GEOLOGIC MAP OF THE

PRIEST TANK 7.5-MINUTE QUADRANGLE,

SIERRA COUNTY, NEW MEXICO

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Scale 1:24,000

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Note on Private-Land Access in the Map Area

The Priest Tank 7.5-minute quadrangle contains significant acreages of public land (Bureau of Land Management or State of New Mexico) but tracts of private land are found, particularly in the northern and southwestern portions of the map area. We ask that all users of this map obtain permission from local owners before entering their lands.

EXECUTIVE SUMMARY

The Priest Tank 7.5-minute quadrangle is located in the northwestern part of the Palomas Basin, an east-tilted half graben in the southern Rio Grande rift. The map area includes the foothills of the Sierra Cuchillo, cored by a thick section of Paleogene volcanics, and Neogene-Quaternary basin-fill of the Santa Fe Group that is well-exposed in the canyons of Alamosa and Cuchillo Negro creeks. These drainages are tributaries to the Rio Grande and feature local relief of up to 120 m. Other major ephemeral stream courses crossing the quadrangle, from north to south, are: Bernal Chavez Canyon, Roque Ramos Canyon, Willow Spring Draw, HOK Farm Canyon, and Old Mill Canyon.

The Priest Tank quadrangle was previously mapped at 1:24,000 scale by Heyl et al. (1983), who placed special emphasis on the volcanic section and structure of the western quadrangle but used a generalized basin-fill stratigraphy because the Santa Fe Group had not yet received close scientific attention in the Palomas Basin. The updated basin-fill stratigraphy presented on our map extends the nomenclature developed and used by Jochems (2015) and Koning et al. (2018), among others. Surrounding quadrangles mapped at 1:24,000 include Chise (Jahns et al., 2006), Cuchillo (Koning et al., 2018), Huerfano Hill (Cikoski and Koning, 2013), Monticello (Koning et al., 2014), and Williamsburg NW (Jochems, 2015). The area was included in a 1:100,000-scale compilation by Harrison and others (1993).

The oldest rocks exposed in the quadrangle include a compositionally diverse suite of Eocene through Miocene volcanic units. The Sugarlump and Kneeling Nun tuffs (Tks, 35.2 and 34.9 Ma, respectively), dacitic flows and tuffs (Td), and basaltic andesite flows (Tba) were mapped in the southwestern part of the quadrangle using previous mapping (Jochems, 2015), vantage mapping, and high-resolution aerial imagery due to land access restrictions. This lower package, inferred to be upper Eocene to lower Oligocene in age, appears to be in fault contact with a younger suite of mostly rhyolitic volcanic strata, as the older units are not observed north of HOK Canyon.

The younger package of volcanic rocks includes a thin, discontinuous lapilli tuff (Tlt); the crystal-poor Vicks Peak Tuff (Tvp); and three rhyolitic units (Tr1, Tr2, Tr3) comprised of flows and domes that overlie the Vicks Peak Tuff. These units span the lower to upper Oligocene, with the Vicks Peak Tuff previously dated at 28.4 Ma (McIntosh et al., 1991; Lynch, 2003) [age of ~28.8 Ma when corrected for revised Fish Canyon Tuff monitor age]. The rhyolites are generally crystal-rich (15-25% sanidine and quartz with minor biotite and plagioclase) and differ primarily in texture and internally variable phenocryst assemblages. Both the tuffs and overlying rhyolite flows have silica contents of >75 wt. % SiO2. Unit Tr1 corresponds to the Rhyolite of Willow Springs and units Tr2 and Tr3 correspond to the Rhyolite of HOK Ranch of Harrison and others (1993). An $^{40}Ar/^{39}Ar$ age of 28.47 ± 0.01 Ma was obtained for unit Tr1 (sample 17PT-193).

Interbedded within the rhyolite flows are a thin marker bed of aphanitic trachyandesite (Tta) and rare, sandy to pebbly volcaniclastic strata. A volcaniclastic conglomerate and sandstone unit (Tvs) caps the rhyolite package, which is intruded by a body of intermediate lithology (Tii) near Roque Ramos Canyon. The youngest volcanic unit in the quadrangle consists of olivine-phyric basalt flows (Tb) that are typically poorly exposed. McLemore and others (2012) dated a basalt flow near Ignacio Pares Tank at 19.06 ± 0.05 Ma ($^{40}Ar/^{39}Ar$).

Most of the Priest Tank quadrangle is underlain by Early Pleistocene through Miocene basin-fill deposits. Piedmont facies of the lower and middle Santa Fe Group (Tsml) unconformably onlap Oligocene volcanic units in the western third of the map area. These deposits consist of indurated conglomerate and subordinate sandstone deposited by debris flows and sheetfloods in proximal to medial alluvial fan settings during an early phase of Rio Grande rift extension. Clast lithologies reflect source areas in the Sierra Cuchillo with intermediate volcanic lithologies common along Cuchillo Negro Creek and felsic volcanics dominant in the northwestern map area. Given that the age of the base of unit Tsml is constrained by an interbedded 19.1 Ma basalt flow, the Sierra Cuchillo must have been elevated to some extent by the early Miocene. The apparent lack of Black Range-derived felsic clasts in the lower and middle Santa Fe Group along modern Cuchillo Negro Creek indicate that the drainage did not integrate across the Sierra Cuchillo fault block until the middle Miocene or later, as suggested by Cikoski and Harrison (2012). The total thickness of the lower and middle Santa Fe Group is estimated at >400 m.

The Palomas Formation is the upper part of the Santa Fe Group and has been dated to the Pliocene and upper Pleistocene. All member-rank Palomas Formation units on the quadrangle represent piedmont facies deposited on proximal to medial alluvial fans or coalescent fans (bajadas) extending eastward from the Sierra Cuchillo and southeastward from the southern San Mateo Mountains.

The lower piedmont facies of the Palomas Formation (Tpl) consists of somewhat indurated gravel/conglomerate and minor sand/sandstone that are commonly calcite-cemented. This unit lies on the piedmont facies of the lower and middle piedmont Santa Fe Group with an angular unconformity of up to 10-12°. It is best exposed along Cuchillo Negro Creek and HOK Farm Canyon where it may be massive or imbricated to cross-stratified. A lack of soils and finer-grained lithologies suggest that unit Tpl was deposited primarily through debris flows and in channels crossing extensive alluvial fan surfaces. Paleosols are seldom observed in the unit and most carbonate present is groundwater-related given its concentration in coarser beds and sharp internal contacts. The maximum thickness of the lower piedmont facies is 150 m.

The upper piedmont facies of the Palomas Formation (Qpu) includes interbedded mud, silt-sand, and channel-fill gravels deposited at medial positions of alluvial fans extending eastward from the Sierra Cuchillo. The unit is found in the southeastern quadrangle and pinches out in HOK Farm Canyon. Its basal part may correlate to middle piedmont facies observed to the east and south (Jochems, 2015; Koning et al., 2018). The upper piedmont facies were deposited through a more diverse set of processes than the lower piedmont facies, including debris flows, hyperconcentrated flows, channelized flows forming cross-stratification and lateral accretion sets, sheetflooding, and extra-channel or perhaps eolian deposition on interfluves. Soils are common in the unit, including argillic and calcic horizons with stage II carbonate accumulation. Common reddish colors (5YR) in the unit are derived primarily from muddy intervals and abundant clay bridges and films in gravel matrices. The unit is up to 35 m thick.

The Palomas Formation is capped by the upper coarse piedmont facies (Qpuc), consisting of stacked gravels with minor silt and sand. This unit is found in the southeastern and southern parts of the quadrangle, where it extends as a thin sheet of gravel onlapping volcanic bedrock of the Sierra Cuchillo foothills in a few locations. The depositional processes represented in the unit's lithofacies are similar to those of the upper piedmont facies, with debris-flow and fluvially deposited gravels most common. Buried soils are rare although the unit sometimes overlies a distinct argillic horizon where it exhibits little scour atop unit Qpu. It is frequently capped by a stage IV calcic soil. The upper coarse piedmont facies in the map area reflects an upward-coarsening trend observed elsewhere in the Palomas Basin (Jochems and Koning, 2015a). The unit is 6-30 m thick.

An undivided coarse piedmont facies of the Palomas Formation (QTpc) forms a 105-115 m thick section along Alamosa Creek in the northeastern quadrangle. This unit is similar to the upper coarse piedmont facies but distinguished by far fewer non-gravelly beds and relatively massive textures except for some imbrication and planar cross-stratification. Clast lithologies are at least 65-70% felsic volcanics derived from the southern San Mateo Mountains with lesser proportions of intermediate volcanics, jasperoid, and basalt eroded from the Monticello graben and northeastern Sierra Cuchillo. Buried argillic horizons are observed in places but calcic horizons are rare to non-existent. The unit is mapped as overlying the lower piedmont facies along Cañada de la Cruz, but the contact could be gradational in places. The undivided coarse piedmont facies were deposited on proximal alluvial fans with high-competency, distributary drainage systems.

The Palomas Formation is typically capped by a ~0.8 Ma constructional surface in the Palomas Basin named the Cuchillo surface (e.g., Lozinsky and Hawley, 1986). However, this surface is largely absent in the Priest Tank quadrangle, where the dominant geomorphic surface in the central map area is graded to a higher position in the landscape. McCraw and Love (2012, fig. 6) considered this a remnant of the Willow Spring Draw fan. It is probably erosional in part, particularly where it caps unit Tpl in the north-central map area. Remnants of the Cuchillo surface, frequently underlain by stage III+ to IV calcic soils, may be found atop unit QTpc and perhaps unit Qpuc in the southeastern quadrangle.

By the middle Pleistocene, the Rio Grande and its tributaries had begun incising to eventually form the modern network of arroyos and stream valleys. Valley-margin deposits include inset stream terraces and valley-floor deposits include low-lying terraces adjacent to modern stream courses as well as alluvial fans graded to these deposits. Broad middle-late Pleistocene piedmont surfaces are graded to inset deposits in the western and northeastern quadrangle. As many as six intervals of valley incision followed by backfilling are indicated by terraces along Alamosa and Cuchillo Negro creeks, Willow Spring Draw, and smaller drainages. An erosional surface (Qpuci) inset into unit Qpuc north of Cuchillo Negro Creek implies a possible early incision event following culmination of Palomas Formation deposition. This surface is in a similar or perhaps slightly higher landscape position as a terrace containing the 640 ka Lava Creek B ash in the Cuchillo 7.5-minute quadrangle downstream (Koning et al., 2018). Aggradational episodes forming younger valley-floor deposits have been dated to 150-600 and >2500 yr BP elsewhere in the Palomas Basin (Jochems and Koning, 2015b).

