Geologic Map of the Ellensburg South 7.5-minute Quadrangle, Kittitas County, Washington

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Geologic Map of the Ellensburg South 7.5-minute Quadrangle

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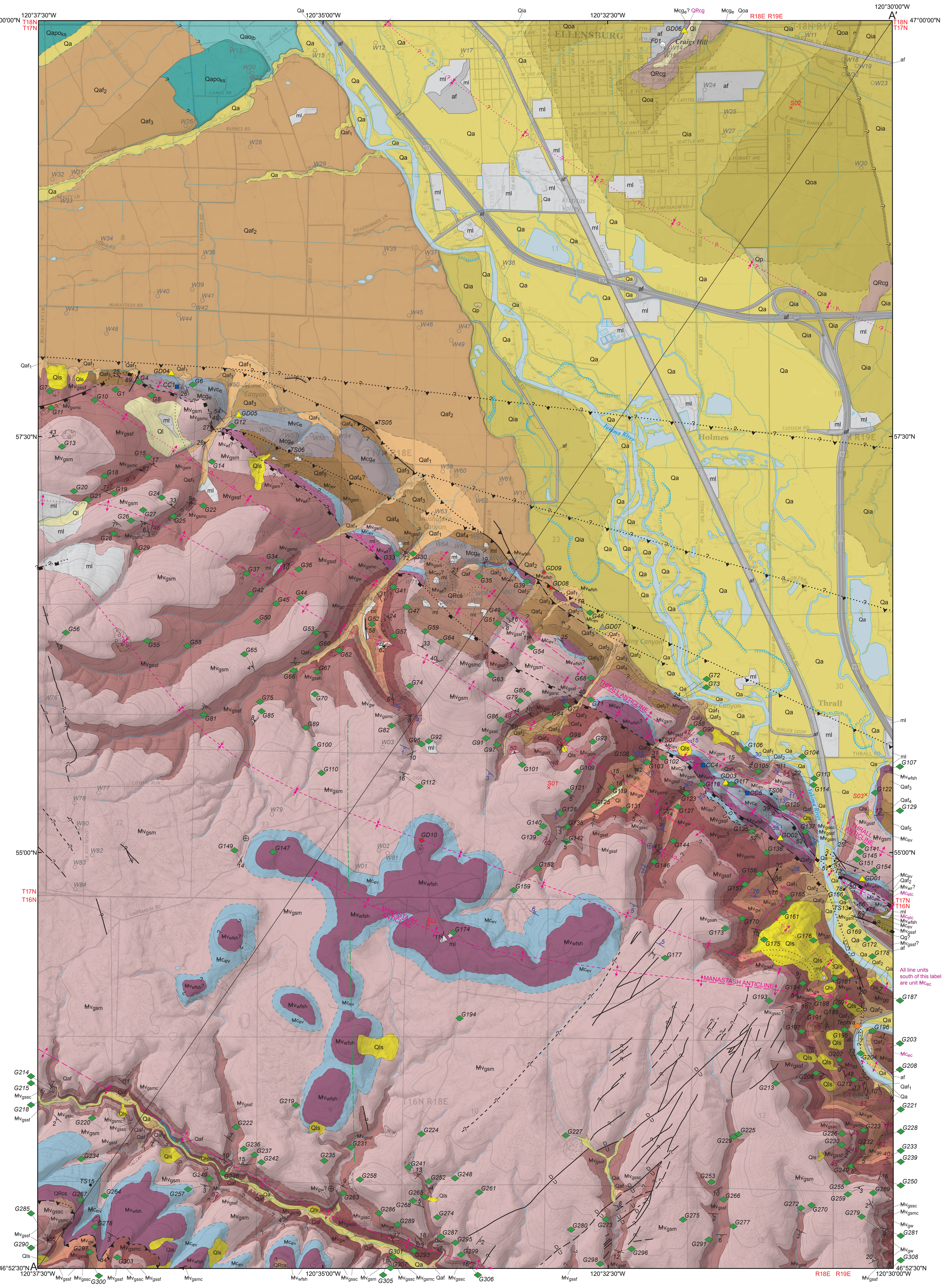

Lambert conformal conic projection
North American Datum of 1983
Base map from U.S. Geological Survey Ellensburg South 7.5-minute quadrangle, 2020
Shaded relief generated from a lidar bare-earth digital elevation model (available from the Washington Geological Survey, https://lidarportal.dnr.wa.gov/)
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SCALE 1:24,000
contour interval 20 feet

APPROXIMATE MEAN DECLINATION, 2024 — 14.5°

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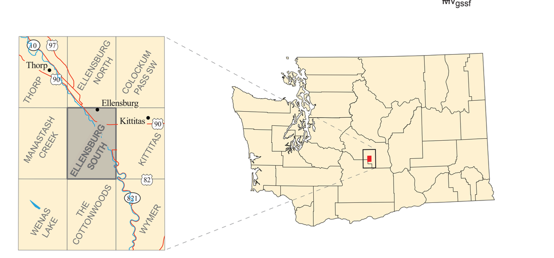

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ABSTRACT

New geological and geophysical investigations of the Ellensburg South quadrangle refine Neogene stratigraphy and characterize geologic structures in southern Kittitas Valley. Whole-rock geochemistry (n=326) locally refines the middle Miocene chemostratigraphic framework of the Columbia River Basalt Group (CRBG). Measurements of the orientations of CRBG basalt columns reveal middle Miocene paleotopography, showing possible channelization of Grande Ronde Basalt (GRB) lava flows. Late Miocene to Pliocene (?) suprabasalt volcaniclastic strata of the Ellensburg Formation are folded in the hanging wall of a frontal thrust.

Tilted bedrock strata, active thrust faults, and fault-related folds record north-south shortening in the map area. Deformation of Quaternary sediments and recent seismicity along frontal faults indicate that contraction is ongoing. Thrusts are northward-verging and gently (<15°) southwest- to south-dipping. Northwest-trending folds are tighter near the range front, and some plunge southeast. Additional structures include previously unrecognized secondary fold-accommodation faults and northerly striking oblique (?) faults, several of which may exist in Yakima canyon.

