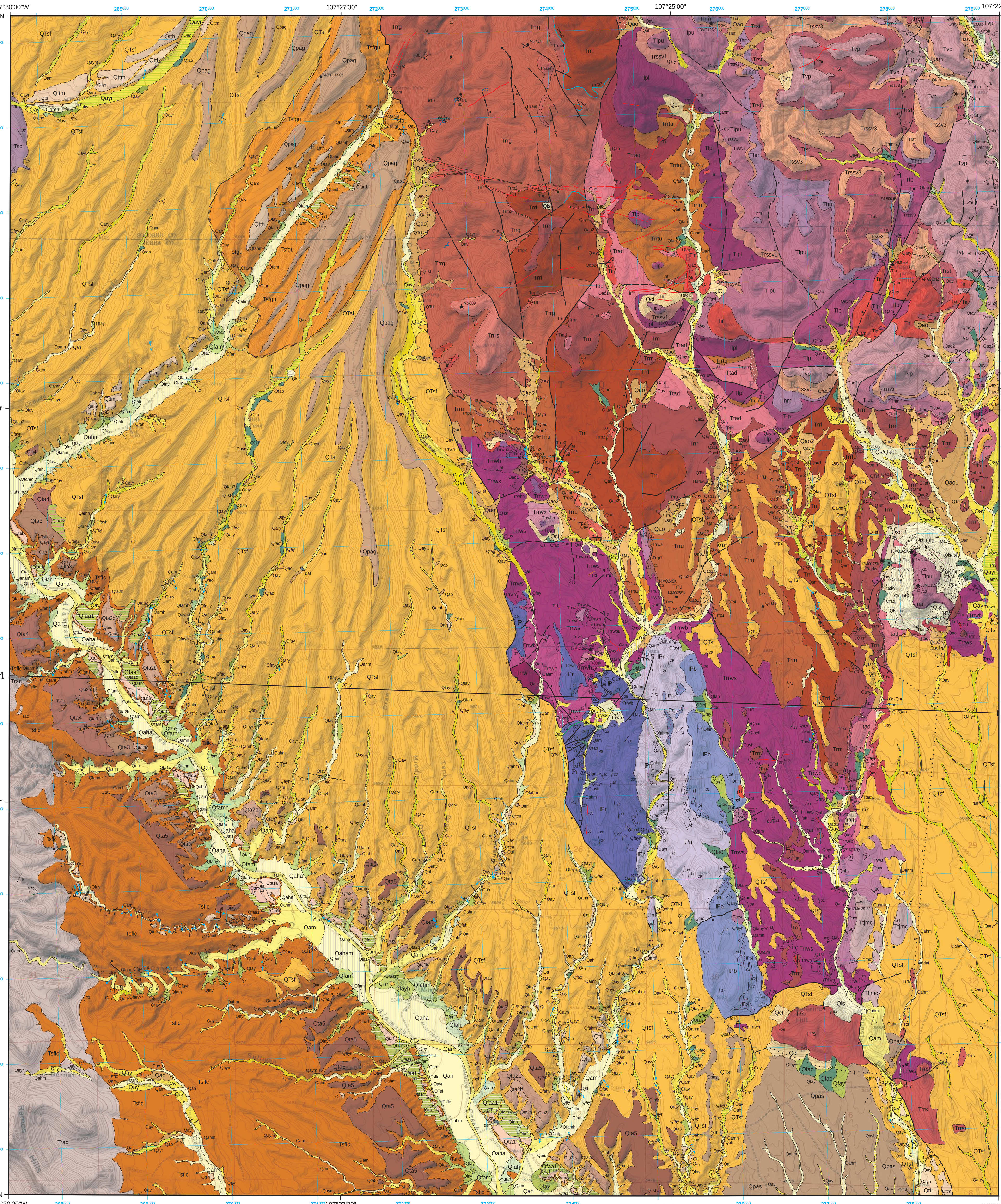


Base map from U.S. Geological Survey 1961, from photographs taken 1958, field checked in 1961, edited in 1980.
1927 North American datum, Polyconic projection. Reprojected to UTM -- zone 13N.
1000-meter Universal Transverse Mercator grid, zone 13, shown in red

Description Of Map Units

(Partial description of units; complete descriptions are found in the accompanying report)

Hillslope and landslide units (Quaternary)

Qct — **Colluvium and talus (middle to upper Pleistocene and Holocene)** – Poorly sorted, angular to subangular, clayey-silty sand and gravel mantling middle-lower hillslopes. Weakly consolidated. <8 m thick.

Qs — **Slopewash deposits (upper Pleistocene to Holocene)** – Sand and pebbly sand forming thin mantles on older Quaternary gravel or on bedrock underlying hill footslopes. Unconsolidated and massive. Maximum thickness 4 m (13.1 ft).

Qs/Qao — **Slopewash deposits overlying older alluvium (upper Pleistocene to Holocene)**

Qs/Qao1 — **Slopewash deposits overlying the younger allostratigraphic unit of the older alluvium (upper Pleistocene to Holocene)**

Qs/Qao2 — **Slopewash deposits overlying the middle allostratigraphic unit of the older alluvium (upper Pleistocene to Holocene)**

Qs/Qao3 — **Slopewash deposits overlying the older allostratigraphic unit of the older alluvium (upper Pleistocene to Holocene)**

Qs/Trrwb — **Slopewash deposits overlying biotite-bearing dacite of the Whiskey Hill Member of the Red Rock Ranch Formation (upper Pleistocene to Holocene)**

Qsc — **Slopewash and colluvium deposits, undivided (middle Pleistocene to Holocene)** – Undifferentiated slopewash and colluvium, mapped at the footslope of the hill labeled 6256 in the southeastern quadrangle, where colluvium grades out laterally into slopewash deposits. 1-4(?) m thick.

Qls — **Landslide deposits (middle to upper Pleistocene)** – Poorly exposed landslide deposits that flank the hill labeled 6256 in the southeastern quadrangle, consisting of clay to sand mixed with gravel of the Luna Park Tuff. Large blocks of Luna Park Tuff within the landslide deposits are differentiated (see below). Also mapped on the northeast side of Seferino Hill and in upper Cedro Canyon.

