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EXPLANATION OF MAP UNITS:

Geologic map of the Talkeetna Mountains C-4 Quadrangle and adjoining areas, central Alaska (1:50,000 scale)

by

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DGGS geologist Larry Freeman looks northeast across upper Paleozoic to Late Triassic rocks of Wrangellia in the Talkeetna Mountains C-4 Quadrangle. Photo by Karri R. Sicard.

This publication is PRELIMINARY in nature and is meant to allow rapid release of field observations or initial interpretations of geology or analytical data. It has not undergone formal peer review. Interpretations or conclusions contained in this publication are subject to change.

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DESCRIPTION OF SURFICIAL-GEOLOGIC MAP UNITS

Map units are identified by the symbols described below. Those symbols, shown in parentheses, such as (Qgd1), indicate combined map units consisting of bedrock overlain by thin or discontinuous deposits of the map unit. Map units with a question mark such as Qgd1?, indicate an uncertain identification.

Unconsolidated Deposits

ALLUVIAL DEPOSITS

Qa UNDIFFERENTIATED FLOODPLAIN ALLUVIUM—Stratified, well- to locally poorly sorted, rounded to subangular, polymictic gravels with silt to coarse sand comprising stream channel and overbank deposits. Stream channels commonly include a cobble and boulder lag. Deposits may include multiple channels and floodplain surfaces at more than one level. Vegetation generally consists of thick stands of willow and alder, especially near channels. Unit includes both active and inactive floodplain deposits (Qaa and Qai) that cannot be differentiated at the scale of mapping. Frequency and timing of deposition is uncertain.

Qaa ACTIVE-FLOODPLAIN ALLUVIUM—Stratified, well- to locally poorly sorted, rounded to subangular, polymictic gravel with silt to coarse sand comprising active stream channels, stream banks, point-bar deposits, and low floodplains along the Talkeetna River that are frequently inundated. Vegetation is sparse and includes willow and low shrubs. Mapped distribution reflects the extent at the time imagery was collected and may change significantly as the active stream channel evolves.

Qaf ALLUVIAL-FAN DEPOSITS—Locally-derived, fan-shaped deposits of stratified, well- to poorly sorted gravel, sand, and silt with scattered cobbles and boulders. Clast size decreases and degree of sorting increases down-fan. Deposits are common at the mouths of smaller streams and gullies, especially where there is a pronounced decrease in gradient as a tributary enters a larger stream.

Qai INACTIVE-FLOODPLAIN ALLUVIUM—Poorly- to well sorted, rounded to subangular polymictic gravel and sand deposited by periodic stream flooding along the Talkeetna River. Unit typically includes numerous interconnected, abandoned stream channels with surfaces at multiple levels. Vegetation is scattered to sparse on lower-level floodplain surfaces and more dense on less-frequently-inundated, higher-level surfaces.

COLLUVIAL DEPOSITS

Qc UNDIFFERENTIATED COLLUVIUM—Heterogeneous blankets, aprons, cones, and fans of angular to subangular rock fragments, gravel, sand, and silt formed by complex, gravity-driven mass movements involving falling, sliding, flowing, solifluction (or gelifluction where frozen), and frost creep. Deposits are commonly formed near rock glaciers and on bedrock slopes. Unit includes Quaternary deposits whose origin is uncertain or where modification by weathering and slope processes has destroyed primary morphology. May be complexly mixed with mixed colluvial and alluvial deposits (Qcf).

Qcf MIXED COLLUVIUM AND ALLUVIUM—Massive to poorly stratified sand and silt mixed with subangular to rounded pebble-cobble gravel with some locally derived bedrock clasts, deposited in small, narrow valleys with steep sidewalls or where streams are not able to remove material faster than it is transported downslope by colluvial processes. May be complexly mixed with colluvial deposits (Qc), especially on lower valley slopes.

Qcd DEBRIS-FLOW DEPOSITS—Elongate to lobate mixtures of bedrock blocks, angular to subangular rock fragments, and polymictic gravel, sand, and silt deposited on steep slopes by creeping, flowing, and sliding of failed bedrock and unconsolidated surface deposits. Surface is typically irregular with steep, unvegetated surfaces and ground cracks where active. May be complexly mixed with talus deposits (Qct).

Qcg ROCK GLACIER DEPOSITS—Tongue-shaped heterogeneous deposits of angular to subangular blocks of local bedrock, with trace to some gravel, sand, and silt at depth, overlying deformed ice. A thin (10- to 20-cm-thick) organic mat may be present on the surface. These deposits accumulate on floors and along lower walls of cirques and glaciated valleys by flow of rock glaciers derived from shrinking of former glaciers (ice cored) or from deposition, cementation, and deformation of precipitation-derived ground ice (ice cemented). Some rock glaciers, such as along Iron Creek in the southwestern part of the map area, display distinct arcuate ridges and furrows arranged convexly downvalley.

Qct TALUS—Heterogeneous mixtures of frost-rived, angular rock fragments with trace to some gravel, sand, and silt deposited on steep bedrock slopes and downslope of bedrock outcrops by free fall, tumbling, rolling, and sliding. May be complexly mixed with rock glacier deposits (Qcg).

GLACIAL DEPOSITS

Qgds3 ICE STAGNATION TILL OF LATEST WISCONSINAN AGE (11,000 to 9,000 years before present [y.b.p.])—Hummocky surfaces of poorly- to well sorted, rounded to subangular, pebble-cobble gravel in a matrix of medium to coarse sand and minor silt, deposited by stagnating glacial ice of the latest Wisconsinan glacial advance. These deposits are characterized by sharp, well-defined moraine crests, numerous eskers, and surfaces littered with exposed boulders and gravel, and commonly have inset terrace surfaces of latest Wisconsinan outwash (Qgf3). Modification by slope processes and frost heaving is typically minor except on steeper slopes, where it may be more extensive. Depth of oxidation is ~3–7 cm. Surface vegetation includes low mosses, grasses, and lichens with scattered willow and alder up to ~3 m high.

Qgd3 TILL AND ASSOCIATED MORAINAL DEPOSITS OF LATEST WISCONSINAN AGE (11,000 to 9,000 y.b.p.)—Undulating deposits of poorly- to well sorted, rounded to subangular, pebble-cobble gravel in a matrix of medium to coarse sand and minor silt deposited by glacial ice of the latest Wisconsinan glacial advance. Landforms include sharp to subrounded, fairly continuous moraine crests found mostly along valley margins, surfaces that are commonly littered with exposed boulders and gravel, and, locally, eskers typical of stagnant ice (Qgds3). Deposits are only minorly modified by slope processes and frost heaving, except on steep slopes, where it may be more extensive. Depth of oxidation is ~3–11 cm. Surface vegetation includes low mosses, grasses, and lichens with scattered willow and alder up to ~3 m high.

Qgd2 DRIFT OF LATE WISCONSINAN AGE, UNDIFFERENTIATED (25,000 to 11,000 y.b.p.)—Poorly- to well sorted, subrounded to subangular, pebble-cobble gravel in a matrix of sand and minor silt; locally includes moderately-well-sorted sand and gravel. Primary glacial morphology is well preserved except where deposits thinly cover bedrock. Deposits form moraines that are more broad and discontinuous, have a greater depth of oxidation (typically 10–15 cm), and are characterized by surfaces that are more subdued, of lower relief, and more modified by slope processes than deposits of latest Wisconsinan age drift (Qgd3). Gullies on slopes are typically more incised than in younger deposits, with a distinct change in depth at the boundary with younger glacial drift deposits. Vegetation includes spruce trees and ~1.5-m-high willow and alder.

Qgds1 ICE STAGNATION TILL OF EARLY WISCONSINAN AGE (75,000 to 40,000 y.b.p.)—Broad, subdued hummocky deposits of poorly- to well sorted, rounded to subangular pebble-cobble gravel in a matrix of medium to coarse sand and minor silt deposited by stagnating glacial ice of early Wisconsinan age. Surface is characterized by numerous lakes and depressions with low-relief margins modified by slope processes, locally occupying former meltwater channels incised into drift. Vegetation includes dense willow and alder in current and former stream channels and along lake margins, with low mosses and grasses dominating higher surfaces of hummocks.