Structures in the Priest Tank quadrangle conform to two or three periods of extensional tectonism. A series of mostly southeast-striking normal faults (average strike approximately 130°) cut volcanic units in the western map area. These terminate along an east-dipping, range-bounding fault that has little surface expression but is indicated by a rapid thinning of Santa Fe Group sediments across its trace and a few exposures of the fault plane where it cuts unit Tr2. This fault exhibits nearly pure dip-slip between Roque Ramos and Bernal Chavez canyons. It clearly postdates the northwest-striking structures and likely displaces a 19.1 Ma basalt, but its upper age limit is unconstrained. It may be an extension of the Palomas Creek fault (zone) of Machette (1987), which offsets the 0.8 Ma Cuchillo surface in the west-central Palomas Basin and has a low slip rate of <0.02 mm/yr. Several small fault scarps (<4-6 m tall) offset surfaces formed on the Palomas Formation in the central and southeastern quadrangle and are probably no younger than ~130 ka.

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APPENDIX A

Detailed descriptions of lithologic units on the
Priest Tank 7.5-minute quadrangle

QUATERNARY

Anthropogenic and Hillslope Units

af Anthropogenic fill (Modern to ~50 years old) – Thick accumulations of sediment used as road fill along New Mexico Highway 52 as well as levees or berms. 1-8 m thick.

ae Anthropogenic excavated ground (Modern to ~50 years old) – Disturbed and excavated ground at former borrow pits.

Qct Colluvium and talus, undivided (Holocene) – Loose, poorly sorted, angular to subrounded cobble-boulder gravel forming aprons or mantles at the footslopes of volcanic uplands in the western part of the quadrangle. <5 m thick.

Valley-floor units

Qam Modern alluvium (Modern to ~50 years old) – Loose, sandy gravel or pebbly sand forming bars and underlying modern channels in ephemeral drainages. Gravel are commonly imbricated, poorly to moderately sorted, subangular to well rounded, and consist of mostly volcanic lithologies. In longitudinal bars and at channel margins are sandy pebble-cobble and pebble-cobble-boulder gravel deposits; estimated clast proportions are 65–90% pebbles, 10–35% cobbles, and 0–15% boulders. Sand is dark grayish-brown to brown or grayish-brown (10YR 4/2-3; 5/2) and consists of mL-vcU grains composed of 65–70% lithics (volcanics, ferromagnesian minerals), 15–20% feldspar, and 10–15% quartz with no clay. At channel margins, sand or gravel may underlie thin deposits of light yellowish-brown (10YR 6/4) silt to vfU sand. In places, these deposits are several 10s of cm thick and exhibit thin horizontal-planar laminations. No topsoil present. Bar-and-swale topography and occasional steep-walled channels characterize the surface, exhibiting up to 0.6 m of relief. Thickness is 1–3 m. In Monticello Canyon, this deposit is subdivided into fine and coarse facies that obscure historical alluvium (Qah):

Qamc Coarse-grained modern alluvium in Monticello Canyon (Modern to ~50 years old) – Gravelly deposits in channelized (single-thread) portions of Monticello Canyon. Gravels are also occasionally found in breaches across natural or artificial levees, deposited during large flood events. Thickness is 1–3 m.

Qamf Fine-grained modern alluvium in Monticello Canyon (Modern to ~50 years old) – Clayey to sandy deposits capping the modern floodplain of Monticello Canyon, deposited during large flood events. Color is typically brownish (10YR) and the deposit obscures historical alluvium (Qah). Thickness is 1–2 m.

Qamh Modern and historical alluvium, undivided (Modern to ~600 years old) – Modern alluvium (Qam) and subordinate historical alluvium (Qah). See detailed descriptions of each unit.

Qar Recent (historical + modern) alluvium (Modern to ~600 years old) – Historical alluvium (Qah) and modern alluvium (Qam) in approximately equal proportions. See detailed descriptions of each unit.

Qary Recent (historical + modern) and younger alluvium, undivided (Holocene) – Recent alluvium (Qah + Qam) and subordinate younger alluvium (Qay). See detailed descriptions of each unit.

Qah Historical alluvium (~50 to ~600 years old) – Loose, pebbly silt-sand and sandy gravel in thin to thick (7–40 cm), tabular to lenticular beds underlying low terraces along valley floors. Very weakly to moderately calcareous and massive to moderately well-imbricated or trough cross-stratified. Gravel consist of mostly clast-supported, poorly sorted, subangular to rounded pebbles (typically >85–90%) with up to 30% cobbles and 0–10% small boulders in places. Clast lithologies are mostly volcanics with 10–20% Paleozoic sedimentary lithologies observed in Cuchillo Negro Creek. Matrix consists of dark grayish-brown to brown (10YR 4/2-3), very poorly to poorly sorted, subangular to rounded, fU-vcL sand composed of 70–80% lithics (volcanics>ferromagnesian minerals), 15–20% feldspar, and 10–15% quartz with no clay. Deposit is occasionally capped by 0.3–0.4 m of brown to yellowish-brown (10YR 5/3-4), massive to horizontal-planar laminated, pebbly (10–20%) silt to fU sand. This deposit is particularly dominant in Questa Blanca Canyon. No topsoil observed. Bar-and-swale surface relief up to 0.35 m is observed. Tread height is 0.7–0.9 m above modern grade. Maximum thickness is <5 m.

Qahm Historical and modern alluvium, undivided (Modern to ~600 years old) – Historical alluvium (Qah) and subordinate modern alluvium (Qam). See detailed descriptions of each unit.

Qahy Historical and younger alluvium, undivided (Holocene) – Historical alluvium (Qah) and subordinate younger alluvium (Qay). See detailed descriptions of each unit.

Qay Younger alluvium (Holocene) – Loose silt-sand and gravel in non-stratified or thin to thick (8–60 cm), tabular to lenticular beds. Weakly calcareous and internally massive to well-imbricated or trough cross-stratified. Gravel consist of mostly clast-supported, very poorly to poorly sorted, subangular to well-rounded pebbles (60–100%), cobbles (0–30%), and boulders (0–15%) of mostly volcanic lithologies. Matrix consists of dark brown to brown (10YR 3/3-4), very poorly sorted, subangular to rounded, fL-vcU sand composed of 85–90% lithics (volcanic) and 10–15% quartz + feldspar with 5–10% dark brownish clay films. Deposit is capped by a 0.2-m-thick A horizon formed in brown (10YR 4/3), pebbly (20-25%, subrounded to rounded, fine to coarse), silt to cL sand of similar composition to gravel matrix but lacking clay. This silty sand is more common in downstream locations across the quadrangle. Rare thin lenses of pebbly, fine to coarse sand are also observed. Calcic soils with stage I carbonate accumulation are rare. Weak varnishing on up to 5% of surface clasts. Commonly bioturbated by fine to very coarse roots and burrows. Tread height is 1–3 m above modern grade. Thickness is 1.0–10.5 m (thicker downstream and in larger drainages).

Qaym Younger and modern alluvium, undivided (Holocene) – Younger alluvium (Qay) and subordinate modern alluvium (Qam). See detailed descriptions of each unit.

Qayh Younger and historical alluvium, undivided (Holocene) – Younger alluvium (Qay) and subordinate historical alluvium (Qah). See detailed descriptions of each unit.

Qayr Younger and recent (historical + modern) alluvium, undivided (Holocene) – Younger alluvium (Qay) and subordinate recent alluvium (Qah + Qam). See detailed descriptions of each unit.

Terrace units

Qtu Terrace gravels in smaller drainages, undivided (Upper to Middle Pleistocene) – Loose to weakly consolidated gravel and minor sand in medium to very thick (12 to >120 cm), tabular to lenticular beds underlying terraces along higher order stream courses. Deposit is clast- or matrix-supported and internally massive to well-imbricated or, less commonly, planar cross-stratified (foresets 20–30 cm tall). Clasts consist of very poorly to poorly sorted, subangular to well-rounded pebbles (40–90%), cobbles (10–60%), and boulders (<5 to 45%) of mostly volcanic lithologies. Matrix consists of non- to moderately calcareous, reddish-brown to dark brown, brown, or strong brown (5YR 4/3-4; 7.5YR 3-4/3-6), poorly to moderately sorted, fU-vcL sand composed of 75–85% lithics (volcanic), 10–15% feldspar, and 10–15% quartz with <30% (dark) reddish-brown clay bridges, films, and chips. Occasional (15–20%) thin, massive to horizontal-planar laminated sand lenses similar to gravel matrix are observed. Soils and surface characteristics generally vary with age; moderate to strong calcic horizons (stage II-III carbonate accumulation), illuviated clay (Bt, Btk horizons where not eroded), and various degrees of desert pavement development and clast varnishing may be observed at the surface. Deposit lacks bar-and-swale topography and buried soils. Terrace treads tend to diverge in a downstream direction and are not necessarily correlative between drainages. Thickness is 2–7 m. Subdivided into three allostratigraphic subunits distinguished by tread height above valley floors:

Qtl Lower terrace gravel (Upper Pleistocene) – Tread lies 2–6 m above valley floors.

Qtm Middle terrace gravel (Upper to Middle? Pleistocene) – Tread lies 4–18 m above valley floors.

Qth Higher terrace gravel (Middle Pleistocene) – Tread lies 8–42 m above valley floors.

Qta Terrace gravels of Alamosa Creek, undivided (Upper to Middle Pleistocene) – Loose to moderately consolidated gravel in medium to very thick (20–90 cm), lenticular beds. Deposit is clast-supported and well-imbricated to trough or planar cross-stratified (foresets up to 20 cm tall). Clasts consist of very poorly to poorly sorted, subangular to well-rounded pebbles (50–95%), cobbles (5–45%), and boulders (0–10%) of mostly felsic volcanic lithologies with minor intermediate volcanics and trace jasperoid. Matrix consists of non- to strongly calcareous, brown to strong brown (7.5YR 4/4-6), very poorly to poorly sorted, vfU-cU sand composed of 75–80% lithics (volcanic), 10–20% feldspar, and 10–15% quartz with <15–25% reddish clay bridges, films, and chips. Soils and surface characteristics generally vary with age; moderate to strong calcic horizons (stage II-III carbonate accumulation), illuviated clay (Bt, Btk horizons where not eroded), and various degrees of desert pavement development and clast varnishing may be observed at the surface. Deposit lacks bar-and-swale topography and buried soils. Thickness is 1–12 m. Subdivided into four to eight allostratigraphic subunits distinguished by tread height above modern grade:

Qta1 Lower terrace gravel of Alamosa Creek (Upper Pleistocene) – Tread lies 8–15 m above modern grade. Three subunits, Qta1a, Qta1b, and Qta1c, can be differentiated that differ 2–3 m in geomorphic height. Thickness is 1–2 m.

Qta2 Lower-middle terrace gravel of Alamosa Creek (Upper to Middle? Pleistocene) – Tread lies 30–42 m above modern grade. Three subunits, Qta2a, Qta2b, and Qta2c, can be differentiated that differ 2–5 m in geomorphic height. Thickness is 2–12 m, thinning upstream.