Qls-lp — Fractured block of undivided Luna Park Tuff that was translated downslope in a landslide.

Qls-lpl — Fractured block of Lower Luna Park Tuff that was translated downslope in a landslide.

Qls-lpu — Fractured block of Upper Luna Park Tuff that was translated downslope in a landslide.

Qlsi — **Individual lobe of a landslide deposits (middle to upper Pleistocene)** – Landslide deposit as described above (unit **Qls**) that is inset into older landslide deposits, indicating a younger age.

Valley bottom units (Quaternary)

daf — **Dam-related artificial fill(modern)** – Valley bottom sand and gravel that has been moved by humans to form dams for impounding water.

Qam — **Modern alluvium (0 to ~50 years old)** – Sand and gravel in active channels and subjected to annual runoff. Bar and swale topography and channel forms are sharp on gravelly surfaces, with 30-100 cm of typical surface relief. Sandy surfaces are relatively flat and smooth. Vegetation is sparse on both sandy and gravelly surfaces. Loose. Thickness is likely 1-3 m.

Qah — **Historical alluvium (50 to ~800 years old)** – Typically well-bedded sand and gravel in valley bottoms. Surface is vegetated, gravelly, and exhibits muted bar and swale topography and channel forms; generally 10-40 cm of surface relief. Sparsely to moderately vegetated and exhibits no obvious soil development. Tread is generally less than 2 m above modern grade. Loose. Possibly up to 3-4 m maximum thickness.

Qaha — **Historical alluvium of Alamosa Creek (50 to ~800 years old)** – Mostly clayey-silty, very fine- to fine-grained sand, with subordinate gravelly interbeds, deposited in the valley bottom alongside Alamosa Creek. Weakly to moderately consolidated and non-cemented. Possibly up to 4 m thick.

Qamh — Modern and subordinate historical alluvium, undivided (0 to ~800 years old)

Qaham — Historical alluvium of Alamosa Creek and subordinate modern alluvium, undivided (50 to ~800 years old)

Qahm — Historical alluvium and subordinate modern alluvium, undivided (0 to ~800 years old)

Qahy — Historical alluvium and subordinate younger alluvium, undivided (~50 to 8,000 years old)

Qar — Subequal modern and historic alluvium (modern to ~800 years old)

Qary — Recent alluvium (historical + modern) and subordinate younger alluvium, undivided (0 to 8,000 years old)

Qay — **Younger alluvium (middle to upper Holocene)** – Sand,with subordinate clay, silt, and gravel, occupying the bottoms of modern valleys and underlying low-level terraces alongside modern arroyos. Unit is overall browner than **Qao**, and less well-bedded and finer-grained than **Qah**. Except where eroded, the top of this unit typically exhibits a weak soil marked by calcium carbonate accumulation (stage I to II carbonate morphology). Surface clasts are non- to weakly varnished and generally the surface is smooth, although locally subtle bar- and swale- topography is present. Surface is slightly higher than the **Qah** surface. Loose to weakly consolidated. Estimated thickness of 1-5 m (base is typically not exposed).

Qaym — Younger alluvium and subordinate modern alluvium, undivided (0 to 800 years old)

Qayh — Younger alluvium and subordinate historic alluvium, undivided (50 to 8000 years old)

Qayr — Younger alluvium and subordinate recent (historical + modern +active) alluvium, undivided (800 to 8000 years old)

Terrace deposits and older alluvium

Sandy gravel terrace deposits associated with Alamosa Creek

Qta1 — **Lower Alamosa terrace deposit (upper-middle to upper Pleistocene)** – Tread stands 8-15 m above modern stream grade. 2-6 m thick. Locally, it can be subdivided into three subunits:

Qta1a — **Lower subunit of the lower terrace deposit along Alamosa Creek (upper-middle to upper Pleistocene)** – 1-2 m thick.

Qta1b — **Middle subunit of the lower terrace deposit along Alamosa Creek (upper-middle to upper Pleistocene)** – Tread lies 2-3 m above the tread of **Qta1a**. Thickness not accurately measured but likely 1-2 m thick.

Qta1c — **Upper subunit of the lower terrace deposit along Alamosa Creek (upper-middle to upper Pleistocene)** – Tread lies ~2 m above the tread of **Qta1b**. Thickness not accurately measured but likely 1-2 m thick

Qtau — **Undifferentiated Alamosa terrace deposit (Pleistocene)** – 1-5 m thick. Lies between the **Qta1** and **Qta2** terrace levels.

Qta2 — **Lower-middle terrace deposit along Alamosa Creek (middle Pleistocene)** – A strath to fill terrace of variable thickness. Strath lies 18-30 m above modern stream grade. Loose. 2-12 m thick, generally thinning upstream. Locally subdivided into three subunits:

Qta2a — Strath lies 18-20 m above modern stream grade.

Qta2b — Strath lies 1-2 m above the strath of **Qta2a**, but tread lies a few meters above the tread of **Qta2a**.

Qta2c — A 6-12 m-thick fill terrace mapped west and north of Placitas. Tread slopes towards southwest and is at least 5 m above the tread of **Qta2b**.

Qta3 — **Upper-middle terrace deposit along Alamosa Creek (middle Pleistocene)** – A 12-18 m-thick fill terrace mapped in the west-center part of the quadrangle. Strath lies 30-38 m above modern stream grade and is inset 10-12 m below the strath associated with unit **Qta4**.

Qta4 — **Upper terrace deposit along Alamosa Creek (middle Pleistocene)** – A 7-15 m-thick fill terrace mapped in the west center part of the quadrangle. Strath lies about 45-54 m above modern stream grade. 7-15 m thick.

Qta5 — **Terrace deposit whose tread projects to the Cuchillo surface (uppermost lower Pleistocene)** – Strath lies 65-85 m above modern stream grade. 4-8 m thick.

Older alluvium and terraces associated with streams other than Alamosa Creek

Qao — **Older alluvium, undivided (middle to upper Pleistocene)** – Alluvium alongside drainages other than Alamosa Creek; its surfaces are higher than those associated with unit **Qay** and typically lower than **Qtt** surfaces. Base of alluvium is very close to modern stream grade. Deposit and associated surfaces are generally lower than those associated with unit **Qtt** (described below). Generally consists of interbedded pebbly sand, sandy pebbles, and sand. Topsoil has illuviated clay horizon(s) underlain by calcic horizon(s) with stage II carbonate morphology. 2-5 m thick. Locally subdivided into presumed allostratigraphic units, although buttress contacts have not been observed in the field.