New U-Pb analysis of detrital zircons from two samples produced maximum depositional ages (MDA) of 15.36 ±0.25 Ma for a sedimentary interbed in the Wanapum Basalt and 9.54 ±0.49 Ma for an upper Ellensburg Formation conglomerate. Both ages agree with previous age analyses of these units from elsewhere around Kittitas Valley. Two luminesence ages from faulted alluvial fans suggest the faulting is ~6,000 years old or younger. A luminescence age of 3.0 ±0.4 ka from a loess mound suggests post-glacial Holocene deposition of loess.

Observed gravity and aeromagnetic data are best fit by geophysical models that include structural thickening of the GRB normal magnetostratigraphic unit N1 in the hanging wall of the low-angle Manastash thrust fault. Within this same hanging wall, misalignment between linear, north-northwest-trending geophysical anomalies and an overall northwest- to west-trending structural fabric suggests that deformation may be distributed among multiple structural blocks.

LIST OF MAP UNITS

Holocene to Pleistocene Nonglacial Deposits

af — **Artificial fill (Holocene)**—Cobbles, pebbles, sand, and boulders; poorly sorted and unconsolidated; includes material brought in from other locations. Unit af is at least 1.5 m thick.

ml — **Modified land (Holocene)**—Sand- through boulder-sized material, redistributed to modify topography for industrial, agricultural, recreational, and residential uses. Unit ml is different from artificial fill because its composition matches the underlying geologic unit, though other original textures are no longer recognizable. Unit ml is at least 1 m thick.

Qp — **Peat (Holocene to Pleistocene)**—Organic and organic-rich sediment; includes peat, gyttja, muck, silt, and clay; typically in closed depressions; mapped in natural or man-made wetlands, bog areas, and ephemeral water bodies.

Qls — **Landslide deposits (Holocene to Pleistocene)**—Clastic aggregate and scree of sand, silt, clay, cobbles, pebbles, boulders, and diamicton; medium to light yellowish brown; weathering is typically mild to moderate; generally loose and poorly consolidated; angular to subangular; unsorted, typically matrix supported; unstratified and structureless; clasts are mostly basaltic; deposits contain large quantities of silt and finer sands derived from nearby soils or sedimentary units (loess and volcaniclastic material); 5–60 m thick.

Holocene? to Pleistocene Glacial Deposits

Deposit morphology and distinctive Cascade-sourced polymict clast composition characterize distal alpine outwash from the Cascade Range that entered the map area from the northwest through the Yakima River corridor. Glacial outwash deposits form either: (1) isolated lens-shaped terraces (unit Qapo$_{ks}$) above broad, monomict alluvial and colluvial fans, or (2) broad bands of lower-lying terraces (unit Qao$_{lb}$) inset into older outwash terraces.

Clast compositions are diagnostically polymict in the northwestern map area including, in order of decreasing abundance, aphyric basalt, porphyritic andesite, metamorphic rocks, felsic intrusive rocks, and rare quartz and (or) chert. These compositions suggest a Cascade Range provenance with input from local Miocene and pre–Cascade arc sources.

Qao$_{lb}$ — **Bullfrog alpine outwash of the Lakedale Drift (Holocene? to Pleistocene)**—Polymict pebbly cobble gravel to pebbly sand; with gray, brown, and yellow clasts in a light to dark brown matrix; mildly weathered with weathering rinds less than 1 mm; poorly indurated, not cemented; subangular to rounded and equant to oblate clasts; with fine to coarse sand; moderately sorted; clast-supported; generally structureless; deposits form broad flat to gently sloping terraces that dip to the east or southeast suggesting a westerly outwash paleo-flow direction; thickness is approximately <10 m.

Qapo$_{ks}$ — **Swauk Prairie alpine outwash of Kittitas Drift (Pleistocene)**—Polymict pebbly cobble gravel to pebbly sand; clast colors include shades of gray, brown, and yellow in a light to dark brown matrix; mildly weathered, with weathering rinds on average about 1 mm thick but up to 2–3 mm thick; poorly indurated, poorly cemented; fine to coarse sand; subrounded to rounded, equant to oblate; moderately sorted, clast-supported; generally structureless; deposits form terraces with steep east-northeast-facing slopes and gentle west-southwest-facing slopes that suggest westerly outwash flow direction; thickness is at least 6 m.

Holocene to Pliocene Nonglacial Alluvial and Colluvial Deposits

Alluvial and colluvial deposits contain particles ranging in size from boulders to clay, all in varied amounts and thicknesses. Colors range from light tannish gray to medium brown. Younger units are less compacted and cemented than older units. In general, sand and gravel of alluvium are well rounded, moderately to well sorted, and mildly to moderately weathered. Alluvial and colluvial units are generally composed of clasts of basalt (monomict) outside of the Yakima River corridor, whereas near the Yakima River clast compositions are more diverse (polymict) and contain abundant porphyritic andesite, dacite, other volcanic rocks, some metamorphic rocks, and rare quartz. We infer the relative ages based on inset relationships of the deposits and proximity to active channels. Multiple flights of alluvial and colluvial fans are inset on the flanks of Manastash Ridge and in Yakima canyon (see units Qaf$_1$–Qaf$_5$).

Qa — **Alluvium (Holocene)**—Sand and gravel from lowest lying stream-channel deposits on active flood plains flanking rivers and creeks; widely distributed throughout low elevations in the map area; unit has been modified by infrastructure or agricultural cultivation. Unit Qa is inset into unit Qia. Fluvial terrace risers are more common on unit Qa surfaces, especially compared to unit Qia surfaces.

Qia — **Intermediate-age alluvium (Holocene to Pleistocene)**—Sand and gravel from expansive low-lying overbank and old channel deposits near active flood plains; poorly sorted silt to coarse sand with pebbles and cobbles. Unit Qia covers large portions of Kittitas Valley and unit Qia is inset into unit Qoa near the Yakima River; expansive Qia deposits from the north reach their southern terminus at a subtle contact between unit Qia and unit Qa in the northeast map area. Uppermost portions of unit Qia may be thinly capped by loess (unit Ql). Unit Qaf$_1$ forms subtle fans on unit Qia surfaces suggesting unit Qia may be slightly older than alluvial fan unit Qaf$_1$, so we infer unit Qia to be similar in age to unit Qaf$_2$.