Qgd1 DRIFT OF EARLY WISCONSINAN AGE (75,000 to 40,000 y.b.p.)—Poorly- to well sorted, subrounded to subangular, pebble-cobble gravel in a matrix of sand and minor silt. Primary glacial morphology is locally preserved but is commonly extensively modified by slope processes, resulting in subdued surfaces with less relief. Deposits are typically discontinuous, especially on bedrock slopes and areas where deposits are thin, and surfaces are more weathered than those of younger glacial deposits (Qgd2, Qgd3), with oxidation depths generally greater than 15 cm. Unit may be complexly mixed with colluvial deposits (Qc).

GLACIOFLUVIAL DEPOSITS

Qgf3 OUTWASH OF LATEST WISCONSINAN AGE—Stratified, generally well- to locally poorly sorted, rounded to subangular, polymictic gravels with silt to coarse sand deposited by glacial streams of latest Wisconsinan age. Deposits form fairly continuous terraces, at multiple levels, that may be up to 30 m above modern streams. Surfaces can be traced upvalley to, and are sometimes inset into, drift deposits of the latest Late Wisconsinan glacial advance (Qgd3 and Qgds3). Abandoned channels are locally spectacularly well preserved, especially in the northeastern map area. Vegetation includes low mosses, grasses, and lichens with scattered willow and alder up to ~3 m high, but surfaces commonly have areas of exposed gravel. Depth of oxidation is ~3–7 cm.

Qgf2 OUTWASH OF LATE WISCONSINAN AGE, UNDIFFERENTIATED—Stratified, generally well- to locally poorly sorted, rounded to subangular, polymictic gravels with silt to coarse sand deposited by glacial streams of late Wisconsinan age. Deposits are found in one locality in the east-central part of the map area where they form several terraces inset into glacial drift of early Wisconsinan age (Qgd1).

GLACIOLACUSTRINE DEPOSITS

Qld LAKE DELTA DEPOSITS—Sand and silt with polymictic gravel that forms fan-shaped deposits southwest of Stephan Lake. Identification is based on sediment grain size and deposit morphology, as well as proximity to proglacial lake deposits (Ql).

Ql LACUSTRINE DEPOSITS—Well-sorted, massive to rhythmically bedded sand, silt, and clay with scattered ice-rafted pebbles and cobbles, found in the northeast–southwest-trending low-lying area around Stephan Lake. Deposit surface is generally low relief and marshy, with vegetation that includes tussock tundra and dense areas of alder, willow, and spruce up to 10 m tall.

PALUDAL DEPOSITS

Qp SWAMP DEPOSITS—Primarily organic silt and sand deposited in water-saturated lowland sites in the northwestern portion of the map area. Standing water is common and vegetation includes water-dependent sedges willow, alder, and stunted black spruce.

DESCRIPTION OF BEDROCK-GEOLOGIC MAP UNITS

Tertiary Volcanic Rocks

Our mapping and supporting geochronologic data divide the Tertiary volcanic rocks (unit Tv of Csejtey and others, 1978) into four informal temporally and geographically defined sequences. The Tafia sequence volcanic rocks are cut by a 54 Ma andesite porphyry stock, making them the oldest Tertiary volcanic rocks in the map area. This unit is dominated by volcanic flows, and is bound to the southeast by the Central Raingellia fault. The ca. 45 Ma (Oswald, 2006) Slot Lake sequence occupies the west-central portion of the map area and is also predominantly volcanic flows; an apparent depositional contact with the underlying Tafia sequence is exposed in the central map area. Basalts of the ca. 48 Ma Deadman volcanic field (Schmidt and others, 2002) may correlate with parts of the Slot Lake sequence. The base of the Remus sequence was dated at 37.6 Ma and is dominated by generally felsic and intermediate volcaniclastic rocks, with lesser interbedded mafic flows. These rocks overlie metamorphic basement southeast of the Central Raingellia fault, and unconformably overlie rocks of the Tafia sequence to the northwest.

REMUS VOLCANIC SEQUENCE

Trrp RHYOLITE PORPHYRY (Tertiary)—High-silica rhyolite porphyry plugs and dikes. Pale green to dark gray, porphyritic, with up to 35 percent of the rock formed by sanidine, plagioclase, and quartz phenocrysts in an aphanitic groundmass. Rare hornblende and biotite phenocrysts. Phenocrysts are often subrounded with resorbed edges. Matrix is recrystallized and locally chloritized, but preserves flow textures. Zeolites(?) fill voids. Median magnetic susceptibility is 3.20×10^{-3} Système International (SI).

Trr2 UPPER RHYOLITE (Tertiary)—Rhyolite to dacite volcaniclastic rocks with volumetrically minor interlayered flows. Tan to pale green on fresh surface, weathers cream–tan with some iron-oxide staining. Volcaniclastic layers are ash-fall tuffs with interlayered polymictic and monomictic breccias. The flows are porphyritic, with quartz and potassium feldspar phenocrysts and rare xenoliths. This unit corresponds to unit Trt (rhyolite tuff) of Oswald (2006). Median magnetic susceptibility is 0.53×10^{-3} SI.

Tril INTERLAYERED UNIT (Tertiary)—Interbedded, dark gray to green basaltic to andesitic flows and volumetrically minor, light tan to pale green felsic to intermediate tuffs. Mafic layers are massive, jointed, often porphyritic, and amygdaloidal. These layers are crystal rich, with resorbed feldspar, up to 5 mm long, as the dominant phenocryst. Groundmass consists of plagioclase (35%), sanidine (25%, often weathered to a higher degree than plagioclase), weathered pyroxene (33%), oxides (2%), and chloritized or iron-hydroxide-altered glass(?). Relict pyroxene phenocrysts, often completely replaced by chlorite, are present in some layers. The rock appears weakly deformed, with all minerals displaying undulose extinction. Some flow alignment of groundmass minerals is visible. Felsic tuff layers contain 5 percent phenocrysts of quartz and feldspar and are strongly altered or weathered to clay minerals and lesser calcite. This unit corresponds to units Tmf (mafic flows) and Tat (minor interbedded andesite tuff) of Oswald (2006). Median magnetic susceptibility is 4.00×10^{-3} SI.

Triv INTERMEDIATE VOLCANICLASTIC ROCKS (Tertiary)—Andesitic to dacitic tuffs or volcaniclastic deposits, with rare basaltic flow and rhyolitic tuff layers. Unit is light to dark gray, greenish, or purplish. Volcaniclastic rocks have lithic and some crystal fragments in the aphanitic matrix. Flows are often amygdaloidal and flow banded; some clastic beds present. The porphyritic layers have plagioclase and sanidine phenocrysts (small laths averaging 1–3 mm in length). Glassy matrix is often weathered to iron oxides and largely replaced by magnetite(?), clay minerals, and mica. Amygdules filled with calcite and chalcedony. Disseminated pyrite is present in tuffs and flows, and locally forms crystal aggregates in vesicles. This unit corresponds to unit Tat (andesite tuff) of Oswald (2006) or to unit Tdt (dacite tuff) of Adams and others (1985). Median magnetic susceptibility is 0.51×10^{-3} SI.

Trr1 LOWER RHYOLITE (Tertiary)—Tan to white rhyolite tuff interbedded with lesser pale greenish gray rhyolite flows. Tuffaceous layers have rhyolite lithic fragments, fiamme, and potassium-rich plagioclase and quartz crystal fragments in an often clay-altered ash matrix. The tuffaceous layers are interbedded with pale greenish gray glass with less than 5 percent quartz and sanidine phenocrysts. Some layers preserve flow textures, which are defined by acicular feldspar crystals. Age of this unit is 37.6 ± 0.2 Ma based on $^{40}Ar/^{39}Ar$ whole-rock step-heating analysis of rhyolite glass (map A5, table 2; Benowitz and others, 2015). Median magnetic susceptibility is 0.50×10^{-3} SI.