Qao1 — Younger allostratigraphic unit of older alluvium – Top is 2-3 m above modern stream grade.

Qao2 — Middle allostratigraphic unit of older alluvium – Upper surface is 1-6 m above the surface of **Qao1**.

Qao3 — Older allostratigraphic unit of older alluvium – Upper surface is 2-3 m above the to surface of unit **Qao2.**

Qtt — **Tributary terrace sandy gravel deposits, undivided (middle to upper Pleistocene)** – Sandy gravel occurring in terrace deposits 1-3 m thick in tributary drainages to Alamosa Creek. The strath lies above modern grade; surfaces and straths are typically higher than those associated with **Qao** (compared to modern stream grade). Clast compositions are typically volcanic, but may include some Paleozoic carbonates in Placitas Canyon and drainages to its east. In a given drainage, this unit is locally subdivided into three terraces whose heights differ in elevation above the modern drainage:

Qttl — **Lower tributary terrace deposit** – Unconsolidated sandy pebble-cobble gravel, with little evidence of calcium carbonate accumulation in its topsoil. Approximately 60-70% of clasts are varnished at the surface. Tread height varies from 10 m above modern grade in Shipman Canyon to 22 m above modern grade in Garcia Falls Canyon. 8-9 m thick in Shipman Canyon.

Qttm — **Middle tributary terrace deposit** –Tread height varies from 18 m above modern grade in Shipman Canyon to 40 m above modern grade in Garcia Falls Canyon. 1-2 m thick in Shipman Canyon.

Qtth — **Higher tributary terrace deposit** –Tread height varies from 20 m above modern grade in Shipman Canyon to 57 m above modern grade in Garcia Falls Canyon. Maximum thickness of 3 m in Shipman Canyon.

Alluvial fan units

Fan gravel is dominated by the lithologies exposed in the catchments from which fans emanate. Clasts are typically angular to subrounded. Clast composition may be = 90% volcanic lithologies in the northern and western parts of the quadrangle and = 60% Paleozoic carbonates in the eastern parts of the quadrangles.

Qfam — **Modern-active alluvium on alluvial fans (0 to ~50 years old)** – Similar to unit **Qam** but located on alluvial fans. Probably less than 3 m thick.

Qfamh — **Modern and historic alluvium on alluvial fans, undivided (0 to ~800 years old)** – Similar to unit **Qamh** but located on alluvial fans. <3 m thick.

Qfamy — **Modern alluvium and subordinate younger alluvium on alluvial fans, undivided (0 to ~800 years old)** – Similar to unit **Qamy** but located on alluvial fans.

Qfah — **Historical alluvium on alluvial fans (0 to ~50 years old)** – Similar to unit **Qah** but located on alluvial fans. <3 m thick.

Qfahy — **Historic and subordinate younger alluvium alluvium in alluvial fans, undivided (0 to ~800 years old)** – Up to ~10 m thick.

Qfahm — **Historic and subordinate modern alluvium on alluvial fans flanking Monticello Canyon, undivided (0 to ~800 years old)** – Similar to unit **Qahm** but located on alluvial fans <3 m thick.

Qfary — **Recent alluvium (historical + modern-active) and younger alluvium on alluvial fans flanking Monticello Canyon, undivided (0 to ~800 years old)** – Similar to unit **Qary** but located on alluvial fans. Up to ~10 m thick.

Qfay — **Younger alluvium on alluvial fans (Holocene)** – Pebbly sand and pebble-cobble-boulder gravel that is commonly matrix-supported and massive. Local stage II carbonate morphology in fine-grained topsoils, but soil development is commonly weaker due to surface erosion. Minimum thickness 1.3 m (4.3 ft).

Qfayh — **Younger alluvium and subordinate historic alluvium in alluvial fans, undivided (0 to ~800 years old)** – Up to ~10 m thick.

Qfayr — **Younger alluvium and recent (modern + historic) alluvium in alluvial fans, undivided (0 to ~8000 years old)** – Up to ~10 m thick.

Qfao — **Older alluvium in alluvial fans flanking Monticello Canyon, undivided (upper-middle Pleistocene to lower Holocene)** – Sandy pebble-cobble gravel to gravelly sand graded to the surface of **Qao**. Maximum carbonate morphology of stage II+. Minimum thickness of 1 m.

Qfaa1 — **Alluvial fans graded to the upper-lower terrace tread of Alamosa Creek (upper-middle(?) to upper Pleistocene)** – Up to 15 m thick.

Qfaa2 — **Alluvial fans graded to the middle terrace tread of Alamosa Creek (upper-middle(?) to upper Pleistocene)** – 1-5 m thick.

Qfaa3 — **Alluvial fans graded to the upper-lower terrace tread of Alamosa Creek (upper-middle(?) to upper Pleistocene)** – 1-5 m thick.

High-level piedmont deposits

Qpag — **High-level piedmont deposits near Garcia Falls (upper Pleistocene to Holocene)** – Pebble-cobble gravel in medium to thick, tabular beds. Clast lithologies include subequal proportions of gravel eroded from either **Trrg** and **Tvp**. Matrix consists of brown, fine- to coarse-grained sand. Deposit may exhibit stage I carbonate morphology in upper 40 cm. Typically 1-3.5 m (3.3-11.5 ft) thick.

Qpas — **High-level piedmont deposits south of Serafino Hill (middle to upper Pleistocene)** – Pebble-cobble gravel in medium to thick, tabular beds. Clast lithologies dominated by unit gravel correlated to **Trrs**. Rarely more than 3 m (9.8 ft) thick.

Quaternary-Tertiary Basin-fill

QTsf — **Santa Fe Group basin-fill (Lower or Middle Miocene through Pliocene, possibly lowest Quaternary)** – Sandy gravel and pebbly sand in very thin to thick, tabular to lencitular to cross-stratified beds. Upper part correlates to the Palomas Formation. Less than 20% moderate to strong cementation over a given 10 m stratigraphic interval. The relatively common, orange-colored intervals seen in this unit, in addition to its lesser cementation, serve to distinguish it from the underlying Tsflc. 300-350 m thick.

