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NATURAL RESOURCES
WASHINGTON GEOLOGICAL SURVEY

Geologic Map of the Adams Mountain and Hunters 7.5-minute Quadrangles, Stevens County, Washington

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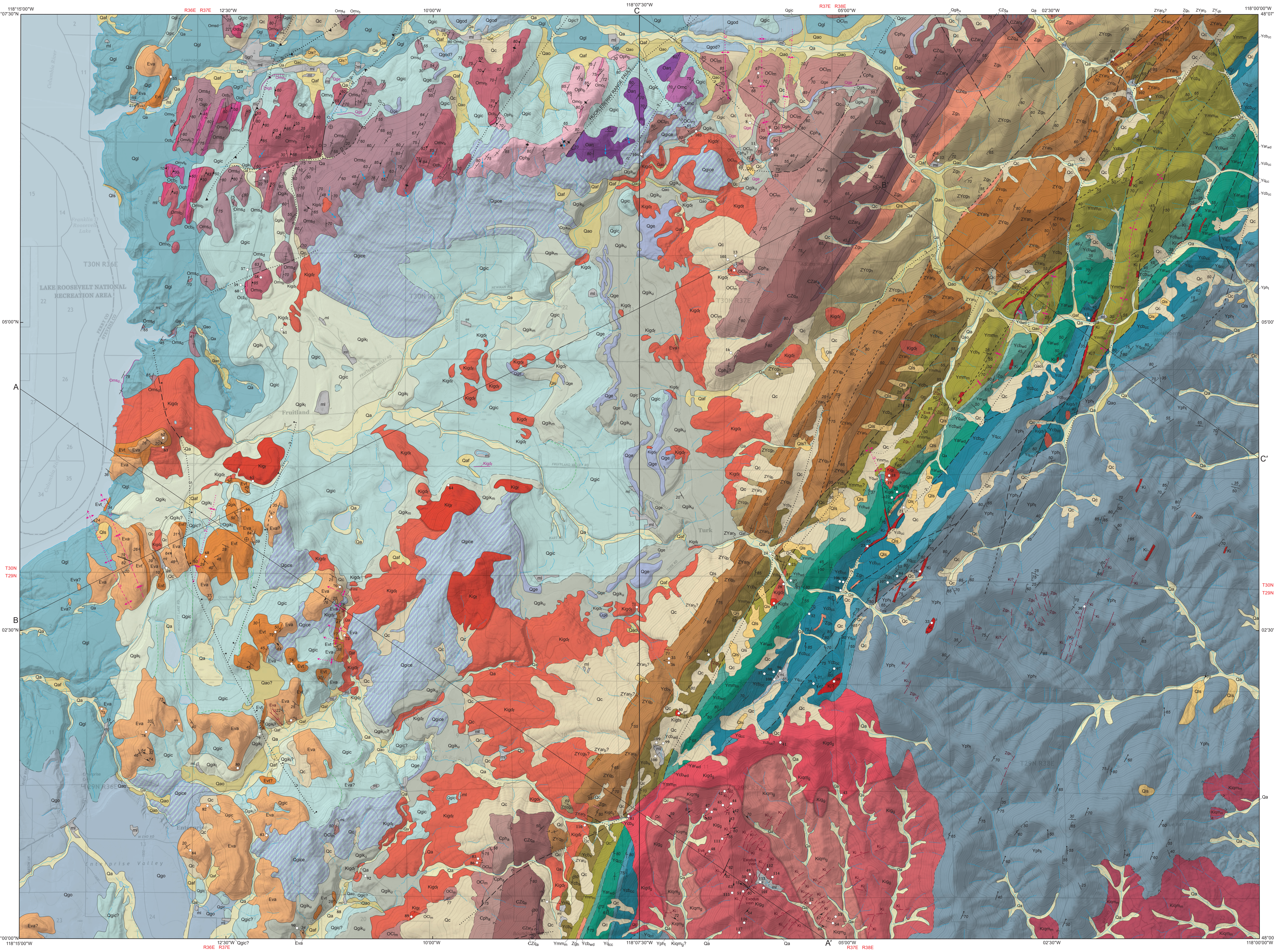
December 2023

WASHINGTON GEOLOGICAL SURVEY
MAP SERIES 2023-06
Geologic Map of the Adams Mountain and Hunters 7.5-minute Quadrangles



Lambert conformal conic projection
North American Datum of 1983
Base map from U.S. Geological Survey Adams Mountain and Hunters 7.5-minute quadrangles, 2020
Shaded relief generated from a lidar bare-earth digital elevation model (available from the Washington Geological Survey, https://lidarportal.dnr.wa.gov/)
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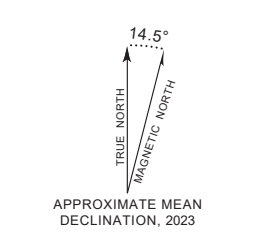
Digital cartography by Nikolas Midttun and Daniel E. Coe
Editing and production by Susan R. Schnur and Nikolas Midttun

SCALE 1:24,000

1 0.5 0 1 MILE
1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 FEET
1 0.5 0 1 KILOMETER