SLOT LAKE VOLCANIC SEQUENCE

Tsdp DACITE PORPHYRY (Tertiary)—Pale gray to yellow, jointed dacite porphyry intrusion. Phenocrysts are fresh, subhedral to euhedral plagioclase, slightly oxidized and altered subhedral hornblende, and anhedral, resorbed quartz in an aphanitic to recrystallized groundmass. Xenoliths of more mafic composition, with an altered groundmass and clinopyroxene phenocrysts, also occur in this unit. Unit is geochemically similar to the extrusive dacite of the Slot Lake volcanic sequence (unit Tsd). An $^{40}Ar/^{39}Ar$ hornblende plateau age of 44.6 ± 1.1 Ma was determined for this lithology by Oswald (2006; equivalent unit Tdp). Median magnetic susceptibility is 5.50×10^{-3} SI.

Tsa ANDESITE FLOWS (Tertiary)—Dark gray, brown, to black andesite flows. Generally aphanitic with some porphyritic and amygdaloidal layers; mostly massive but also flaggy, with flow banding locally present. The groundmass comprises plagioclase laths (65%) showing flow alignment, interstitial clinopyroxene (20%), rare olivine (4%), and abundant (1%) oxide minerals (magnetite?). The plagioclase laths have undulose extinction but appear unaltered. While most of the andesites in the map area have low Nb, Y, and Zr concentrations consistent with volcanic arc geochemistry (Wypych and others, 2014), the uppermost portion of this andesite has anomalously high Zr (>500 ppm), Y (~80 ppm), and Nb (>30 ppm). Ce, Zn, and Rb are also significantly elevated. This unit is equivalent to unit Ta (andesite flows) of Oswald (2006, Map A). Median magnetic susceptibility is 7.35 x 10^{-3} SI.

Tsd DACITE (Tertiary)—Dacite; often jointed to massive, but can be layered or knobby. Green to gray, porphyritic to aphanitic, with feldspar, quartz, and hornblende phenocrysts in aphanitic groundmass. Phenocrysts include large fragments of zoned plagioclase with disequilibrium textures (15%), small hornblende (2%) with oxide rims, altered to clay and iron hydroxides, and clinopyroxene(?) (10%). Matrix is clay-altered with some oxides. Similar to the andesite of this age (unit Tsa), this unit has two distinctive trace-element compositions, with the stratigraphically uppermost dacites having elevated Zr, Y, Nb, and Rb (Wypych and others, 2014). Median magnetic susceptibility is 8.25 x 10^{-3} SI.

Tsr RHYOLITE (Tertiary)—White, tan to pale gray rhyolite tuff to rhyolitic conglomerate. Thin layers of ash with laminations, interlayered with glassy material for the basal 2 m of the section, grade upward into a matrix-supported conglomerate with rounded to subangular, pebble- to cobble-size, rhyolitic and vitrophyric clasts in a white-weathering ash matrix. The ash contains pumice fragments and small, euhedral sanidine laths. Trace-element geochemical data indicate this unit formed in a volcanic arc setting (Wypych and others, 2014). This unit is equivalent to unit Trt of Oswald (2006; Map A). Median magnetic susceptibility is 5.00 x 10^{-3} SI.

Tsb BASALT FLOWS (Tertiary)—Basalt flows; black to dark gray, massive, aphanitic to porphyritic with amygdaloidal layers. Phenocrysts of plagioclase and rare olivine in a groundmass of plagioclase, interstitial pyroxene, olivine, and glass. Amygdules are filled with plagioclase laths in an iron-hydroxide/clay/zeolite matrix. Some phenocrysts are completely altered to zeolites. A whole-rock sample yielded an $^{40}Ar/^{39}Ar$ plateau age of 44.9 ± 1.0 Ma (Oswald, 2006). This unit is equivalent to unit Tb of Oswald (2006; Map A). Unit exhibits the same bimodal trace-element geochemical signature as units Tsa and Tsd, including populations with ‘normal’ and highly elevated Zr, Nb, and TiO_2 contents (Wypych and others, 2014). Median magnetic susceptibility is 1.50 x 10^{-3} SI.

DEADMAN VOLCANIC SEQUENCE

Tdb BASALT (Tertiary)—Dark gray, vesicular to diktytaxitic, aphanitic to porphyritic basalt with up to 5 percent 2-mm-long plagioclase-lath phenocrysts. Olivine(?) and orthopyroxene (2%) are completely replaced by iron oxides. Contains large (≤5 mm diameter), very rare (<1%) xenocrysts with disequilibrium textures of more-potassium-rich feldspar. Groundmass comprises weakly aligned plagioclase laths (50%) with interstitial clinopyroxene (20%), iron hydroxides (20%) replacing remnant olivine(?) and magnetite(?) (2%). Amygdules are filled with radiating plagioclase, interstitial calcite, and iron hydroxides or zeolites. Geochemically, this unit is similar to the low Zr, low TiO_2 group of the Slot Lake volcanic sequence (unit Tsb) (Wypych and others, 2014). Median magnetic susceptibility is 0.85 x 10^{-3} SI.

TAFIA VOLCANIC SEQUENCE

Ttap ANDESITE PORPHYRY (Tertiary)—Dikes and plugs of dark gray, porphyritic to diabasic andesite with rare (~1%) calcite-filled amygdules. In thin section, this unit is characterized by fine-grained plagioclase phenocrysts and rare hematite-colored flakes in an aphanitic groundmass. A whole-rock sample yielded an $^{40}Ar/^{39}Ar$ plateau age of 54.0 ± 0.8 Ma (map A6, table 2; Benowitz and others, 2015). Median magnetic susceptibility is 27.30 x 10^{-3} SI.

Tta ANDESITE FLOWS (Tertiary)—Andesite to basaltic-andesite flows with rare interbedded tuffs. Andesite is dark gray, brown-weathering or iron-oxide-stained, aphanitic to porphyritic, and often amygdaloidal. Phenocrysts total about 5 percent and include about 1–3 percent 1-mm-long plagioclase crystals, which are often broken and have undulose extinction; plagioclase-biotite pseudomorphs which may reflect a larger, 5-mm-long feldspar-phenocryst population; and biotite(?) and relict clinopyroxene pseudomorphs after ~3-mm-diameter clinopyroxene phenocrysts. Groundmass is dominated by feldspar, glass, and biotite. Feldspar, which forms about 90 percent of the rock, is often aligned, indicating flow textures. Amygdules are filled with a calcite–quartz–chlorite–zeolite assemblage. This unit is equivalent to unit Tva (andesitic lava) of Amos and Cole (2003). Median magnetic susceptibility is 8.54×10^{-3} SI.

Ttb BASALT FLOWS (Tertiary)—Basalt flows; black, dark gray, red-brown, or brownish gray colored, and weathering with an iron-oxide to light brown stain. Porphyritic to aphanitic, with up to 15 percent, calcite-, chalcedony-, and zeolite-filled amygdules. Subophitic, with euhedral, up to 7-mm-long plagioclase laths (1–25%) as well as clinopyroxene and orthopyroxene in a basaltic groundmass. This unit is equivalent to unit Tvb (basaltic lava) of Amos and Cole (2003). Median magnetic susceptibility is 6.32×10^{-3} SI.

Ttd DACITE FLOWS (Tertiary)—Dacite flows; dark to light gray, porphyritic to aphanitic, and locally vesicular (5–10%). Phenocrysts include plagioclase (5%), K-feldspar (~10%), quartz (~7%), hornblende (~7%), and biotite (5%). Plagioclase phenocrysts range from 1 to 7 mm in length and display zonation and polysynthetic twinning, with some resorption. The K-feldspars are generally smaller than plagioclase, resorbed, and locally twinned. Hornblende phenocrysts are spatially associated with clinopyroxene and are partially chloritized. Median magnetic susceptibility is 9.19×10^{-3} SI.

Intrusive Rocks

Our mapping defines several distinct episodes of post-Triassic intrusive rocks. New $^{40}Ar/^{39}Ar$ ages (table 2; Benowitz and others, 2015) place the large tonalite to granodiorite (unit Jgd) pluton at map center in the 207–167 Ma time period of Talkeetna Arc magmatism defined by Amato and others (2007). This intrusive relationship implies the amalgamation of the Talkeetna Arc and Wrangellia by ca. 168 Ma, consistent with the findings of Rioux and others (2007).