Tsfgu — **Upper Gracia falls lithosome in the Santa Fe Group (upper Miocene)** – Pebbly sand/sandstone, with subordinate pebble-cobble gravel/conglomerate, in thin to thick, tabular beds. Clast composition dominated by intermediate volcanic rocks, including 30-40% clasts from unit **Trrg**. Sandy beds make up approximately 85% of unit. Approximately 75-80 m thick.

Tsfgl — **Lower Gracia falls lithosome in the Santa Fe Group (upper Miocene)** – Sandy pebble-cobble and pebble-cobble-boulder gravel/conglomerate in medium to thick, tabular to broadly lenticular beds. Clast lithologies include subequal proportions of plagioclase-phyric andesite (typically **Trrg**), crystal-poor Tvp, and aphanitic rhyolite. Minimum thickness of 25 m.

Tsflc — **Lower, coarse-grained Santa Fe Group (Oligocene to lower Miocene)** – Sandy conglomerate, with minor pebbly sandstone intervals, that is gray and weakly to strongly cemented. 1500 m thick.

Intrusions

Ti — **Undifferentiated intrusions** – Intrusions in northern part of the quadrangle that were not field-checked but are likely felsic. In northern Serefino Canyon, this unit is a highly weathered sill with maroon, clay-rich material at the surface.

Tir — **Rhyolitic intrusions (upper Oligocene)** – Intrusions filling dikes and (less commonly) stocks that are composed of potassium feldspar and lesser quartz phenocrysts.

Tia — **Intermediate composition dikes (upper Eocene to Oligocene)** – gray dikes that variably have a fine-grained, equigranular matrix with no obvious phenocrysts or are slightly porphyritic (<<1% plagioclase and pyroxene <2 mm across) with an aphanitic matrix.

Tid — **Dacitic intrusion (upper Eocene)** – Dacite dikes in the southeastern quadrangle. Rock is light gray (fresh) and composed of plagioclase with 7% hornblende, 2-4% biotite, and <5% quartz.

Volcanic bedrock

Tsc — **Tuff of Shipman Canyon (upper Oligocene)** – Purplish gray (weathering brownish tan), massive to thick-bedded, porphyritic to aphanitic, fine- to medium-grained ash-flow tuff. Forms cliffs in lower Shipman Canyon. Phenocrysts include 6-8% quartz, 2% sanidine, and trace to 1% biotite. Also contains 2-3% glass shards up to 2.5 mm. Somewhat to densely welded. Unit consists of many interbedded flows, including light purplish gray air-fall tuff containing lapilli to fine bombs of aphanitic rhyolite and tuff. Overlies rhyolite of Alamosa Creek. $^{40}Ar/^{39}Ar$-dated at 28.4 Ma (Lynch, 2003; McLemore, 2010). Approximately 75 m (246 ft) thick.

Trac — **Rhyolite of Alamosa Creek (upper Oligocene)** – Light gray to gray (weathering to a reddish brown to brown), fine-grained, flow-banded rhyolite. Trace to 2% sanidine phenocrysts. Tops and bases of flows exhibit thick (up to tens of meters) breccia zones. As much as 50-220 m thick west of the caldera boundary (McLemore, 2010). Age is 28.4±0.04 Ma by $^{40}Ar/^{39}Ar$ (McLemore, 2010).

Tvp — **Vicks Peak Tuff (upper Oligocene)** – Pink to white, crystal-poor, welded tuff with less than 1% sanidine; commonly is foliated. Greenish black vitrophyre is common near the base. $^{40}Ar/^{39}Ar$ age of 28.39±0.19 Ma (Chapin et al., 2004). Maximum preserved thickness of 105 m. Top not exposed.

Rock Springs Formation (upper Eocene to lower Oligocene) – Volcaniclastic sediment and trachyte flows interbedded with formation-rank ignimbrites (note that these ignimbrites are not included in this formation).

Trssv3 — **Interbedded sediment and trachytic volcanic flows, stratigraphically above the Hells Mesa Tuff (lower Oligocene)** – Breccia composed of clasts of light gray trachytic lava containing hornblende and plagioclase in an aphanitic matrix; higher up-section the matrix of the lava clasts is more equigranular and contains hornblende and plagioclase. Interbedded with trachytic lavas (unit **Trst**). About 30 m thick.

Trst — **Trachytic lava (lower Oligocene)** – Lavas that contain less than 1% phenocrysts of plagioclase and pyroxene (<2 mm long) in an aphanitic matrix. Above the Hells Mesa Tuff, it includes sandy to conglomeratic to ashy intervals. Individual flows are <30 m thick.

Trssv2 — **Interbedded sediment and andesite volcanic flows, stratigraphically between the Hells Mesa and the Upper Luna Park Tuffs (lower Oligocene)** – Red volcaniclastic deposits interbedded with andesites. Sediments are variably silty to conglomeratic. Lavas include vesicular andesite lava containing 15-20% plagioclase phenocrysts and <1% xenocrystic quartz in a fine-grained crystalline matrix, Other lavas in this interval have no phenocrysts and exhibit a fine-grained crystalline matrix. Total interval is 3 to 15 m thick.

Trssv1 — **Interbedded sediment and andesite volcanic flows, stratigraphically between the Upper and Lower Luna Park Tuffs (upper Eocene to lower Oligocene)** – In the vicinity of Red Rock Arroyo, the lower 1.5-3 m consists of a reddish-brown pebble conglomerate in a sandy to silty matrix.. Overlying lavas in this interval include brown, foliated, porphyritic andesite(?) containing 3-5% phenocrysts in an aphanitic to crystalline matrix; phenocrysts include plagioclase, potassium feldspar, and pyroxene. ~15 m thick.

Tuffs below the Vicks Peak Tuff

Thm — **Hells Mesa Tuff (upper Oligocene)** – White to pink to peach-colored, lithic-poor (<5%), moderately welded tuff with 5-20% phenocrysts of quartz, biotite, sanidine, titanite, and sparse hornblende. 40Ar/39Ar age is 31.97±0.12 Ma (Chapin et al., 2004). Thickness is variable, ranging from 15 to 60 m.

