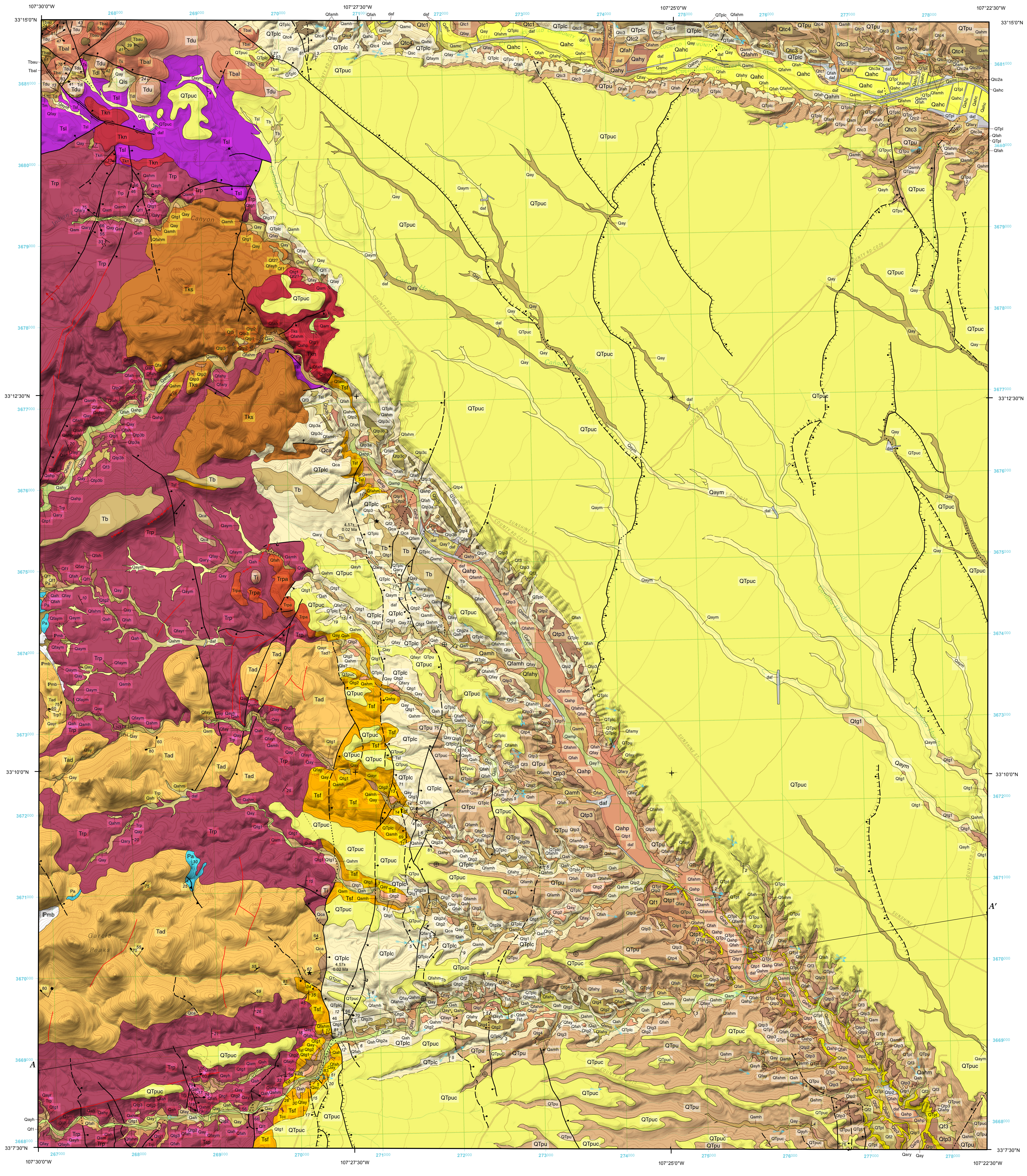
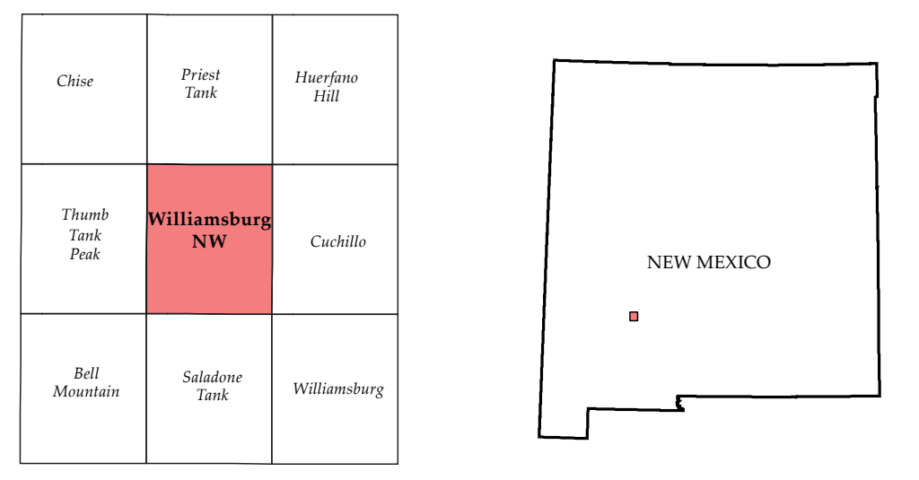
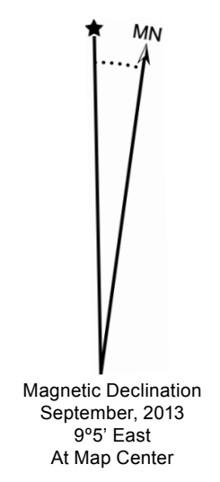


Base map from U.S. Geological Survey 2010.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 13S
10 000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in blue.

