ma (sample A6; table 1), 184.8 ± 1.4 Ma (sample A7; table 1), and 204.1 ± 1.5 Ma (sample A8; table 1). A ^{40}Ar/^{39}Ar minimum age of 178.7 ± 1.3 Ma (sample A9; table 1) was determined for a granodioritic dike located near a Miocene basalt dike. The smaller size and absence of magmatic epidote in the Jurassic bodies of the Eagle A-1 Quadrangle suggests these bodies are exposed at a shallower level than those of the Eagle A-2 Quadrangle.

METAMORPHIC ROCKS

MAFIC AND ULTRAMAFIC ROCKS METAMORPHOSED TO LOWER GREENSCHIST FACIES: SEVENTYMILE TERRANE

Dunite and gabbro metamorphosed to lower greenschist facies occur together in the southeastern Eagle A-1 Quadrangle; their similar character, metamorphism, and spatial proximity suggests a genetic relationship. There are numerous serpentinized ultramafic bodies in interior Alaska, especially in the Eagle Quadrangle (Foster and Keith, 1974), currently described as the 'Seventymile Terrane' and interpreted to represent dismembered ophiolites. Gabbro is associated with dunite and harzburgite at Mount Sorenson (Keith and others, 1981) but not reported with the other large ultramafic bodies. The serpentinite of the Eagle A-1 Quadrangle is universally considered part of the Seventymile Terrane; the gabbro has been included within a quartz mica schist and greenschist unit (Foster, 1976; Foster and others, 1985) that, in turn, has been either assigned to the Seventymile Terrane (Foster and others, 1994) or to the Klondike Schist (Dusel-Bacon and others, 1998). We group together the altered gabbro and dunite as Seventymile Terrane and distinguish them from nearby upper greenschist and amphibolite facies rocks. The serpentinite and metagabbro occur as discontinuous wedges along the thrust contact between the amphibolite and greenschist facies rock units.

Permian chert is spatially associated with the two largest ultramafic bodies (Foster and others, 1978; Keith and others, 1981) in Interior Alaska; Late Triassic limestones are spatially associated with ultramafic rocks in western Yukon Territory (Abbott, 1983). These ages most likely set an upper limit to the ages for the mafic and ultramafic rocks; the lower limit is undefined, but presumably Paleozoic.

MzPzs SERPENTINITE (Mesozoic to Paleozoic) — Green to dark gray, orange-brown weathering, slightly foliated, fine-grained rock dominated by serpentine with accessory chromite, local relict olivine, and secondary magnetite + magnesite. In samples not totally serpentinized, olivine relicts are optically continuous for up to 5 mm, occupying a volume representing greater than 90 percent of the primary modal mineralogy. Magnetic susceptibility of the serpentinite is very high, typically 10–60 x 10^{-3} SI. Consequently, serpentinite has also been mapped in areas lacking rock exposures but displaying strong magnetic anomalies. Aeromagnetic data also indicate that serpentinite locally underlies amphibolite-facies metamorphic rocks, i.e., that serpentinite occurs imbricated in thrust faults, and not as the structurally highest block. Waxy massive serpentinite with relatively low magnetic susceptibility (0.1–1 x 10^{-3} SI) is present near some fault contacts. Chrysotile typically is scarce, and is most common near fault contacts.

MzPzmg METAGABBRO (Mesozoic to Paleozoic) — Green and white, medium- to coarse-grained, slightly- to un-foliated rock consisting of sub-equal clinopyroxene and plagioclase entirely pseudomorphically replaced by fine-grained actinolite + chlorite + epidote–clinozoisite + albite + sphene. Primary silicates were 3–15 mm, but locally several centimeters, in size. Includes sparse coarse-grained actinolite ± chlorite schist and rare very coarse-grained chlorite rock. Magnetic susceptibility is variable, between 0.1 and 6, but averaging 0.3 x 10^{-3} SI. Like the serpentinite, interpreted to occur as imbricate wedges in thrust faults.

ROCKS METAMORPHOSED TO UPPER GREENSCHIST FACIES: NASINA AND KLONDIKE SERIES

Greenschist-facies assemblages of predominantly metasedimentary and metavolcanic rocks in the eastern Eagle A-1 Quadrangle are mapped as the Nasina and Klondike series, respectively, after McConnell (1905). The Nasina and Klondike series in this area are greenschist facies; the local presence of biotite (and more commonly, its compositional equivalent, muscovite + chlorite) and the rare occurrence of kyanite (and pyrophyllite) suggest that these rocks were metamorphosed to borderline upper greenschist facies. A biotite-in isograd could not be mapped; either there has been too much deformation subsequent to metamorphism or the rocks of the area essentially straddle the isograd. The Nasina series primarily contains carbonaceous metasedimentary rocks, and the Klondike schist predominantly metavolcanic and lesser non-carbonaceous metasedimentary rocks (Mortensen, 1988b). These rocks were previously mapped as "quartz mica schist and greenschist" (Foster, 1976; Foster and others, 1985) that, in turn, have been assigned either to the Y_1 subterrane of the Yukon–Tanana terrane (Churkin and others, 1982), the Seventymile Terrane (Foster and others, 1994), or to the Klondike and Nasina units of the Yukon-Tanana terrane (Dusel-Bacon and others, 1998).