Qta3 Upper-middle terrace gravel of Alamosa Creek (Upper Pleistocene) – Deposit commonly features matrix-supported pebble gravel in upper 1.5 m, where it is overprinted by a stage III calcic soil. Moderate to strong varnish observed on 35–45% of clasts at surface. Tread lies 45–56 m above modern grade. Maximum thickness is 9 m.

Qta4 Upper terrace gravel of Alamosa Creek (Upper Pleistocene) – Deposit commonly features strong calcic soil development in upper 2 m, including stage III soil in upper 1.5 m. Weak to moderate varnish observed on 10–25% clasts at surface (obscured by carbonate coats/rinds). Tread lies 52–70 m above modern grade. Maximum thickness is 7 m.

Qtc Terrace gravels of Cuchillo Negro Creek, undivided (Upper to Middle Pleistocene) – Loose to weakly consolidated gravel in medium to thick (20–100 cm), tabular to lenticular beds. Deposit is clast-supported with rare open-framework texture and well-imbricated or, less commonly, trough or planar cross-stratified (foresets 25–40 cm tall). Clasts consist of very poorly to poorly sorted, subangular to well-rounded pebbles (40–95%), cobbles (5–45%), and boulders (<5 to 20%) of mostly volcanic lithologies with minor proportions of chert, carbonate, and Abo Formation. Matrix consists of calcareous, reddish-brown to brown or yellowish-brown (5YR 5/4; 7.5YR 4-5/3-4; 10YR 5/4), poorly to moderately sorted, subangular to well-rounded, vfU-cU sand composed of 80–85% lithics (volcanic), 10–15% quartz, and 5–10% feldspar with 5–20% reddish-brown clay bridges, films, and chips. Soils and surface characteristics generally vary with age; moderate to strong calcic horizons (stage I-III carbonate accumulation), illuviated clay (Bt, Btk horizons where not eroded), and various degrees of desert pavement development and clast varnishing may be observed at the surface. Deposit lacks bar-and-swale topography and buried soils. Thickness is 2–11 m. Subdivided into six to seven allostratigraphic subunits distinguished by tread height above modern grade:

Qtc1 Lowest terrace gravel of Cuchillo Negro Creek (Upper Pleistocene) – Deposit commonly features stage I calcic soil in upper part. Weak varnish observed on 10–15% clasts at surface. Tread lies 4–11 m above modern grade. Thickness is 2–4 m.

Qtc2 Lower terrace gravel of Cuchillo Negro Creek (Upper Pleistocene) – Deposit commonly features stage I+ calcic soil in upper 50 cm. Weak varnish observed on up to 55% clasts at surface. Tread lies 8–24 m above modern grade. Thickness is 4–11 m.

Qtc3 Lower-middle terrace gravel of Cuchillo Negro Creek (Upper to Middle? Pleistocene) – Topsoil commonly eroded. Weak to moderate varnish observed on 40–45% clasts at surface. Tread lies 28–46 m above modern grade. Two subunits, Qtc3a and Qtc3b, can be differentiated that differ several m in geomorphic height. Thickness is 6–8 m.

Qtc4 Upper-middle terrace gravel of Cuchillo Negro Creek (Middle Pleistocene) – Deposit occasionally features stage III calcic soil in upper part. Weak to moderate varnish observed on >40% clasts at surface. Tread lies 51–67 m above modern grade. Thickness is 3–11 m.

Qtc5 Upper terrace gravel of Cuchillo Negro Creek (Middle Pleistocene) – Tread lies 65–80 m above modern grade.

Qtc6 Uppermost terrace gravel of Cuchillo Negro Creek (Middle Pleistocene) – Tread lies 85-95 m above modern grade.

Qtw Terrace gravels of Willow Spring Draw, undivided (Upper to Middle Pleistocene) – Loose to weakly consolidated gravel and silt-sand in medium to very thick (20–130 cm), mostly lenticular beds. Deposit is clast-supported and moderately well-imbricated or, less commonly, trough cross-stratified. High-angle lateral accretion sets are rarely observed. Clasts consist of very poorly sorted, subrounded to well-rounded pebbles (50–90%), cobbles (10–50%), and boulders (<2%) of mostly volcanic lithologies with minor proportions of chert, carbonate, and Abo Formation. Matrix consists of weakly calcareous, yellowish-red (e.g., 5YR 4/6), poorly sorted, subangular to rounded, mL-vcL sand composed of 55–60% lithics (volcanic) and 35–45% quartz + feldspar with >20% reddish clay bridges, films, and chips. Up to 5% of deposit may consist of light brown (7.5YR 6/4), very calcareous, massive silt to vfU sand. Deposit also contains up to 5–10% lenses of planar to trough cross-stratified, pebbly sand similar to gravel matrix. Soils and surface characteristics generally vary with age; moderate to strong calcic horizons (stage I to II or III carbonate accumulation), illuviated clay (Bt, Btk horizons where not eroded), and various degrees of desert pavement development and clast varnishing may be observed at the surface. Deposit lacks bar-and-swale topography and buried soils. Thickness is 2–5 m. Subdivided into three allostratigraphic subunits distinguished by tread height above modern grade:

Qtw1 Lower terrace gravel of Willow Spring Draw (Upper Pleistocene) –Weak varnish observed on 10–20% clasts at surface. Tread lies 1–4 m above modern grade.

Qtw2 Middle terrace gravel of Willow Spring Draw (Upper to Middle? Pleistocene) – Most extensive Willow Spring Draw terrace deposit in quadrangle. Weak to moderate varnish observed on 15–20% clasts at surface. Tread lies 6–11 m above modern grade.

Qtw3 Upper terrace gravel of Willow Spring Draw (Middle Pleistocene) – Deposit commonly features stage II calcic soil (occasionally eroded) in upper part. Weak to moderate varnish observed on 10–45% clasts at surface. Tread lies 8–12 m above modern grade.

Alluvial fan and piedmont units

Qfm Modern fan alluvium (modern to ~50 years old) – Loose, sandy gravel underlying fan channels, bars, and levees. Gravel are clast-supported to open-framework and imbricated. Clasts consist of very poorly to poorly sorted, subangular to well-rounded, pebbles (50–90%), cobbles (10–50%), and boulders (<15%) of mostly volcanic lithologies. Matrix consists of brown to dark yellowish brown or light brownish-gray (7.5-10YR 4/4; 10YR 6/2), very weakly calcareous, very poorly to poorly sorted, subangular to well-rounded, vfU-cU sand composed of 80–85% lithics (volcanic) and 15–20% quartz + feldspar with trace brownish clay chips. On some fans, unvegetated, open-framework gravels represent recent debris-flow deposits with cobbly concentrations in levees. Imbrication in these deposits is downslope in the center and inward along flanks. Bar-and-swale topography characterizes the surface, exhibiting up to 0.5 m of relief. Deposit thickness is <3 m in most places.

Qfmh Modern and historical fan alluvium, undivided (Modern to ~600 years old) – Modern (Qfm) and subordinate historical fan alluvium (Qfh). See detailed descriptions of each unit.

Qfr Recent (historical + modern) fan alluvium (Modern to ~600 years old) – Historical (Qfh) and modern fan alluvium (Qfm) in approximately equal proportions. See detailed descriptions of each unit.

Qfry Recent (historical + modern) and younger fan alluvium, undivided (Holocene) – Recent (Qfh + Qfm) and subordinate younger fan alluvium (Qfy). See detailed descriptions of each unit.

Qfh Historical fan alluvium (~50 to ~600 years old) – Loose, sandy gravel and silty sand in medium to thick (10–60 cm), tabular to lenticular beds. Moderately well-imbricated (gravel) or internally massive (silty sand). Gravel consist of clast-supported, very poorly to poorly sorted, subangular to rounded pebbles (55–

95%) and cobbles (5–45%) of mostly volcanic lithologies. Matrix consists of dark brown (e.g., 7.5YR 3/4), weakly calcareous, poorly sorted, angular to rounded, fL-cL sand composed of 70–80% lithics (volcanics, ferromagnesian minerals), 15–20% quartz, and 10–15% quartz with trace clay. Silty sand beds consists of brown (e.g., 7.5YR 4/4), moderately sorted, subrounded, vfU-mL grains of similar composition to gravel matrix. No topsoil observed. Bar-and-swale surface relief up to 0.35 m is observed. Tread height is 0.75–1.0 m above modern grade. Thickness is <3–5 m in most places.

Qfhm Historical and modern fan alluvium, undivided (Modern to ~600 years old) – Historical (Qfh) and subordinate modern fan alluvium (Qfm). See detailed descriptions of each unit.

Qfy Younger fan alluvium (Holocene) – Loose, sandy gravel in non-stratified to thick (>40–50 cm), tabular to wedge-shaped beds. Internally massive to weakly imbricated with slope-parallel fabric. Gravel consist of mostly matrix-supported, very poorly to poorly sorted, angular to subrounded pebbles (60–55%) and cobbles (15–40%) of mostly volcanic lithologies. Matrix consists of dark brown to yellowish brown (10YR 3/3-4), strongly calcareous, very poorly sorted, angular to rounded, vfL-vcL sand composed of 80–85% lithics (volcanic), 10–15% feldspar, and 5–10% quartz with up to 5% dark brownish clay films. Soil development varies from A and weak cambic (Bw) horizons in upper 0.4 m to occasional stage I calcic horizons. Bar-and-swale surface relief is mostly obliterated. Tread height is 1.5–2.5 m above modern grade. Thickness is <6 m in most places.

Qfyr Younger and recent (historical + modern) fan alluvium, undivided (Holocene) – Younger (Qfy) and subordinate recent (Qfh + Qfm) fan alluvium. See detailed descriptions of each unit.

Qfo Older fan alluvium (Upper to Middle? Pleistocene) – Loose pebble-cobble-boulder or cobble-boulder gravel in non-stratified to thick or very thick (>60 cm), tabular to wedge-shaped beds. Internally massive to imbricated. Clasts consist of clast- to matrix-supported, very poorly to poorly sorted, angular to subrounded pebbles (35–60%), cobbles (40–60%), and boulders (5–25%) of mostly volcanic lithologies. Matrix consists of dark brown to brown (7.5YR 3-5/3-4), strongly calcareous, very poorly sorted, angular to rounded, fL-vcL sand composed of 75–80% lithics (volcanic), 15–20% quartz, and 5–10% feldspar with 5–10% pinkish free-grain argillans. Stage I-I+ calcic horizons are observed in the upper 0.75 m of the deposit. Weak to moderate varnish is observed on 10–50% of clasts at the surface. Minimum thickness is 2.5–3.0 m.