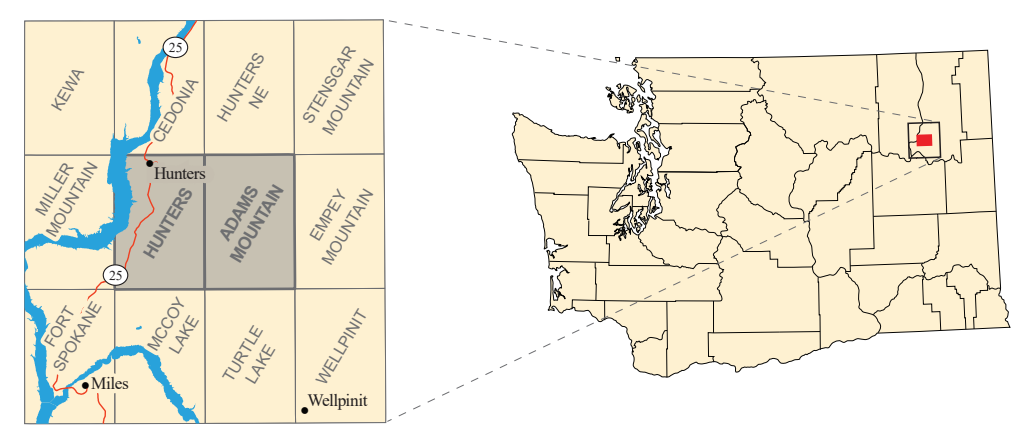
contour interval 40 feet

This geologic map was funded in part by the U.S. Geological Survey Earth Mapping Resources Initiative, under USGS award number G21AC10361.



APPROXIMATE MEAN DECLINATION, 2023

Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G21AC10361. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.



CROSS SECTION EXPLANATION

Qgos Geologic unit too thin to show as polygons at the scale of the cross section—Location accurate

Geologic boundary—Identity and existence certain, location accurate; long-dashed where approximate

Arrows show relative fault movement in the plane of the cross section.

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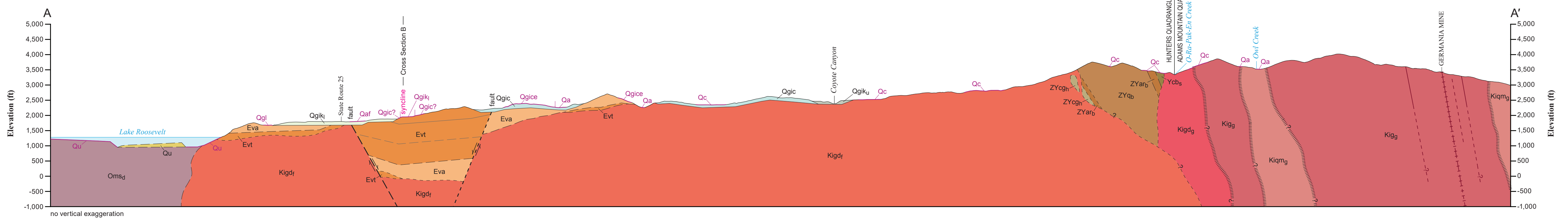
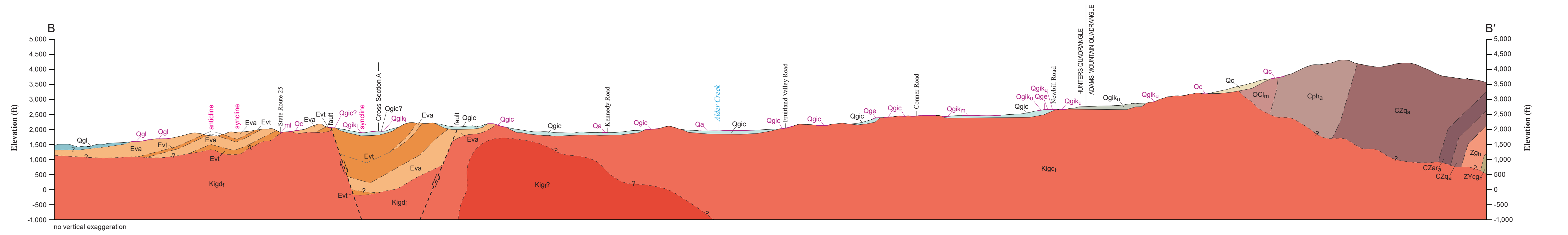




ABSTRACT

New geologic mapping, geochemistry, and geochronology, and compilation of existing geologic maps, improve our understanding of the >1.3 billion-year geologic history in the Adams Mountain and Hunters 7.5-minute quadrangles.

Metasedimentary and metavolcanic rocks of the Deer Trail Group and Windermere Group are the oldest in the area (~1.3–0.7 Ga). These rocks are typically foliated or cleaved, and contain evidence for the rifting of Rodinia. The Addy Quartzite straddles the Precambrian–Paleozoic boundary and underlies a thick sequence of metacarbonate and shale, which are exposed in a now-vertical sequence of thrust sheets. Paleozoic metasedimentary and metavolcanic rocks of the Roberts Mountains allochthon are found in the northern part of the map area.

Two voluminous granitic plutons intrude the Paleozoic and older rocks: a 100–105 Ma zoned pluton near the Germania mine, which hosts tungsten and molybdenum mineralization (in addition to other critical and commodity elements), and a 71–74 Ma pluton near Fruitland, which is locally associated with mineralized skarn.