Roads............©2006-2010 Tele Atlas
Names............GNIS, 2008
Hydrography............National Hydrography Dataset, 2005
Contours............National Elevation Dataset, 2000





Magnetic Declination
September, 2013
9°5' East
At Map Center

Quadrangle Location

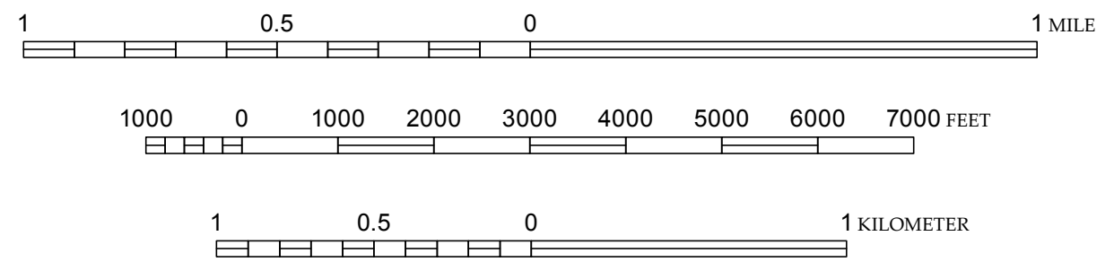
New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico 87801-4796

[575] 835-5490

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

http://geoinfo.nmt.edu

1:24,000



CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1988

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act (Fund Number G14A500006), 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, *Assoc. Director for Mapping Programs*).

This geologic quadrangle was originally mapped using photogrammetry and field observations at a scale of 1:12,000. This data was then generalized to a scale of 1:24,000 for the publication of this 7.5-minute quadrangle. The 1:12,000 GIS data is available on the New Mexico Bureau of Geology and Mineral Resources website http://geoinfo.nmt.edu/publications/maps/geologic/home.html for download.

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 251

Geologic Map of the Williamsburg NW 7.5-Minute Quadrangle, Sierra County, New Mexico

June, 2015

by
Andrew P. Jochems[1]

[1] *New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM 87801*

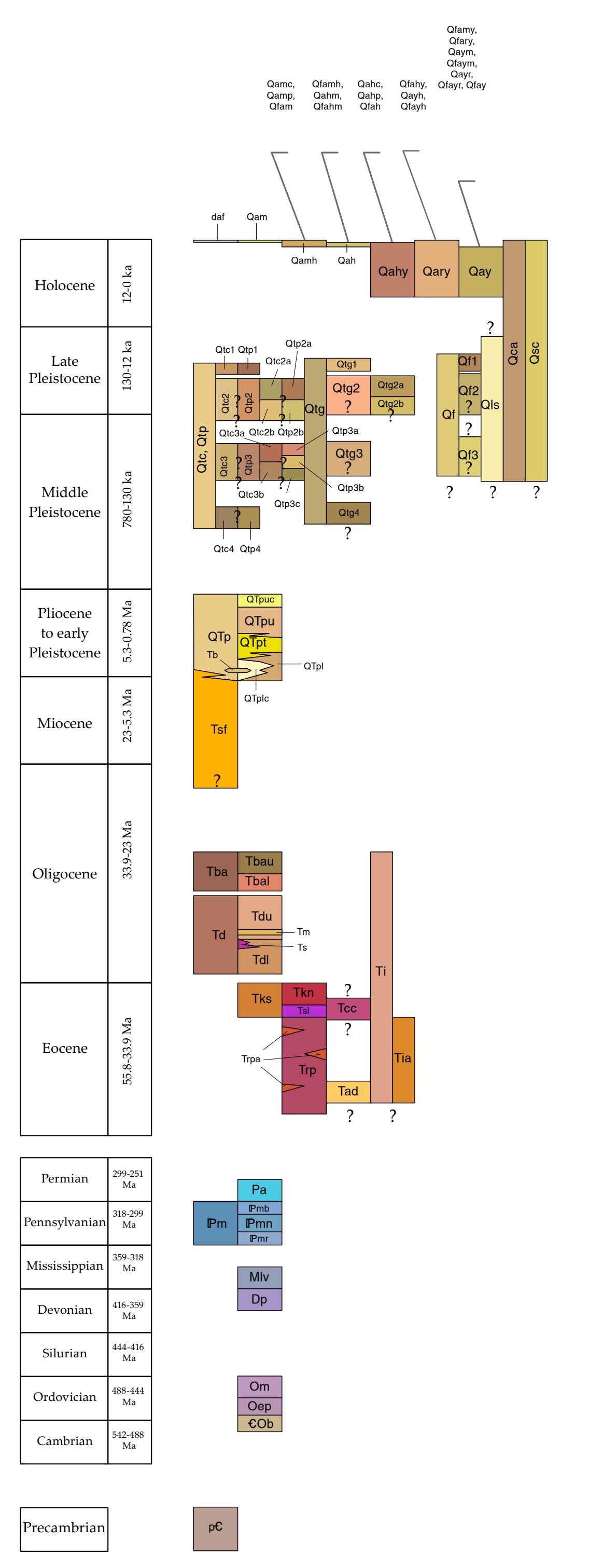
Comments to Map Users

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.