Tlp — **Luna Park Tuff, undivided (upper Eocene)**

Tlpu — **Upper unit of Luna Park (upper Eocene)** – Gray to tan to white and contains phenocrysts of 5-15% sanidine, plagioclase, and biotite. Welding is variable, but generally most pronounced at the base and less welded near the top. The welded intervals are gray and can have rheomorphic fluidal textures. The top of Luna Park Tuff in the north-central part of the quadrangle has 5-10% lithic fragments (up to 0.5 m long), but most lithics are <15 cm in diameter. 75-120 m thick.

Tlpl — **Lower unit of Luna Park (upper Eocene)** – Near its base, this unit has 15-25% sanidine as well as subordinate biotite, plagioclase, magnetite, and a trace of quartz; near the top of the unit there is 2-15% lithic fragments. The top of this unit near Luna Park Campground is gray, welded, and contains 3-5% biotite, sanidine, and plagioclase phenocrysts with a trace of quartz; the unit here has <1% 5mm lithics. The top of the lower Luna Park Tuff on the east side of Red Rock Arroyo and in the southeastern quadrangle has 10-15% lithic fragments. In the southeastern quadrangle, this unit is relatively thin (6-15 m), has 10-15% fiame (up to 18 cm long), 1-25% volcanic lithic fragments, and contains 5-10% sanidine (up to 5 mm long), 1-3% biotite, and 0.5% hornblende. A basal 1-3 m-thick vitrophyre may be present. Pumice in less welded section is crystal-poor and vapor-phase altered. 10-100 m thick.

Ttad — **Tuff of Aragon Draw (upper Eocene)** – A lapilli- and volcanic block-rich, upward-coarsening, inferred ash-fall tuff whose basal 1-12 m is commonly welded (see **Ttadw**, below). Overlying the welded zone is a reddish, massive, breccia-like, generally indurated zone consisting of scattered pebble- to cobble-size clasts (minor boulder-size) in a silt to fine-grained sand matrix. Rheomorphic textures are commonly observed. About 25-30 m thick, not including the lower welded unit.

Ttadw — **Welded basal part of Tuff of Aragon Draw** – Lower 1-12 m of the aforementioned tuff that is pale red to reddish gray and contains 10-20% flattened pumices (fiame). Phenocrysts include trace to 12% (mostly <8%) mafic grains (hornblende and biotite) and 5-20% sanidine-dominated potassium feldspar. Thickness increases to the south.

Ttjmc — **Tuff of Jose Maria Canyon (upper Eocene)** – Light gray (weathering gray or tannish orange), largely aphanitic tuff. Correlative to the Jose Maria andesite of Farkas (1969). Occupies a similar stratigraphic position as the tuff of Aragon Draw (**Ttad**) and may possibly be associated with that ash-fall event. Contains trace amounts of medium-grained, euhedral sanidine and sparse lithic fragments up to 1.2 cm (0.5 in) across. Approximately 40 m thick.

Red Rock Ranch Formation (upper Eocene) – Interbedded volcaniclastic sediment, lake sediment, and trachyandesite-dacite flows that lie largely below regional tuffs (i.e., below the Luna Park

Trrs — **Seferino Hill conglomerate** – Brownish red, well indurated conglomerate containing clasts up to 1.5 m long. Clasts lithologies dominated by Jose Maria tuff and Whiskey Hill hornblende-bearing andesite. Approximately 35-65 m thick.

Trrst — **Tuffaceous, fine-grained sediment (upper Eocene)** – Tuffaceous, massive sediment in the southeastern part of the quadrangle that lies stratigraphically between units **Ttad** (bottom) and **Tlpl** (top). Thickness is poorly constrained, but is at least 15 m, and the unit thins to the northwest.

Trrtu — **Upper trachyte (upper Eocene)** – Bluish-gray lava that contains <1% phenocrysts of plagioclase in an aphanitic to crystalline matrix. The lava filled rugged paleotopography that developed on top unit **Trraq**. Thickness is variable, ranging from 20-45 m, and pinches out to the east.

Trrsu — **Upper volcanclastic sediment (upper Eocene)** – Reddish gray to light greenish maroon, volcaniclastic sediment consisting of siltstone and sandstone, with minor pebbly sandstone. Laminated to very thin, tabular beds. Unit is preserved between the upper trachyte (**Trrut**) and the Questa Spring andesite (**Trraq**) on the west side of Red Rock Arroyo. At least 5 m thick.

Trraq — **Andesite of Questa Spring (upper Eocene)** – Brownish to greenish gray lava, highly porphyritic andesite. Phenocrysts include 30-50% plagioclase, with lesser amounts of pyroxene and magnetite. The plagioclase crystals are < 1 cm and generally 5 to 8 mm long. Unit overlies the Tuff of Aragon Draw in upper Uvas Canyon. Thickness ranges from 30-90 m, pinching out to the south.

Trrsm — **Middle sediment tongue (upper Eocene)** – Fine-grained sand (loess) and volcaniclastic sandy pebbles that lie stratigraphically between the Red Rock Arroyo andesite (**Trrr**) and the tuff of Aragon Draw (**Ttad**). Massive to weakly consolidated. 1-10 m thick.

Trrr — **Red Rock Arroyo andesite (upper Eocene)** – Gray (typically weathering to light brown to reddish brown), vesicular, ledge-forming, plagioclase-phyric lavas with minor pyroxene phenocrysts. Phenocrysts include 7-25% plagioclase and 0.5-5% pyroxene. Hornblende is locally seen (trace to 3%, 1-15 mm), especially north of Red Rock Ranch. North of Seferino Hill, these occur as tongues in the Whiskey Hill member. 50-110 m thick, being thickest near Forest Road 139 and thinning to the north and south.

Trrl — **Luna Peak trachyandesite (upper Eocene)** – Gray to light gray (weathering to brown or light brown), plagioclase-megacrystic trachyandesite flows, where >10% of the plagioclase phenocrysts are =10 mm. Very porphyritic and vesicular. Phenocrysts include 40-70% plagioclase, which are commonly aligned, and 0.5-7% pyroxene. Groundmass is =0.2 mm and composed of plagioclase with minor mafic grains. 120 m thick in the north-central part of the quadrangle, thinning to the south-southeast until it pinches out near Jose Maria well.