Eocene andesitic to rhyolitic flows and tuffs were rapidly emplaced 51.5–52.2 Ma on the exhumed 71–74 Ma pluton and are found in fault-bounded half grabens that presumably developed above the Kettle detachment fault. The volcanic rocks are similar to the Sanpoil Volcanics farther west; both are adakites and likely formed by partial melting of continental crust and not from subduction.

Much of the map area was repeatedly covered by continental glaciers during the Pleistocene, the most recent of which left a variety of deposits from lacustrine beds of Glacial Lake Columbia, to ice-marginal kame terraces and deeply incised bedrock gorges that record glacial retreat.

LIST OF MAP UNITS

Holocene and Late Pleistocene Nonglacial Deposits

ml **Modified land and artificial fill (Holocene)—**Mixed earth materials of varied grain size and sorting placed to elevate the land or to modify topography; where mapped adjacent to mine sites, likely contains waste rock or spoils; may be engineered.

Qa **Alluvium (Holocene)—**Gravel, sand, silt, and clay, in varied abundance; locally contains scattered boulders; well to poorly sorted; may be stratified, unstratified, or contain other sedimentary structures indicative of fluvial transport; generally loose. Unit is mapped where there is at least some evidence of geologically recent fluvial deposition or erosion; as such it is found along major perennial streams and rivers. Where unit Qao is present, unit Qa is topographically lower and (or) inset into unit Qao.

Qao **Alluvium, older (Holocene)—**Gravel, sand, silt, and clay, in varied abundance; locally contains scattered boulders; lithologically similar to unit Qa; mapped adjacent to major perennial streams and rivers where evidence for geologically recent fluvial deposition or reworking is absent; the top of the deposit is typically several meters above the stream channel.

Qaf **Alluvial fan (Holocene)—**Pebble to boulder gravel and sand in varied abundance; may contain organic material; mapped largely from lidar along and adjacent to streams where they emerge from confined channels into broader and flatter topography. Unit is differentiated from other Holocene units primarily based on the presence of fan-shaped surface morphology.

Qls **Landslide (Holocene to late Pleistocene (?))—**Boulders, cobbles, pebbles, sand, silt, clay, soil, organic material, and blocks of older deposits or bedrock, in varied abundance; typically matrix supported; generally unsorted; clasts angular to rounded, depending on source material; loose to compact. May include deposits from both shallow (depth less than that of tree roots) and deep-seated landslides, debris flows, and rock fall. Absence of a mapped landslide does not indicate the absence of landslide hazard.

Qc **Colluvium and talus (Holocene to late Pleistocene (?))—**Boulders, cobbles, pebbles, sand, silt, clay, soil, organic material, and semi-intact blocks of older deposits or bedrock, in varied abundance; clast to matrix supported; clasts range from angular to rounded, depending on source material; loose to compact. Includes talus, scree, and colluvium; may include deposits from small, unmapped shallow landslides.

Late Pleistocene Glacial Deposits

Qgo **Glacial outwash (Pleistocene)—**Light gray to tan sand and pebble to cobble gravel; minor silt and clay; rare diamicton (till); typically moderately to well sorted and well stratified; weakly developed soil profile and little to no weathering of clasts; locally contains scattered boulders up to 4 m across; contains a wide variety of clast lithologies, including granitic rock, both high- and low-grade metasedimentary rock, gneiss, and volcanic rocks.

Qgod **Glacial outwash, delta facies (Pleistocene)—**Light gray to tan or olive-drab gravel and sand; loose to somewhat consolidated; clasts are typically pebbles and cobbles with some boulders. This unit is mapped near the mouths of two incised bedrock gorges that empty into Hunters Creek just north of the map area. Here the deposits are fan shaped with flat tops, steep outer edges, and multiple inset flat surfaces; clast lithologies match the bedrock exposed in the gorges just upstream of the deposits.

Qgl **Glacio-lacustrine deposits (Pleistocene)—**White to gray or buff sand, silt, clay, and gravel, in varied abundance typically found below about 1,700 ft; lenses or beds of glacial diamicton are rare; unit typically consists of consolidated and cohesive laminated fine sand, silt, and clay interbedded with ~1-m-thick poorly sorted to well-graded sand and rounded pebble to cobble-gravel; some coarse beds are cross bedded and (or) have ripple cross lamination; most are broadly lenticular or wavy over tens to hundreds of meters.

Qgik$_l$
Qgik$_m$
Qgik$_u$
Ice-contact kame terraces (Pleistocene)—Light gray, dark gray, buff, or olive-gray gravel and sand in varied amounts, with minor lenses and beds of pebble to boulder diamicton (till). Well-developed unpaired terrace surfaces are typical and are interpreted as kame terraces deposited between glacial ice to their west and mountainous terrain to their east. Deeply incised bedrock gorges connect these deposits across transverse bedrock ridges. Three separate subunits (lower, middle, and upper) are mapped based mostly on elevation.

Qgic **Ice-contact deposits (Pleistocene)—**Light gray to tan varied assortment of diamicton (till) and structureless to stratified, poorly sorted silty sand to cobble and boulder gravel; clasts have little to no weathering; diamicton ranges from very compact to somewhat compact and typically consists of unsorted lenses of silt and clay matrix with dispersed pebbles to large boulders, locally up to 3 or 4 m across. The surface of this unit is locally littered with boulders; in many locations abundant kettles are preserved; elsewhere, the surface may be somewhat dimpled or preserve elongate drumlins.