Correlation of Map Units



Explanation of Map Symbols

—— — — ·····?	Geologic Contact—Identity and existence certain. Solid where exposed, dashed where intermittent, and dotted where concealed. Queried where identity or existence is questionable.
—— — — ·····?	Fault—Identity and existence certain. Solid where exposed, dashed where intermittent, and dotted where concealed. Queried where identity or existence is questionable.
—— — — ·····?	Normal Fault—Identity and existence certain. Solid where exposed, dashed where intermittent, and dotted where concealed. Queried where identity or existence is questionable. Bar and ball on downthrown block.
⇄	Oblique-slip Fault, right-lateral offset—Identity and existence certain, location accurate. Arrows show relative motion.
▼	Thrust Fault—Identity and existence certain, location accurate. Sawteeth on upper (tectonically higher) plate.
┬┬┬	Scarp on normal fault—Solid where exposed, dashed where intermittent. Hachures point downscarp.
‖‖‖	Gradational contact—Identity and existence certain, location accurate.
—	Dike—Identity and existence certain, location accurate
+++	Dike —Identity and existence certain, location accurate
↕	Anticline—Identity or existence questionable, location accurate
★	Selected locality; location of radiometrically dated sample
⊕	Horizontal bedding
4	Inclined bedding—Showing strike and dip
4	Inclined flow banding, lamination, layering, or foliation in igneous rock—Showing strike and dip
◇	Vertical flow banding, lamination, layering, or foliation in igneous rock—Showing strike
●	Inclined magmatic foliation
79	Inclined fault—Showing dip value and direction
+	Vertical or near-vertical fault
4	Small, minor inclined joint—Showing strike and dip
■	Small, minor vertical or near-vertical joint—Showing strike
4	Small, minor inclined (dip direction indicated with tic) joint, for multiple observations at one locality—Showing strike and dip
■	Small, minor vertical or near-vertical joint, for multiple observations at one locality—Showing strike
4	Inclined slickenline, groove, or striation on fault surface—Showing bearing and plunge
↑	Fluvial transport direction
↑ 8	Sediment transport direction determined from imbrication
∾	Spring—tail in direction of spring outflow
A ⊢⊣ A′	Cross section line and label