Trrp2 — **Upper Placitas Canyon member (upper Eocene)** – Interbedded shale and limestone, with sandstone beds becoming more common to the north. The main body lies stratigraphically between the top of the Uvas basaltic trachyandesite and the base of the Luna Peak trachyandesite; however, 1-5 m-thick interbeds of this unit are present in the overlying Luna Peak trachyandesite. 1-50 m thick, thinning to the north. Not mapped where it is less than 3 m thick.

Trrael — **Andesite east of Luna Peak (upper Eocene)** – Relatively fine-grained, gray, porphyritic, vesicular andesite. Located on the west slopes of Luna Peak and lies stratigraphically between the Garcia Falls trachyandesite (bottom) and Luna Peak andesite (top). Correlates to Hermann's (1986) upper andesite member of the Red Rock Ranch Formation. Phenocryst assemblage includes: 25-40% plagioclase and 1-10% pyroxene. Approximately 100-120 m thick.

Trrrs — **Rhyolite east of Stanley Springs (upper Eocene)** – Light bluish to light greenish gray, porphyritic, relatively fine-grained lava that forms cliffs on the hill immediately southeast of Stanley Spring. Typically is well foliated. Probably rests on top of the Garcia Falls andesite and may occupy the same stratigraphic position as unit Trrael. Phenocrysts include: 10-15% hornblende, 8-10% potassium feldspar + lesser plagioclase, and 1-3% quartz. Aphinitic groundmass. 100-110 m thick.

Trrg — **Gracia Falls trachyandesite (upper Eocene)** – Greenish gray to gray (weathering to brown), porphyritic, vesicular, fine- to coarse-grained trachyandesite. Although the unit appears to extend slightly over the Uvas Canyon member in a southward direction, in general the two units interfinger with one another. Phenocrysts include 15-80% plagioclase that are locally aligned, 5-10% pyroxene, and trace to 1% hornblende. Commonly altered to chlorite-epidote±albite assemblage, especially near the Deep Canyon Fault. At least 400 m thick.

Trru — **Uvas Canyon basaltic trachyandesite (upper Eocene)** – Gray to dark gray, porphyritic, relatively coarse-grained basaltic trachyandesite whose weathered surfaces are typically varnished. Generally conformably bounded above and below by tongues of the Placitas Canyon member. Phenocrysts include: 30-70% plagioclase, 3-10% pyroxene, trace to 5% megacrysts of plagioclase and pyroxene (10-18 mm long), and trace olivine(?). Aphinitic groundmass. Chlorite locally is an alteration product and phenocrysts may be altered to goethite or limonite. 300-480 m thick.

Trrp1 — **Lower Placitas Canyon member (upper Eocene)** – Laminated shale interbedded with sandstone and silty sandstone. To the west, strata transition up-section from light greenish gray, sandstone-dominated sediment to tan-yellow-gray sandstone to horizontal laminated, light to dark gray shale. Entire unit is 15-60 m thick and thickens to the northwest.

Trrup — **Uvas Canyon basaltic trachyandesite lavas interbedded with the Placitas Canyon Member (upper Eocene)** – Uvas Basaltic Andesites, as described above (**Trru**), that are interbedded with sediment correlative to the Placitas Canyon Member. 20-25 m thick.

Whiskey Hill member (upper Eocene) – Thickness of entire unit is about 320-330 m. Differentiated into several subunits:

Trrws — **Volcaniclastic sedimentary rocks interbedded with hornblende-phyric dacite** – Light gray to light bluish gray or purplish gray (weathering orange-tan or maroon-brown), volcaniclastic pebble-cobble gravel and fine-grained sandstone; interbedded with fine- to medium-grained dacite flows with the following phenocrysts: 38% plagioclase phenocrysts, trace to 14% biotite, trace to 8% hornblende, and trace to 7% pyroxene. Approximately 130 m thick.

Trrwsj — **Jasperized volcaniclastic and sedimentary rocks** – Strata correlative to unit **Trrws** that have been replaced and cemented by jasper. 20-25 m thick.

Trrwa — **Plagioclase-phyric andesites of Whiskey Hill member** – Porphyritic andesite containing 10-30%, aligned plagioclase phenocrysts and 1-5% pyroxene +/- hornblende phenocrysts.

Trrwhe — **Equigranular hornblende-phyric dacite (upper Eocene)** – Equigranular, hornblende-bearing dacite.

Trrwhn — **Dacite with needle-like hornblende phenocrysts** – Porphyritic dacite lava with 10% needle-like hornblende phenocrsyts; other phenocrysts include plagioclase laths and pyroxene. Locally plagioclase-phyric.

Trrwx — **Crystal-rich dacite** – Crystal-rich dacite lava with phenocrysts that include gray feldspar, hornblende, and pyroxene.

Trrwr — **Rhyolite lava in eastern quadrangle** – Flow-laminated, reddish gray to pale red, aphinitic rock interpreted as a rhyolite.

Trrwbu — **Upper biotite-bearing dacite** – Thin (2 m-thick), porphyritic dacite lava with phenocrysts of plagioclase, pyroxene, hornblende, and a trace of biotite. 3% xenoliths.

Trrwp — **Pyroxene-bearing dacite** – Pyroxene-bearing, porphyritic dacite with 15% phenocrysts of plagioclase, potassium feldspar, hornblende, and pyroxene.

Trrwh — **Hornblende-bearing dacite** – Hornblende-bearing, porphyritic dacite with 4-30% phenocrysts that include plagioclase, hornblende, and pyroxene.

Trrwt — **Tuff** – Dacitic tuff, pink to white, where lithics are more common near the top. Contains phenocrysts of hornblende, pyroxene, and biotite. 1 m thick.

Trrwk — **Potassium-bearing dacites** – Crystal-rich lava that contains phenocrysts of potassium feldspar (< 1 cm long).

Trrwb — **Biotite-bearing dacite** – Dacite with biotite and hornblende phenocrysts.

Trrwl — **Porphyritic dacite that includes the following phenocrysts: hornblende, pyroxene, and plagioclase** . At least 60 m thick.