Qgice **Ice-contact deposits with eskers (Pleistocene)—**Light gray to tan varied assortment of diamicton (till) and structureless to stratified, poorly to moderately sorted sandy cobble gravel; lithologically similar to unit Qgic, but contains abundant and narrow linear to sinuous ridges several meters tall of somewhat stratified gravel that are interpreted as eskers.

Qge **Eskers (Pleistocene)—**Light gray to tan generally stratified sand and gravel; typically somewhat consolidated; clasts have little to no weathering and are mostly subrounded; the matrix is usually fine to coarse sand and contains abundant pebbles and cobbles with uncommon boulders; silty layers are locally present, but minor overall; beds are crudely stratiform and locally have lenticular geometries. Deposits of this unit have a characteristic sinuous trace, and are usually 5–10 m tall and 10–70 m wide.

Undivided Quaternary Glacial and Nonglacial Deposits

Qu **Undivided deposits beneath Lake Roosevelt (Quaternary) (cross section only)—**Inferred fluvial and alluvial deposits of the Columbia River, glacio-lacustrine deposits, and (or) till, outwash, or ice-contact deposits; may contain some landslide deposits; likely covered by a thin veneer of Holocene lacustrine deposits of Lake Roosevelt.

Tertiary Volcanic Rocks

Eva **Intermediate to felsic flows and minor tuff (Eocene)—**Light to dark gray andesite and trachyandesite flows with minor dacite flows and interbedded pale-colored tuff and lapilli tuff; flows are typically porphyritic with lustrous black 2–10 mm hornblende; plagioclase and augite phenocrysts are less common; biotite and quartz are rare; mapped where flows are thicker and (or) more abundant than tuffs. Also mapped as dikes in a few localities, including within the Cretaceous plutonic rocks and Proterozoic rocks east of the main exposures of flows; ^{40}Ar/^{39}Ar ages are 51.5–52.2 Ma (stations 62, 73, 77, and 90).

Evt **Felsic to intermediate pyroclastic rock and minor flows (Eocene)—**Light gray, silver gray, light green, and beige tuff, lapilli tuff, and tuff breccia with minor interbeds of flow rock similar to that from unit Eva; pyroclastic rocks range in composition from andesite to rhyolite and are most commonly dacite; typically crystal vitric, with euhedral to subhedral zoned plagioclase and less abundant hornblende, augite, biotite, and magnetite in a groundmass of devitrified glass and minor glass shards; lithic fragments are uncommon; typically unwelded; alteration is weak to strong, pervasive, and has generally altered the groundmass and smaller lapilli to various clays and zeolites; weathers easily. Three ^{40}Ar/^{39}Ar ages (stations 66, 74, and 88) are 51.9–52.1 Ma.

Cretaceous Intrusive Rocks

Ki **Dikes (Cretaceous)—**White, light to dark gray, yellowish gray, or greenish gray slightly porphyritic rhyodacite, quartz latite porphyry, quartz porphyry, granophyre; granite, monzogranite, alaskite, aplite, and pegmatite; thickness ranges from about 1 m to more than 30 m; contacts with metasedimentary rocks are commonly sharp and lack evidence of chilling. U-Pb dates are 103.4 ±0.2 Ma (station 41) and 104.4 ±0.2 Ma (station 23); two ^{40}Ar/^{39}Ar ages (stations 33 and 38) are 95.1 ±0.2 Ma and 71.6 ±0.1 Ma.

PLUTONIC ROCKS NEAR FRUITLAND

Kig$_f$ **Granite near Fruitland (Late Cretaceous)—**Light to medium gray granite; medium grained; seriate to equigranular; quartz 30–34 percent; K-feldspar 29–30 percent; plagioclase 26–30 percent; biotite typically present at <6 percent; minor to trace hornblende, titanite, apatite, and zircon; plagioclase weakly altered; biotite moderately altered; hornblende, where present, completely altered. U-Pb ages are 73.3 ±0.3 Ma (station 64) and 74.2 ±0.3 Ma (station 18). This unit is likely a more-felsic interior zone of the expansive granodiorite near Fruitland (unit Kigd$_f$).

Kigd$_f$ **Granodiorite near Fruitland (Late Cretaceous)—**Light gray to yellowish gray granodiorite and quartz monzodiorite; medium to coarse grained; typically equigranular but locally slightly porphyritic; quartz typically makes up 13–22 percent of the rock; K-feldspar ranges from 7–21 percent; plagioclase is 50–75 percent; subhedral to euhedral biotite to 5 percent is the most common mafic phase; euhedral hornblende is sparse (1–3%); accessory minerals include magnetite, titanite, apatite, and zircon; plagioclase and biotite are weakly altered; calc-silicate skarn or hornfels are locally common in country rock. Three U-Pb ages are tightly clustered between 73.4–74.0 Ma (stations 19, 63, and 92); one other is a bit younger at 71.4 ±0.4 Ma (station 28).

Kigb$_f$ **Gabbro near Fruitland (Late Cretaceous)—**Dark gray gabbro; fine grained; equigranular to slightly porphyritic; primarily composed of actinolite (59%) and plagioclase (30%) with some K-feldspar (5%) and minor titanite and opaques; mapped in two small outcrops, one of which is adjacent to an exposure of unit Kigd$_f$ and could represent a more-mafic border phase.