Qoa — **Older alluvium (Pleistocene)**—Sand and gravel overbank and older channel deposits that form broad, tall terraces; unit is found in the northern map area with southwest-dipping surfaces that suggest sourcing from the northeast. Unit Qoa terraces are 2–3 m above unit Qia near Craigs Hill. Unit Qoa is inset into unit QRcg and unit Qia is inset into unit Qoa. Top surfaces of unit Qoa are about the same elevation as tops of units Qao$_{lb}$ and Qaf$_2$. Unit Qoa is distinguished from other units by its inset relationships, relative elevation, sourcing direction, and monomict clast assortment.

Qaf, Qaf$_1$, Qaf$_2$, Qaf$_3$, Qaf$_4$, Qaf$_5$ — **Alluvial fan and colluvial deposits (Holocene to Pliocene?)**—Silt, sand, and gravel deposits; generally brown to medium gray; weathering rinds on clasts range from less than 1 to 10 mm wide and are thicker where older; loose or poorly consolidated; clay- to boulder-sized particles and generally silt to cobble gravel; angular to subrounded; moderately to very poorly sorted; generally clast supported; clasts are basalt sourced from Manastash Ridge. Unit thickness estimated to be less than 15 m. Colluvial deposits may be possible where deposits do not have clear fan shapes, are more poorly sorted, and have matrix support.

Unit is subdivided and numbered from lowest and youngest (unit Qaf$_1$) to highest and oldest (unit Qaf$_5$) based on relative elevation and differences in surface morphologies. Infrared stimulated luminescence (IRSL) ages suggest ~6 ky old age for unit Qaf$_2$. Fault scarps are mapped between Shushuskin and Spring Canyons on intermediate age surfaces of units Qaf$_2$, Qaf$_3$ and Qaf$_4$.

Qg? — **Terrace gravel deposits (Pleistocene)**—Polymict gravel in Yakima canyon; light to medium brown to yellowish brown or yellowish gray; loose, poorly cemented; pebbles, cobbles, and silt (paleosol?) with boulders and medium sand; rounded to subrounded; poorly sorted; polymict clasts may include rhyo(?)dacite; contains capping calcrete and caliche. Unit extent is based on abundant polymict float in only a single queried polygon located on the east side of Yakima canyon. We question the existence and age of this unit because the polymict gravel may derive from polymict gravels of underlying Ellensburg Formation interbeds, and a fluvial strath terrace may not be here.

QRc — **Sand and gravel, undivided (Pleistocene to Pliocene) (cross section only)**—Pebbly cobble gravel with sand lenses; lithologies are inferred at depth in Kittitas Valley based on unit descriptions of QRcs and QRcg. Unit may also include lithologies and polymict clast assortments akin to the Thorp Gravel. The contact between unit QRc and suprabasalt Miocene Ellensburg Formation (unit Mc$_e$) is not exposed and is difficult to identify based on well data alone given their similar lithologies. So we infer the subsurface contact may be somewhere above the combined thickness of suprabasalt Ellensburg Formation units Mvc$_e$ and Mcg$_e$.

QRcs — **Volcaniclastic sandstone (Pleistocene? to Pliocene)**—Variably pumiceous or pebbly sandstone; light orange to light orangish brown matrix containing light gray to white pumice fragments that weather to a fuzzy, ‘frothy’ texture, moderately weathered; moderately indurated, usually well cemented; fine- to coarse-grained sand to granules to pebbles, with rare cobbles and boulders; moderately sorted, matrix-supported; structureless to weakly laminated; generally angular to rounded with angular sand grains. Clast composition is a polymict mixture of abundant locally sourced basalt and Cascade Range-sourced pumice, andesite, and hornblende dacite(?). Unit thickness is 15–30 m. The unit is poorly exposed as low (<0.5 m tall) outcrops.

QRcg — **Oldest alluvium, gravelly unit (Pleistocene to Pliocene)**—Monomict basaltic gravel; yellowish light brown to medium brown; moderately to strongly weathered with weathering rinds 1–20 mm thick; moderately compacted; cobbles and pebbles in a coarse to medium sand matrix; well-rounded to rounded; moderately sorted, clast-supported; unit thickness is greater than 2 m and likely thicker at depth based on well log interpretations. The unit is likely sourced from Naneum Canyon and possibly from Wilson Creek to the north.

Quaternary Eolian Deposits

Ql — **Loess (Holocene to Pleistocene)**—Eolian silt to fine sand; light to medium brown; moderately weathered; loose; angular to subangular; moderately to well sorted, matrix supported; structureless; varies from 2 m thick near Strande Road to 11 m thick at Craigs Hill and is otherwise thin (<1 m thick), especially across Manastash Ridge. Loess is mined near Stone Quarry Canyon. Loess is present nearly everywhere in the map area, but we only map it where it exceeds about 2 m thick (see Figure 1 in the Pamphlet). For example, Manastash Ridge is covered by abundant, thin, patchy loess that was not mapped so that the underlying bedrock geology remains legible. We report a luminescence age of 3.0 ±0.4 ka (IRSL) from a loess mound near Durr Road on Manastash Ridge (age site GD10).

Tertiary Sedimentary and Volcanic Bedrock

SEDIMENTARY ROCKS OF THE ELLENSBURG FORMATION

Sedimentary rocks within and above CRBG flows are broadly split into lower and upper Ellensburg Formation units, respectively. The three lower units (Mc$_{ec}$, Mc$_{ev}$, and Mc$_{elc}$) are interbedded within Wanapum and Grande Ronde Basalts and contain micaceous, tuffaceous, and basaltic sandstone to siltstone. The two upper units (Mvc$_e$ and Mcg$_e$) locally overlie the uppermost CRBG (Wanapum Basalt) and contain volcaniclastic-pyroclastic and fluvial-conglomeratic lithologies.