U–Pb (zircon) dates for felsic interlayers in Nasina quartzite of 361 ± 2 and 358.5 ± 1.5 Ma (Mortensen, 1999) indicate a latest Devonian age; galena from several stratiform Pb–Zn–Ba occurrences in Nasina rocks give Devonian lead isotope model ages (Mortensen, 1996). Most likely the age range of the Nasina series extends into the Mississippian. We follow Dusel-Bacon and others (1988) in correlating the Nasina series with the Devono–Mississippian Keevy Peak formation of the central Alaska Range and rocks of similar age and appearance in the Fairbanks and Big Delta quadrangles. Numerous UPb (zircon) age determinations from Klondike schist metafelsites, including one from 3 km east of the Eagle A-1 Quadrangle, give ages of 253 to 263 Ma, that is, mid to late Permian (Mortensen, 1990; Dusel-Bacon and others, 1998; Mortensen, 1999). Metavolcanic rocks of Permian age have not been identified in Interior Alaska outside of easternmost Eagle Quadrangle, but are common in western Yukon Territory, extending as far east as the Klondike district (Mortensen, 1999). The Chicken metamorphic complex, a greenschist-metamorphosed package of metavolcanic and metasedimentary rocks with a Permian U–Pb (zircon) age (Mortensen, written commun., 2001) in the Eagle A-2 Quadrangle may be correlated. However, a significant thickness of Devono–Mississippian bimodal metavolcanic and metasedimentary rocks overlies the Keevy Peak formation in Interior Alaska. These rocks are only confidently distinguished from lithologically similar Klondike series through U–Pb zircon dating; hence, unrecognized Klondike series rocks may occur elsewhere in Alaska.

The contact between the Nasina and the Klondike series is most recently mapped as a younger-over-older thrust fault in west-central Yukon Territory (e.g., Mortensen, 1988a). However, there is no obvious increase in deformational fabrics near the contact between the Nasina units and Klondike schist units in the Eagle A-1 Quadrangle, there are no exotic lithologies at this contact, there is no obvious difference in structural grain, nor is there an abrupt change in rock type. If Nasina series rocks are equivalent to Keevy Peak formation, however, then a considerable amount of metavolcanic-dominant section is missing between the Nasina and the Klondike series present in the Eagle A-1 Quadrangle. We follow Green (1972) and map this as an unconformable contact.

Pks KLONDIKE SCHIST (Permian) — Predominantly rusty-weathering, fine- to medium-grained, albite–chlorite–phengite–quartz schist and lesser albite–phengite–quartz schist, with an apparent thickness of ~500 m. Pks is distinguished from Pkf based on abundance of metafelsites—rare in Pks and abundant in Pkf. Magnetic susceptibility is low, 0.03–0.25 x 10^{-3} SI, with sporadic higher values. In the southeast Eagle A-1 Quadrangle this unit was explored in the 1970s for volcanogenic massive sulfide deposits, and a polymetallic (Pb–Zn–Cu–Ag) soil anomaly was defined (Resource Associates of Alaska, 1977; Smit, 2000). Several short core holes drilled in upper Brophy Creek drainage did not encounter massive sulfide, although highly pyritic zones were intersected, with rare galena and sphalerite (Resource Associates of Alaska, 1977). Galena from this core displayed lead isotope ratios indistinguishable from those of syngenetic Klondike schist-hosted prospects in Yukon Territory (J.K. Mortensen, written commun., 2002). Rocks in upper Arkansas Creek and, to a lesser extent, Brophy Creek, are heavily iron-stained. Phengite yielded a ^{40}Ar/^{39}Ar plateau age of 157.5 ± 1.2 Ma (sample A10; table 1), which represents cooling from peak metamorphism.

Pkf KLONDIKE METAFELSITE (Permian) — Fine-grained, greenschist-facies, feldspar-rich felsic to intermediate-composition metavolcanic rocks, commonly with relict igneous texture, up to 300 m thick. Most commonly present as chlorite–clinozoisite–phengite–albite–quartz metafelsite and schist (locally with minor biotite); clinozoisite–phengite–quartz schist; and phengite–albite–quartz–K-feldspar metarhyolite. Mineral proportions vary considerably; those of apparently meta-intermediate composition contain abundant chlorite, clinozoisite, albite, and phengite. X-ray diffraction analysis indicates the unit locally contains pyrophyllite in addition to phengite. Disseminated pyrite and quartz lenses are locally common. Albite and K-feldspar are present in variable proportions, and are fine-grained to porphyroclastic (up to 2 mm in size); some rocks appear to be metaporphyritic. Magnetic susceptibility is low, 0.02–0.2 x 10^{-3} SI.