Small stocks of unit Khg hornblende gabbro intrude both Wrangellia and Kahiltna assemblage rocks and have a range of middle Cretaceous $^{40}Ar/^{39}Ar$ ages. This unit contains abundant magnetite, indicative of a high oxidation state similar to coeval intrusions in southwestern Alaska, including mineralized intrusive systems at Nyac, Pebble, and Whistler (Graham and others, 2013).

A third group of intrusions have a reduced, non-magnetic character and ages around 68 Ma. Intrusions of this age north of the Range Front fault are medium- to coarse-grained plutonic rocks (unit Kg), whereas our study found a porphyry dike (unit Kdp) of this age to the south; the apparent difference in erosion levels implies multiple kilometers of northwest-down displacement along this structure. Exposures of altered porphyry intrusions assigned to unit Kdp in the northwestern corner of the map area carry Au–Cu–Ag-mineralized quartz veinlets with anomalous Mo–Bi–Te–Sn (Wypych and others, 2014). This trace-element signature is typical of reduced intrusion-related mineralization in the regional context (Clautice and others, 2001). The Au:Ag ratio, relatively low Sn values, and inferred age suggest a possible correlation with mineral systems such as Golden Zone deposit 80 km to the northwest.

Kdp DACITE PORPHYRY (Late Cretaceous)—Dikes and small stocks of dacite porphyry. Gray to off-white, porphyritic, with up to 50 percent medium-grained phenocrysts in an aphanitic, recrystallized groundmass. Phenocrysts include subhedral feldspar (30 percent), subhedral quartz (≤10%), hornblende, and phlogopite. Feldspars are almost completely replaced by sericite; some show single twinning characteristic of sanidine and some show polysynthetic twinning characteristic of plagioclase. Mafics are also completely replaced by chlorite and sericite. Phlogopite yielded an $^{40}Ar/^{39}Ar$ weighted-average age of 67.1 ± 0.9 Ma (map A2, table 2; Benowitz and others, 2015). We reinterpreted some of the intrusions previously mapped as Tertiary dacite porphyry (unit Tdp: Map B) by Oswald (2006) to be latest Cretaceous on the basis of lithologic similarity and proximity to this sample. Median magnetic susceptibility is 3.93 x 10^{-3} SI.

Kg GRANITIC ROCKS (Late Cretaceous)—A multi-phase plutonic body that includes granodiorite, monzogranite, quartz monzonite, quartz syenite, and monzonite; possibly a zoned or composite pluton. Equigranular to porphyritic, holocrystalline, medium to coarse grained, massive, with some flow foliation on the edges of the pluton. The rock consists of 20–60 percent plagioclase, 10–58 percent potassium feldspar (microcline), with 10–28 percent quartz, 10 percent biotite, and ±3 percent hornblende. Crystals are fresh, with undulose extinction, subhedral to anhedral, with ~5-mm-long feldspar; interstitial, small quartz and ~2-mm-diameter biotite. Hornblende from this unit yielded an $^{40}Ar/^{39}Ar$ plateau age of 68.8 ± 0.6 Ma, and biotite yielded a weighted-average age of 60.4 ± 0.4 Ma (map A1, table 2; Benowitz and others, 2015). Median magnetic susceptibility is 0.30 x 10^{-3} SI.

Khg HORNBLENDE GABBRO (Cretaceous)—Equigranular to porphyritic hornblende gabbro to hornblende monzogabbro intrusions. Equigranular plagioclase up to 5 mm in length, with polysynthetic twinning, makes up 70–80 percent of the rock. Feldspars in some samples are completely sericitized. About 20–25 percent of the rock is composed of hornblende, which in fresher samples is ~3 mm long, with some biotite overgrowths. In more altered samples the hornblende is completely replaced by chlorite and biotite overgrowths. In some more felsic samples, potassium feldspar is present (~10%) as well as interstitial quartz (5%). Mineral separates from two discrete plutons from this unit yielded $^{40}Ar/^{39}Ar$ plateau ages of 76.9 ± 0.5 Ma for biotite (map A3, table 2; Benowitz and others, 2015), and 105.8 ± 0.4 Ma for hornblende (map A10, table 2; Benowitz and others, 2014). Median magnetic susceptibility is 16.50 x 10^{-3} SI.

Jgd GRANODIORITE TO TONALITE (Middle Jurassic)—Seriate to medium-grained, equigranular granodiorite, quartz diorite, quartz monzodiorite, and tonalite, with subtle foliation textures defined by hornblende. Composed of subhedral plagioclase (45%) with polysynthetic twinning and rare sericitization; subhedral potassium feldspar (12%) with clear zonation and often more sericitized than plagioclase; anhedral quartz (20%); biotite (15%) with bird's eye extinction and some chlorite and muscovite alteration; rare (5%) hornblende crystals (≤7 mm long), often broken, with biotite inclusions; and anhedral opaques (3 percent). All minerals exhibit undulatory extinction, an indication of a small amount of strain. Locally contains gneissic xenoliths, and is cut by quartz veins with pyrite and chalcopyrite. Hornblende from this unit yielded an $^{40}Ar/^{39}Ar$ weighted-average age of 168.0 ± 0.7 Ma, biotite yielded an $^{40}Ar/^{39}Ar$ plateau age of 183 ± 0.9 Ma, and K-feldspar yielded an $^{40}Ar/^{39}Ar$ weighted-average age of 144.3 ± 0.6 Ma (map A7, table 2; Benowitz and others, 2015). The $^{40}Ar/^{39}Ar$ spectra indicate a complex geologic history for this sample, including a probable argon-loss or resetting event. Median magnetic susceptibility is 18.90 x 10^{-3} SI.

Kahiltna Assemblage

Lower amphibolite facies (hornblende and biotite bearing) metasedimentary rocks assigned to the Kahiltna assemblage are exposed in very limited outcrop in the lowlands around Stephan Lake. Csejtey and others (1978) show the south-dipping Talkeetna thrust separating the Kahiltna from the Wrangellia terrane to the southeast; however, our mapping, supported by detailed airborne magnetic and resistivity surveys (Burns and others, 2014), indicates that lower amphibolite facies Kahiltna rocks are juxtaposed against prehnite-pumpellyite facies rocks of Wrangellia by a high angle (the Range Front fault), and possibly a northwesterly-dipping reverse fault. These observations are in agreement with geophysical models of Glen and others (2007). Exhumation of these metamorphic rocks and associated plutons occurred between 68 Ma ($^{40}Ar/^{39}Ar$ for hornblende in unit Kg; Benowitz and others, 2015) and the extrusion of the ca. 48 Ma Deadman volcanic field (Schmidt and others, 2002).

KJmf METAFLYSCH (Late Jurassic to Early Cretaceous)—Variably metamorphosed, interbedded sandstone, metasandstone, volcaniclastic rocks, and argillite. Gray to black, weathers brown or rust colored. Modal mineral percentage of 50–60 percent quartz, 20–30 percent feldspar, and 15–40 percent lithic clasts. Lithic clasts consist of chert and volcanic rocks as well as possible metamorphic lithic clasts, detrital amphibole, and biotite. Clasts are subangular and moderately to poorly sorted. Metamorphism of this unit reaches amphibolite facies adjacent to a granodiorite pluton and may partly reflect contact metamorphism. Hornblende (ferropargasite) and biotite define a weak foliation. Amphibolite in the contact metamorphic zone has modal-mineral percentages of 15–20 percent quartz, 10–60 percent plagioclase, 20–60 percent hornblende, and 0–5 percent biotite. The age assignment (Kimmeridgian to Albian) is based on correlation with the Kahiltna assemblage depositional ages of Hampton and others (2007) for the northwestern Talkeetna Mountains. Median magnetic susceptibility is 0.27 x 10^{-3} SI.