Description of Map Units

Quaternary

Qca	**Colluvium and alluvium, undivided**—Poorly sorted gravel with subordinate silt and sand forming aprons at the base of high angle slopes. Gravel are typically angular to subangular. Maximum thickness ≤6 m.
Qsc	**Sheetwash and colluvium, undivided**—Pebbly silt and silty to sandy gravel in wedges prograded over terrace deposits and in the hanging walls of low relief fault scarps, unconsolidated, somewhat to moderately calcareous, and massive. Color reflects source lithology; for example, reddish-brown (5YR 5/4) to dark-yellowish-brown (10YR 4/4). Stage I carbonate morphology observed in upper part, with occasional stage II–III paleosols. 0.8-2.1 m thick.
Qls	**Landslide deposit**—Unstratified/massive sand and gravel comprising translational slide material, weakly consolidated, gravel is poorly sorted, angular to subrounded, and consists of pebbles, cobbles, and up to 20% boulders, light-yellowish-brown to pale-brown (2.5Y 6-7/3) matrix. Deposits are located on failure planes formed on weak volcaniclastic material or on over-steepened, fault-bound slopes. ≤8 m thick.
daf	**Disturbed or artificial fill**—Sand and gravel that has been moved by humans to form earthen dams or has been removed for construction.
Qam	**Modern alluvium**—Unconsolidated sandy gravel and gravelly sand underlying channels and forming transverse to longitudinal bars with 0.7–1.25 m of local relief. Thickness likely ≤3 m. Unit subdivided along two major drainages in quad.
Qamc	**Modern alluvium of Cuchillo Negro Creek**—Dark-grayish-brown (10YR 4/2), massive to trough cross-bedded to well imbricated, and clast lithologies are approximately 45% adesite+dacite, 30–35% Paleozoic carbonate and detrital sedientary lithologies, 20% felsite and 5–10% chert and conglomerate. Lithic sand grains are somewhat less heterogeneous than **Qamp**.
Qamp	**Modern alluvium of Palomas Creek**—Gray to grayish-brown (10YR 5/1-2), massive to rippled to well imbricated, and clast lithologies are approximately 40% andesite, 30% felsite, 15–20% diorite, and 10–15% basalt and Palezoic sedimentary lithologies. Sand typically contains more mafic and chert grains than **Qamc**.
Qamh	**Modern and historical alluvium, undivided**
Qah	**Historical alluvium**—Pebbly sand and sandy gravel underlying very low terraces in valley bottoms, unconsolidated, clast to matrix-supported, and tabular to lenticular. Retains bar-and-swale topographywith up to 50 cm of relief. May be horizontally laminated. Tread height up to 1.6 m above modern grade. Perhaps up to 3 m maximum thickness. Unit subdivided along two major drainages in quad.
Qahc	**Historical alluvium of Cuchillo Negro Creek**—Massive to well imbricated to trough cross-stratified, sandy pebble-cobble gravel and clayey sand; latter may be horizontally lamiated, clast lithologies dominated by **Tba** and **Tkn** with subordinate **Pa**, with a brown (10YR 4/3) matrix. Sandy beds typically thinner and more tabular than gravelly beds. Deposit is capped by an A horizon (<10 cm thick).
Qahp	**Historical alluvium of Palomas Creek**—Silty, very fine- to fine-grained sand and pebble-cobble gravel; latter are imbricated, internally ripple cross-laminated to planar or trough cross-stratified, with a brown (10YR 4-5/3) matrix. Upper 40 cm consists of moderately calcareous sandy silt and 5–20% clay. Clast lithologies dominated by **Tb**, **Tad**, various Eocene–Oligocene andesites and **Pa**.
Qahm	**Historical and modern alluvium, undivided**
Qahy	**Historical and younger alluvium, undivided**
Qary	**Recent (historical + modern) and younger alluvium, undivided**
Qay	**Younger alluvium**—Sandy gravel underlying low terraces in valley bottoms, unconsolidated strongly calcareous, tabular, and massive to moderately imbricated, dark-yellowish-brown (10YR3/6), a darker and browner color than other valley bottom units. Retains subdued bar-and-swale topography with less than 30 cm of local relief. Dark A horizon is observed in upper 20 cm. No varnish observed on clasts at surface. Tread height 1.8–4 m above modern grade. Maximum thickness of 4 m.
Qaym	**Younger and modern alluvium, undivided**
Qayh	**Younger and historical alluvium, undivided**
Qayr	**Younger and recent (historical + modern) alluvium, undivided**
Qtc	**Terrace deposit of Cuchillo Negro Creek**—Imbricated, sandy gravel occuring in fill and strath terrace deposits with surfaces higher than those associated with **Qay**. Clast compositions are dominated by intermediate to felsic, Eocene–Oligocene volcanic lithologies derived from the Sierra Cuchillo to the west with subordinate Paleozoic sedimentary lithologies (especially **Pa**). Locally subdivded into four main deposits:
Qtc1	**First or lowest terraces deposit of Cuchillo Negro Creek**—Sandy, pebble-cobble-boulder gravel in mostly tabular beds with yellowish-brown (10YR 5/4) matrix. Stage I carbonate morphology (weak carbonate cement). Varnish on 10–15% of clasts at surface. Tread is 5–11 m above modern grade. 1.7–3.8 m thick.