Mc$_e$ — **Ellensburg Formation, undivided (middle Miocene to early Pliocene?) (cross section only)**—Micaceous, feldsarenite, volcaniclastic sandstone, lapillistone, siltstone, and conglomerate; light to medium brown or light to medium gray. Description is summarized based on adjacent mapping in Kittitas Valley (Sadowski and others, 2020, 2021, 2022, 2023). At depth, unit Mc$_e$ groups local suprabasalt Miocene sedimentary rocks (upper Ellensburg Formation) within the cross section. Based on lithology and stratigraphic position relative to CRBG units, we locally subdivided the Ellensburg Formation into:

Upper Ellensburg Formation

Mcg$_e$ — **Conglomeratic rocks of the upper Ellensburg Formation (late Miocene to early Pliocene?)**—Conglomerate with lenses of siltstone to sandstone; light to medium brown or light brownish gray with light brownish-gray or pinkish-tan lenses; moderately to strongly weathered; mildly to moderately cemented. Pebbly cobble conglomerate is subrounded to rounded, poorly sorted, and clast supported with a matrix of coarse to fine sand, whereas sandy lenses have angular to subangular grains, are moderately to well sorted, and matrix supported. Conglomerate and lenses are variably stratified. The conglomerate commonly contains boulder-sized rip-up clasts of siltstone (paleosol). Lower portions of the conglomerate are basalt-rich, whereas upper portions have more Cascade Range volcanics and less basalt. Unit Mcg$_e$ is at least 50 m thick and its top is poorly exposed. Unit Mcg$_e$ diagnostically contains more conglomerate and fewer volcaniclastic layers than the underlying unit Mvc$_e$.

Mvc$_e$ — **Volcaniclastic rocks of the upper Ellensburg Formation (late Miocene)**—Volcaniclastic sandstone and pumiceous pyroclastic rocks with conglomerate; greenish bluish, light to medium gray; moderately indurated to friable, mildly to moderately cemented, non-welded; pumice easily dislodged; fine- to coarse-grained sandstone and pumice-rich crystal-lithic lapillistone (>11 layers); may contain thin (<1 cm) layers of siltstone, ash fall tuff, and accretionary lapilli tuff; sand is angular to subangular, lithic and pumice clasts subrounded; generally matrix supported, but portions of lapillistone may be clast-supported. Very fine to fine sandstone is well sorted, medium to coarse sandstone is moderately sorted, and lapillistone is moderately to poorly sorted. Unit shows planar stratification. Siltstone contains plant fragment impressions. Pumice content (3–80%, ~1 mm to 20 cm) is diagnostic for this unit and greatest in lapillistone layers. Unit Mvc$_e$ is at least ~30 m thick, though its thickness may be variable. Unit may grade into overlying unit Mcg$_e$, where pumice is less abundant.

Lower Ellensburg Formation

These lower units are typically micaceous to tuffaceous sandstone to siltstone, 35 m thick or less, compact, stiff, and variably lithified.

Mc$_{elc}$ — **Lmuma Creek Member of the lower Ellensburg Formation (middle Miocene)**—Micaceous feldsarenite; light gray to white, moderately weathered; mildly indurated or friable, mildly to moderately cemented; fine- to medium-grained sandstone; subrounded to angular; moderately to well sorted, matrix supported; structureless to poorly stratified with planar parallel laminations to thin beds and (or) subtly cross-laminated; some polymict pebble-cobble conglomerate near top; sand includes quartz (50–60%), feldspar (40–50%, plagioclase > microcline), and lithic fragments (5–10%, igneous + breccia fragments) with mica (1–5%, muscovite + biotite). Unit Mc$_{elc}$ is generally less than 15 m thick and thins westward.

Unit Mc$_{elc}$ is sedimentary rock above unit Mv$_{wfsh}$ and below unit Mvc$_e$. Near Yakima canyon, unit Mc$_{elc}$ also underlies and overlies pillow basalt of the Roza Member (unit Mv$_{wr}$) that invaded Mc$_{elc}$ sediments.

Mc$_{ev}$ — **Vantage Member of the lower Ellensburg Formation (middle Miocene)**—Micaceous or volcaniclastic feldsarenite that unconformably overlies Grande Ronde Basalt unit Mv$_{gsm}$ and underlies Wanapum Basalt unit Mv$_{wfsh}$; light brownish gray to light gray or white-yellowish tan; moderately to strongly weathered; mildly to moderately indurated, mildly cemented; subrounded to subangular; generally moderately sorted. From bottom to top the unit consists of (1) 1–2 m of a basal micaceous siltstone to very fine sandstone that is structureless to thinly laminated, (2) a set of five intervals of normally graded, fine- to coarse-grained volcanic-lithic-rich sandstone that is thickly-bedded, and (3) a capping 2–3 m thick polymict conglomerate that is structureless.

Compared to unit Mc$_{elc}$, unit Mc$_{ev}$ generally has more mica, more lithic fragments, less quartz, and lacks microcline. Unit thickness is <20 m near Yakima canyon and thins westward.

Mc$_{ec}$ — **Coleman member of the lower Ellensburg Formation (middle Miocene)**—Micaceous feldsarenite and siltstone between the Ortley and Grouse Creek members (GRB); medium brown to light gray; moderately weathered, weakly to moderately cemented; fine- to medium-grained; angular to subangular; well sorted, matrix-supported; structureless; sand matrix contains feldspar (40–50%), quartz (~40–50%), and varied muscovite (10–20%). The unit is less than 20 m thick and has multiple lenticular interbeds that thin out discontinuously over short distances within GRB units. Peperitic hyaloclastite (peperite) is found in Ortley basalt. Unit Mc$_{ec}$ is poorly exposed and only found in Yakima canyon.

VOLCANIC ROCKS OF THE COLUMBIA RIVER BASALT GROUP (CRBG)

Mv$_w$ — **Wanapum Basalt, undivided (middle Miocene) (cross section only)**—Porphyritic and aphyric basalt to basaltic andesite; dark gray to grayish brown; dense; mostly microporphyritic to weakly glomerocrystic, commonly with groundmass crystals larger than 1.0 mm and less commonly aphyric than GRB units. In Yakima canyon, we estimate less than ~70 m of Wanapum Basalt, and the unit thins westward. Sedimentary interbeds are common in Wanapum Basalt subunits. Unit Mv$_w$ includes all local Wanapum Basalt subunits at depth in the cross section. Wanapum Basalt is subdivided based on geochemistry into subunits that include:

Mv$_{wr}$ — **Roza Member (middle Miocene)**—Porphyritic basalt and basaltic andesite with a medium to fine groundmass; dark gray to grayish brown, weathers dark to medium brown; dense; diagnostically porphyritic; centimeter-scale (4–14 mm) plagioclase phenocrysts (total phenocrysts: 5–10%), generally contains about a dozen phenocrysts per hand-sized sample, but top of unit Mv$_{wr}$ can be more aphyric. Unit is less than ~20 m thick. Unit invaded sediments of unit Mc$_{elc}$ in Yakima canyon. Unit likely pinches out completely in the central map area.