Metamorphic Complex

Greenschist to amphibolite grade metamorphic rocks along the southeastern edge of the map area include tonalite to granodiorite orthogneiss (JPzog), amphibolite (JPza), and paragneiss (JPzpg); these units correlate to the Strelna metamorphic complex of Wilson and others (1998). Metamorphic grade and strain increase to the southeast, either gradationally or across a series of concealed (and herein unmapped), northeasterly-striking faults in the vicinity of Tsisi Creek. Based on compositional and textural similarity, we correlate unit JPzpg paragneiss with the lower grade metasedimentary rocks of unit TRPs. Amphibolite bodies (unit JPza) have mafic composition and an apparently conformable attitude; we tentatively interpret this unit to be a more metamorphosed equivalent of the unit TRg1 Late Triassic gabbro sills. Orthogneiss (unit JPzog) apparently intrudes the above units; we infer that this unit represents Early to Middle Jurassic Talkeetna Arc-related plutonism in a pre- to syn-metamorphic setting based on its proximity and compositional similarity to dated plutons in the area (such as unit Jgd). Early Jurassic metamorphic cooling ages (table 2; Benowitz and others, 2015) constrain the minimum age of these units.

JPzog ORTHOGNEISS (Late Paleozoic to Early Jurassic)—Hornblende-biotite gneiss. White and black to gray, fine to coarse grained. The unit has a matrix of quartz, plagioclase, biotite, and amphibole with occasional potassium feldspar and quartz augen up to 2 mm in diameter. Generally granodiorite to tonalite bulk composition, with typical modal mineralogy of 35–60 percent quartz, 35–55 percent plagioclase, 0–3 percent K-feldspar, 2–10 percent biotite, 3–25 percent hornblende (magnesiohornblende), and 0–3 percent epidote. May also contain trace garnet, iron oxides, iron sulfides, sericite replacement of plagioclase, and chlorite after biotite and amphibole. Unit has poor to moderate foliation due to the combination of low amounts of foliation-defining minerals (biotite and amphibole) and a lack of segregation of those minerals. Median magnetic susceptibility is 13.00 x 10^{-3} SI.

JPza AMPHIBOLITE (Late Paleozoic to Early Jurassic)—Amphibolite. Occurs as lenses or layers ranging from less than a meter to tens of meters thick, and is interlayered in unit JPzpg. The lens and layering nature of this unit suggests that prior to metamorphism, the morphology was either mafic dikes or sills. Black to dark gray and weathering to rusty browns or reds, very fine to coarse grained. Unit consists of 50–80 percent hornblende (ferrotschermakite), 5–20 percent plagioclase, 5–25 percent quartz, 0–15 percent biotite, up to 5 percent epidote, minor iron oxides, iron sulfides, and chlorite replacement of amphibole and biotite. Epidote is present both in the matrix as tabular grains oriented along foliation and in altered augen as equant grains. Hornblende yielded an $^{40}Ar/^{39}Ar$ metamorphic-cooling plateau age of 195.0 ± 1.6 Ma (map A9, table 2; Benowitz and others, 2015). Median magnetic susceptibility is 0.53 x 10^{-3} SI.

JPzpg PARAGNEISS (Late Paleozoic to Early Jurassic)—Muscovite-biotite gneiss. White and black to light gray, weathers dark gray to brown, fine to coarse grained. Consists of 30–75 percent quartz, 10–60 percent plagioclase, 5–25 percent biotite, 5–20 percent muscovite, 0–5 percent epidote, and may also contain minor garnet, K-feldspar, iron oxides, iron sulfides, sericite replacement of feldspar, and chlorite replacement of biotite and muscovite. Foliation is defined by biotite and muscovite as well as occasional quartz rods and augen, 3–6 mm in length, and mica clots. There are lenses of amphibolite (unit JPza) and more schistose layers within this unit. The schistose lenses differ from the paragneiss by a slightly elevated biotite and muscovite content and are finer grained. Locally migmatitic at the contacts with unit Jgd plutons. Median magnetic susceptibility is 3.07 x 10^{-3} SI.

Metavolcanic and Metasedimentary Rocks of the Wrangellia Terrane

Late Paleozoic to Late Triassic metavolcanic and metasedimentary rocks in the map area resemble the normal stratigraphy of Wrangellia terrane as defined in central Alaska (Nokleberg and others, 1994). The base of the stratigraphy in the map area includes metavolcanic rocks of units PIPmv, PIPfv, and PIPva, which are dominated by volcaniclastic textures with lesser mafic to felsic flows. We tentatively correlate these units to the Station Creek and Slana Spur Formations (PIPasc; Wilson and others, 1998). This correlation, as well as the stratigraphic relationship to unit Pl, is the basis for our age assignment.

Metasedimentary rocks (ŦPs and limestone [Pl]) conformably overlie the metavolcanic section; we assign these units to the Eagle Creek formation (Pe; Wilson and others, 1998) based on Permian brachiopod ages, stratigraphic position, and overall lithologic similarity. Limited fossil age control allows that the upper parts of unit ŦPs may be as young as Late Triassic; however, our mapping in the northeastern part of the map area shows unit Ŧn1 Nikolai Greenstone in inferred unconformable contact with unit Pl limestone. The extent of this unconformity in the map area has not yet been resolved due to poor age control.

Nikolai Greenstone (units Ŧn1 and Ŧn2) in the map area correlates to the regionally-defined unit of the same name (Ŧn of Wilson and others, 1998) and is subdivided into a basal, low-TiO_2 subunit (Ŧn1) and an overlying, high-TiO_2 subunit (Ŧn2) following the example of Greene and others (2008). This geochemical subdivision gives a stratigraphic top to the otherwise homogenous and highly deformed greenstone. The lower subunit (Ŧn1) has an approximate stratigraphic thickness of 600 m, while the upper subunit (Ŧn2) is greater than 1,000 m thick; structural complications prevent accurate measurement of the full unit thickness. We interpret the numerous gabbro sills (units Ŧg, Ŧg1, Ŧg2) of similar composition to be cogenetic; part of the magmatic system feeding the overlying metabasalts.

Limited exposures of limestone and marble (unit Ŧl) as well as metavolcanic rocks (unit Ŧsv) have a spatial association with the Nikolai Greenstone upper member (Ŧn2), and in the southern part of the map area these rocks are 2 km along strike from similar rocks containing late Carnian to middle Norian conodonts (Schmidt and others, 2003). On this basis, we tentatively correlate unit Ŧl limestone and marble to the Chitistone Limestone (unit Ŧls; Wilson and others, 1998).

Based on map relationships, cross-sectional interpretations, and comparisons to regional unit thicknesses (Nokleberg and others, 1994), our work suggests structural thickening and repetition of the Wrangellia section by northwest-vergent thrust faulting and a series of upright, northeasterly-trending folds (see cross section A–A'). The timing of this deformation is unclear: northeasterly-trending faults that crosscut Middle Jurassic plutons (unit Jgd), including the Central Raingellia fault, have known reactivation during the Eocene and later.

Ŧl LIMESTONE AND MARBLE (Late Triassic)—Limestone. Gray to light gray, fine to medium grained, and predominantly comprised of sparry, but locally micritic, calcite. Laminated to massive; locally interbedded with chert. In the southern part of the map area, unit is contiguous with limestone in the Iron Creek area (unit Ŧl, Werdon and others, 2002), which contain late Carnian to middle Norian conodonts (Schmidt and others, 2003). Median magnetic susceptibility is 0.00×10^{-3} SI.

Ŧsv METASEDIMENTARY AND METAVOLCANIC ROCKS (Late Triassic)—Heterogeneous metasedimentary and metavolcanic unit comprised of chloritic phyllite, phyllitic siltstone, and quartzite. Green to light gray, massive to thinly bedded, and locally calcareous. Cleavage is well developed. This unit is along strike and interpreted as equivalent to unit Ŧsv of Werdon and others (2002) in the Talkeetna Mountains B-5 Quadrangle. Median magnetic susceptibility is 0.23×10^{-3} SI.

Ŧn1, Ŧn2 NIKOLAI GREENSTONE (Late Triassic) —Metabasalt. Remnant primary volcanic structures, including flow boundaries, are preserved but exposures in the map area lack convincing pillow structures that are characteristic of this unit in other localities (for example, Greene and others, 2010). Green to dark green, locally maroon. Amygdules 2–10 mm in diameter constitute 5–10 percent of this unit in about half of the mapped occurrences. Unit retains relict intersertal to intergranular textures, and primary mineralogy consists of 0.1–0.25-mm-long plagioclase, clinopyroxene, altered primary glass, and magnetite. Metamorphic mineralogy varies across the map area and consists of albite and lesser epidote after plagioclase, actinolite and chlorite after clinopyroxene, chlorite after primary glass, and amygdule-filling quartz, carbonate, and chlorite.