Qpy Younger piedmont alluvium (Holocene) – Loose to weakly consolidated silt-sand in non-stratified to vaguely thick or very thick (>60 cm), tabular beds. Silt-sand consists of strong brown to dark yellowish-brown (7.5YR 4/6 to 10YR 3/6), very weakly calcareous, internally massive, moderately to moderately well sorted, silt to vfL sand with ~10% subangular to rounded, fL-vcL sand grains that are >90–95% lithics (volcanic). Up to 10–15% clay is present in this sediment in addition to <7% rhyolite pebbles and cobbles (angular to subrounded). Subordinate deposits include weakly consolidated, thick-bedded (>40 cm), tabular, internally massive or weakly imbricated, pebble-cobble gravel. Clasts consist of clast- to matrix-supported, very poorly to poorly sorted, angular to rounded pebbles (40–70%) and cobbles (30–60%) of mostly or entirely felsic volcanic lithologies. Gravel matrix is very weakly calcareous and texturally similar to silt-sand except with up to 20% fine to very coarse sand grains. An A horizon is observed in the upper 20–30 cm of the deposit; no calcic horizons are found. Weak to moderate varnish is observed on no more than 10% of surface clasts that may be recycled from older deposits. Faint bar-and-swale surface relief up to 0.1–0.2 m may be observed. Minimum thickness is 2 m.

Qpo Older piedmont alluvium (Upper? to Middle Pleistocene) – Loose to very weakly consolidated silt-sand and sandy gravel in non-stratified to vaguely thin to medium (4–20 cm; silt-sand) or thick to very thick (>60 cm; gravel), tabular to lenticular beds. Silt-sand consists of yellowish-brown (10YR 5/4), weakly to moderately calcareous, internally massive, well-sorted, silt and vfL-fL sand with 5–10% granules to medium pebbles (angular to subrounded) of mostly volcanic lithologies. Gravel deposits are moderately well-imbricated. Clasts consist of clast-supported, poorly sorted, angular to rounded pebbles (70–95%) and cobbles (5–30%). In the northeastern part of the quadrangle, clast lithologies consist of local Paleogene volcanic or sedimentary lithologies, including Uvas basaltic andesite, Vicks Peak and Luna Park tuffs, and Seferino Hill conglomerate. Gravel matrix consists of dark yellowish-brown (10YR 3/4-6), very poorly sorted, angular to subrounded, vfU-cL sand (10–15% very coarse sand to granules) composed of 85–90% lithics (volcanic) and 10–15% quartz + feldspar with up to 5% light brownish clay chips. Channel-fill gravels may be up to 2.2 m thick but are more typically 0.6–0.8 m thick. In the upper 2.5 m of the deposit, silty beds feature stage II-III calcic soils 0.2–0.3 m thick. Deposit is commonly capped by a 1.5-m-thick stage III soil, typically developed in gravel. Maximum thickness is 20–25 m.

QUATERNARY-TERTIARY

Basin-fill units

QTpc Coarse piedmont facies of the Palomas Formation, undivided (Lower Pleistocene to Pliocene?) – A thick package of loose to somewhat consolidated, stacked gravels and minor sand in medium to thick (20–70 cm), mostly tabular (occasionally lenticular) beds exposed on either side of Monticello Canyon. Gravel are clast-supported and well-imbricated to planar cross-stratified (foresets up to 40 cm tall). Clasts consist of very poorly to poorly sorted, subangular to well-rounded pebbles (55–100%) and cobbles (0–45%) of approximately two-thirds felsic volcanics, one-third intermediate volcanics, and trace to 2% jasperoid and basalt (visual estimate). Matrix consists of reddish brown (5YR 5/3-4), non- to weakly calcareous, very poorly sorted, subangular to rounded, fL-vcL sand (15–20% vcU sand to granules) of mostly volcanic grains with 20–30% reddish clay bridges and films. Less common (<5–10%) are beds of reddish brown (5YR 5/4), loose to weakly consolidated, non-calcareous, massive to tabular, medium- to thick-bedded (25+ cm), internally massive, poorly to moderately sorted, subrounded to rounded, vfU-mU sand (5–10% coarse to very coarse sand), composed of 70–80% lithics (volcanic), 15–20% feldspar, and 10–15% quartz with abundant clay occurring as films on coarser grains. These deposits contain 3–7% floating pebbles (fine to coarse) and become browner (7.5YR 5/4) in the upper 20 cm. Illuviated clay (Bt) horizons may be observed in places and are 30–35 cm thick. Well data indicates that this unit may be as much 105–115 m thick.

Qpuc Upper coarse piedmont facies of the Palomas Formation (Lower Pleistocene) – Loose to weakly consolidated, sandy channel-fill gravel intercalated with minor silt-sand and sand in thick (50–80 cm), broadly lenticular beds. Deposits are internally massive (silt-sand) or well-imbricated (gravel) and may exhibit lateral accretion sets dipping 25–30° in places, as well as normal grading within beds. Clasts consist of clast-supported, very poorly to poorly sorted, subrounded to rounded pebbles (40–80%), cobbles (20–60%), and boulders (trace to 3%) up to 45 cm across. Clast lithologies include mostly volcanics with up to 35% Paleozoic sedimentary lithologies and 10% monzonite porphyry in the southern part of the quadrangle. Matrix consists of reddish brown (5YR 4/4), moderately to strongly calcareous, very poorly sorted, subangular to rounded, mL-vcL sand (5% vcU sand to granules) composed of 80–85% lithics (volcanic), ~10% feldspar, and 5–10% quartz. Minor deposits include: (A) <10% beds of light brown (7.5YR 6/3), slightly bioturbated (massive), well-sorted silt to very fine sand; and (B) <5% beds of sand similar to gravel matrix but grayish (10YR?) and with horizontal-planar laminations or planar crossbeds (foresets up to 20 cm tall). Commonly scours underlying units (e.g., Qpu) by up to 0.8 m. Unit may feature a stage IV K horizon at its top that is up to 0.6 m thick. At its base, an illuviated clay (Bt) horizon is sometimes observed where little scour has occurred. This unit is distinguished from QTpc by greater variety in and proportion of non-gravel beds and a greater array of sedimentary structures. Thickness is 6–30 m.

Qpuci Upper coarse piedmont facies of the Palomas Formation, inset subunit (Lower Pleistocene) – Gravel bed(s) as in Qpuc but underlying a mostly erosional surface inset into local aggradational surfaces by 2–7 m in the southern part of the quadrangle. Moderate to very strong varnish observed on up to 65% of clasts at surface.

Qpu Upper piedmont facies of the Palomas Formation (Lower Pleistocene) – Weakly to moderately consolidated, sandy mud interbedded with subordinate silt and sandy channel-fill gravel in medium to very thick (20–110 cm), tabular to lenticular beds. Internally massive (silt and mud) to moderately well-imbricated or trough cross-stratified with possible lateral accretion sets (gravel). Mud constitutes up to 60% of unit by volume and is yellowish-red (5YR 5/6), weakly calcareous, and rarely low-angle cross-laminated. Contains <5% subrounded to rounded, vfL-mU sand grains that are mostly volcanic lithics. Rare stringers or lags of vaguely imbricated, subrounded to rounded, fine to very coarse pebbles. Muddy beds feature common cambic (Bw) soil development with occasional stage II carbonate accumulation as nodules (Btk or Bk horizons). Gravel constitutes 20–35% of unit by volume and consists of non- to very weakly calcareous, mostly clast-supported, poorly sorted, subrounded to well-rounded pebbles (75–90%) and cobbles (10–25%). Clast lithologies include subequal proportions of felsic and intermediate volcanics with minor amounts of feldspar porphyry, Paleozoic sedimentary lithologies, and carbonate nodules (<5% each). Gravel matrix consists of reddish brown (5YR 4/3-4), poorly sorted, subangular to rounded, vfU-mU (10% cL-vcL) sand composed of 80–90% lithics (volcanic), 10–15% quartz, and 5–10% feldspar with up to 30% reddish clay bridges and films. Silt-sand constitutes 15–20% of unit by volume and is brown (7.5YR 5/4), strongly calcareous, internally massive, and moderately well-sorted. Contains 25–40% subangular to rounded, vfL-cU sand grains composed of 85–90% lithics (volcanic) and 10–15% quartz + feldspar with 0% to trace reddish clay chips. Silt-sand also contains trace to 3% floating subangular to rounded, fine to medium pebbles and cobbles of volcanic lithologies. Common clay-lined, fine to medium root casts. Overall, unit is 0–35 m thick.

Tpl Piedmont facies of the lower Palomas Formation (Lower Pliocene) – Weakly to moderately consolidated, sandy gravel and minor sand in thin to thick (5–65 cm), tabular to lenticular beds. Gravel are commonly carbonate-cemented and moderately to well-imbricated or low-angle planar cross-stratified (foresets <20 cm tall) to trough cross-stratified or internally massive. Clasts consist of mostly clast-supported, very poorly to poorly sorted, subrounded to rounded pebbles (60–100%), cobbles (0–40%), and small boulders (0–3%) of mostly volcanic lithologies with <10% Paleozoic carbonates and minor proportions of tuffs and monzonite. Matrix consists of brown to dark brown (7.5YR 4/3-4 to 3/3) or occasionally reddish brown (5YR 4/4), weakly to strongly calcareous, very poorly to poorly sorted, subrounded to rounded, fU-vcL sand composed of 70–90% lithics (volcanic), <20% quartz, and 5–15% feldspar with 5–20% brownish clay films and bridges. Unit contains rare to occasional (<10–15%) lenses of brown (7.5YR 5/3), weakly to moderately calcareous (not cemented), trough cross-stratified, moderately sorted, subrounded to rounded, mU-vcU sand composed of similar lithologies as gravel matrix. Also present are rare (<5–7%) beds of medium- to thick-bedded (20–85 cm), tabular, internally massive, pebbly silt to fine sand (5–10% floating fine to very coarse pebbles). Soils are very rare and most carbonate is groundwater-related with sharp contacts and concentrated in coarser layers. Thickness is 0–150 m.

Tsml Lower and Middle Santa Fe Group, piedmont facies (Miocene) – Conglomerate and subordinate sandstone in thin to thick (4–85 cm), tabular beds (minor lenticular or trough-shaped beds). Conglomerate is moderately to strongly indurated, calcite-cemented, and internally massive to moderately imbricated or vaguely trough cross-stratified; it may be either normal- or reverse-graded. Clasts consist of mostly clast-supported, very poorly to poorly sorted, subangular to rounded pebbles (55–100%), cobbles (0–45%), and boulders (<1 to 20%) of volcanic lithologies; intermediate volcanics dominate along Cuchillo Negro Creek whereas felsic clasts are most common near Roque Ramos Canyon. Conglomerate matrix consists of light reddish-brown to pink (5YR 6-7/3) or pinkish-gray to light-brown (7.5YR 6-7/2, 6/3), moderately calcareous, very poorly to poorly sorted, subangular to rounded, mL-cU (~5% vcL-vcU) sand composed of 55–80% lithic (volcanic) and 15–45% quartz + feldspar grains. Occasional conglomerate beds feature up to ~30% pinkish clay cement; beds in the northwestern part of the quadrangle typically lack clay. Sandstone beds constitute up to ~20% of unit by volume and are pink or pinkish gray to light-brown (7.5YR 6-7/2-3; 6/4) or, less commonly light reddish-brown to reddish-yellow (5YR 6/4-6), weakly to moderately consolidated, calcareous, and internally massive to thickly horizontal-planar laminated. Sand is very poorly to poorly sorted, angular to rounded, silty, and consists of vfL-cU grains composed of 35–50% quartz, 15–45% lithics (volcanic), and 5–45% feldspar with <5–8% pinkish red clay bridges. Strongly oxidized layers of sand up to 5 cm thick are observed in places. Sandstones may contain 7–10% floating fine to coarse pebbles (subangular to subrounded) of felsic volcanic lithologies in the northern part of the quadrangle. Rarely, unit contains sandstone beds similar to conglomerate matrix but more pebbly and thin- to medium-bedded (7–30 cm) with abundant pinkish to reddish clay bridges and films. Total thickness is >400 m.