Mv$_{wf}$ — **Frenchman Springs Member, undivided (middle Miocene)**—Medium-grained basalt to basaltic andesite that is sparsely porphyritic to weakly glomerocrystic or aphyric. This unit is typically inferred wherever geochemistry was unavailable above unit Mc$_{ev}$ and below unit Mc$_{elc}$, or grouped within unit Mv$_w$ at depth in cross section. Unit Mv$_{wf}$(?) is usually labeled as questionable where exposures are poor and unit is inferred. With geochemistry, we identify only one Frenchman Springs sub-member in the map area: basalt of Sand Hollow (unit Mv$_{wfsh}$). The Frenchman Springs Member is less than ~50 m thick based on map patterns, but pinches out against a fault in the northwestern map area. In general, the Frenchman Springs Member is less porphyritic than the Roza Member.

Mv$_{wfsh}$ — **Basalt of Sand Hollow (middle Miocene)**—Medium-grained basalt and basaltic andesite that is weakly porphyritic to aphyric; medium to dark gray, weathers to dark reddish brown or reddish gray; dense; typically contains a few 1–15-mm-long euhedral plagioclase phenocrysts (usually 1–3, or <6) per hand-sized sample (total phenocrysts: ~1%), phenocrysts may cluster to form glomerocrysts; ~1-m-wide columns can internally exhibit flat to curved platy foliation; pillow breccia and palagonite (hyaloclastite) are also common. Unit is less than 50 m thick (usually ~30 m) and thins westward.

Mv$_g$ — **Grande Ronde Basalt (GRB), undivided (middle Miocene) (cross section only)**—Aphyric basaltic andesite, described in detail in the following subunits classified by chemostratigraphy. Generally, GRB rocks in hand specimen are very dark to medium gray where fresh, dark to medium brown where weathered, and dense. We map a minimum thickness of 400 m for GRB in the map area, though the base of the unit is not exposed.

The unit contains reverse (R) and normal (N) magnetostratigraphic units (MSU), from oldest to youngest: R1, N1, R2, and N2. We observe only MSU R2 and N2 in the map area. Unit Mv$_g$ is inferred at depth in cross section where geochemical results are unavailable.

Mv$_{gs}$ — **Sentinel Bluffs Member, undivided (middle Miocene) (cross section only)**—Basaltic andesite; commonly aphyric; the uppermost member of the Grande Ronde Basalt; the map area contains five subunits, from oldest to youngest: basalts of McCoy Canyon, Airway Heights, Stember Creek, Spokane Falls, and Museum. Member has normal remanent magnetization (N2). Unit Mv$_{gs}$ is used in the cross section to group its sub-members at depth. With geochemistry, we subdivide the Sentinel Bluffs Member into:

Mv$_{gsm}$ — **Basalt of Museum (middle Miocene)**—Fine-grained aphyric basaltic andesite. From map patterns, unit thickness is >24 m in Yakima canyon to >61 m in the central map area. The upper contact with the Vantage Member is poorly exposed. Unit contains at least two flows with colonnade, entablature, and vesicular top that are all well developed. Unit is widespread and found along Manastash Ridge and its range front.

Mv$_{gssf}$ — **Basalt of Spokane Falls (middle Miocene)**—Fine-grained aphyric basaltic andesite. From map patterns, unit Mv$_{gssf}$ is ~15 m thick near Yakima canyon, ~30 m elsewhere, and more common than unit Mv$_{gssc}$. Unit Mv$_{gssf}$ contains at least two flows, inconsistently overlies the basalt of Stember Creek, and may interfinger with the basalt of Stember Creek. Unit Mv$_{gssf}$ forms robust cliffs with common basal colonnade, interior entablature, vesicular flow top, and rare hyaloclastite. Unit Mv$_{gssf}$ is common at middle elevations.

Mv$_{gssc}$ — **Basalt of Stember Creek (middle Miocene)**—Fine-grained aphyric basaltic andesite. The unit is less than ~50 m thick near Yakima and Umtanum canyons, and irregularly—or entirely—pinches out to the northwest. Unit Mv$_{gssc}$ contains at least two flows and forms robust cliffs with common basal colonnade, interior entablature, vesicular flow top, and uncommon hyaloclastite horizons. Basalt of Stember Creek is more sparsely mapped and inconsistently interfingers with or overlies flows of Spokane Falls basalt.

Mv$_{gsah}$ — **Basalt of Airway Heights (middle Miocene)**—Fine-grained basaltic andesite; medium gray; strongly weathered; dense; aphyric; exposed at two localities (geochemistry sites G66 and G170); approximate unit thickness is < 30 m, irregularly thins based on map patterns. Lacking more geochemical analyses for support, we interpret only small lenses of unit Mv$_{gsah}$ overlying basalt of McCoy Canyon (unit Mv$_{gsmc}$) and underlying basalt of Spokane Falls (unit Mv$_{gssf}$). We report the first instance of this unit identified in the Kittitas Valley.

Mv$_{gsmc}$ — **Basalt of McCoy Canyon (middle Miocene)**—Fine-grained aphyric basaltic andesite. From map patterns, unit Mv$_{gsmc}$ is ~30–50 m thick. Unit Mv$_{gsmc}$ contains at least two flows and forms robust cliffs with well-developed entablature, short basal colonnade, common vesicular flow top, and common hyaloclastite near its base. Unit Mv$_{gsmc}$ is common at mid to high elevations in Yakima canyon and low elevations in Umtanum canyon.