Unit is subdivided into two stratigraphic subunits on the basis of whole-rock and handheld XRF trace-element geochemistry (Wypych and others, 2014). The basal member of the Nikolai Greenstone (TRn1) has TiO_2 <1.2 percent, while the texturally indistinguishable but stratigraphically higher upper Nikolai Greenstone subunit (TRn2) has TiO_2 >1.2 percent. Additionally, unit TRn2 (median magnetic susceptibility 8.78 x 10^{-3} SI) typically has magnetic susceptibility values that are an order of magnitude higher than those of unit TRn1 (median magnetic susceptibility 0.57 x 10^{-3} SI).

TRg, TRg1, TRg2 GABBRO (Late Triassic)—Metagabbro and locally hornblende gabbro sills ranging from <1 m to ~250 m in thickness. Dark gray to dark green, fine-grained, subophitic to locally ophitic textures, with a primary mineralogy of 0.2–3-mm-long plagioclase, 0.1–5-mm-diameter clinopyroxene, and magnetite. A minority of samples contain hornblende (magnesiohornblende) rather than clinopyroxene. Metamorphic mineralogy varies across the map area; secondary mineralogy includes albite and minor epidote or sericite after plagioclase, actinolite or chlorite after clinopyroxene and hornblende, carbonate, quartz, and opaque minerals.

This unit closely resembles the Nikolai Greenstone (units TRn1 and TRn2) in terms of mineralogy and geochemistry but is of coarser grain size. We interpret these units to be the intrusive equivalent of units TRn1 and TRn2; these sills likely represent the part of the subvolcanic feeder system. We have mapped corresponding low TiO_2 (TRg1, <1.2%; median magnetic susceptibility 0.49 x 10^{-3} SI.) and high TiO_2 (TRg2; median magnetic susceptibility 0.91 x 10^{-3} SI) subunits where geochemical data are available.

Magmatic hornblende from unit TRg1 yielded an $^{40}Ar/^{39}Ar$ plateau age of 223.0 ± 4.0 Ma (map A4, table 2; Benowitz and others, 2015), a Late Triassic age consistent with regional observations for this unit (Benowitz and others, 2014; Bittenbender and others, 2007).

Pl LIMESTONE AND MARBLE (Late Permian)—Variably silicified and recrystallized limestone and marble. Gray to light yellowish gray, thickly bedded to massive; in many areas has decimeter-scale siliceous siltstone interbeds, especially adjacent to contacts. Textures range from micritic (locally biomicritic) to sparry (locally biosparry). Locally fossiliferous, particularly in the northwestern portion of the map area. Fauna include disarticulated crinoid ossicles and, rarely, brachiopods belonging to genera *Horridonia* and *Spiriferella* (table 3). This assemblage is Late Permian, and represents a typical high-latitude Arctic Permian boreal fauna. Median magnetic susceptibility is 0.03 x 10^{-3} SI.

TRIPs METASEDIMENTARY ROCKS (Pennsylvanian to Triassic)—Heterogeneous interbedded sedimentary unit dominated by interbedded sandstone and siliceous siltstone, with local conglomerate, chert, and sparse limestone interbeds. In some parts, the unit is rhythmically graded from conglomerate to sandstone to siltstone. Overall median magnetic susceptibility of this unit is 0.25 x 10^{-3} SI.

Sandstones are gray to pale green feldspathic litharenite to lithic arkose and are moderately to poorly sorted, with subrounded to angular clasts dominated by felsic to mafic volcanic rocks (40–71%), feldspar (25–60%), and minor quartz (1–4%). Cements include chlorite, sericite, quartz, and carbonate.

Siliceous siltstone is light to dark gray, laminated to thinly bedded, and often interlayered with chert. Slate and phyllite, interpreted as metamorphosed equivalents of the siltstone, are pale green to black, siliceous, cleaved, and have a well-formed foliation. Variably calcareous, and generally lack pyrite. Phyllites characteristically have well-developed cleavage and locally preserve laminated bedding.

PIPfv FELSIC METAVOLCANIC ROCKS (Pennsylvanian to Permian)—Pale green to white felsic metavolcanic rocks with volcaniclastic and lesser coherent volcanic textures. The volcaniclastic member is massive, with angular to subangular clasts up to cobble-size, supported by an aphanitic pale green matrix; locally contains fiamme. Coherent metarhyolite locally preserves igneous flow textures and may contain ≤ 20 percent, 2-mm-diameter, euhedral quartz phenocrysts and ≤ 50 percent, 2–5-mm-long feldspar phenocrysts. In thin section, this unit is dominated by quartz and feldspar phenocrysts (or phenocryst pseudomorphs comprising quartz, carbonate, and chlorite), and a ± 0.05 mm average grain diameter, granoblastic groundmass of quartz, carbonate, epidote, and chlorite. Whole-rock and hand-held XRF geochemical data indicate dacite to rhyolite bulk compositions (Wypych and others, 2014). Median magnetic susceptibility is 0.15×10^{-3} SI.

PIPmv MAFIC TO INTERMEDIATE METAVOLCANIC ROCKS (Pennsylvanian to Permian)—Polymictic volcaniclastic breccia of basaltic to andesitic composition with lesser volcanic flows and local sandstone to argillite sedimentary interbeds. Gray-green to dark green, massive, poorly sorted, and matrix supported but locally displays bedding and moderate sorting. Clasts are generally angular to subrounded and range in size from fine sand to cobbles and locally larger. Clast lithologies are dominated by mafic to intermediate volcanic fragments, although quartz grains constitute a minor component in some locations. Matrix is composed of silt- to fine-sand-sized clastic material variably metamorphosed to granoblastic quartz, feldspar, chlorite, white mica, clinozoisite, carbonate, and opaques. Amygdaloidal, locally porphyritic basalt to andesite volcanic flows are interlayered with the volcaniclastic breccias and constitute ~20 percent of the unit. Thin beds of metasedimentary rocks similar to unit TRIPs constitute 5 percent of the unit. Median magnetic susceptibility of the unit as a whole is 0.46×10^{-3} SI.

PIPva ALTERED METAVOLCANIC ROCKS (Pennsylvanian to Permian)—Pyritic schist. Light gray to white, with weathered surfaces characterized by intense iron-oxide staining. Forms a 500-m-wide, northeast–southwest-trending zone in the southwestern part of the Talkeetna Mountains C-4 Quadrangle. Median magnetic susceptibility is 0.15×10^{-3} SI. Hand-held XRF analyses of trace TiO_2 and Zr indicate that, despite high silica values and light color, the protolith of this unit is chemically similar to mafic to intermediate metavolcanic rocks (unit PIPmv) or metasedimentary rocks (unit TRIPs) rather than unit PIPfv felsic metavolcanic rocks. Locally contains Cr-bearing mica, and gradational transitions between this unit and mafic schist support the interpretation that this unit represents a widespread alteration zone rather than a felsic metavolcanic unit. White mica yielded an $^{40}Ar/^{39}Ar$ plateau age of 186.3 ± 0.8 Ma (map A8; table 2; Benowitz and others, 2015), which is in general agreement with the metamorphic hornblende cooling age of 195.0 ± 1.6 Ma determined for unit JPza (map A9, table 2; Benowitz and others, 2015). We interpret the quartz–sericite–pyrite alteration and accompanying base-metal anomalies (Wypych and others, 2014) to have formed in a pre-to synmetamorphic setting, probably either accompanying Permian to Pennsylvanian (?) volcanism, or plutonic activity during the Jurassic.

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Table 1. Descriptive statistics for magnetic-susceptibility values (x 10^{-3} SI) by map unit. Each data point (n) represents the mean of 3 to 5 individual measurements performed on outcrop material using a handheld magnetic-susceptibility meter.