Qtc2 Qtc2a Qtc2b	**Second or middle-lower terrace deposit of Cuchillo Negro Creek**—Sandy, pebble-cobble gravel in tabular beds witha brown (7.5YR 4-5/4) matrix. Lower 40 cm moderately well cemented by clay (bridges). Stage I+ carbonate morphology in upper 50 cm indicated by carbonate coats on 70–90% of clasts. Varnish on 55–70% of clasts at surface. Locally subdivded into two deposits: **Qtac2a** and **Qtac2b** with treads 15–16 and 20–24m above modern grade respectively. 4–11 m thick.
Qtc3 Qtc3a Qtc3b	**Third or middle-upper terrace deposit of Cuchillo Negro Creek**—Sandy, pebble-cobble gravel in tabular to lenticular beds, may be planar cross-stratified with a reddish-brown (5YR 5/4) matrix. Soil development uncommon (likely eroded). Varnish on 40–45% of clasts at surface. Locally subdivided into 2 deposits: **Qtac3a** and **Qtac3b** with treads 28–32 m and 33–45 m above modern grade, respectively. 6–8 m thick.
Qtc4	**Fourth or upper terrace deposit of Cuchillo Negro Creek**—Sandy, pebble-cobble-boulder gravel in lenticular to tabular beds, may feature vague trough cross-stratification with a strong brown (7.5TY 5/6) matrix. A 30 cm thick zone of strage III carbonate morphology is observed in places. Varnish on 40–80% of clasts at surface. Tread is 54–67 m above modern grade. 3–11 m thick.
Qtp	**Terrace deposit of Palomas Creek**—Imbricated, sandy gravel occuring in fill and strath terrace deposits with surfaces higher than those associated with **Qay**. Clast compositions are dominated by **Tad** and other volcanic lithologies derived from the eastern Black Range and Garcia Peaks, with subordinate Paleozoic sedimentary lithologies (especially **Pa**). Locally subdivided into four main deposits:
Qtp1	**First or lowest terrace deposit of Palomas Creek**—Sandy, pebble-cobble-boulder gravel in broadly lenticular beds, massive to well imbricated to trough cross-bedded, with a yellowish brown (10YR 5/4) matrix. Rarely, beds have up to 35% clasts with whole or partial Mn-oxide coats. Stage I+ carbonate morphology observed in upper 1.3 m where 45% of clasts have partial carbonate coats. Varnish on 10–15%of clasts at surface. Tread is 9–13 m above modern grade. 3–7 m thick.
Qtp2 Qtp2a Qtp2b	**Second or middle-lower terrace deposit of Palomas Creek**—Sandy, pebble-cobble-boulder gravel in tabular beds, rare sand lenses, with a brown (7.5YR 4/3) matrix that may containing up to 5% clay films. Locally subdivded into two deposits: **Qtap2a** and **Qtap2b** with treads 14–17 and 17–22 m above modern grade, respectively. 2–5 m thick.
Qtp3 Qtp3a Qtp3b Qtp3c	**Third or middle-upper terrace deposit of Palomas Creek**—Sandy, pebble-cobble-boulder gravel in broadly lenticular beds, well imbricated with subordinate cross-stratification, with a brown to light-brown (7.5Yr 5-6/3) matrix. Deposit exhibits stage I+ carbonate morphology with 50% of clasts coated up to 80% by carbonate rinds. Varnish on 40–50% of clasts at surface. Locally subdivded into three deposits: **Qtap3a**, **Qtap3b**, and **Qtap3c** with treads 27–34, 33–38, and 38–40 m above modern grade, respectively. 2–7 m thick.
Qtp4	**Fourth or upper terrace deposit of Palomas Creek**—Sandy, pebble-cobble-boulder gravel with a brown (7.5Yr 4-5/3) matrix. Varnish on 55–75% of clasts at surface. Soil development uncommon (likely eroded). Tread is 48–53 m above modern grade. 3–7 m thick.
Qtg	**Tributary terrace deposit**—Relatively thin sandy gravel underlying terraces alongside drainages other than Cuchillo Negro and Palomas creeks. Surfaces typically feature weakly to moderately varnished clasts and exhibit topsoils with weak calcium carbonate accumulation (stage I–II carbonate morphology). Locally subdivided into four deposits.
Qtg1	**First or lowest tributary terrace deposit**—Sandy, pebble-cobble-boulder gravel in lenticular beds, unconsolidated and very weakly calcareous with a brown (7.5YR 4/4) matrix. Tread is 5–8 m above modern grade. 3–4 m thick.
Qtg2 Qtg2a Qtg2b	**Second or middle-lower tributary terrace deposit**—Sandy, pebble-cobble gravel in tabular to lenticular beds, unconsolidated and massive to imbricated with a brown (7.5Yr 4/4) matrix. Surface features very weakdesert pavement. Locally subdivded into two deposits: **Qtg2a** and **Qtg2b** with treads 10–12 and 14–23 m above modern grade, respectively. 3–9 m thick.
Qtg3	**Third or middle-upper tributary terrace deposit**—Sandy gravel in medium- to thick-, tabular to lenticular beds, unconsolidated and well imbricated. Tread is 26–30 m above modern grade. 5–6 m thick.
Qtg4	**Fourth or upper tributary terrace deposit**—Sandy gravel in medium- to thick-, tabular to lenticular beds, unconsolidated and well imbricated. Tread is 34–33 m above modern grade. 3–7 m thick.