TERTIARY

Volcanic and volcaniclastic units

Tb Basalt (Lower Miocene) – Poorly exposed, vesicular olivine basalt flows and small intrusive plugs and dikes feeding flows. Corresponds to olivine basalt (unit QTb) of Heyl et al. (1983). $^{40}Ar/^{39}Ar$-dated at 19.06 ± 0.05 Ma by McLemore et al. (2012). Likely <10 m thick [modified from Heyl et al. (1983)].

Tvs Volcaniclastic sediment (Upper Oligocene) – Weakly consolidated conglomerate in non-stratified to thick (>60 cm) beds. Clasts consist of matrix-supported, subrounded to rounded pebbles (70–90%) and cobbles (10–30%) of mostly quartz-rich pumice with subordinate light grayish rhyolite containing 4–5% medium to coarse quartz and trace plagioclase phenocrysts. Rare clasts of reddish-brown to purplish, aphanitic andesite <3 cm in diameter may also be present. Tuffaceous matrix consists of very poorly sorted, subangular to rounded, silt to cU-sized particles of >70% lithics (mostly pumice and rhyolite), ~20% quartz, and ~10%

feldspar (mostly sanidine). This unit grades upward into a buff-colored, clast-supported, pebble-cobble conglomerate with <65% cobbles of mostly quartz-phyric rhyolite. At its top, the unit is a yellowish-tan, pebbly, medium- to very coarse-grained sandstone with a more heterogeneous clast assemblage. Unit is exposed only in Roque Ramos Canyon near the western quadrangle boundary where it underlies Tsml with angular unconformity. Total thickness unknown but probably <15–25 m.

Tii Intrusive intermediate rocks (Upper Oligocene) – Slope-forming, very dark-gray or black, weathering dark-gray to reddish-brown, non-vesicular, massive, porphyritic, intrusive rocks intermediate composition. Phenocrysts include 3–5% medium quartz (1–3 mm; anhedral), 1–4% medium feldspar (1–3 mm; anhedral to subhedral), and 1–2% fine to medium biotite (0.5–2 mm; subhedral). Occasional cumulophyric texture. Nearly all phenocrysts are strongly altered, featuring halos of whitish, dusty appearance. Feldspars are commonly sericitized and this alteration complicates their exact identification. Whole-rock geochemistry indicates that this rock is similar in composition to trachyandesite (57.99 wt% SiO_2, 6.97 wt% Na_2O + K_2O). Forms a small stock or plug in Roque Ramos Canyon. Corresponds to unit Td2 of Heyl et al. (1983).

Tr3 Upper rhyolite (Upper Oligocene) – Rubbly weathering rhyolite that is petrographically similar to older rhyolite flows but nearly always massive. Contains 15–20% phenocrysts of quartz and sanidine in a light-gray groundmass. Unit exhibits a dome-like geometry in places. Exposed thickness is up to 35 m.

Tr2 Middle rhyolite (Upper Oligocene) – Slope- to ledge-forming, purplish to light-gray, weathering (dark) reddish-brown, well-foliated, porphyritic rhyolite flows and domes. May contain numerous, fist-sized vugs in places; these commonly interrupt foliation. Phenocrysts include 20–25% total quartz + sanidine, with lesser amounts of biotite and plagioclase up to 3.5 mm across. Quartz phenocrysts are more common than sanidine higher in the section, where the latter may be kaolinitized. In a fault block north of Roque Ramos Canyon, the rhyolite weathers light tannish-gray and is non-vesicular and massive. There, the flow contains phenocrysts that include 5–20% medium quartz + sanidine (1–4 mm; anhedral to euhedral), 2–3% very fine to medium pyroxene (<0.5–3.5 mm; subhedral to euhedral; prismatic), 1–3% medium plagioclase (1–2 mm; subhedral; striated), and trace to 1% fine biotite (<1 mm; anhedral to subhedral). Groundmass has strongly frothy appearance. Outcrop faces are manganese-stained in a few locations. The base of this unit contains cobble- to small-boulder-sized rip-ups of andesite (Ta) south of Roque Ramos Canyon. Correlative with the Rhyolite of HOK Ranch of Harrison et al. (1993). Maximum thickness is ~320 m.

Tta Trachyandesite (Upper Oligocene) – Very dark-gray or black, weathering grayish-green, massive, dense, aphanitic trachyandesite flow. Commonly columnar-jointed. Flow commonly exhibits scoriaceous texure in upper 0.5 m. Forms a distinct marker bed between lower (Tr1) and middle (Tr2) rhyolite packages. Thickness is 2–3 m.

Tr1 Lower rhyolite (Upper Oligocene) – Slope-forming, light-gray, weathering very pale-brown to buff, blocky to spheroidally weathering, well-foliated, porphyritic rhyolite flows. Phenocrysts include 10–15% medium to coarse sanidine (subhedral to euhedral; glassy to chatoyant; commonly shattered), 3–7% medium to coarse quartz (anhedral; clear to smoky), and 1–2% fine to medium biotite (subhedral to euhedral; commonly altered to reddish brown, earthy/dull mineral). Contains trace dark-gray, lapilli-sized lithic fragments. Southeast of Roque Ramos Peak, the unit contains a thin (<10–20 m) interval of white to pinkish gray (7.5YR 8/1 to 5YR 7/2), moderately consolidated, non-calcareous, matrix-supported, thin- to medium-bedded (2–25 cm), tabular, internally massive, poorly to moderately sorted, angular to rounded, volcaniclastic pebble conglomerate. Clast lithologies are bimodal, consisting of dark purplish brown, plagioclase-phyric andesite, and light gray, aphyric rhyolite. Matrix consists of moderately to well-sorted, ashy material with 10–15% outsized cL sand grains to granules of lithics similar to pebble clasts. Matrix also contains fine to medium, intact phenocrysts of quartz and sanidine. Rare beds consisting entirely of ashy material are 2–4 cm thick. Unit is correlative to coarse moonstone porphyritic rhyolite tuff (unit Tcrt) of Heyl et al. (1983), Rhyolite of Willow Springs of Harrison et al. (1993), and units Tr, Trr, and Trv of the rhyolite-trachyte sequence of Jahns et al. (2006). 40Ar/39Ar age of 28.47 ± 0.01 Ma (sample 17PT-193). Thickness is <125 m.

Tvp Vicks Peak tuff (Lower Oligocene) – Bench-forming, whitish to very light-gray or very light tan-gray, weathering buff, non-vesicular, massive, aphanitic, rhyolitic ash-flow tuff. Poorly to strongly welded. Phenocrysts include trace to 1% very fine to fine quartz (up to 0.5 mm across; anhedral), trace to 1% fine sanidine (0.5–1 mm; subhedral to euhedral; tabular), and trace fine biotite (0.75–1 mm; subhedral; highly altered). Groundmass is highly devitrified. Contains up to 1% miarolitic cavities lined by drusy quartz and/or sericitized feldspar. Likely an outflow facies of the Vicks Peak tuff (rhyolite) of Furlow (1965) and Farkas (1969). $^{40}Ar/^{39}Ar$ age of 28.4 Ma (McIntosh et al., 1991; Lynch, 2003). Thickness is <120 m.

Tlt Lapilli tuff (Lower Oligocene) – Ledge-forming, light purplish-gray, weathering very light-gray or purplish-gray, non-vesicular, porphyritic, rhyolitic ash-flow tuff. Moderately welded and eutaxitic. Fiamme length:width ratios vary from 15:2 to 25:1. Phenocrysts include 3–5% fine to medium biotite (0.5–1.5 mm; anhedral to subhedral; commonly altered), 2–3% medium sanidine (1–2 mm; subhedral to euhedral; tabular; occasionally chatoyant), trace to 2% medium quartz (1–2 mm; euhedral; bipyramidal), and trace to 1% medium plagioclase (1–2 mm; subhedral; striated). Quartz phenocrysts usually occur in lapilli-sized pumice constituting 20–30% of rock and are up to 3 cm across. Devitrified groundmass. Thickness is unknown but probably <10 m.

Tba Basaltic andesite (Lower Oligocene) – Rubbly slope- to ledge-forming, very dark-gray to gray or black, weathering brown to grayish-brown, dense to vesicular, thinly foliated, aphanitic basaltic andesite. Phenocrysts include trace to 4% fine to medium pyroxene (anhedral), trace to 2% fine olivine (anhedral), and trace plagioclase. Unit contains up to 5% amygdules filled by calcite or silica. Groundmass may contain trace glass and/or disseminated magnetite. Correlates to units Tb and Tyaf of Heyl et al. (1983), basaltic andesite of Poverty Creek of Harrison et al. (1993), and unit Ta of Jahns et al. (2006). Maximum thickness is estimated at 130 m [modified from Jochems (2015)].

Td Dacite flows and tuffs (Lower Oligocene?) – Fine-grained, in part porphyritic dacite flows and tuffs. Locally shows good flow banding; elsewhere it is still welded or partly welded tuff that grades into quartz dacite in places and has columnar jointing. Corresponds to unit Tdt of Heyl et al. (1983) and unit Ta of Jahns et al. (2006). Thickness is 90–150 m [description modified from Heyl et al., 1983].

Tks Kneeling Nun and Sugarlump Tuffs, undivided (Upper Eocene) – Kneeling Nun and Sugarlump Tuffs mapped by air photo interpretation due to land access restrictions. The Kneeling Nun Tuff contains 15–35% phenocrysts of quartz, sanidine, and biotite. Lithic-rich Sugarlump Tuff contains 3–10% phenocrysts (mostly biotite). $^{40}Ar/^{39}Ar$ ages of 34.9 and 35.2 Ma (McIntosh et al., 1991; Chapin et al., 2004). Total thickness unknown [modified from Jochems (2015)].

Tvl Lower volcanic strata (Eocene) – Andesitic to rhyolitic tuffs and lavas with intercalated volcaniclastic facies. The upper part is correlative to the Kneeling Nun and Sugarlump Tuffs (Tks). The lower part is partly or entirely correlative to the Rubio Peak Formation and unit Tla of Jahns et al. (2006). Total thickness is unknown. Cross-seciton only.