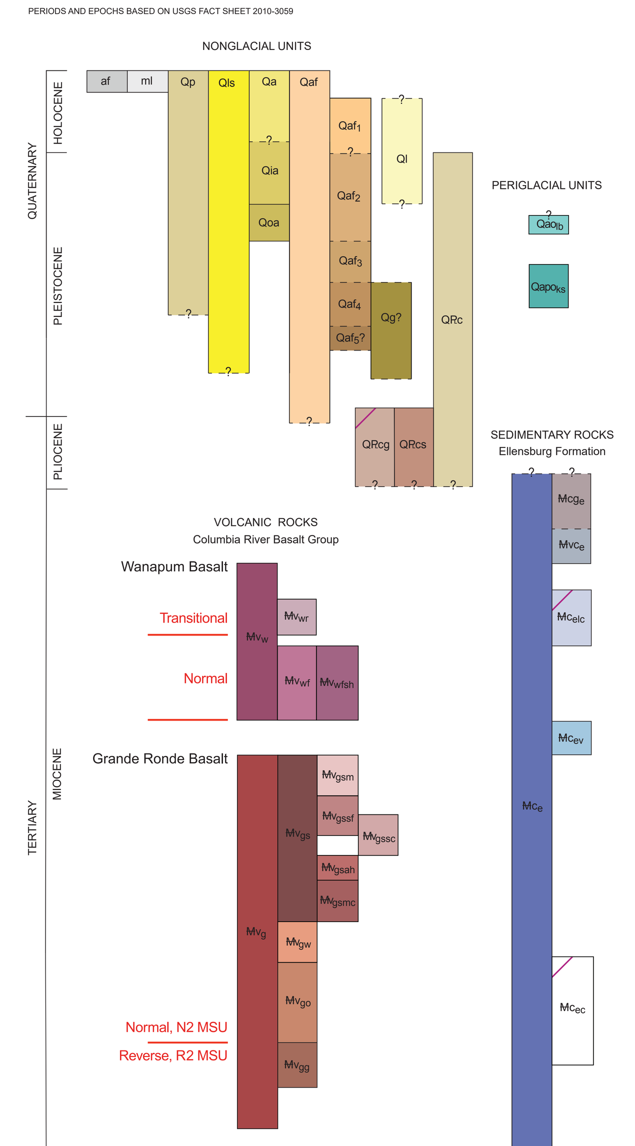
Mv$_{gw}$ — **Winter Water Member (middle Miocene)**—Fine- to medium-grained basaltic andesite; locally aphyric, but may be sparsely to abundantly glomerocrystic to porphyritic, especially farther south; medium to dark gray, weathers medium to dark brown; dense. From map patterns, unit Mv$_{gw}$ is <60 m thick. Unit Mv$_{gw}$ contains at least two flows and forms subdued cliffs with well-developed entablature, common stacks of segmented and tilted basal colonnade, common vesicular flow top, and hyaloclastite near its base. Unit Mv$_{gw}$ has a normal remanent magnetization.

Mv$_{go}$ — **Ortley member (middle Miocene)**—Fine- to medium-grained aphyric basaltic andesite. Unit Mv$_{go}$ and unit Mv$_{gg}$ can be difficult to distinguish because they have similar geochemical compositions, however unit Mv$_{go}$ exhibits normal remanent magnetization whereas unit Mv$_{gg}$ has reversed remanent magnetization. From map patterns, unit Mv$_{go}$ is ~50 m thick. Unit Mv$_{go}$ is widespread at the lower elevations in Yakima canyon and in deep canyons along the Manastash range front. Unit Mv$_{go}$ contains two to four flows and commonly forms well-developed vesicular flow top, entablature, and palagonitic and peperitic hyaloclastite, whereas basal colonnade is rare. Unit Mv$_{go}$ represents the base of N2 MSU in the map area. Ortley basalt incorporates light gray sedimentary rock fragments of unit Mc$_{ec}$, strongly suggesting that lavas of unit Mv$_{go}$ invaded unconsolidated, water-saturated sediments of unit Mc$_{ec}$.

Mv$_{gg}$ — **Grouse Creek member (middle Miocene)**—Medium- to fine-grained aphyric basaltic andesite; groundmass crystals slightly larger than those of the Sentinel Bluffs Member. Unit Mv$_{gg}$ and Ortley member (unit Mv$_{go}$) can be difficult to distinguish because they have similar geochemical compositions. However, unit Mv$_{gg}$ exhibits reverse remanent magnetization whereas the Ortley member (unit Mv$_{go}$) exhibits normal remanent magnetization. Unit represents the top of R2 MSU in the map area and its base is not observed locally. From map patterns, the unit is at least 150 m thick and may be much thicker. Unit Mv$_{gg}$ contains multiple flows and forms robust cliffs that commonly show fanning entablatures and some places show vesicular top, platy entablature, and autobreccia. Colonnade of this unit is rare. Unit Mv$_{gg}$ is well exposed low in Yakima canyon.

CORRELATION OF MAP UNITS

PERIODS AND EPOCHS BASED ON USGS FACT SHEET 2010-3059



Red font denotes remanent paleomagnetic polarity

GEOLOGIC SYMBOLS

Mass Wasting—Mapped where landforms suggest mass movement on unstable slopes, but where evidence for landslide deposits is inconclusive. Overlays mark areas of hummocky or irregular surface morphology that generally lack landslide features such as head scarps, flanking scarps, and toes.

Miocene hyaloclastite—Volcaniclastic aggregate in or between basalt flows; pillow breccia with volcanic glass (tachylyte ± sideromelane) and its alteration product palagonite; light yellowish brown to orange brown or tan and generally strongly weathered; less dense than basalt, moderately well consolidated; generally composed of sand- to boulder-sized clasts in a very-fine-grained matrix; angular to subangular; poorly sorted; some exposures may contain cobble- to boulder-size fragments of basalt pillows (centimeter to meter scale) that are matrix supported. Where pillows are absent, exposures are convoluted and structureless. The following are common in hyaloclastite and vesicular tops: petrified wood fragments, fragments or sizeable pods (~10–30 cm diameter) of yellowish- green to brownish- yellow common opal, and thin, patchy coatings of clear to white botryoidal hyalite. Hyaloclastite forms from the quenching of hot lava in water, and where the lava forced its way into saturated sediments this is called peperitic hyaloclastite or peperite. Thickness varies but is generally less than 20 m. Hyaloclastite is common near the base of lava flows.