MDq NASINA QUARTZITE (Mississippian–Devonian) — Fine-grained, predominantly dark gray, commonly pyritic, carbonaceous quartzite and phengite–quartz schist, with lesser graphite–quartz schist and light gray quartzite. Locally grades into thin layers of biotite–albite-bearing quartz schist and quartzite, and are locally calcite-rich and include some marble. Apparent thickness is greater than 1,000 m, as this unit underlies a large adjacent area in Yukon Territory (Mortensen, 1988a). Foliation is locally crenulated; quartz lenses are common and commonly isoclinally folded. Magnetic susceptibility unit is very low, 0.01–0.15 x 10^{-3} SI, with sporadic higher values. The carbonaceous rocks are strongly conductive, although low-conductivity quartzite with little to no carbon is interlayered throughout the unit. Consequently, high conductivity, covered zones near outcrops of Nasina quartzite were also mapped as Nasina. Phengite from a phengite–quartz schist layer yielded ^{40}Ar/^{39}Ar plateau ages of 106.3 ± 0.6 Ma and 116 ± 0.9 Ma (sample A11; table 1), presumably reflecting age of cooling from peak metamorphism.

MDkq NASINA KYANITE QUARTZITE (Mississippian–Devonian) — Fine- to medium-grained, bluish-gray quartzite containing ~two-thirds quartz and one-third 1–2 mm euhedral kyanite, with several percent each of 0.5 mm euhedral chlorite and white mica, and <1 percent each of apatite, rutile, opaque, and graphite. The absence of garnet, biotite, and tourmaline—invariably seen with kyanite-bearing rocks of the amphibolite facies rocks—and the presence of primary chlorite indicates that kyanite quartzite is most similar to lithologies in the Nasina quartzite unit (MDq). Lacking any evidence of fault contacts with surrounding MDq, it is included within the Nasina Series. Most likely the protolith was a highly weathered or altered rock, for example, a paleosol or pyrophyllite-altered metarhyolite. Mortensen (1990) describes rare metarhyolite intervals in the Nasina series, which may be less-metamorphosed equivalents to the kyanite quartzite. Magnetic susceptibility is low to moderate, 0.05–0.7 x 10^{-3} SI.

MDa NASINA ACTINOLITE SCHIST (Mississippian–Devonian) — Fine- to coarse-grained, green actinolite schist consisting of 70 to more than 90 percent actinolite + minor quartz ± clinozoisite ± biotite. Major and minor oxide analyses indicate the actinolite schist has mafic to ultramafic composition. Magnetic susceptibility is moderate: 0.1–0.5 x 10^{-3} SI. Actinolite schist grades into Nasina quartzite in several places in the Eagle A-1 Quadrangle and vicinity (Flynn and Newberry, 2001) and mafic interlayers within Nasina quartzite are described in the Yukon Territory (Mortensen, 1990). The presence of biotite distinguishes this unit from the lower-grade, but actinolite-rich metagabbro of the Seventymile Terrane.

ROCKS METAMORPHOSED TO AMPHIBOLITE FACIES: FORTYMILE RIVER ASSEMBLAGE

Foster (1969) grouped all the amphibolite-facies rocks in the Eagle A-1 Quadrangle as a single gneiss and schist unit. Although individual lithologic unit boundaries were not delineated, marble-rich, garnet-rich, quartzite-rich areas, and augen gneiss localities encountered on ridgeline traverses are indicated by various symbols on her map. Based on mineral assemblages in metabasalts and metapelites, rocks of the Eagle A-1 Quadrangle have experienced epidote–amphibolite facies metamorphism (Dusel-Bacon and others, 1995; this study). Local presence of staurolite and kyanite, invariably with tourmaline, in schist is apparently related to local aluminum–boron-rich protoliths and not to significant variations in metamorphic conditions. Pre-, syn-, and post-tectonic mineral fabrics are observed in the rocks, indicating a complex thermal and structural history, probably involving multiple deformational episodes. Hornblendes from these amphibolite-facies metamorphic rocks have yielded highest-temperature ^{40}Ar/^{39}Ar fraction ages of 190–214 Ma and stepped pseudo-plateau, plateau, and saddle ages of 188–204 Ma (Cushing, 1984; Hansen and others, 1991). Metaplutonic rocks, which intrude the amphibolite-facies package, have ages as old as mid-Devonian (Aleinikoff and others, 1986; Mortensen, 1990; Mortensen, 1999) although metaplutonic rocks in the Eagle A-1 Quadrangle and immediate vicinity yield Mississippian U–Pb (magmatic) ages (Mortensen, 1999; Mortensen, written commun., 2001; Day and others, in press). Thus, *most* of the amphibolite-facies metamorphic rocks are of Devonian or older age. Notably, the metaharzburgite (Pzum) and amphibolite, paragneiss, and schist (Pza) units are not intruded by orthogneiss and their ages are poorly constrained. Churkin and others (1982) referred to the amphibolite facies rocks of the Eagle Quadrangle as subterrane Y_4; Hansen and Dusel-Bacon (1998) call it the Taylor Mountain Terrane. The amphibolite-grade metamorphic rocks of the Eagle Quadrangle were distinguished from other amphibolite-facies rocks of interior Alaska based on the alleged scarcity of Devono–Mississippian meta-plutonic rocks and abundance of metapelitic rocks in the former (Churkin and others, 1982; Foster and others, 1994). However, Day and others (2000) and Werdon and others (2001) have shown that metaplutonic rocks are abundant, at least in the Eagle A-1 and A-2 quadrangles. Similarities in protolith age, major- and trace-element composition, and metamorphic facies to metamorphic rocks of the Tanacross Quadrangle (Dusel-Bacon and Cooper, 1999) and to the Fairbanks area (Newberry and others, 1996) suggest that this unit of amphibolite-facies metamorphic rocks is widespread in eastern Interior Alaska. Although previously referred to as the Taylor Mountain Terrane (Hansen and Dusel-Bacon, 1998), these units are not in contact with the Taylor Mountain Batholith (Werdon and others, 2001) and the name is consequently inappropriate. The amphibolite-facies units of the Eagle Quadrangle are currently referred to as the Fortymile River Assemblage (C. Dusel-Bacon, written commun., 2000). We infer that this unit was structurally juxtaposed with the lower-grade Permian and Devono–Mississippian metamorphic rocks during the early Mesozoic, as the youngest foliated rocks are of latest Permian age and the oldest little-deformed rocks of the region are the early Jurassic plutons. Most contacts between the amphibolite facies rocks and the lower-grade rocks are obscured by extensive high-angle faulting and generally poor exposures characteristic of the region; however, locally, the high-grade rocks are seen in thrust contact with the low-grade rocks; a thin zone of serpentinite is invariably present within such thrusts.