APPENDIX B

Geochemical data from the Priest Tank 7.5-minute quadrangle

Whole-rock geochemistry was acquired for seven samples of volcanic and intrusive rock from the Priest Tank quadrangle. Non-mineralized samples were crushed, split, and pulverized to <75 µm and analyzed by x-ray fluorescence (XRF). Analyses were performed by ALS USA, Inc.

Table B.1. Major-element geochemistry of extrusive and intrusive rocks in the Priest Tank 7.5' quadrangle.

Sample ID	19PT-472	19PT-471	17PT-193	18PT-895	18PT-922	19PT-587	18PT-899
	Lapilli Tuff	Vicks Peak Tuff	Lower Rhyolite	Trachyandesite	Middle Rhyolite	Middle Rhyolite	Intrusive Intermediate
Map Unit	Tlt	Tvp	Tr1	Tta	Tr2	Tr2	Tii
Al_2O_3	11.65	11.04	12.05	14.75	11.76	11.86	14.75
BaO	0.03	0.02	0.03	0.11	0.05	0.04	0.12
CaO	0.14	0.11	0.33	5.04	0.83	0.51	5.23
Cr_2O_3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	1.68	1.72	1.40	8.76	1.68	1.85	9.04
K_2O	5.30	5.00	4.94	2.96	4.99	4.64	3.06
MgO	0.21	0.14	0.14	1.79	0.46	0.17	2.09
MnO	0.08	0.09	0.05	0.14	0.08	0.04	0.15
Na_2O	3.53	3.70	3.53	4.01	2.52	3.57	4.08
P_2O_5	0.02	0.04	0.05	0.89	0.03	0.04	0.93
SO_3	0.03	0.01	<0.01	0.01	0.01	0.12	<0.01
SiO_2	75.93	77.03	76.71	57.99	72.63	75.95	57.99
SrO	0.01	0.01	<0.01	0.05	0.01	<0.01	0.05
TiO_2	0.19	0.22	0.19	2.02	0.18	0.17	2.09
LOI	0.40	0.51	0.18	0.72	3.81	0.61	0.42
Total	99.28	99.73	99.65	99.35	99.14	99.62	100.10

NOTE: Oxide analysis by X-ray fluorescence, ALS USA, Inc. LOI = loss on ignition. All reported values are wt %.

APPENDIX C

Clast count data from the Priest Tank 7.5-minute quadrangle

This appendix contains tabulated clast count data (lithology type) from select geologic units exposed in the Priest Tank quadrangle, including modern alluvium (Willow Spring Draw) and Palomas Formation units. Clast counts were conducted by random selection of clasts of ≥0.5 cm diameter from 50-200 cm^2 areas of unit outcrops. Clast lithology categories are modified from Table 2 of Koning et al. (2016). Lithology abbreviations include: Tkn = Kneeling Nun Tuff, Psa = Permian San Andres Formation and Pay = Permian Abo and Yeso Formations, undivided. Location coordinates for all counts are given in NAD83 UTM zone 13S.

TABLE C.1 CLAST-COUNT DATA FOR UNIT Qam (WAYPOINT 190208_3-2)

Date	02/08/19	*n = 104*
UTM Location	3686506N, 276595E	
	n	% total
Total felsic volcanics	30	29%
Crystal-poor felsic volcanics	15	14%
Crystal-rich felsic volcanics	15	14%
Tuffs, undivided	4	4%
Tkn	2	2%
Vicks Peak Tuff	0	0%
Total intermediate volcanics	31	30%
Crystal-poor intermediate volcanics	14	13%
Crystal-rich intermediate volcanics	17	16%
Monzonite porphyry	5	5%
Paleozoic carbonates	23	22%
Psa + Pay	6	6%
Sandstone+siltstone, undivided	0	0%
Chert and jasperoid	1	1%
Basalt	0	0%
Other	2	2%
Comments	Other = 1% vein quartz, 1% unknown.	

TABLE C.2 CLAST-COUNT DATA FOR UNIT Qpuc (WAYPOINT 170907_2c)

Date	09/07/17	*n = 100*
UTM Location	3686340N, 275012E	
	n	% total
Total felsic volcanics	2	2%
Crystal-poor felsic volcanics	1	1%
Crystal-rich felsic volcanics	1	1%
Tuffs, undivided	13	13%
Tkn + porphyritic rhyolite	5	5%
Vicks Peak Tuff	0	0%
Total intermediate volcanics	32	32%
Crystal-poor intermediate volcanics	12	12%
Crystal-rich intermediate volcanics	20	20%
Monzonite porphyry	7	7%
Paleozoic carbonates	23	23%
Psa + Pay	10	10%
Sandstone+siltstone, undivided	1	1%
Chert and jasperoid	2	2%
Basalt	0	0%
Other	5	5%
Comments	Other = 4% undivided intrusives, 1% unknown.	

TABLE C.3 CLAST-COUNT DATA FOR UNIT Qpu (WAYPOINT 180322_2-1)		
Date	03/22/18	*n = 100*
UTM Location	3681747N, 278391E	
	n	% total
Total felsic volcanics	35	44%
Crystal-poor felsic volcanics	6	8%
Crystal-rich felsic volcanics	3	4%
Tuffs, undivided	20	25%
Tkn + porphyritic rhyolite (tuff)	2	3%
Vicks Peak Tuff	4	5%
Total intermediate volcanics	36	46%
Crystal-poor intermediate volcanics	25	32%
Crystal-rich intermediate volcanics	11	14%
Monzonite porphyry	2	3%
Paleozoic carbonates	2	3%
Psa + Pay	1	1%
Sandstone+siltstone, undivided	0	0%
Chert and jasperoid	2	3%
Basalt	0	0%
Other	1	1%
Comments	Other = 1% carbonate nodules.	

TABLE C.4 CLAST-COUNT DATA FOR UNIT Tpl (WAYPOINT 190207_2-2)		
Date	02/07/19	*n = 101*
UTM Location	3683898N, 272333E	
	n	% total
Total felsic volcanics	40	40%
Crystal-poor felsic volcanics	23	23%
Crystal-rich felsic volcanics	17	17%
Tuffs, undivided	7	7%
Tkn	3	3%
Vicks Peak Tuff	1	1%
Total intermediate volcanics	28	28%
Crystal-poor intermediate volcanics	17	17%
Crystal-rich intermediate volcanics	11	11%
Monzonite porphyry	5	5%
Paleozoic carbonates	14	14%
Psa + Pay	0	0%
Sandstone+siltstone, undivided	0	0%
Chert and jasperoid	1	1%
Basalt	1	1%
Other	1	1%
Comments	Other = 1% chalcedony.	

APPENDIX D

Maximum clast size data from the Priest Tank 7.5-minute quadrangle

Maximum clast size measurements were made of the 10 largest clasts in an area of approximately 75-100 m^2. The longest (a) and intermediate (b) axes of each clast were measured. Clast lithologies were noted as well; lithology abbreviations include: Tvp = Vicks Peak Tuff and Tkn = Kneeling Nun Tuff. All UTM coordinates are given in NAD83 UTM zone 13S.

TABLE D.1 MAXIMUM CLAST SIZE MEASUREMENTS AT WAYPOINT 190208_3-1c				
Willow Spring Draw		a axis (cm)	b axis (cm)	Lithology
Northing	3688791	88	45.5	Crystal-rich felsite
Easting	267464	49	28.5	Monzonite
Unit	Qam	39	35	Monzonite
Mean (a axis)	50	39.5	21	Crystal-rich felsite
Median (a axis)	48	67	34.5	Crystal-rich felsite
Mean (b axis)	34	49	48.5	Crystal-rich felsite
Median (b axis)	32.75	43	38	Crystal-rich felsite
n	10	47	26	Tkn
		50.5	31	Crystal-rich felsite
		31.5	29	Monzonite

TABLE D.2 MAXIMUM CLAST SIZE MEASUREMENTS AT WAYPOINT 190207_2-1c				
		a axis (cm)	b axis (cm)	Lithology
Northing	3685015	30	17	Crystal-rich felsite
Easting	271437	29	15	Crystal-rich felsite
Unit	Qpuc	33	23	Monzonite
Mean (a axis)	37	41	22	Crystal-rich felsite
Median (a axis)	34	34	21	Crystal-poor felsite or Tvp
Mean (b axis)	24	66	45	Undivided tuff
Median (b axis)	22.5	29	26	Crystal-rich felsite
n	10	35	27	Crystal-rich felsite
		30	24	Crystal-poor intermediate
		42	21	Crystal-rich felsite

TABLE D.3 MAXIMUM CLAST SIZE MEASUREMENTS AT WAYPOINT 180322_2-1				
		a axis (cm)	b axis (cm)	Lithology
Northing	3681747	15	6	Crystal-poor intermediate
Easting	278391	13.5	7.5	Undivided tuff
Unit	Qpu	17	13	Crystal-poor intermediate
Mean (a axis)	16	20	12	Feldspar porphyry
Median (a axis)	15	14.5	6	Crystal-poor intermediate
Mean (b axis)	9	12	6.5	Paleozoic carbonate
Median (b axis)	8.25	12	9.5	Crystal-poor felsite
n	10	15.5	7.5	Crystal-poor intermediate
		18	9	Undivided tuff
		19.5	12	Crystal-poor felsite

TABLE D.4 MAXIMUM CLAST SIZE MEASUREMENTS AT WAYPOINT 180322_2-1				
		a axis (cm)	b axis (cm)	Lithology
Northing	3683898	29	25.5	Crystal-rich felsite
Easting	272333	32.5	23	Crystal-poor intermediate
Unit	Tpl	23.5	15	Crystal-rich intermediate/intrusv
Mean (a axis)	28	27	18	Undivided tuff
Median (a axis)	28	30	14.5	Tkn
Mean (b axis)	18	27.5	12	Crystal-poor felsite
Median (b axis)	15.75	32	16.5	Crystal-rich intermediate/intrusv
n	10	40	27	Crystal-poor felsite
		25	14.5	Crystal-rich intermediate/intrusv
		17	15	Paleozoic carbonate

TABLE D.5 MAXIMUM CLAST SIZE MEASUREMENTS AT WAYPOINT 190228_2-1				
		a axis (cm)	b axis (cm)	Lithology
Northing	3692760	39.5	21.5	Crystal-rich felsite
Easting	269129	71	38	Crystal-rich felsite
Unit	Tsml	31	29.5	Crystal-rich felsite
Mean (a axis)	43	29	19	Crystal-rich felsite
Median (a axis)	43	48	25	Crystal-rich felsite
Mean (b axis)	25	52	30	Crystal-rich felsite
Median (b axis)	24.5	47	25	Crystal-rich felsite
n	10	37	24	Crystal-rich felsite
		26	23	Crystal-rich felsite
		46	18	Crystal-rich felsite

APPENDIX E

Paleocurrent data from the Priest Tank 7.5-minute quadrangle

This appendix contains tabulated paleocurrent direction data (azimuthal) measured from imbrication of gravels and channel axes from Palomas Formation units exposed in the Priest Tank quadrangle. A Brunton pocket transit was used for all measurements. Location coordinates for all measurements are given in NAD83 UTM zone 13S. Mean paleocurrent directions are shown on the geologic map.