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

Geologic boundary—Identity and existence certain; solid where location accurate; long-dashed where approximate; short-dashed where inferred; In this map, symbol shows internal contacts between lava flows of the same unit, or boundaries between alluvial fans of similar age

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

Reverse fault—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; rectangles on upthrown block

Oblique-slip fault, reverse right lateral offset—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrows show relative motion; rectangles on upthrown block

High-angle dip-slip fault—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; relative motion shown by U and D

Oblique-slip fault, high-angle right-lateral offset—Short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; relative horizontal motion shown by arrows; relative vertical 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

Monocline, anticlinal bend—Short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrows show direction of dip; shorter arrow on steeper limb

Geologic unit too thin to show as a polygon—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable

Fault scarp—Identity or existence questionable; location accurate; hachures point down slope

A —— A′ Cross section line

Perennial stream

Intermittent stream

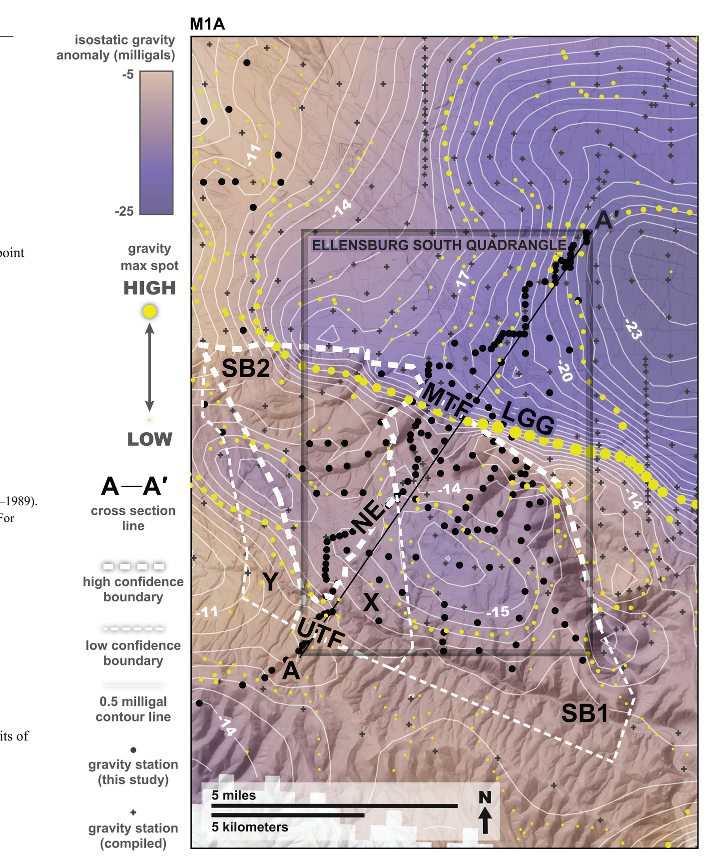
Geophysical lineament

Fluvial terrace riser—Location accurate; queried where identity or existence questionable; hachures point down slope

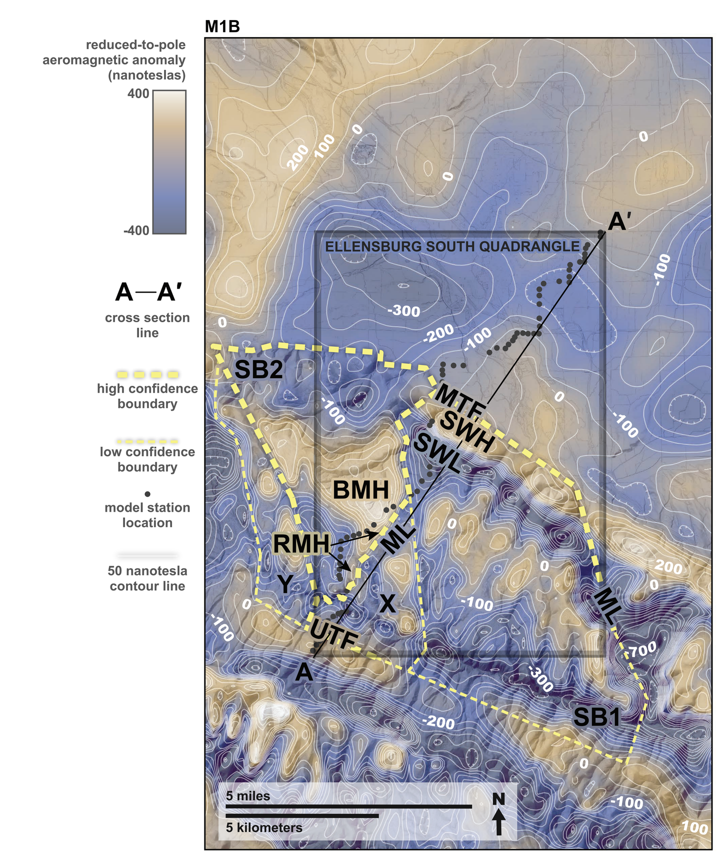
Surficial data (explained below) were collected by the Washington Geological Survey except for those shown as **blue symbols** (compiled surface data from R. Bentley and J. Powell, Central Washington University, unpub. mapping, 1980–1989). **Maroon symbols** indicate orientations that may be affected by an intrachannel flow (see *Methods* in the Pamphlet). For map legibility, we omitted some structural data, geochemistry, clast count, and thin section sites from the plate.

- Inclined bedding—showing strike and dip
- Horizontal bedding
- Small, minor inclined joint—showing strike and dip
- Small, minor vertical or near-vertical joint—showing strike
- Small, minor inclined fault—showing strike and dip
- Small, minor vertical or near-vertical fault—showing strike
- Inclined slickenline, groove, or striation on fault surface—showing bearing and plunge
- Inclined foreset bedding in unconsolidated sedimentary deposits or unconsolidated fragmental deposits of volcanic origin—showing strike and dip
- Inclined contact—showing dip value and direction
- Inclined flow banding, lamination, layering, or foliation in igneous rock—showing strike and dip
- Spring
- GD07 Age site, tephra sample
- F01 Age site, fossil
- GD06 Age site, uranium-lead (U-Pb)
- GD10 Age site, infrared stimulated luminescence (IRSL)
- G63 Geochemistry sample*
- W04 Water well
- CC1 Clast count sample*
- S01 Geophysical data collection location (seismometer, see Pamphlet)
- Tephra Significant site
- TS05 Thin section sample*

* For map legibility, we omitted some sampling sites from the plate. For complete data, see Data Supplement.