PLUTONIC ROCKS NEAR THE MIDNITE MINE

Kiqm$_m$ **Quartz monzonite near the Midnite Mine (Late Cretaceous)—**Gray to pinkish gray porphyritic quartz monzonite, monzogranite, and granite; typically deeply weathered; medium to coarse grained groundmass with phenocrysts of K-feldspar ranging from 1.5 to 5.5 cm in length; quartz is typically anhedral, smoky and up to 1.5 cm long; contains 3–5 percent biotite, typically altered; muscovite is typically less than 4 percent of the rock; accessory minerals include magnetite, titanite, apatite, fluorite, garnet, zircon, monazite, and rare rutile, pyrite, and epidote. A range of ages from near the Midnite Mine are generally between 65 to 80 Ma (Ludwig and others, 1981); a Rb-Sr age of 74.7 ±3 Ma is reported by Asmerom and others (1988).

PLUTONIC ROCKS NEAR THE GERMANIA MINE

Kigd$_g$ **Granodiorite near the Germania Mine (Middle Cretaceous)—**Very light to medium gray equigranular granodiorite; medium grained; the rock is 22–34 percent quartz, 10–17 percent K-feldspar, 40–58 percent plagioclase, 7–10 percent biotite, and <1–2 percent hornblende; accessory minerals include epidote, apatite, zircon, titanite, and opaques. Alteration is ubiquitous. U-Pb dates are 103.5 ±0.2 Ma (station 41), and 100.1 ±0.4 Ma (station 43).

Kig$_g$ **Granite near the Germania Mine (Middle Cretaceous)—**Light to medium gray, pinkish gray, or yellowish gray medium- to coarse-grained granite; typically moderately to weakly porphyritic; uncommonly equigranular or seriate; phenocrysts include quartz and plagioclase up to 0.6 cm in size; phenocrysts of K-feldspar are common, locally abundant, subhedral to euhedral, and up to 5 cm in size; quartz makes up 25–40 percent of the rock, K-feldspar is 16–30 percent, and plagioclase is 25–43 percent; biotite content varies from <1–8 percent and where biotite is less abundant, phlogopite is up to 4 percent; hornblende is typically <2 percent; apatite, zircon, tourmaline, titanite, magnetite, and other opaques are common accessory minerals. Alteration is ubiquitous; typically deeply weathered to soil and grus. U-Pb ages are 104.0 ±0.5 Ma (station 42) and 101.8 ±0.5 Ma (station 49) near the Germania mine and 100.5 ±0.4 Ma (station 21) farther north; 40Ar/39Ar ages on muscovite from mineralized mica-rich veins are 88.1 ±0.1 Ma (station 45) and 99.0 ±0.2 Ma (station 50).

Kiqm$_g$ **Quartz monzonite near the Germania Mine (Middle Cretaceous)—**Light gray to yellowish gray quartz monzonite; grain size varies from fine to coarse but is most commonly medium; typically equigranular, but locally porphyritic as it grades into unit Kig$_g$; typically 20–40 percent quartz, commonly somewhat gray; K-feldspar makes up 20–35 percent of the rock, plagioclase is 25–35 percent, and biotite is 1–5 percent; accessory minerals include apatite, various types of epidote, hornblende, zircon, muscovite, titanite, and opaques. Alteration is similar to that seen in unit Kig$_g$; deeply weathered; abundant northeast-striking dikes of alaskite, aplite, and (or) pegmatite cut this unit.

Paleozoic Rocks West of the Huckleberry Range Fault

Oigb **Intrusive hornblende gabbro (Ordovician?)—**Dark gray to green hornblende gabbro; typically coarse grained; weakly foliated and (or) sheared; found in sill-like lenses intruding rocks of the Covada Group south of Hunters.

BRADEEN HILL ASSEMBLAGE (ORDOVICIAN)

Omc$_b$ **Chert of the Bradeen Hill assemblage—**Dark gray to black chert; bedded; phyllitic partings between beds are common; locally laminated; recrystallized; occurs as thin layers and lenses within the phyllite of unit Oph$_b$.

Oph$_b$ **Phyllite of the Bradeen Hill assemblage—**Dark gray to black phyllite, slate, and minor quartzite.

COVADA GROUP (ORDOVICIAN)

Ocb$_c$ **Limestone and marble of the Covada Group—**Medium to dark gray impure limestone; in places sandy with phyllitic partings; typically found as thin lenses and beds within and dividing clastic and volcanic units of the Covada Group; commonly recrystallized. There is a well-exposed outcrop of calc-silicate skarn along Highway 25 just north of Fruitland that is included in this unit.

Butcher Mountain Formation of the Covada Group

Omv$_b$ **Greenstone of the Butcher Mountain Formation—**Black, dark gray, or dark green metabasalt (greenstone) with minor basaltic breccia, metatuff, and slate; structureless to well foliated or schistose; locally highly sheared; basalt includes flows and flow breccia and is commonly calcareous; primary textures are generally absent, though pillows are locally present but not abundant.

Omvt$_b$ **Meta-tuff of the Butcher Mountain Formation—**Ash tuff to coarse lapilli tuff; finely laminated; predominantly found interbedded with greenstone (unit Omv$_b$), but also sparsely distributed as thin layers throughout unit Oms$_d$.