Paleozoic bedrock

Pennsylvanian Magdalena Group

IPbj / IPnj / IPrj — **Jasperoids replacing sedimentary strata of the Bar B, Nakaye, and Red House formations (Pennsylvanian?)** – Pervasively silicified carbonate, sandstone, and conglomerate. Drusy quartz and globular chalcedony commonly fill voids. Individual outcrops are 2-4 m (7-13 ft) thick.

IPb — **Bar B Formation (upper Desmoinesian-Missourian)** – Dark gray to dark brownish gray, thin- to medium-bedded limestone overlain by shale and conglomerate (containing pebbles and granules of limestone, dolostone, and chert). Approximately 75 m thick.

IPn — **Nakaye Formation (upper Atokan to middle Desmoinesian)** – Light tannish to dark maroon-gray, ledge- to cliff-forming, blocky weathering, thin- to thick-bedded limestone. Sparse covered intervals are probably underlain by poorly exposed, grayish yellow shale. Approximately 330 m thick.

IPr — **Red House Formation (upper Morrowan to Atokan)** – Interbedded, maroon to pinkish white, quartzose sandstone and conglomerate, dark gray shale, and light gray- to yellowish tan-weathering limestone. Approximately 555 m thick.

Subsurface Units (Cross section only)

Qau — **Quaternary deposits, undivided (0 years old to upper Holocene)** – Valley bottom units principally comprising Qam, Qah, Qar, and/or Qay. Maximum thickness 5 m (16.4 ft).

Tvu — **Oligocene volcanic strata, undivided (lower Oligocene)** – Includes andesite-latite of Montoya Butte and perhaps associated basal mudflow breccia (Maldonado, 2012). Maximum thickness ~900 m (2953 ft) according to Jahns (1955).

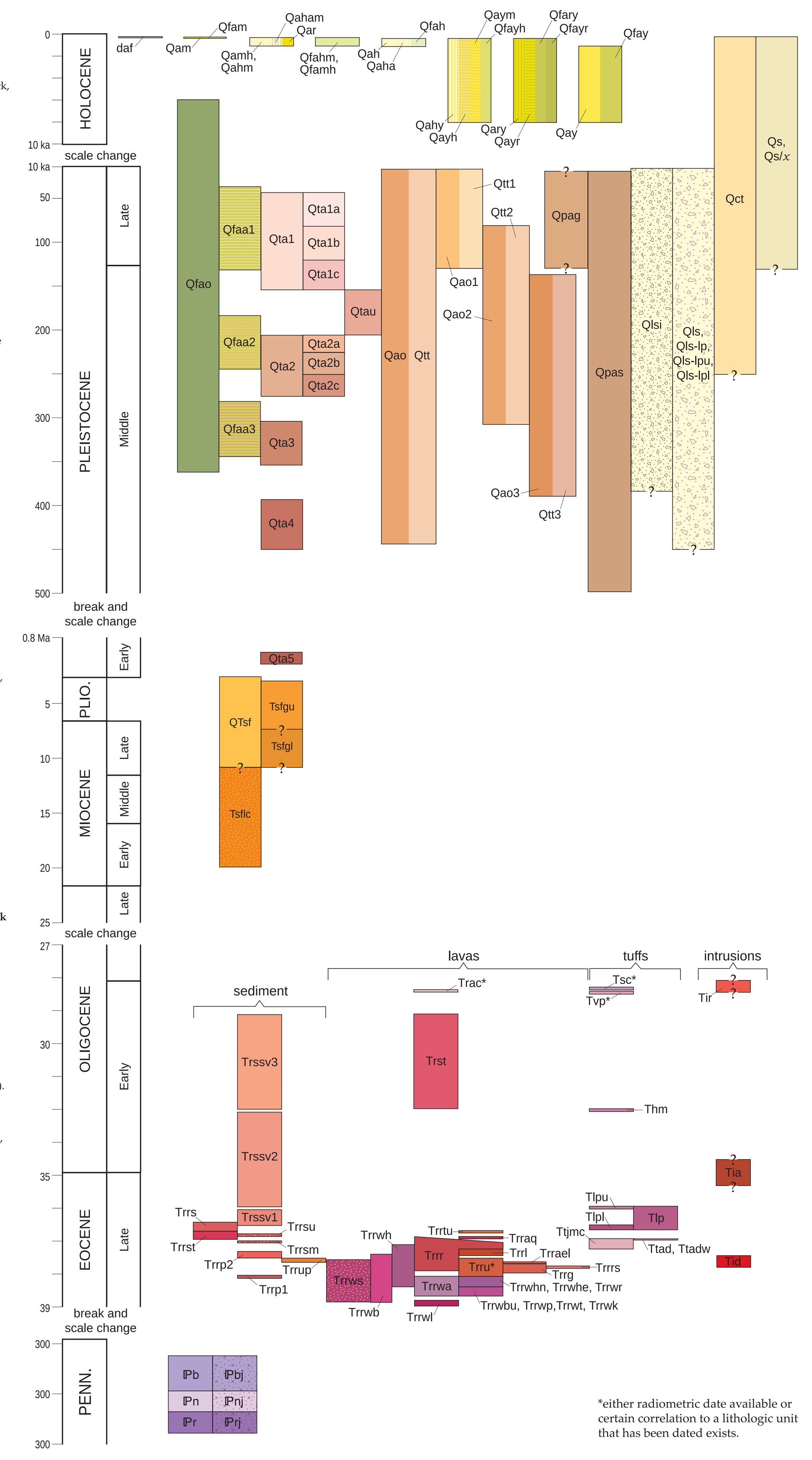
Ku — **Cretaceous strata, undivided (upper Cretaceous)** – Includes the McRae Formation, Dakota Sandstone, and Mancos Shale. Maximum thickness of ~200 m (656 ft) extrapolated from the Gartland 1 Brister exploratory well (Cikoski and Koning, 2013).

Pu — **Permian strata, undivided (lower to upper Permian)** – Includes the San Andres, Yeso, Abo, and Bursum formations. Mostly siliciclastic beds interbedded with limestone and gypsum in places. Maximum thickness of ~525 m (1723 ft) extrapolated from the Gartland 1 Brister exploratory well (Cikoski and Koning, 2013).