Qfam	**Modern fan alluvium**—Sandy gravel in channels and low-lying bars of modern fan surfaces, unconsolidated and commonly imbricated, dark-brown (10YR 3/3), and commonly contains up to 20% boulders. Generally inset against **Qfah** or **Qfay**. Thickness likely ≤ 3 m.
Qfamh	**Modern and historical fan alluvium, undivided**
Qfamy	**Modern and younger fan alluvium, undivided**
Qfah	**Historical fan alluvium**—Sandy gravel and pebbly sand underlying alluviual fans graded to the surface of **Qfah**, unconsolidated, slightly calcareious, and clast- to matrix-supported, with a brown (7.5Yr 4/4) matrix. Deposit features upper A horizon 11 cm thick; otherwise, little to no soil/carbonate development. 0.6 to perhaps 3 m thick.
Qfahm	**Historical and modern fan alluvium, undivided**
Qfahy	**Historical and younger fan alluvium, undivided**
Qfary	**Recent (historical + modern) and younger fan alluvium, undivided**
Qfay	**Younger fan alluvium**—Pebbly sand and gravel underlying alluvial fans graded to the surface of **Qfay**; loose, clast- to matrix-supported, and tabular to lenticular with wavy beds, with clasts that may be in an open-framework texture with weak-clay flims, and a brown (10Yr 4-5/3) matrix. Deposit is capped by topsoil with a weak 8–12 cm thick A horizon. Stage I+ carbonate morphology occcasionally observed. Base not observed in thickest deposits; perhaps up to 3 m maximum thickness.
Qfaym	**Younger and modern fan alluvium, undivded**
Qfayh	**Younger and historical fan alluvium, undivided**
Qfayr	**Younger and recent (historical + modern) fan alluvium, undivded**
Qf	**Older alluviual fan deposits**—Sandy gravel occurring in fan deposits graded to sufaces associated with **Qtc1**, **Qtp1**, **Qtg1**, **Qtc2**, **Qtp2**, **Qtg2**, **Qtc3**, and **Qtg3**. Locally subdivided into three deposits:
Qf1	**Alluvial fan deposits graded to lower terraces**—Sandy, pebble-cobble gravel in thin to thick, tabular beds, unconsolidated, strongly calcareous, clast- to matrix-supported, and massive to weakly imbricated, and a light-brown to light-yellowish-brown (7.5-10YR 6/4) matrix. Stage I carbonate morphology in upper 60 cm of deposit. 3–4 m thick.
Qf2	**Alluvial fan deposits graded to middle-lower terraces**—Sandy, pebble-cobble-boulder gravel in tabular beds, unconsoidated calcareous, and weakly imbricated, and a reddish-brown (5YR 4/4) to brown (7.5YR 5/4) matrix. Varnish on 60–70% of clasts at the surface. Maximum thickness 4 m.
Qf3	**Aluvial fan deposits graded to middle-upper terraces**—Sandy, pebble-cobbble gravel in medium- to very thick-tabular beds, weakly consolidated, and massive to weakly imbricated, matrix-supported, pinkish-gray to light-brown (7.5YR 6/2-3) matrix. Features stage II–III carbonate morphology in upper 70 cm. Maximum thickness 5 m.
QTpuc	**Upper, coarse-grained piedmont facies of the Palmoas Formation**—Sandy, pebble-cobble-boulder gravel in medium- to thick-, tabular to lenticular beds—rare pebbly sand lenses may be ripple laminated to trough cross-bedded—clast-supported and massive to imbricated, and a yellowish-red (5YR 5/6) matrix sand that is fine- to coarse-grained. Generally unconsoliated but locally features 1–1.5 m thick calcrete (stage IV carbonate morphology) in upper park. Basal contact is scoured. 9–45 m thick.
QTpu	**Upper piedmont facies of the Palomas Formation**—Sandy, pebble-cobble gravel interbedded with very fine- to medium-grained sand, silt, and mud, thin- to very thick-, tabular to lenticular beds, unconsolidated and non- to moderately calcareous—sandy beds may be planar cross-stratified—gravels are commonly imbricated and silt/mud is massive, redish-brown (5YR 5/4) with minor-brown (7.5YR 4/4) beds. Contains up to 25% clay chips and/or films. Cambic (Bw horizon) paleosols occasionally observed. 50–60 m thick.
QTpt	**Transitional piedmont facies of the Palomas Formation**—Pebbly sand and sandy-pebble gravel in thin- to thick-, mostly-tabular beds, moderately to strongly cemented by calcite, forming promient ledges, sand and gravel are massive to planar cross-stratified with occasional pebble imbrication, and commonly brown (7.5YR 4-5/3) with little to no clay in matrix. Paleosols uncommon. 10–15 m thick.
QTpl	**Lower piedmont facies of the Palomas Formation**—Pebbly, silt/mud to very fine- or fine-grained sand in eastern part of quad, mostly unconsolidated, and light-brown to pink (7.5YR 6-7/3). Massive with commonstage II–III carbonate morphology. 20–70 m thick.
QTplc	**Lower, coarse-grained piedmont facies of the Palomas Formation**—Pebble-cobble gravel in western part of quad that may be laterally gradational with fine-grained **QTpl** in northeastern part of quad, unconsolidated to moderately cemented by calcite, imbricated and/or planar or trough cross-stratified, and light-brownish-gray to pale-brown (!)YR 6/2-3). Lower part may be correlative to the Rincon Valley Formation of Seager et al. (1971). 20–350 m thick.