M1A—Isostatic gravity anomaly and hillshade topography map. Gravity contours are 0.5 mGal. Black dots are gravity stations (this study) and gray crosses are older WGS compiled gravity data. White dashed lines are boundaries of structural blocks inferred from geophysical data. A and A′ are the end points of the geophysical model. Gray box marks the boundary of the Ellensburg South quadrangle.



M1B—Reduced-to-pole aeromagnetic anomaly and hillshade topography map. Gray dots are locations where the aeromagnetic grid was sampled for the geophysical model. A and A′ are the end points of the geophysical model. White lines are 50 nT contours. Dotted yellow lines show boundaries of structural blocks inferred from geophysical data. Gray box marks the boundary of the Ellensburg South quadrangle.

ABBREVIATIONS USED IN FIG. M1

BMH—Broad Magnetic High
HF—High-Angle Fault
LGG—Large Gravity Gradient
ML—Magnetic Lineament
MTF—Manastash Thrust Fault
NE—Northeast-Trending Gradient
RMH—Relative Magnetic High
SB1—Structural Block A
SB2—Structural Block B
SWH—Short-Wavelength High
SWL—Short-Wavelength Low
UN1a—Uplifted N1 subblock
UN1—Uplifted N1
UTF—Umtanum Thrust Fault
X—Small Structural Block X
Y—Small Structural Block Y

Group	Unit	Magnetic Polarity	Model Properties ρ	Model Properties χ	Magnetic Remanence Mr	Incl	Decl
	Quaternary sediment	---	1,450–2,100	0	0	---	---
Wanapum Basalt	Priest Rapids member	R	2,650	8	2.5	-65	191
Wanapum Basalt	Roza member	T	2,870	0	0	---	---
Wanapum Basalt, Frenchman Springs member	Basalt of Sand Hollow	N	2,760	16	2.5	58	0
Wanapum Basalt, Frenchman Springs member	Basalt of Ginkgo	N	2,850	2	2.5	44	158
	Ellensburg Formation	---	1,810–1,820	0	0	---	---
Grande Ronde Basalt, Sentinel Bluffs member (N2, divided)	Basalt of Museum	N	2,720	2	1.5	58	16
Grande Ronde Basalt, Sentinel Bluffs member (N2, divided)	Basalt of Spokane Falls	N	2,650	4	1.5	58	16
Grande Ronde Basalt, Sentinel Bluffs member (N2, divided)	Basalt of Stember Creek	N	2,620	10	1.5	58	16
Grande Ronde Basalt, Sentinel Bluffs member (N2, divided)	Basalt of California Canyon	N	2,862	3	1.5	58	16
Grande Ronde Basalt, Sentinel Bluffs member (N2, divided)	Basalt of McCoy Canyon	N	2,660	3	1.5	58	16
Grande Ronde Basalt (N2, divided)	Winter Water member	N	2,800	7	1.5	58	16
Grande Ronde Basalt (N2, divided)	Ortley Member	N	2,520	7	1.5	58	16
Grande Ronde Basalt	R2, undivided	R	2,600	4	4	-72	219
Grande Ronde Basalt	N1, undivided	N	2,770	6	2.5	58	355
Grande Ronde Basalt	R1, unidivided	R	2,780	6	2.5	-66	171
	Eocene/Oligocene sediment	---	2,470	0	0	---	---

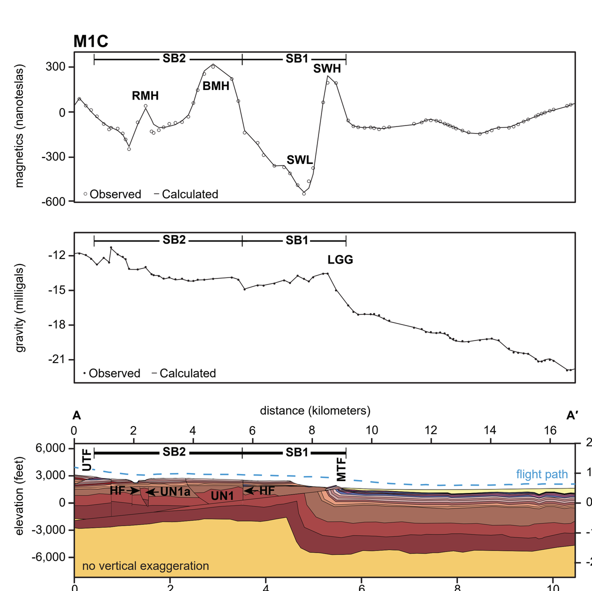
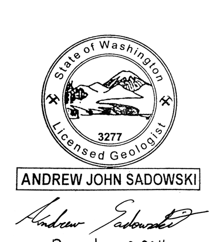
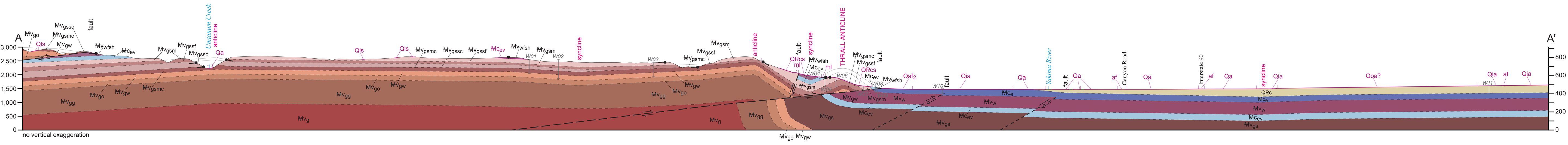


Figure M1C—Two-dimensional potential-fields forward model of profile **A–A′**. Units and properties shown in the legend panel predict gravitation and magnetic anomalies shown in the top two panels (ρ—saturated bulk density in kg/m^3, χ—magnetic susceptibility in SI x10^3, Mr—magnetic remanence in A/m, incl—inclination in degrees, and decl—declination in degrees. The diameters of the gravity data points are equal to the data error; magnetic data error is too small to show at print scale. "Flight path" shows the altitude of the airplane that flew the aeromagnetic survey. Magnetic remanence properties follow Staisch and others (2018).





CROSS SECTION EXPLANATION

Geologic units too thin to show as polygons at the scale of the cross section—Location accurate; vertical tics separate different units

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

Arrow point shows fault movement toward the viewer; arrow feathers show fault movement away from the viewer

W04 Water well or boring

Measured orientation of inclined bedding or flow foliation