Pzu — **Lower Paleozoic strata, undivided (Cambrian through Ordovician)** – Includes the Bliss Sandstone, El Paso Group, and Montoya Formation. The Bliss Sandstone is overlain by a thick sequence of limestone and dolostone. Silurian and Devonian strata are absent in the northern Mud Springs Mountains (Maxwell and Oakman, 1990), and are likely not present in cross-section A-A′. Maximum thickness of ~230 m (755 ft) extrapolated from the West Elephant Butte Federal No. 1 well (Cikoski and Koning, 2013).

XYu — **Proterozoic strata, undivided (Meso- to Neoproterozoic)** – Reddish gray quartzite, dark gray to brown quartz schist, quartz-biotite schist, foliated amphibolite, and reddish, porphyritic granitic gneiss. Complexly interlayered and contorted (Maxwell and Oakman, 1990).

Correlation Of Map Units



*either radiometric date available or certain correlation to a lithologic unit that has been dated exists.

Explanation of Map Symbols

- Location of geologic cross section
- Geologic contact. Solid where exposed or known, dashed where approximately known, queried where uncertain.
- Probable geologic contact. Solid where location accurate, dashed where location approximate.
- Gradational geologic contact, location accurate.
- Gradational geologic contact, location approximate.
- Generic dip-slip fault. Solid where exposed, dashed where approximately known, dotted where concealed, queried where uncertain.
- Probable generic dip-slip fault. Solid where location accurate, dashed where location approximate.
- Normal fault. Solid where exposed, dashed where approximately located, dotted where concealed, queried where uncertain. Tic shows fault plane dip value and direction.
- Probable normal fault. Solid where location accurate, dashed where location approximate, dotted where location uncertain.
- Right lateral strike-slip fault, location accurate.
- Left lateral oblique-slip fault, location accurate.
- Stratiform lineament of jasper silicification, ~4 m-thick. Mostly white to red and dipping 55 degrees to SE.
- Trrp2 — Undivided marker-beds within the Placitas Canyon member interval, solid where location accurate, dashed where location approximate.
- Undifferentiated intrusions, likely felsic. In northern Serefino Canyon, this unit is a highly weathered sill with maroon, clay-rich material at the surface. Solid where location accurate, dashed where location approximate.
- Tia — Gray dikes that variably have a fine-grained, equigranular matrix with no obvious phenocrysts or are slightly porphyritic (<<1% plagioclase and pyroxene <2 mm across) with an aphanitic matrix.
- Tir — Upper Oligocene rhyolitic intrusions filling dikes and stocks that are composed of potassium feldspar and lesser quartz phenocrysts. Solid where location accurate, dashed where location approximate.
- Tid — Upper Eocene dacite dikes, light gray and composed of plagioclase with 7% hornblende, 2-4% biotite, and <5% quartz. Solid where location accurate, dashed where location approximate.
- Small, minor fault—Showing strike and dip
- Small, minor vertical joint
- Small, minor inclined joint, showing dip
- Horizontal bedding
- Vertical bedding
- Strike and dip of inclined bedding
- Inclined bedding, where top direction of beds is known from local features—Showing strike and dip
- Inclined bedding, as determined remotely or from aerial photographs—Showing approximate strike and direction of dip
- Inclined flow banding, lamination, layering, or foliation in igneous rock — Showing strike and dip
- Location of radiometric date sample
- Location of geochemistry sample
- Paleocurrent vectors; tail of arrow is located at measurement. Measurements taken from: channel-axis (c), imbrication (i), or tool marks, grooves (t).

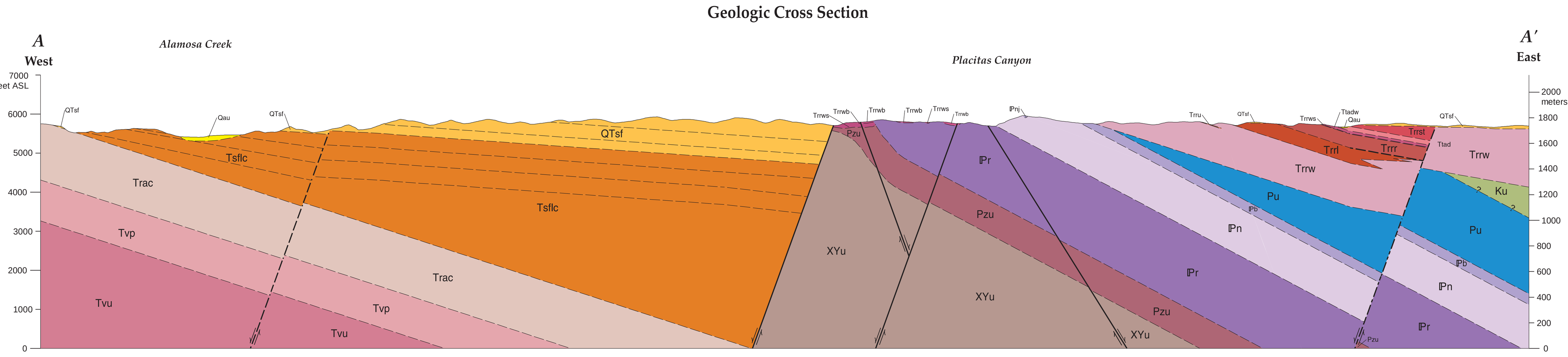
Comments To Map Users

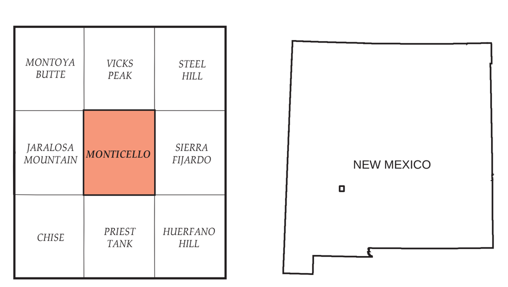
A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology and Mineral Resources. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government.

Geologic Cross Section





QUADRANGLE LOCATION

Magnetic Declination
Nov. 2011
9.30º East
At Map Center

1:24,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

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This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

DRAFT

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 245

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act (Award Number: G13AC00186), administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

Geologic map of the Monticello 7.5-minute quadrangle, Sierra County, New Mexico.

June 2014

by
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