Map Unit	n	Mean	Standard deviation	Minimum	25th percentile	Median	75th percentile	Maximum
Trrp	17	4.11	3.49	0.30	2.00	3.20	6.00	15.00
Trr2	22	3.09	4.83	0.02	0.20	0.53	2.34	16.00
Tril	64	6.70	7.04	0.02	0.59	4.00	12.00	24.20
Triv	42	2.75	4.20	0.04	0.29	0.51	4.00	16.90
Trr1	52	2.34	5.79	0.02	0.08	0.50	2.08	39.10
Tsdp	8	5.87	1.89	3.00	4.99	5.50	6.50	9.00
Tsa	9	6.21	3.81	1.20	2.00	7.35	10.00	10.00
Tsd	8	9.20	6.64	0.30	4.75	8.25	12.40	19.00
Tsr	3	5.04	4.94	0.12	2.56	5.00	7.50	10.00
Tsb	48	4.48	5.06	0.10	0.75	1.50	7.00	18.50
Tdb	1	0.85	—	0.85	0.85	0.85	0.85	0.85
Ttap	2	27.30	4.53	24.10	25.70	27.30	28.90	30.50
Tta	51	9.82	6.00	0.50	6.00	8.54	12.75	29.00
Ttb	36	7.46	4.98	0.21	4.00	6.32	10.25	22.50
Ttd	44	10.68	10.02	0.36	5.00	9.19	12.25	66.00
Kdp	4	4.06	2.71	1.00	2.50	3.93	5.49	7.37
Kg	28	3.64	6.61	0.08	0.20	0.30	2.90	25.00
Khg	15	24.18	24.90	0.10	6.60	16.50	27.20	74.30
Jgd	21	19.33	13.33	0.43	9.50	18.90	27.10	60.00
KJmf	8	1.61	3.72	0.14	0.21	0.27	0.51	10.80
JPzog	15	14.84	10.07	1.21	10.00	13.00	15.50	45.20
JPza	9	0.55	0.12	0.40	0.48	0.53	0.60	0.80
JPzpg	60	5.74	9.06	0.03	0.51	3.07	8.12	61.50
TRl	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRsv	4	0.19	0.12	0.02	0.16	0.23	0.26	0.29
TRn2	180	14.08	16.85	0.13	1.00	8.78	21.13	99.30
TRn1	117	2.75	5.09	0.06	0.41	0.57	2.00	28.70
TRg2	54	3.89	6.53	0.20	0.50	0.91	4.00	40.00
TRg1	89	1.99	3.93	0.15	0.40	0.49	0.80	21.70
TRg	15	3.08	7.71	0.12	0.45	0.60	2.10	30.60
Pl	19	0.05	0.05	0.01	0.02	0.03	0.06	0.18
TRIPs	141	1.76	8.45	0.00	0.12	0.25	0.38	68.90
PIPfv	33	1.40	3.39	0.04	0.10	0.15	0.30	16.00
PIPva	24	0.23	0.42	0.04	0.10	0.15	0.18	2.20
PIPmv	296	3.60	9.17	0.02	0.30	0.46	1.58	76.30

Table 2. $^{40}Ar/^{39}Ar$ step-heating analyses in the map area. The most robust age for each analysis is shown in bold**.** The coordinates are WGS84 datum.

Map No.	Sample	Latitude	Longitude	Mineral	Map Unit	Integrated Age (Ma)	Plateau Age (Ma)	Plateau Information	Reference
A1	14AW266	62.73503°N	148.87460°W	Hornblende	Kg	69.5 ± 0.8	**68.8 ± 0.6**	4 of 9 fractions 95.9% ^{39}Ar release	Benowitz and others, 2015
A1	14AW266	62.73503°N	148.87460°W	Biotite	Kg	60.1 ± 0.2	**60.4 ± 0.4***	5 of 8 fractions 62.9% ^{39}Ar release	Benowitz and others, 2015
A2	14AW299	62.43419°N	148.67791°W	Phlogopite	Kdp	61.4 ± 0.4	**67.1 ± 0.9***	4 of 8 fractions 44.8% ^{39}Ar release	Benowitz and others, 2015
A3	14DR003B	62.56229°N	148.93128°W	Biotite	Khg	74.8 ± 0.3	**76.9 ± 0.5**	4 of 8 fractions 55.0% ^{39}Ar release	Benowitz and others, 2015
A4	14ET158	62.59850°N	148.43544°W	Hornblende	TRg1	231.4 ± 4.8	**223.0 ± 4.0**	4 of 8 fractions 87.6% ^{39}Ar release	Benowitz and others, 2015
A5	14ET231	62.40161°N	148.92799°W	Whole rock	Trr1	36.0 ± 0.2	**37.6 ± 0.2**	5 of 8 fractions 53.0% ^{39}Ar release	Benowitz and others, 2015
A6	14ET424	62.42509°N	148.94430°W	Whole rock	Ttap	48.9 ± 0.4	**54.0 ± 0.8**	4 of 8 fractions 52.3% ^{39}Ar release	Benowitz and others, 2015
A7	14LL220	62.56990°N	148.51069°W	Hornblende	Jgd	165.2 ± 0.7	**168.0 ± 0.7***	2 of 11 fractions 60.4% ^{39}Ar release	Benowitz and others, 2015
A7	14LL220	62.56990°N	148.51069°W	Biotite	Jgd	180.5 ± 0.7	**183.8 ± 0.9**	4 of 11 fractions 65.1% ^{39}Ar release	Benowitz and others, 2015
A7	14LL220	62.56990°N	148.51069°W	Feldspar	Jgd	150.0 ± 0.6	**144.3 ± 0.6*** (Loss event?)	4 of 14 fractions 29.4% ^{39}Ar release	Benowitz and others, 2015
A8	14RN301	62.51296°N	148.57072°W	White mica	PIPva	186.3 ± 0.8	**186.3 ± 0.8**	3 of 8 fractions 55.2% ^{39}Ar release	Benowitz and others, 2015
A9	14RN694	62.47367°N	148.49031°W	Hornblende	JPza	197.3 ± 1.9	**195.0 ± 1.6**	5 of 9 fractions 96.8% ^{39}Ar release	Benowitz and others, 2015
A10	13RN490B	62.65477°N	148.80791°W	Hornblende	Khg	107.4 ± 0.5	**105.8 ± 0.4**	5 of 14 fractions 69.1 % ^{39}Ar release	Benowitz and others, 2014
A11	13RN503A	62.56897°N	148.52753°W	Amphibole	TRIPs	162.2 ± 1.0	**165.2 ± 2.1***	6 of 11 fractions 72.5 % ^{39}Ar release	Benowitz and others, 2014
A12	01PJ05A	62.5650°N	148.8899°W	Hornblende	Tsdp		**44.6 ± 1.1**	6 of 10 fractions 86% ^{39}Ar release	Oswald, 2006
A13	01PJ10D	62.5889°N	148.8662°W	Whole rock	Tsb		**44.9 ± 1.0**	9 of 13 fractions 93% ^{39}Ar release	Oswald, 2006
A14	01PJ20B	62.4170°N	148.6881°W	Whole rock	Tril		**21.6 ± 2.1**	6 of 12 fractions 64% ^{39}Ar release	Oswald, 2006

**Does not meet all the criteria for a plateau age determination: weighted-average age presented.*

Table 3. Macrofossils from the Talkeetna Mountains C-4 Quadrangle (macrofossil types and ages determined by Dr. Robert B. Blodgett). Sample coordinates are from handheld GPS; WGS 84 datum.

Map No.	Sample	Latitude	Longitude	Rock Type	Map Unit	Macrofossils	Age
F1	14DR034	62.58385°N	148.63506°W	Medium-gray limestone, highly silicified limestone, cherty argillite	Pl	Crinoid ossicles; sponge spicules or productoid brachiopod spines?	Paleozoic, probably Late Permian based on the lithological resem-blance of some of the limestone here with that of 14DR207
F2	14DR094	62.52640°N	148.49673°W	Gray limestone, silicified in zones	Pl	Abundant crinoid ossicles of varying sizes, often very large (some ossicles are articulated into short crinoid column pieces)	Probably Late Permian, based on similarities of the crinoid ossicles to those found in the other definitive Late Permian collections
F3	14DR207	62.67348°N	148.65761°W	Light yellowish brown, silicified limestone	Pl	*Horridonia sp.* (brachiopod), abundant crinoid ossicles, some in large-sized stem pieces	Late Permian
F4	14DR214	62.66745°N	148.65051°W	Light yellowish gray, crinoid-bearing limestone	Pl	*Spiriferella sp.* (brachiopod), *Horridonia sp.* (brachiopod), and crinoid ossicles (some relatively large)	Late Permian
F5	14ET340	62.61503°N	148.75849°W	Grayish maroon, mottled (bioturbated?) mudstone	Pl	Articulate crinoid stem piece, numerous crinoid ossicles, several small planar trace fossils	Paleozoic (most likely Permian), based on the abundance of crinoid ossicles

REFERENCES CITED

Adams, D.D., Burns, L.E., Pessel, G.H., Little, T.A., Newberry, R.J., and Flynn, L.R., 1985, Preliminary geologic map of the central Talkeetna Mountains, Alaska: Unpublished mapping by the Alaska Division of Geologic & Geophysical Surveys.