Daisy Formation of the Covada Group

Oms$_d$ **Quartzite and minor slate of the Daisy Formation—**Gray, brown, olive, or greenish quartzite and subordinate interbedded gray to black slate; sandstone is typically fine to medium grained, but locally as coarse as granules; thin to very thickly bedded, though difficult to recognize, partly due to a locally developed foliation; slaty intervals laminated to thinly bedded; sandstone ranges from feldspathic wacke to rare quartz arenite; along the shore of Lake Roosevelt near Cretaceous plutons the unit is a garnet-bearing schist.

Paleozoic Rocks East of the Huckleberry Range Fault

Oar$_l$ **Ledbetter Slate (Ordovician)—**Medium to dark gray slate, argillaceous limestone, and calcareous slate; some beds of blue-weathering limestone; light gray to white crystalline dolomite locally present; argillaceous intervals highly fissile; poorly exposed.

Omc **Chert (Ordovician)—**Dark gray to black chert and thinly interlaminated limestone; chert is microcrystalline; limestone is more abundant in the map area compared to farther north; many secondary quartz veins and irregular voids with quartz and limonite; may be partly equivalent to the Ledbetter Slate; unit is poorly exposed.

OꞒl$_m$ **Metaline Formation (Middle Ordovician to Middle Cambrian)—**Light gray, dark gray, or bluish gray limestone and minor thin interbeds of dark gray slate and medium gray dolomite; limestone is typically fine grained and thin bedded; black chert nodules are common in carbonate rocks; light and dark banded dolomite is locally common, especially near the base of the unit south of the Hunters–Springdale road. The limestone is recrystallized into white to bluish gray coarse-grained marble near intrusive rocks and calc-silicate skarn is locally well developed.

Cambrian to Neoproterozoic Rocks

ADDY QUARTZITE

Ꞓph$_a$ **Phyllite, argillite, and quartzite of the Addy Quartzite (Cambrian)—**Brown, green, and gray phyllite, siltite, and argillite alternating with white to tan quartzite; fine-grained intervals are 10 to 20 m thick and consist of thin to thick beds that are locally mottled; Planolites and Cruziana trace fossils are present; well-developed cleavage and foliation is common; quartzite intervals are typically 1 to 20 m thick, decrease in abundance and thickness up section, and are fine to medium grained with rare medium beds of pebbly quartzite; may correlate with part of the Maitlen Phyllite.

ꞒZar$_a$ **Argillite of the Addy Quartzite (Cambrian to Neoproterozoic)—**Dark gray to black argillite and siltite; laminated to medium bedded; about 80 m thick; overlies about 50–60 m of basal quartzite (unit ꞒZq$_a$).

ꞒZq$_a$ **Quartzite of the Addy Quartzite (Cambrian to Neoproterozoic)—**White, tan, light brown, blue, or lavender quartzite with minor interbeds of argillite; basal interval is fine to medium grained, medium to thick bedded, and contains rare coarse-grained beds and thin discontinuous interbeds and thin partings of purple and brown argillite; a purple-banded quartzite locally overlies the basal portion and has distinctive purple to red banding and layers of heavy minerals (zircon, rutile, and magnetite); a coarse-grained quartzite generally caps this unit and ranges from medium-grained to gritty, with locally common thin pebble conglomerate beds; Scolithos burrows are found locally near the top of the unit.

Neoproterozoic to Mesoproterozoic Rocks

WINDERMERE GROUP

Huckleberry Formation of the Windermere Group

Zg$_h$ **Greenstone of the Huckleberry Formation (Neoproterozoic)—**Dark greenish gray to greenish black or grayish green fine-grained metabasalt (greenstone) and less abundant tuffs and volcaniclastic rocks; metabasalt occurs chiefly as aphyric to porphyritic flows with up to 10 percent plagioclase; dikes, locally gabbroic, are altered and well cleaved or phyllitic and absent in younger units; most dikes are thin and poorly exposed and are mapped only where relatively thick and continuous. Outside of the map area, the upper part of the greenstone has a whole-rock Sm-Nd age of 762 ±44 Ma (Devlin and Bond, 1988).

ZYcg$_h$ **Metaconglomerate and metadiamictite of the Huckleberry Formation (Neoproterozoic to Mesoproterozoic)—**Pale green, pale gray, buff, or rarely black matrix-supported conglomerate and diamictite; poorly sorted to unsorted; clasts typically pebble size, angular to rounded, and include dolomite, argillite, siltite, quartzite, and milky quartz; matrix mostly sand and silt and much altered to chlorite; bedding poorly developed or obscured by schistosity; well foliated to phyllitic; locally well developed and closely spaced slaty cleavage; clasts typically at least somewhat flattened and locally stretched.

DEER TRAIL GROUP

Buffalo Hump Formation of the Deer Trail Group

ZYar$_b$ **Argillite of the Buffalo Hump Formation (Neoproterozoic to Mesoproterozoic)—**Light to medium gray, greenish gray, or olive brown slate, argillite, and minor phyllite; bedding usually absent, but a minor amount is laminated to thinly bedded; in some locations slate grades up into quartzite; thin cleavage is typically well developed, but locally absent.

ZYq$_b$ **Quartzite of the Buffalo Hump Formation (Neoproterozoic to Mesoproterozoic)—**White, gray, pinkish gray, yellow, brown, or bluish subvitreous to vitreous quartzite; generally fine to medium grained; includes minor thin beds of white, gray, brown, or maroon siltite, argillite, or slate and uncommon stringers and lenses of stretched quartzite-pebble conglomerate; bedding ranges from indistinct to well developed; where visible, bedding is planar to cross bedded; sorting increases and the unit is more typically medium grained as the quartzite thickens to the south; jointing and fracturing are abundant.