TABLE E.1 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_1e

		Flow direction measurements				
Northing	3691088	114	105	110	134	157
Easting	277802	114	105	110	134	145
Unit	QTpc	114	91	110	134	145
Mean	121	114	91	95	134	160
Median	113	155	91	95	134	160
n	49	155	99	95	113	89
		155	99	95	113	89
		104	99	152	113	159
		104	99	152	113	159
		104	110	152	157	

TABLE E.2 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004A_1f

		Flow direction measurements		
Northing	3691296	121	146	90
Easting	277485	121	125	
Unit	QTpc	121	125	
Mean	122	105	125	
Median	121	105	125	
n	21	146	113	
		146	113	
		146	113	
		146	90	
		146	90	

TABLE E.3 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004B_1f

		Flow direction measurements		
Northing	3691296	130	156	115
Easting	277485	130	156	115
Unit	QTpc	149	156	117
Mean	132	149	156	117
Median	130	149	156	117
n	29	149	99	174
		149	99	174
		90	99	174
		90	99	174
		90	99	

TABLE E.4 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_2						
		Flow direction measurements				
Northing	3692298	134	188	127	116	138
Easting	276645	134	188	127	116	138
Unit	QTpc	134	144	88	121	138
Mean	122	144	123	88	121	80
Median	121	144	123	88	86	80
n	50	144	123	88	86	115
		144	115	125	117	115
		114	115	125	117	115
		149	115	121	117	86
		149	127	121	138	86

TABLE E.5 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_2f							
		Flow direction measurements					
Northing	3691626	146	124	104	170	142	136
Easting	276987	146	124	104	170	142	110
Unit	QTpc	125	105	155	170	142	
Mean	132	125	149	112	124	135	
Median	135	125	149	112	124	135	
n	52	125	149	112	162	135	
		125	104	112	162	135	
		110	135	121	162	135	
		124	135	121	142	135	
		124	104	121	142	136	

TABLE E.6 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_BH-40								
		Flow direction measurements						
Northing	3690700	153	152	120	175	130	89	155
Easting	278153	132	152	64	175	120	155	161
Unit	QTpc	132	152	120	179	151	180	
Mean	135	136	129	182	158	191	131	
Median	131	126	140	129	158	192	131	
n	62	126	138	129	158	78	117	
		113	129	130	127	74	117	
		127	90	152	181	74	115	
		127	107	187	77	62	115	
		152	140	182	135	110	120	

TABLE E.7 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_BH-47						
		Flow direction measurements				
Northing	3690374	130	68	75	125	73
Easting	278786	130	80	100	228	73
Unit	QTpc	140	62	113	208	70
Mean	118	144	137	113	143	109
Median	113	114	45	97	110	178
n	48	103	122	92	155	178
		70	135	83	165	184
		73	148	90	187	182
		52	80	151	187	
		56	113	125	78	

TABLE E.8 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004A_BH-50				
		Flow direction measurements		
Northing	3692298	124	92	80
Easting	276363	124	92	
Unit	QTpc	133	88	
Mean	106	119	104	
Median	104	96	127	
n	21	91	127	
		128	112	
		117	103	
		88	105	
		90	91	

TABLE E.9 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004A_BH-50					
		Flow direction measurements			
Northing	3692298	90	89	69	75
Easting	276363	100	115	112	100
Unit	QTpc	109	115	130	170
Mean	113	109	96	109	175
Median	111	112	83	109	193
n	40	102	83	89	74
		114	88	107	74
		114	135	142	122
		126	135	142	104
		126	135	142	122

TABLE E.10 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181004_BH-53

		Flow direction measurements							
Northing	3692455	132	359	98	153	92	147	138	104
Easting	276081	132	177	120	151	110	122	147	87
Unit	QTpc	116	53	179	103	98	86	136	104
Mean	124	126	157	179	124	143	120	132	
Median	124	100	157	176	94	143	143	126	
n	73	50	145	197	84	124	148	123	
		79	171	92	61	162	97	106	
		55	171	52	124	137	118	99	
		17	163	67	127	137	118	130	
		46	187	153	71	132	144	108	

TABLE E.11 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181206_2

		Flow direction measurements						
Northing	3693567	144	154	136	133	143	147	165
Easting	278837	144	154	195	133	143	198	165
Unit	QTpc	144	154	195	133	143	137	165
Mean	154	159	154	195	133	143	137	
Median	146	159	146	155	133	143	134	
n	63	159	146	159	133	143	134	
		159	136	159	222	143	134	
		159	136	131	222	143	134	
		154	136	131	222	147	165	
		154	136	131	222	147	165	

TABLE E.12 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181206_3b

		Flow direction measurements				
Northing	3692528	146	151	152	165	135
Easting	277888	146	151	152	165	135
Unit	QTpc	146	151	152	165	154
Mean	148	146	151	152	159	154
Median	151	146	151	125	159	154
n	50	111	151	158	133	154
		111	147	158	133	154
		111	147	158	133	171
		128	162	165	156	149
		128	152	165	135	149

TABLE E.13 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 181206_4a

		Flow direction measurements				
Northing	3693715	139	162	131	142	112
Easting	277837	139	156	131	142	112
Unit	QTpc	139	156	149	133	129
Mean	139	149	156	149	133	129
Median	140	149	169	145	133	126
n	49	123	140	145	150	126
		162	140	145	150	126
		162	140	145	130	126
		162	131	145	130	126
		162	131	77	130	

TABLE E.14 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 170907_2e

		Flow direction measurements					
Northing	3686351	95	76	80	73	46	83
Easting	274940	95	121	74	74	71	
Unit	Qpuc	95	84	74	74	71	
Mean	81	95	84	74	74	104	
Median	77	95	84	30	74	104	
n	51	95	62	30	74	104	
		95	77	73	63	95	
		125	77	73	63	95	
		125	80	73	64	83	
		125	80	73	46	83	

TABLE E.15 CHANNEL AXIS PALEOCURRENT MEASUREMENTS AT WAYPOINT 170907_2g

		Flow direction measurements
Northing	3686235	150
Easting	274830	105
Unit	Qpuc	105
Mean	118	110
Median	108	
n	4	

TABLE E.16 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 170907_2k

		Flow direction measurements					
Northing	3686590	80	115	140	95	107	74
Easting	273857	80	115	140	95	107	
Unit	Qpuc	80	115	140	89	110	
Mean	101	80	115	103	89	110	
Median	95	94	87	95	89	110	
n	51	94	84	95	140	78	
		94	84	95	140	78	
		94	84	95	140	78	
		94	84	95	140	74	
		115	140	95	107	74	

TABLE E.17 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180905_1-1a

		Flow direction measurements					
Northing	3686630	135	168	107	169	144	130
Easting	276548	135	168	112	169	144	130
Unit	Qpuc	126	130	112	169	180	147
Mean	145	139	165	132	169	180	147
Median	146	165	146	132	169	164	147
n	57	125	146	132	100	175	147
		132	146	132	100	175	147
		118	146	149	152	175	
		118	107	136	152	175	
		168	107	136	175	162	

TABLE E.18 CHANNEL AXIS PALEOCURRENT MEASUREMENTS AT WAYPOINT 180906_2-1d

		Flow direction measurements
Northing	3686338	106
Easting	277293	94
Unit	Qpuc	125
Mean	108	99
Median	106	114
n	5	

TABLE E.19 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180906_2-1e

		Flow direction measurements					
Northing	3686262	65	114	115	140	92	67
Easting	277220	65	68	115	140	92	67
Unit	Qpuc	65	68	115	140	92	
Mean	93	65	134	109	140	92	
Median	91	61	90	109	140	84	
n	52	61	90	100	70	84	
		114	90	68	70	84	
		114	115	68	70	84	
		114	115	68	70	40	
		114	115	140	92	40	

TABLE E.20 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207_2-1a

		Flow direction measurements				
Northing	3685144	135	154	156	123	157
Easting	271025	135	154	156	123	157
Unit	Qpuc	135	154	156	123	157
Mean	141	135	154	156	126	157
Median	139	135	106	156	126	140
n	50	135	106	154	126	140
		135	106	154	139	167
		130	106	154	139	167
		130	126	141	139	167
		130	126	141	139	167

TABLE E.21 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207A_2-1d

		Flow direction measurements			
Northing	3684614	125	94	104	149
Easting	271758	125	124	104	103
Unit	Qpuc	125	124	135	103
Mean	122	190	96	135	127
Median	125	190	96	135	127
n	36	139	96	135	127
		139	96	135	
		139	105	135	
		139	104	99	
		94	104	99	

TABLE E.22 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207B_2-1d							
		Flow direction measurements					
Northing	3684614	190	120	130	177		
Easting	271758	190	120	128	177		
Unit	Qpuc	124	120	128	190		
Mean	147	124	120	128	190		
Median	143	150	120	148	190		
n	38	150	168	148	190		
		119	168	148	129		
		119	130	148	129		
		176	130	148			
		138	130	156			

TABLE E.23 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207_2-3							
		Flow direction measurements					
Northing	3683588	91	182	104	92		
Easting	271234	91	145	119	92		
Unit	Qpuc	91	145	119	140		
Mean	127	91	125	119	140		
Median	123	121	125	128	103		
n	36	121	130	128	103		
		121	130	182			
		130	104	182			
		130	104	182			
		182	104	182			

TABLE E.24 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190208_3-3a							
		Flow direction measurements					
Northing	3683113	79	31	95	40	70	59
Easting	273837	79	31	100	40	70	59
Unit	Qpuc	79	82	100	40	70	59
Mean	62	79	82	100	40	95	
Median	59	44	82	100	44	95	
n	53	44	48	100	44	95	
		44	48	60	44	104	
		325	48	60	44	104	
		325	48	64	44	59	
		31	95	64	53	59	

TABLE E.25 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190208_3-3j

		Flow direction measurements				
Northing	3682513	201	114	140	71	159
Easting	273901	201	195	140	71	159
Unit	Qpuc	201	195	140	96	94
Mean	122	201	119	115	96	94
Median	115	201	119	115	113	94
n	45	107	119	115	113	
		107	119	115	58	
		114	119	55	58	
		114	115	55	125	
		114	115	71	125	

TABLE E.26 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190208_3-4a

		Flow direction measurements						
Northing	3681695	95	121	147	93	91	77	101
Easting	277339	95	121	147	93	106	77	101
Unit	Qpuc	95	96	140	93	106	75	133
Mean	108	117	96	140	93	106	75	133
Median	103	117	96	140	123	106	86	
n	64	117	96	140	123	115	86	
		117	147	105	104	95	86	
		117	147	105	104	95	101	
		117	147	91	91	95	101	
		117	147	91	91	95	101	