Tertiary

Tsf	**Santa Fe Group predating the Palomas Formation**—Pebbly sandstone and conglomerate in thin- to thick-, tabular to lenticular beds, moderately consolidated (silica or calcite cementation), massive to imbricated to cross-stratified—minor horizontal lamination in finer beds—Rare open-framework texture in gravels, and yellowish-red (5YR 5/6) to light-brown (7.5YR 6/4) to very-pale-brown (10YR7/3). Likely correlative to lower part of the Rincon Valley Formation of Seager et al. (1971). 105 m thick (Mayer, 1987).
Ti	**Undivided intrusive lithologies**—Dikes, sills, small stocks, and plugs composed of varying mafic to felsic lithologies. Commonly form prominent ledges or buttes.
Tm	**Mafic sill**—Black (N 2.5/), weathering dark-grayish-brown to grayish-brown (10YR 4-5/2), aphanitic-porphyritic, fine- to medium-grained, mafic sill intruding lower part of **Tdu**; phenocrysts include 3–6% plagioclase set in a glassy groundmass and contains deformed xenoliths of dusky red (10R 3/3), flow-banded, aphanitic lava. 2–11 m thick.
Tia	**Andesitic dike**—Light-gray, weathering orange-tan, fine- to medium-grained intrusive andesite forming dikes up to 30 m wide; phenocrysts include 3–14% plagioclase, 4–9% hornblende, and trace to 2% pyroxene. Chilled margins are 1.5–2.5 m wide.
Tad	**Andesite-quartz diorite stock**—Light-gray (N 7/), weathering gray to brown (7.5YR 5/1-2), porphyritic, fine- to coarse-grained, intrusive and andesite to quartz diorite, dense; phenocrysts include 8–10% hornblende, 5% biotite, trace to 3% plagioclase, and trace to 2% quartz. Forms main body of Garcia Peaks stock. An 40Ar/30Ar-dated sample returned an age of 40.35±0.05 Ma. Equivalent to units **Td** and **Tqd** of Mayer (1987). Thickness unknown.
Tb	**Basalt flows**—Dark-gray (N 4/), weathering gray to grayish-brown (!)YR 5/1-2), aphanitic to aphanitic-porphyritic, very fine- to medium-grained basalt, dense to somewhat vesicular or scoriaceous and commonly contains amygdules filled by calcite, silica, and/or zeolites; phenocrysts include 2–5% pyroxene and 2–3% olivine. The lowermost flow of the Palomas Creek basalts was dated at 4.57±0.02 Ma (40Ar/39Ar). 12–20 m thick.
Tba	**Basaltic andesite**—Aphanitic to aphanitic-porphyritic basaltic andesite; obersved phenocrysts are fine-grained. Likely correlates to unit **Tba2** of Jochems et al. (2014) in the Hillsboro quad and **Ta** units of Jahns et al (2006) in the Chise quad. Subdivided into two units:
Tbau	**Upper basaltic andesite**—Very dark-gray to gray (N 3-5/), weathering light-brown to grayish-brown (10YR4/3 to 6/2), dense/non-vesicular and occasionally foliated (flow layering); phenocrysts include 2–4% pyroxene and trace to 2% olivine. Contains trace glass and disseminated magnetite. Correlates to unit **Tyaf** of Heyl et al. (1983). 10–20 m thick.
Tbal	**Lower basaltic andesite**—Black (10YR 2/1) to very dark-gray or dark-gray (10YR-2.5Y 3-4/1), weathering grayish-brown (10YR 4-5/2) to gray (2.5Y 6/1), typically vesicular and thinly foliated (flow layering); phenocrysts include trace to 2% pyroxene and trace olivine and plagioclase set in a slightly glassy groundmass. Up to 5% amygdules filled by calcite or silica. Correlates to unit **Tb** of Heyl et al. (1983). 32–57 m thick.
Td	**Dacitic lava flows and tuffs**—Aphanitic to porphyritic, fine- to medium-grained, dacitic flows, tuffs, and tuff breccia. Correlates to **Td** units of Jahns et al. (2006) in the Chise quad. Subdivided into two units:
Tdu	**Upper dacitic tuff and tuff breccia, with subordinate flows**—Weak-red (10R 4/4) to very dark-gray (5YR3/1), weathering reddish-brown (2.5YR 4-5/4) or dark-reddish-gray (5YR 4/2), dense to vesicular and porphyritic; phenocrysts include 2–16% plagioclase, 1% quartz, and trace amounts of biotite, sanidine, and pyroxene. Tuff and tuff breccia contain 10–20% fragments of pumice; typically non- to weakly welded. 18–25 m thick.
Tdl	**Lower dacitic flows**—Dark-gray (7.5YR 4/1), weathering brown (7.5YR 4/2), vesicular and aphanitic-porphyritic; phenocrysts include 2–4% plagioclase, 2% hornblend, 1–2% biotite, and trace pyroxene. Contains 5–10% amygdules filled by calcite or silica. 15 m thick.
Ts	**Volcaniclastic sand**—Siltstone to very fine-grained sandstone in thin beds, exhibits planar cross-stratification with foresets 15–20 cm thick, light-grayish-olive (10Y 6/2) and non-calcareous. Fills paleovalleys cut into **Tdl**. Maximum thickness 20 m.
Tks	**Kneeling Nun and Sugarlump tuffs, undivided**—Mapped by vantage reconnaissance and air photo interpretation due to land access restrictions.
Tkn	**Kneeling Nun Tuff**—Pinkish-gray (5YR 6/2), weathering brown (7.5YR 4-5/3), non-welded, slightly vesicular, porphyritic, fine- to medium-grained, rhyolitic tuff; phenocrysts include 12–15% sanidine, 7–10% quartz, and trace to 2% biotite. Contains 1–2% lithic fragments and pumice. 40Ar/39Ar-dated at 35.34±0.10 Ma (McIntosh et al., 1991). 12–18 m thick.
Tsl	**Sugarlump Tuff**—White (N 8.5-9/), weathering grayish-brown (10YR 5/2), non-welded, aphanitic-porphyritic, fine- to medium-grained, lithic tuff; phenocrysts include 1–6% biotite and trace to 2% hornblende, contains 7–8% andesitic fragments and 5–8% pumice fragments, non-welded, aphanitic-porphyritic, fine- to medium-grained, lithic tuff. 40Ar/39Ar-dated at 35.63±0.15 Ma (McIntosh et al., 1991). Maximum thickness 33 m.
Tcc	**Chavez Canyon Tuff**—White (N 8.5-9/)—less commonly brown (7.5YR 5/4)—non-welded, massive to medium- or very thick-bedded, porphyritic, fine- to medium-grained tuff; phenocrysts include 15–30% quartz and 5% biotite. Commonly weathered to clay. Contains lapilli to fine blocks of light pinkish-purple pumice and minor (5–15%) andesite. Locally 5 m thick.
Trp	**Rubio Peak Formation**—Laharic breccia, conglomerate, and tuffaceous sandstone in thin- to very thick-beds, minor laminated mudstone, weakly to strongly consolidated, clast- to matrix-supported, and massive to imbricated, commonly silica-cemented with variable color, including light-reddish-brown (2.5YR 6/3) to dark-gray (2.5Y 4/1). Maximum thickness ~1000 m from cross-section. Frequently interbedded with andesite.
Trpa	**Andesitic flows of the Rubio Peak Formation**—Light-gray weathering buff, porphyritic, fine- to medium-grained, equigranular andesite; phenocrysts include 10–12% plagioclase and 5–7% hornblende. Typically ~4 m thick.

Permian

Pa	**Abo Formation**—Sandstone and siltstone in thin beds, rippled to cross-stratified, and red to yellow where altered. Thickness unknown but may be as much as 130 m in the subsurface [Description from Mayer, 1987].

Carboniferous

IPm	**Magdalena Group, undivided**—Interbedded shale, limestone, and conglomerate. Locally subdivided into:
IPmb	**Barb-B Formation**—Limestone and mudstone with subordinate shale and conglomerate. Limestone is typically thin-bedded and nodular with brachiopods, bryozoans, crinoids, and gastropods. Mudstone is red, calcareous, and interbeds with chert to quartz-rich pebble conglomerate in the upper part of the unit quartz-rich pebble conglomerate in the upper part of the unit. 165 m thick [Description from Mayer,1987].
IPmn	**Nakaye Formation**—Grainstone to micritic wackestone and packstone, lacy to globular chert occurs in micritic beds, whereas chert lenses/beds and nodules occur in grainstone and packstone. Fossils include horn corals, forams, crinoids, brachiopods, and bryozoans. 123 m thick [Description from Mayer, 1987].
IPmr	**Red House Formation**—Shale and subordinate limestone, siltstone, and conglomerate. Shale is black, red, or green and fissile. Limestone features lacy chert near top of unit and contains forams and phylloid algae among other fossils. Conglomerate is cross-stratified and quartzose, and occurs in the upper part of the unit. 91 m thick [Description from Mayer, 1987].
Mlv	**Lake Valley Formation**—Grainstone, crinoidal packstone, and boundstone interbedded with shale in places. Upper part is strongly silicified to jasperized. Total thickness 48 m [Description from Mayer, 1987].