Stensgar Dolomite Formation of the Deer Trail Group

Ycb$_s$ **Stensgar Dolomite (Mesoproterozoic)—**White, tan, or gray dolomite and dolomitic marble with minor thin interbeds and bedding-plane partings of argillite; dolomite is typically fine grained and becomes coarse where recrystallized; weathers medium gray, which is unique among the Proterozoic carbonates; generally thin bedded to laminated except where recrystallized and bedding is absent. All known occurrences of magnesite in the region are found in this unit; zones up to 100 m wide have been replaced by fine- to coarse-grained gray, black, and red magnesite, locally in alternating dark and light layers; magnesite parallels and cuts across bedding.

McHale Slate Formation of the Deer Trail Group

Ymm$_m$ **McHale Slate (Mesoproterozoic)—**Dark to light gray slate, slaty argillite, argillite, and minor phyllite; weathers brown to olive brown; lower third typically gray with tan to pale gray laminae; upper two thirds typically gray at base grading into alternating intervals of pale green or lavender gray; bedding ranges from thin laminations to fining-upward intervals up to 3 cm thick; laminated light and dark gray siltite beds are present locally; thin quartzite beds are rare; slaty cleavage is typical, locally well developed, and ranges from thick to very thin, but in some locations is mostly absent; faults are common within, above, and below the McHale Slate.

Wabash Detroit Formation of the Deer Trail Group (Mesoproterozoic)

Yq$_{wd}$ **Quartzite of the Wabash Detroit Formation—**Vitreous light gray, buff, or grayish pink quartzite; poorly defined thick to thin beds; quartzite is discontinuously present near the top of the Formation in the map area and southward; where present, typically about 20–45 m thick. Miller (1996) suggests that the unit may have been continuous but is either faulted out or covered where it appears to be absent.

Ycb$_{wd}$ **Dolomite of the Wabash Detroit Formation—**Impure off-white, buff, pale gray, or rarely dark gray dolomite with minor thin interbeds of pale green to gray argillite or slate; dolomite is fine grained, locally siliceous, ferruginous, or calcareous; ranges from very thin bedded to thick bedded; chert-bearing beds are present; thick and distinctive brick-red soil in low-lying areas or saddles is commonly the only indication of this unit at the surface.

Yar$_{wd}$ **Argillite and slate of the Wabash Detroit Formation—**Light brown to dark gray slate and argillite with minor siltite; typically appears unbedded with thin bedding preserved only in slightly coarser-grained sections; paper-thin cleavage is common and typically well developed, though not everywhere present; locally siliceous.

Chamokane Creek Formation of the Deer Trail Group (Mesoproterozoic)

Ycb$_{cc}$ **Dolomite and minor argillite of the Chamokane Creek Formation—**Tan, buff, or light gray impure fine-grained dolomite interbedded with carbonate-bearing quartzite, siltite, and slaty argillite to phyllite; dolomite generally thin bedded, but ranges from thick bedded to laminated; locally a thin cleavage is developed parallel to bedding; pyrite is ubiquitous but sparse; dolomite only rarely exposed due to development of thick dark red to reddish-brown soils, locally with chips of green to brown slate.