Motr TRONDHJEMITIC ORTHOGNEISS (Mississippian) — Bodies consisting primarily of leucocratic, medium- to coarse-grained, (K-feldspar)–biotite–quartz–sodic plagioclase gneiss with trondhjemitic composition and remnant plutonic textures. Typical grain size is 2–5 mm, and texture is sub-equigranular; K-feldspar porphyroclasts are consistently absent. Major mineral abundances: 45–80 percent plagioclase (average 63), 0–10 percent K-feldspar (average 4), 15–40 percent quartz (average 26), 0–10 percent biotite (average 6), 0–10 percent muscovite (average 2), and 0–3 percent garnet. Plagioclase is typically An_{5-15} with little obvious zoning; albite replacement textures are seen in some samples. Myrmekite is commonly present. Total mafic mineral abundances of 10 percent or less give this rock a very white appearance; foliation may be difficult to discern in very low mafic samples. Magnetic susceptibility is low, rarely more than 0.2 x 10^{-3} SI. A sample from the Eagle A-2 Quadrangle gave a U–Pb (zircon) age of approximately 335–340 Ma (J. Mortensen, written commun., 2001).

Motn TONALITIC ORTHOGNEISS (Mississippian) — Bodies consisting primarily of medium-grained, (hornblende)–biotite–quartz–feldspar gneiss with tonalitic composition and remnant plutonic textures. Includes some granodiorite and quartz diorite. Typical grain size is 1–3 mm, with evidence for granulated quartz phenocrysts of originally 3–6 mm size. Major mineral abundances: 40–75 percent plagioclase (average 50), 0–20 percent K-feldspar (average 3), 15–40 percent quartz (average 27), 10–30 percent biotite (average 15), 0–10 percent hornblende (average 3), 0–5 percent garnet, 0–7 percent epidote, and 0–2 percent oxides. Plagioclase is typically oligoclase-andesine; zoning is sometimes present and myrmekite is rare. Magnetic susceptibility is moderate, typically 0.2–0.5 x 10^{-3} SI. A tonalitic orthogneiss sample from the Eagle A-1 Quadrangle (sample A12; table 1) gave a U–Pb (zircon) age of 343 ± 4 Ma (Day and others, in press).

Mog FELSIC ORTHOGNEISS (Mississippian) — Bodies consisting primarily of fine- to coarse-grained, biotite–quartz–feldspar gneiss with granite or granodiorite mineralogy and bulk composition and some remnant igneous texture. Typical grain size is 1–4 mm, but quartz grains especially are granulated remnants of larger (commonly 3–8 mm) phenocrysts. Feldspar augen are occasionally present, but most feldspar is finer-grained than quartz. Major mineral abundances: 20–55 percent plagioclase (average 39), 7–40 percent K-feldspar (average 23), 15–42 percent quartz (average 28), 1–25 percent biotite (average 9), 0–7 percent hornblende, 0–10 percent muscovite, and 0-15 percent epidote. Apatite, zircon, sphene, and opaques are present in trace amounts. Myrmekite is commonly present. Magnetic susceptibility is usually low (average 0.2 x 10^{-3} SI), but ranges up to 1.5 x 10^{-3} SI. A sample from the Moose Creek granodiorite orthogneiss, 3 km to the east of the Eagle A-1 Quadrangle, gave a U–Pb (zircon) age of 348.2 ± 0.7 Ma (Mortensen, 1988b).