TABLE E.27 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-1

		Flow direction measurements						
Northing	3682801	119	150	101	165	192	123	114
Easting	274297	119	150	101	165	192	123	114
Unit	Qpuc	119	150	144	107	192	123	114
Mean	135	99	150	144	107	132	134	114
Median	123	99	150	144	107	132	134	
n	64	99	150	123	107	132	196	
		99	150	123	197	132	196	
		99	139	123	197	118	196	
		94	139	123	197	118	114	
		94	139	123	192	123	114	

TABLE E.28 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-4

		Flow direction measurements					
Northing	3681854	135	125	137	118	131	90
Easting	276795	135	125	137	122	111	90
Unit	Qpuc	121	125	137	120	111	132
Mean	123	121	125	137	120	111	132
Median	125	121	112	137	120	111	111
n	57	117	112	137	150	111	107
		117	130	137	131	126	107
		117	130	118	131	126	
		125	137	118	131	126	
		125	137	118	131	126	

TABLE E.29 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180907_3-1h

		Flow direction measurements					
Northing	3682813	51	80	72	49	64	45
Easting	278512	51	80	72	49	64	45
Unit	Qpu	51	80	72	49	64	
Mean	45	13	36	72	52	48	
Median	49	13	36	2	52	34	
n	52	13	31	2	52	34	
		13	31	2	64	34	
		80	31	2	64	34	
		80	31	2	64	34	
		80	31	49	64	45	

TABLE E.30 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190208_3-3d

		Flow direction measurements			
Northing	3683104	142	146	140	112
Easting	273496	142	99	136	116
Unit	Qpu	142	99	136	116
Mean	121	142	143	136	
Median	136	142	86	84	
n	33	146	86	84	
		146	86	71	
		146	121	71	
		146	121	112	
		146	140	112	

TABLE E.31 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-1b

		Flow direction measurements					
Northing	3682089	131	147	127	171	129	194
Easting	274596	131	147	155	171	136	194
Unit	Qpu	131	150	155	171	139	
Mean	147	131	150	155	171	139	
Median	142	131	150	155	133	142	
n	52	131	150	177	133	142	
		106	150	177	133	142	
		114	127	177	133	142	
		114	127	177	133	142	
		147	127	171	129	194	

TABLE E.32 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-3

		Flow direction measurements			
Northing	3681998	124	127	186	91
Easting	274957	124	105	109	91
Unit	Qpu	84	105	109	91
Mean	117	84	105	96	91
Median	115	135	126	96	131
n	39	135	126	111	131
		135	126	111	75
		135	115	164	75
		146	115	164	75
		127	115	164	

TABLE E.33 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-4b

		Flow direction measurements					
Northing	3681587	137	104	127	149	136	139
Easting	276672	137	104	114	149	136	139
Unit	Qpu	137	135	114	130	144	139
Mean	134	116	135	114	130	144	
Median	135	116	135	183	165	144	
n	53	110	114	183	165	126	
		110	114	183	154	126	
		110	127	141	154	126	
		104	127	141	154	126	
		104	127	141	154	126	

TABLE E.34 CHANNEL AXIS PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207_2-2		
		Flow direction measurements
Northing	3683898	125
Easting	272333	113
Unit	Tpl	91
Mean	110	
Median	113	
n	3	

TABLE E.35 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207_2-2d					
		Flow direction measurements			
Northing	3682763	161	164	129	163
Easting	272099	161	164	129	163
Unit	Tpl	161	115	129	163
Mean	149	161	115	129	
Median	158	161	114	140	
n	33	161	191	134	
		161	191	134	
		161	170	134	
		158	129	145	
		158	129	145	

TABLE E.36 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190207_2-2i					
		Flow direction measurements			
Northing	3682924	115	139	100	155
Easting	271652	145	139	100	155
Unit	Tpl	145	139	106	155
Mean	122	101	116	106	92
Median	120	101	116	129	92
n	36	127	112	129	92
		120	112	142	
		120	112	142	
		131	79	142	
		139	79	155	

TABLE E.37 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 190227_1-2b							
		Flow direction measurements					
Northing	3681749	89	108	69	120	74	104
Easting	275030	89	108	88	120	76	104
Unit	Tpl	89	108	88	120	131	104
Mean	104	89	108	88	120	131	
Median	107	120	107	88	90	131	
n	53	120	107	134	92	131	
		120	107	134	92	104	
		120	107	122	92	104	
		120	69	122	74	104	
		108	69	122	74	104	

TABLE E.38 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 170907A_1a				
		Flow direction measurements		
Northing	3682061	115	157	140
Easting	270276	100	157	140
Unit	Tsml	110	157	140
Mean	129	110	138	140
Median	128	146	138	140
n	28	146	118	140
		128	118	100
		128	118	100
		128	118	
		128	112	

TABLE E.39 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 170907B_1a			
		Flow direction measurements	
Northing	3682061	148	105
Easting	270276	92	105
Unit	Tsml	92	81
Mean	111	156	114
Median	105	156	114
n	17	96	114
		96	104
		102	
		112	
		105	

TABLE E.40 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180919_1-1d					
		Flow direction measurements			
Northing	3692621	98	79	107	102
Easting	269768	98	79	75	102
Unit	Tsml	98	113	75	88
Mean	100	74	113	129	105
Median	107	74	105	129	57
n	40	109	111	110	57
		109	107	110	57
		109	107	110	127
		109	107	102	127
		79	107	131	127

TABLE E.41 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180920_2-1h							
		Flow direction measurements					
Northing	3693212	128	76	90	67	97	148
Easting	269387	128	66	61	83	97	129
Unit	Tsml	128	66	61	83	97	129
Mean	103	128	66	61	83	114	
Median	106	128	66	116	127	114	
n	53	113	106	116	127	114	
		113	106	116	127	114	
		105	106	134	97	114	
		105	106	134	97	97	
		76	90	67	97	126	

TABLE E.42 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180920_2-2a				
		Flow direction measurements		
Northing	3693472	88	108	132
Easting	269445	88	108	
Unit	Tsml	88	108	
Mean	108	98	108	
Median	108	98	108	
n	21	98	125	
		101	125	
		101	132	
		93	132	
		93	132	

TABLE E.43 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180920_2-2a			
		Flow direction measurements	
Northing*	3693473	86	80
Easting*	269456	86	80
Unit	Tsml	117	80
Mean	93	117	103
Median	92	92	103
n	16	92	103
		92	
		92	
		92	
		80	

*Estimated from Google Earth.

TABLE E.44 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180920_2-3g						
		Flow direction measurements				
Northing	3693879	105	105	75	54	40
Easting	269903	105	40	75	54	63
Unit	Tsml	105	40	73	54	63
Mean	73	105	40	73	71	63
Median	69	105	40	69	71	63
n	50	105	74	69	71	50
		105	74	69	71	50
		105	131	54	55	50
		105	131	54	55	41
		105	131	54	40	41

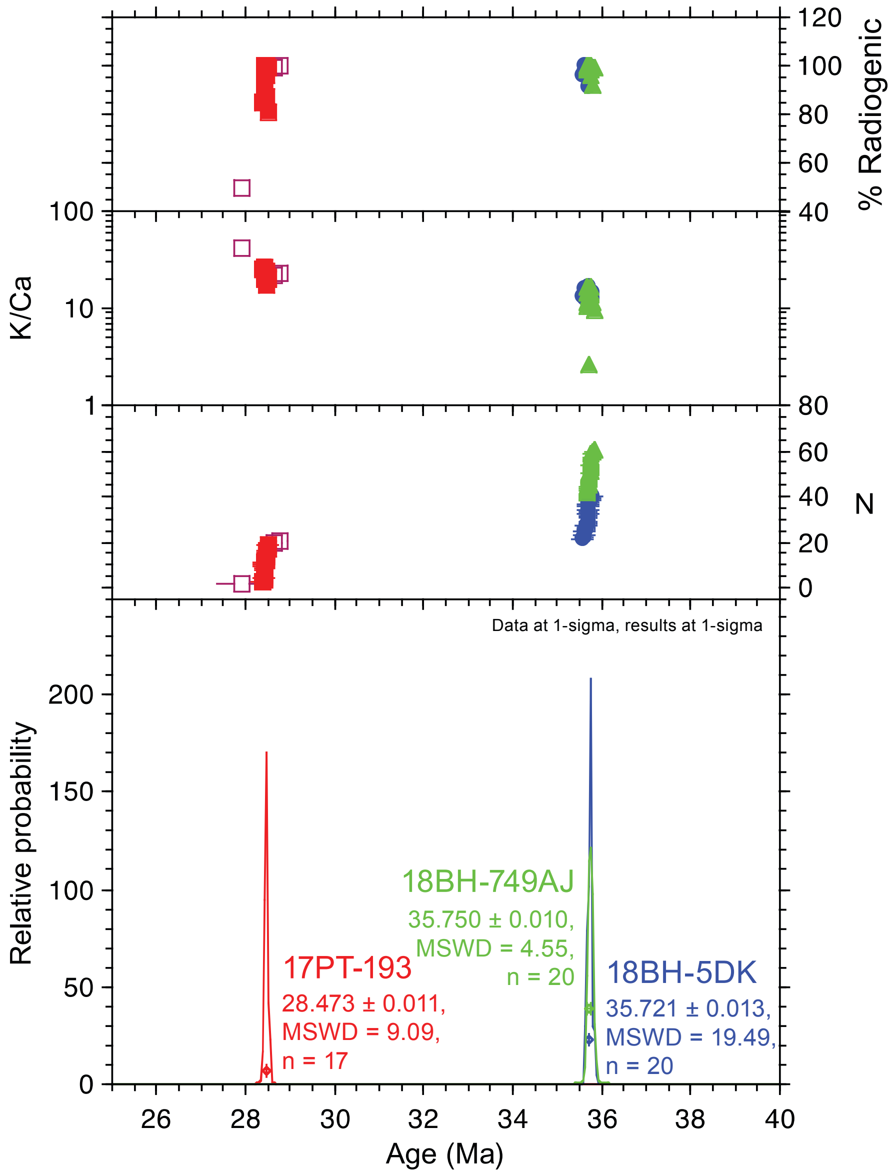
TABLE E.45 IMBRICATION PALEOCURRENT MEASUREMENTS AT WAYPOINT 180920_2-4b						
		Flow direction measurements				
Northing	3694871	148	122	125	131	125
Easting	269699	148	122	134	131	122
Unit	Tsml	148	122	134	187	122
Mean	127	148	108	134	187	122
Median	125	148	108	42	187	122
n	49	148	108	42	187	105
		148	108	108	187	105
		106	116	108	126	126
		106	116	103	126	126
		106	116	131	126	

APPENDIX F

40Ar/39Ar dating analysis from a sample collected on the Priest Tank 7.5-minute quadrangle

Sample 17PT-193 was collected from the Lower Rhyolite (Tr1) at 268502 mE, 3690238 mN (NAD83 UTM 13S).

Age-Probability Spectra for Samples 17PT-193, 18BH-5DK, and 18BH-749AJ



Green and blue samples on Black Hill 7.5-minute quadrangle