Amato, J.M., Rioux, M.E., Kelemen, P.B., Gehrels, G.E., Clift, P.D., Pavlis, T.L., and Draut, A.E., 2007, U-Pb geochronology of volcanic rocks from the Jurassic Talkeetna Formation and detrital zircons from prearc and postarc sequences—Implications for the age of magmatism and inheritance in the Talkeetna arc, *in* Ridgway, K.D., Trop, J.M., O'Neill, J.M., and Glen, J.M.G., eds., Tectonic growth of a collisional continental margin—Crustal evolution of southern Alaska: Geological Society of America Special Paper 431, p. 253–271.

Amos, K.E., and Cole, R.H., 2003, Tertiary volcanic rocks of the central Talkeetna Mountains, Alaska, *in* Galloway, J.P., ed., Studies by the U.S. Geological Survey in Alaska, 2001: U.S. Geological Survey Professional Paper 1678, p. 71–82.

Benowitz, J.A., Layer, P.W., and Twelker, Evan, 2014, $^{40}Ar/^{39}Ar$ data from rocks collected in 2013 in the Wrangellia mineral assessment area, Gulkana, Healy, Mount Hayes, and Talkeetna Mountains quadrangles, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2014-18, 10 p. doi:10.14509/29119

Benowitz, J.A., Layer, P.W., Wypych, Alicja, and Twelker, Evan, 2015, $^{40}Ar/^{39}Ar$ data from the Talkeetna Mountains C-4 Quadrangle and adjoining areas, central Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2015-10, 19 p. doi:10.14509/29454

Bittenbender, P.E., Bean, K.W., Kurtak, J.M., and Deininger, James, 2007, Mineral assessment of the Delta River mining district area, east-central Alaska: U.S. Bureau of Land Management Alaska Technical Report 57, 697 p.

Burns, L.E., Geoterrex-Dighem, WGM, Inc., Emond, A.M., and Graham, G.R.C., 2014, Iron Creek airborne electromagnetic and magnetic geophysical survey data compilation: Alaska Division of Geological & Geophysical Surveys Geophysical Report 2014-6. doi:10.14509/27360

Clautice, K.H., Newberry, R.J., Blodgett, R.B., Bundtzen, T.K., Gage, B.G., Harris, E.E., Liss, S.A., Miller, M.L., Reifenstuhl, R.R., Clough, J.G., and Pinney, D.S., 2001, Bedrock geologic map of the Chulitna region, southcentral Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2001-1A, 31 p., 1 sheet, scale 1:63,360. doi:10.14509/2768

Csejtey, Béla, Jr., Nelson, W.H., Jones, D.L., Silberling, N.J., Dean, R.M., Morris, M.S., Lanphere, M.A., Smith, J.G., and Silberman, J.L., 1978, Reconnaissance geologic map and geochronology, Talkeetna Mountains quadrangle, northern part of Anchorage quadrangle, and southwest corner of Healy quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-558-A, scale 1:250,000, 1 sheet, 62 p.

Glen, J.M.G., Schmidt, Jeanine, Pellerin, Louise, McPhee, D.K., and O'Neill, J.M., 2007, Crustal structure of Wrangellia and adjacent terranes inferred from geophysical studies along a transect through the northern Talkeetna Mountains, *in* Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., Tectonic growth of a collisional continental margin—Crustal evolution of southern Alaska: Geological Society of America Special Paper 431, p. 21–42.

Graham, G.E., Goldfarb, R.J., Miller, M., Gibler, K., and Roberts, M., 2013, Tectonic evolution and Cretaceous gold metallogenesis of southwestern Alaska: Society of Economic Geologists Special Publication 17, p. 169–200.

Greene, A.R., Scoates, J.S., and Weis, Dominique, 2008, Wrangellia flood basalts in Alaska—A record of plume–lithosphere interaction in a Late Triassic accreted oceanic plateau: Geochemistry, Geophysics, Geosystem, v. 9, no. 12, p. 34.

Greene, A.R., Scoates, J.S., Weis, D., Katvala, E.C., Israel, S., and Nixon, G.T., 2010, The architecture of oceanic plateaus revealed by the volcanic stratigraphy of the accreted Wrangellia oceanic plateau: Geosphere, v. 6, no. 1, p. 47–73.

Hampton, B.A., Ridgway, K.D., O'Neill, J.M., Gehrels, G.E., Schmidt, J.M and Blodgett, R.B., 2007, Pre-, syn-, and post-collisional stratigraphic framework and provenance of Upper Triassic–Upper Cretaceous strata in the northwestern Talkeetna Mountains, Alaska, *in* Ridgway, K.D., Trop, J.M., O'Neill, J.M., and Glen, J.M.G., eds., Tectonic growth of a collisional continental margin—Crustal evolution of southern Alaska: Geological Society of America Special Paper 431, p. 401–438.

Nokleberg, W.J., Plafker, George, and Wilson, F.H., 1994, Geology of south-central Alaska, *in* Plafker, George, and Berg, H.C., eds., The Geology of Alaska: Boulder, CO, Geological Society of America, The Geology of North America, v. G-1, p. 311–364.

Oswald, P.J., 2006, Eocene volcanic rocks of the southern Talkeetna Mountains, Alaska—Anomalous forearc volcanism in an extensional setting: Moscow, ID, University of Idaho, M.S. thesis, 70 p.

Rioux, J.M., Hacker, B.R., Mattinson, James, Kelemen, Peter, Blusztajn, Jurek, and Gehrels, G.E., 2007, Magmatic development of an intra-oceanic arc—High-precision U-Pb zircon and whole-rock isotopic analyses from the accreted Talkeetna arc, south-central Alaska: Geological Society of America Bulletin v. 119, no. 9-10, p. 1,168–1,184.

Schmidt, J.M., Oswald, P.J., and Snee, L.W., 2002, The Deadman and Clark Creek fields—Indicators of early Tertiary volcanism in an extensional tectonic setting in the northern Talkeetna Mountains, Alaska: Geological Society of America Abstracts with Programs, v.34, no. 5, p. A-101.

Schmidt, J.M., Werdon, M.B., and Wardlaw, Bruce, 2003, New mapping near Iron Creek, Talkeetna Mountains, indicates presence of Nikolai greenstone, *in* Clautice, K.H., and Davis, P.K., eds., Short Notes on Alaska Geology 2003: Alaska Division of Geological & Geophysical Surveys Professional Report 120J, p. 101–108. doi:10.14509/2917

Werdon, M.B., Riehle, J.R., Schmidt, J.M., Newberry, R.J., and Pessel, G.H., 2002, Geologic map of the Iron Creek area, Talkeetna Mountains B-5 Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2002-4,1 sheet, scale 1:63,360. doi:10.14509/7144

Wilson, F.H., Dover, J.H., Bradley, D.C., Weber, F.R., Bundtzen, T.K., and Haeussler, P.J., 1998, Geologic map of central (Interior) Alaska: U.S. Geological Survey Open-File Report 98-133, 62 p., 3 sheets.

Wypych, Alicja, Twelker, Evan, Freeman, L.K., Lande, Lauren, Newberry, R.J., Reioux, D.A., and Sicard, K.R., 2014, Major-oxide and trace-element geochemical data from rocks collected in 2014 in the Wrangellia mineral assessment area, Talkeetna Mountains C-4, C-3, and B-4 quadrangles, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2014-22, 4 p. doi:10.14509/29140