Mo UNDIFFERENTIATED ORTHOGNEISS (Mississippian) — Composite orthogneiss bodies or bodies with considerable compositional variability, as indicated by chemical analyses and feldspar staining. Individual bodies can range through the spectrum of granite–granodiorite–trondhjemite–tonalite–quartz diorite, but more commonly exhibit a smaller range in composition. Also locally includes schist, gneiss, and other metamorphic rock types present in minor abundance. Nearly always contain 15–40 percent quartz and more than 50 percent total feldspar; the remainder is mostly biotite ± muscovite or hornblende. Fine-grained orthogneiss, of potentially metavolcanic origin, constitutes up to one-third of a given body. Many bodies appear sill-like, either because they were intruded as sills or because they were deformed into sub-parallelism with the surrounding layered rocks. Magnetic susceptibility varies with rock type; 0–0.5 x 10^{-3} is typical but values up to 3 x 10^{-3} SI. These composite bodies presumably possess the same Mississippian ages as displayed by less compositionally diverse ones.

pMq QUARTZITE (Pre-Mississippian) — Fine- to medium-grained quartz-rich (>70–90 percent quartz) metamorphic rock. Greenish-gray to pure white, locally color banded, foliated, relatively pure quartzite with minor white mica and (or) feldspar; variable garnet and magnetite; and occasional pyrite and limonite disseminations and fracture fillings. Contains occasional slightly carbonaceous or magnetite-rich layers; locally interlayered with marble, lesser feldspar–quartz paragneiss (± garnet, ± biotite), and schist. Forms bold, massive outcrops where not strongly jointed. Highly fractured quartzite is quarried near Jack Wade Junction for road aggregate and used throughout the Eagle A-1 Quadrangle. Magnetic susceptibility for quartzite is generally very low (0.01–0.11 x 10^{-3} SI) except in magnetite-rich areas (up to 9 x 10^{-3} SI).

pMqgs QUARTZITE, PARAGNEISS, AND SCHIST (Pre-Mississippian) — Mixed unit consisting of, in decreasing order of abundance, interlayered quartzite, paragneiss, and schist. Quartzite is fine grained, contains ± garnet, ± feldspar, muscovite (1–20 percent), biotite (± chloritized), and is locally calcareous and (or) marble bearing. Magnetic susceptibility for quartzite is bimodal, 0.01–0.5 x 10^{-3} SI and 5–30 x 10^{-3} SI. Gneiss varies from a fine- to medium-grained, locally banded, equigranular biotite–muscovite–feldspar–quartz paragneiss grading into a locally schistose, garnet–biotite ± muscovite feldspar quartz paragneiss. Magnetic susceptibility for gneiss is generally 0–0.6 x 10^{-3} SI, but occasionally as high as 16 x 10^{-3} SI. Schist is fine- to coarse-grained, and varies from a ± garnet–biotite–muscovite schist to a ± muscovite, biotite (± chloritized)–feldspar–quartz–schist. Locally asymmetrically folded. Magnetic susceptibility for schist is generally 0.1–0.4 x 10^{-3} SI.

pMsg SCHIST AND PARAGNEISS (Pre-Mississippian) — Mixed unit characterized by abundant aluminous metasedimentary rocks. Small-scale isoclinal folds are locally visible, suggesting that the entire unit is isoclinally folded. Primarily interlayered, medium- to coarse-grained, schist (commonly crenulated and folded) and paragneiss, with minor local biotite quartzite, marble, and fine-grained plagioclase-rich (metavolcanic?) gneiss. The schist contains a minimum of 30 percent mica and typically contains 1–10 percent rotated, poikiloblastic garnet, 10–15 percent biotite, 15–75 percent muscovite, 2–20 percent plagioclase, 20–50 percent quartz, and 0–5 percent K-feldspar. Garnets are commonly 1–5 mm, other minerals typically 1–2 mm in size. Kyanite (0.2–0.5 mm, to 5 percent), staurolite (0.3–1 mm, to 5 percent), and tourmaline (0.1 mm, to 1 percent) are variably present, especially in the northwestern part of the Eagle A-1 Quadrangle. Staurolite, kyanite, and tourmaline are more abundant than shown on the geologic map, as they are virtually never identifiable in hand specimen. The common occurrence of staurolite with kyanite and tourmaline suggests that their occurrence is caused by aluminum–boron-rich bulk composition and not variations in metamorphic grade within the Fortymile River Assemblage. The paragneiss contains less than 30 percent micas and typically 40–60 percent quartz, 5–20 percent biotite, 1–20 percent muscovite, 10–25 percent plagioclase and 0–2 percent garnet, all with average grain sizes of 0.5–1 mm. The plagioclase-rich gneiss contains mineral abundances similar to that of the tonalite gneiss (Motn), but grain sizes of 0.20.5 mm suggest it may represent local (andesitic?) metavolcanic layers within a largely metasedimentary sequence. Magnetic susceptibilities for rocks of this unit are highly variable, with values between 0 and 20 x 10^{-3} SI, although low values (< 0.3 x 10^{-3} SI) are more common.

pMag AMPHIBOLITE AND GNEISS (Pre-Mississippian) — Amphibolite with a MORB-like trace element signature (Dusel-Bacon and Cooper, 1999) grading into fine-grained hornblende–epidote–plagioclase gneiss. The amphibolite characteristically contains significant amounts of magnetite with trace biotite and garnet and has a high magnetic susceptibility (average 3.5 x 10^{-3} with values to 20 x 10^{-3} SI). The gneiss commonly contains magnetite and sphene and also has a high magnetic susceptibility (average 2 x 10^{-3}, with values to 10 x 10^{-3} SI). Mineralogical and major oxide composition of the gneiss indicates a basaltic andesite or graywacke protolith. This unit appears to underlie the schist and gneiss unit (pMsg).