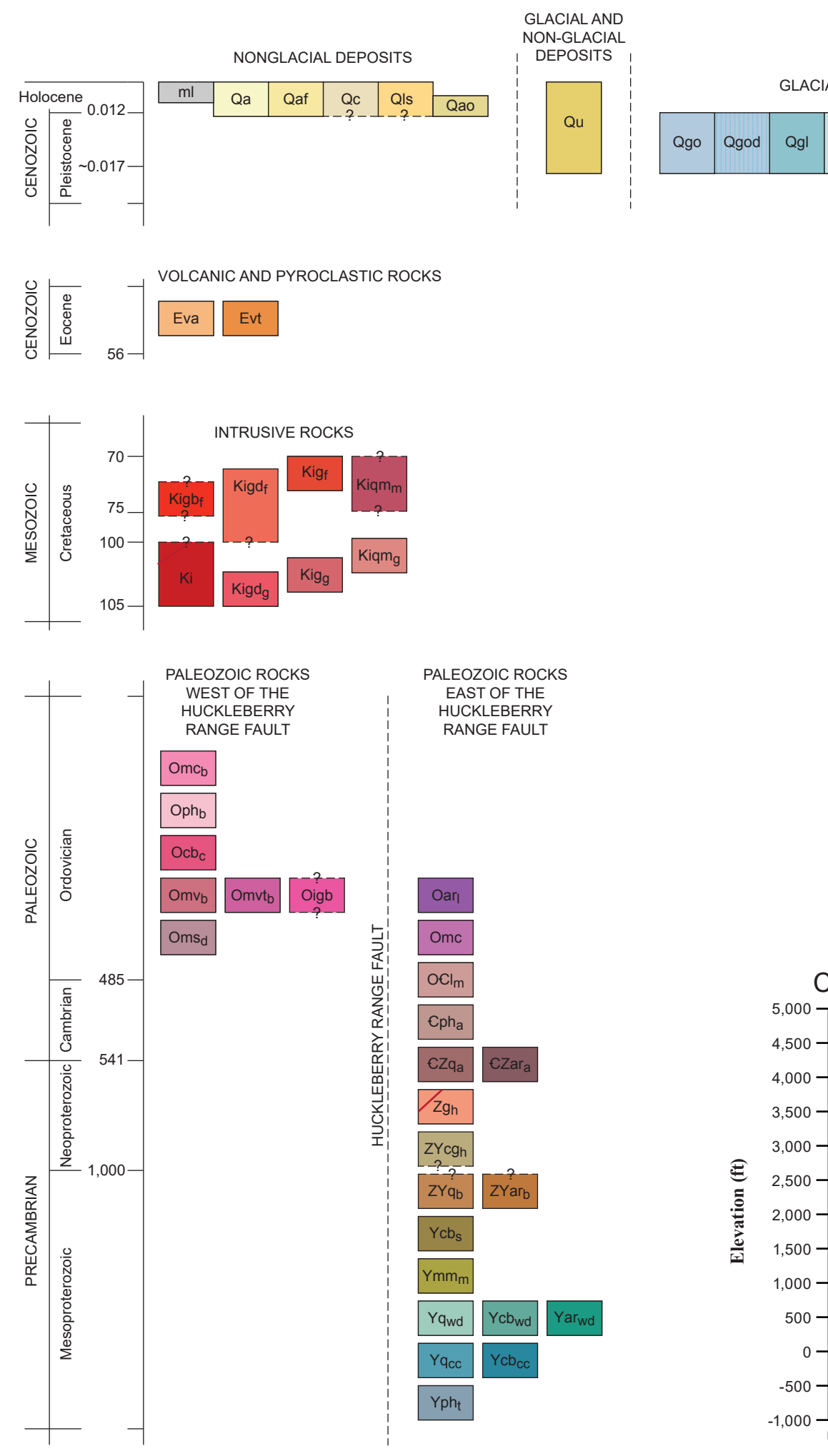
Yq$_{cc}$ **Quartzite of the Chamokane Creek Formation—**Light gray to white, greenish or bluish gray, or reddish brown fine- to medium-grained quartzite with thin interbeds and partings of dark gray to greenish phyllite, slate, and (or) argillite. The quartzite beds range from quartzitic slate to slaty quartzite, with few beds of pure quartzite; bedding varies from poorly to thinly bedded.

Togo Formation of the Deer Trail Group (Mesoproterozoic)

Yph$_t$ **Phyllite and argillite of the Togo Formation—**Light to dark gray or black phyllite and thinly interbedded slaty argillite to siltite; locally green to dark brown; thinly bedded to laminated, with a prominent and well-developed bedding-plane cleavage; a few beds of quartzite are found in this unit; within a few hundred meters of younger plutonic rocks, the phyllite has 5–15 mm ovoid clots of dark fine-grained magnetite and biotite and Campbell and Loofbourow (1962) report dark gray poikilitic andalusite porphyroblasts up to 2.5 cm long and some cordierite and tourmaline.

CORRELATION OF MAP UNITS

PERIODS AND EPOCHS BASED ON USGS FACT SHEET 2010-3059



GEOLOGIC SYMBOLS

——— — — - - - ?······	Contact—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable
⦀⦀⦀?⦀⦀	Gradational contact—Identity and existence certain; location accurate; queried where identity or existence questionable
——— — — - - -?······	Fault—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable
—▼— — —?- - - - ·▼··	Thrust fault—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; Sawteeth on upper plate
— — - - -•- - -······	Normal fault—Long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; bar and ball on downthrown block
——— - - U/D - - ······	High-angle dip-slip fault—Solid where location accurate; short-dashed where inferred; dotted where concealed; relative motion shown by U and D
←——— — —↕- - ?······	Anticline—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrow on line indicates plunge direction
←——— — —⨯- - ?······	Syncline—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrow on line indicates plunge direction
Qge ———	Geologic unit too thin to show as a polygon—Location accurate
——— — —?— - - -	Dike—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; queried where identity or existence questionable;
- - - - - - - -	Glacial moraine
A ——— A′	Cross section line
———	Perennial stream
—·· —··	Intermittent stream
40	Inclined bedding—showing strike and dip
55	Overturned bedding—showing strike and dip
✕	Vertical bedding—showing strike
⊕	Horizontal bedding
70	Inclined metamorphic or tectonic foliation—showing strike and dip
	Vertical metamorphic or tectonic foliation—showing strike
70	Inclined bedding, where top direction of beds is known from local features—showing strike and dip
80	Overturned bedding, where top direction of beds is known from local features—showing strike and dip
59	Small, minor inclined joint—showing strike and dip
65	Inclined cleavage—showing strike and dip
62	Small, minor inclined fault—showing strike and dip
15	Inclined slickenline, groove, or striation on fault surface—showing bearing and plunge
20	Inclined bedding in unconsolidated sedimentary deposits or unconsolidated fragmental deposits of volcanic origin—showing strike and dip
71	Small, minor inclined vein, veinlet, or mineralized stringer—showing strike and dip
→	Younger glacial striation or groove—showing measured bearing and direction of flow
88	Inclined fault—showing dip value and direction
78	Inclined dike—showing dip value and direction
85	Inclined contact—showing dip value and direction
20	Inclined flow banding, lamination, layering, or foliation in igneous rock—showing strike and dip
50 ○	Station (location of analysis or observation—see Pamphlet)