pMg GNEISS (Pre-Mississippian) — Predominantly fine-grained, typically plagioclase-rich gneiss, including rocks with apparently sedimentary and volcanic/volcaniclastic protoliths, and includes local orthogneiss and minor amphibolite. Primary mineralogy consists of garnet, biotite, plagioclase, and quartz ± muscovite ± hornblende, and all minerals with grain sizes of 0.5–1 mm. Rock types present suggest a protolith package of mixed arenites, possibly graywackes, with some volcanic rocks. Magnetic susceptibilities are generally moderate to low (0.1–1 x 10^{-3} SI), with some high values.

pMm MARBLE AND CALCAREOUS ROCKS (Pre-Mississippian) — Massive outcrops of non-fossiliferous, fine- to coarse-grained, light gray, usually calcite, marble. Coarse-grained (5 mm), graphitic, dolomite marble occurs locally in the southeastern part of the Eagle A-1 Quadrangle. Mapped as a separate unit where semi-continuous, massive marble outcrops or float are abundant within other amphibolite-facies units. Also includes minor calcareous quartzite and calcareous or calc–silicate gneiss and schist. Magnetic susceptibility <0.01 x 10^{-3} SI. Mostly light gray with lesser green, reddish brown, and pink color variations, folded and discontinuous, with granoblastic polygonal texture. Locally contains veins, bands, and (or) disseminated crystals of quartz, clinopyroxene, epidote, tremolite, garnet, apatite, plagioclase, white mica, and (or) iron sulfides/oxides. Most calc–silicates were produced by regional metamorphism of impure carbonates; hydrothermal skarn is locally developed in pMm adjacent to Jurassic intrusions. The common presence of diopside and absence of wollastonite is compatible with regional metamorphism at epidote–amphibolite facies.

pMa AMPHIBOLITE, GNEISS, AND SCHIST (Pre-Mississippian) — Mixed unit defined by amphibolite, with arc chemistry (Dusel-Bacon and Cooper, 1999), plagioclase-rich gneiss, and minor schist. Amphibolite is dark green, foliated, fine- to medium-grained, with typical mineralogy of ± epidote, ± garnet, ± quartz, ± biotite, and plagioclase (± sericite altered). Magnetite is locally abundant and titanium-rich minerals (sphene, rutile, ilmenite) are notably absent or nearly so. Locally quartz-veined and bearing disseminated iron sulfides. Amphibolite grades into and (or) is banded with fine-grained, hornblende—epidote–biotite–quartz–feldspar (± garnet, magnetite) gneiss on various scales. Typical modal mineralogy for the unit as a whole is 10–70 percent hornblende, 30–50 percent plagioclase, 0–10 percent biotite, 0–20 percent quartz, 0–5 percent garnet, and 0–5 percent epidote. Typical grain sizes are 0.5–1 mm, with locally coarser hornblende (1–2 mm). Commonly altered to epidote, locally cut by quartz veins with 1–3 percent pyrite, and occasionally contains pyrrhotite, limonite, and carbonate. Locally contains kyanite-bearing garnet–quartz–muscovite schist and muscovite–quartz schist. Compositions, mineralogy and mineral abundances suggest this unit consists primarily of arc basalt, basaltic andesite, and andesite protoliths, with some graywacke and minor aluminous sediment. Magnetic susceptibilities are quite variable, generally 0.1–2.5 x 10^{-3} SI, with locally high values (5–50 x 10^{-3} SI).

pMam AMPHIBOLITE (Pre-Mississippian) — Mixed unit defined by epidote amphibolite with within-plate chemistry (Dusel-Bacon and Cooper, 1999), with lesser quartzite, paragneiss, schist, and minor marble. Amphibolite is green to dark green, fine- to coarse-grained, locally plagioclase–porphyroblastic, and consists of hornblende, epidote, plagioclase, sphene (to 3 percent), and minor biotite. Magnetic susceptibilities are generally low, 0.1–0.4 x 10^{-3} SI, with locally high values (1–2 x 10^{-3} SI). Interlayered with biotite–feldspar–quartzite ± carbonate, ± white mica, ± garnet, fine- to coarse-grained muscovite–biotite (1–10 percent)–feldspar–quartz paragneiss, muscovite–biotite–quartz schist ± garnet, and rarely, with siliceous and (or) calc–silicate-bearing marble. Spatially associated with a thick quartzite unit (Pmq) and apparently restricted to the central part of the Eagle A-1 Quadrangle and occasional fault slivers. Stratigraphic setting is unclear, but the restricted occurrence suggests it either underlies or overlies the other, more abundant, pre-Mississippian units.

Pza AMPHIBOLITE, PARAGNEISS, AND SCHIST (Paleozoic) — Mixed unit: approximately half epidote amphibolite, and half muscovite-quartz-rich paragneiss grading into garnet–biotite–muscovite–quartz schist. Layers of amphibolite 1–50 m thick alternate with schist–gneiss layers of similar thickness. The amphibolite lacks biotite, commonly contains several percent sphene, and displays a MORB-like (Dusel-Bacon and Cooper, 1999) trace element signature. This particular combination is present exclusively in a fault-bounded wedge in the southwestern part of the Eagle A-1 Quadrangle, spatially associated with the meta-harzburgite unit (Pzum). Asymmetric folds in the unit indicate top-to-the-north movement and suggest this unit is in thrust fault contact with pre-Mississippian metamorphic rocks to the north. This setting suggests unit Pza and associated unit Pzum are older than the pre-Mississippian units, but the lack of orthogneiss in these two units is also compatible with an age younger than Devono–Mississippian. Consequently, their absolute and relative age is unknown, but most likely Paleozoic. Magnetic susceptibility of the amphibolite is moderate, typically 0.3–0.5 x 10^{-3} SI; that of the schist and paragneiss is low, typically 0.05–0.2 x 10^{-3} SI.

Pzum META-HARZBURGITE (Paleozoic?) — Medium-grained, moderately foliated ultramafic rock, with an original mineralogy of olivine > orthopyroxene >> clinopyroxene, partly converted to an assemblage of talc ± chlorite ± anthophyllite, and overprinted by a variable degree of serpentinization. Serpentinization is inferred to be a late-stage alteration as the grain size of serpentine in the rocks is much smaller (<0.1 mm) than that of the anthophyllite, chlorite, or talc (1–5 mm). Spatially associated with an amphibolite-bearing unit (Pza) with MORB-type trace element signature. The origin of this body is unknown, but it differs from the serpentinized ultramafic rocks of the southeastern Eagle A-1 Quadrangle by (1) significantly higher pyroxene abundance, (2) abundance of metamorphic talc, chlorite, and anthophyllite, and (3) less abundant serpentine. The presence of anthophyllite suggests it was metamorphosed with the adjacent amphibolite-facies rocks. Magnetic susceptibility is high, 5–30 x 10^{-3} S.I.

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REFERENCES

Abbott, J.C., 1983, Origin of the Clinton Creek asbestos deposit, *in* Yukon Exploration and Geology, 1982: Indian and Northern Affairs Canada, p. 18–25.
Aleinikoff, J.N., Dusel-Bacon, C., and Foster, H.L., 1986, Geochronology of augen gneiss and related rocks, Yukon–Tanana terrane, east-central Alaska: Geological Society of America Bulletin, v. 97, p. 626–637.
Churkin, M., Jr., Foster, H.L., Chapman, R.M., and Weber, F.R., 1982, Terranes and suture zones in east-central Alaska: Journal of Geophysical Research, v. 87, no. B5, p. 3718–3730.
Cushing, G.W., 1984, The tectonic evolution of the eastern Yukon–Tanana upland, Alaska: Albany, New York, State University of New York, unpublished M.S. Thesis, 255 p.
Day, W.C., Gamble, B.M., Henning, M.W., and Smith, B.D., 2000, Geologic setting of the Fortymile River area—Polyphase deformational history within part of the eastern Yukon–Tanana Uplands of Alaska, *in* Kelley, K.D., and Gough, L.P., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1998: U.S. Geological Survey Professional Paper 1615, p. 65–82.
Day, W.C., Aleinikoff, J.N., and Gamble, B.M., in press, Geochemistry and age constraints on metamorphism and deformation of the Fortymile River Area, eastern Yukon–Tanana Upland, Alaska, *in* Wilson, F.H., and Galloway, J., eds., Studies by the U.S. Geological Survey in Alaska, 2000: U.S. Geological Survey Professional Paper 1662.
Dusel-Bacon, Cynthia, Bressler, J.R., Takaoka, Hidetoshi, Mortensen, J.K., Oliver, D.H., Newberry, R.J., and Bundtzen, T.K., 1998, Stratiform zinc–lead mineralization in Nasina assemblage rocks of the Yukon–Tanana Upland in east-central Alaska: U.S. Geological Survey Open-File Report 98-340, 20 p.
Dusel-Bacon, Cynthia, and Cooper, K.M., 1999, Trace-element geochemistry of metabasaltic rocks from the Yukon–Tanana Upland and implications for the origin of tectonic assemblages in east-central Alaska: Canadian Journal of Earth Sciences, v. 36, p. 1671–1695.
Dusel-Bacon, Cynthia, Hansen, V.L., and Scala, J.A., 1995, High-pressure amphibolite facies dynamic metamorphism and the Mesozoic evolution of an ancient continental margin, east-central Alaska: Journal of Metamorphic Geology, v. 15, p. 9–24.
Flynn, R.L. and Newberry, R.J., 2001, Geology of the Boundary area, Eagle A-1 Quadrangle, east-central Alaska: U.S. Geological Survey EDMAP program, under assistance Award No. 00HQAG0061, 1 sheet, 1:25,000 scale.
Foster, H.L., 1969, Reconnaissance geology of the Eagle A-1 and A-2 quadrangles, Alaska: U.S. Geological Survey Bulletin 1271-G, 30 p.
Foster, H.L., 1976, Geologic map of the Eagle Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map I-922, scale 1:250,000.
Foster, H.L., Cushing, G.W., Keith, T.E.C., and Laird, J., 1985, Early Mesozoic tectonic history of the Boundary area, east-central Alaska: Geophysical Research Letters, v. 12, p. 553–556.
Foster, H.L. and Igarashi, Y, 1990, Fossil pollen from nonmarine sedimentary rocks of the eastern Yukon–Tanana region, east-central Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1989: U.S. Geological Survey Bulletin 1946, p. 11–20.
Foster, H.L., and Keith, T.E.C., 1968, Preliminary geologic map of the Eagle B-1 and C-1 quadrangles: U.S. Geological Survey Open-File Report 68-103, scale 1:63, 360.
———1974, Ultramafic rocks of the Eagle Quadrangle, east-central Alaska: U.S. Geological Survey Journal of Research, v. 2, no. 6, p. 657–669.
Foster, H.L., Jones, D.L., Keith, T.E.C., Wardlaw, B., and Weber, F.R., 1978, Late Paleozoic radiolarians and conodonts found in chert of Big Delta quadrangle, *in* Johnson, K.M., ed., The U.S. Geological Survey in Alaska: Accomplishments during 1977: U.S. Geological Survey Circular 772-B, p. B34–B36.
Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1994, Geology of the Yukon–Tanana area of east-central Alaska, *in* Plafker, George, and Berg, H.C., eds., The geology of Alaska: Boulder, Colorado, Geological Society of America, The Geology of North America, v. G1, p. 205–240.
Green, L.H., 1972, Geology of Nash Creek, Larsen Creek, and Dawson map areas: Geological Survey of Canada Memoir 364, 157 p, 3 sheets, scale 1:250, 000.
Hansen, V.L. and Dusel-Bacon, Cynthia, 1998, Structural and kinematic evolution of the Yukon–Tanana upland tectonites, east-central Alaska: a record of late Paleozoic to Mesozoic crustal assembly: Geological Society of America Bulletin, v. 110, p. 211–230.
Hansen, V.L., Heizler, M.T., and Harrison, T.M., 1991, Mesozoic thermal evolution of the Yukon–Tanana composite terrane: new evidence from ^{40}Ar/^{39}Ar data: Tectonics, v. 10, p. 51–76.
Hunt, P.A. and Roddick, J.C., 1991, A compilation of K–Ar ages, report 20, in Radiogenic Age and Isotopic Studies, Report 4: Geological Survey of Canada Paper 90-2, p. 113–143.
Keith, T.E.C., Foster, H.L., Foster, R.L., Post, E.V., and Lehmbeck, W.L., 1981, Geology of an alpine-type peridotite in the Mt. Sorenson area, east-central Alaska: U.S. Geological Survey Professional Paper 1170-E, p. A1–A9.
Layer, P.W., Drake, J., and Szumigala, D.J., in prep., ^{40}Ar/^{39}Ar dates for mineralization and igneous and metamorphic rocks in a portion of the Fortymile mining district, Eagle Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report, in prep.
McConnell, R.G., 1905, Report on the Klondike gold fields: Geological Survey of Canada Annual Report, v. XII, 1901, Part B, 71 p.
Mortensen, J.K., 1988a, Geology of southwestern Dawson Map area, Yukon Territory (NTS 116B, C): Geological Survey of Canada, Open File 1927, scale 1:250, 000.
———1988b, Geology of southwestern Dawson Map area, Yukon Territory (NTS 116B, C), *in* Current Research, Part E: Geological Survey of Canada, Paper 88-1E, p. 73–78.
———1990, Geology and U–Pb geochronology of the Klondike District, west-central Yukon Territory: Canadian Journal of Earth Sciences, v. 27, p. 903–914.
———1996, Geological compilation maps of the northern Stewart River map area, Klondike and Sixtymile districts, 115 N/15, 16, 115 O/13, 14 and parts of 115 O/15, 16: Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 1996-1G, six maps with accompanying notes, 1:50, 000 scale.
Mortensen, J.K. (compiler), 1999, Yukon age: an isotopic age database for the Yukon Territory, *in* Gordey, S.P., and Makepeace, A.J., compilers, Yukon digital geology: Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada.
Newberry, R.J., Bundtzen, T.K., Clautice, K.H., Combellick, R.A., Douglas, T., Laird, G.M., Liss, S.A., Pinney, D.S., Reifenstuhl, R.R., and Solie, D.N., 1996, Preliminary geologic map of the Fairbanks mining district, Alaska: Alaska Division of Geological & Geophysical Surveys Public Data File 96-16, 2 sheets, 1:63,360 scale, 32 p.
Newberry, R.J., Layer, P.W., Solie, D.N., and Burleigh, R.E, 1998, New ^{40}Ar/^{39}Ar dates for intrusions and mineral prospects in the eastern Yukon–Tanana Terrane, Alaska—regional patterns and significance, *in* Gray, J.E., and Riehle, J.R., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1996: U.S. Geological Survey Professional Paper 1595, p. 131–159.
Resource Associates of Alaska, 1977, Boundary prospect report: Ocean Home Exploration Company, Limited report, p. 27–43.
Smit, Hans, 2000, Boundary property: Grayd Resource Corporation report, unpublished, 3 p., 1 map sheet.
Werdon, M.B., Newberry, R.J., and Szumigala, D.J., 2001, Bedrock geologic map of the Eagle A-2 quadrangle, Fortymile mining district, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2001-3b, scale 1:63,360.

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