Devonian

Dp	**Percha Shale**—Fissile shale with discontinuous, thin beds of siltstone and very fine-grained sandstone. Maximum thickness 45 m [Description from Mayer, 1987].

Ordovician

Om	**Montoya Formation**—Quartz arenite and strongly altered dolostone. Quartz arenite is fine- to medium-grained. Dolostone silicified, jasperized, and/or brecciated. Maximum thickness 30–60 m [Descriptionfrom Mayer, 1987].
Oep	**El Paso Formation**—Limestone that is locally sandy with minor silicified sandstone near top. Maximum thickness 20 m [Description from Mayer, 1987].

Cambrian

€Ob	**Bliss Formation**—Arkosic pebble conglomerate grading upward to arkosic oolitic, or quartzose sandstone. Commonly iron-rich and locally glauconitic. 47 m thick [Description from Mayer, 1987].

Precambrian

p€	**Proterozoic rocks, undivided**—Granite, muscovite schist, and metadiorite. Aplitic granite comprises as much as 65% of Proterozoic lithologies exposed southwest of quad. [Description from Mayer, 1987].

FIGURE 1—Pliocene basalt flow (unit **Tb**, above) resting on reddish lower, coarse-grained facies of the Palomas Formation (unit **QTplc**, below) southwest of San Miguel church (sec. 10, T. 13 S., R. 6 W.). Note nearly horizontal beds of **QTplc**, deposited in proximal environments of the paleo-Palomas Creek alluvial fan complex. An 40Ar/39Ar sample from nearby **Tb** exposures yielded an age of 4.57 ± 0.02 Ma for the lowest flow.

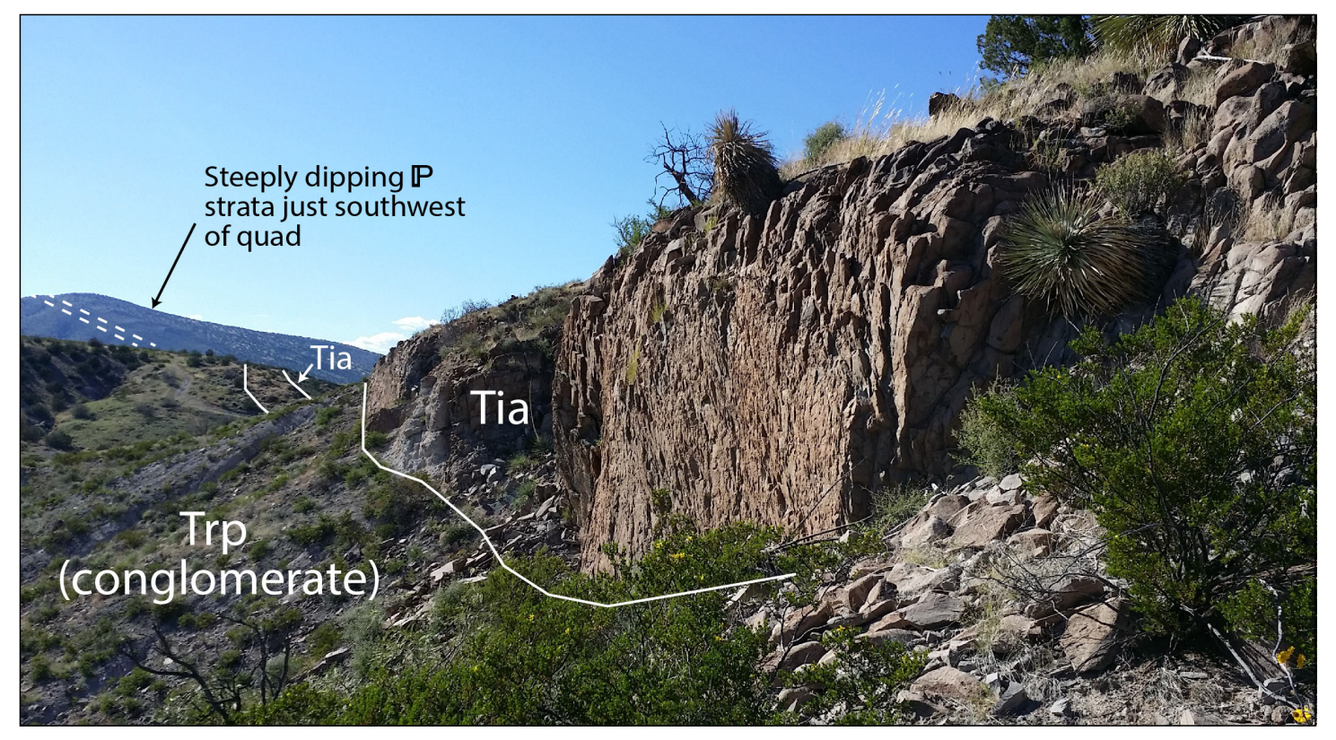


FIGURE 2—Andesite dike (unit **Tia**) intruding laharic conglomerate and breccia of the Rubio Peak Formation (unit **Trp**) in sec. 31, T. 13 S., R. 6 W. Plagioclase- and hornblende-bearing dike is up to 30 m wide and does not intrude strata younger than Eocene in age. Dipping Pennsylvanian beds just southwest of quad boundary are located in the footwall of a north-vergent thrust fault in the Salado Mountains.

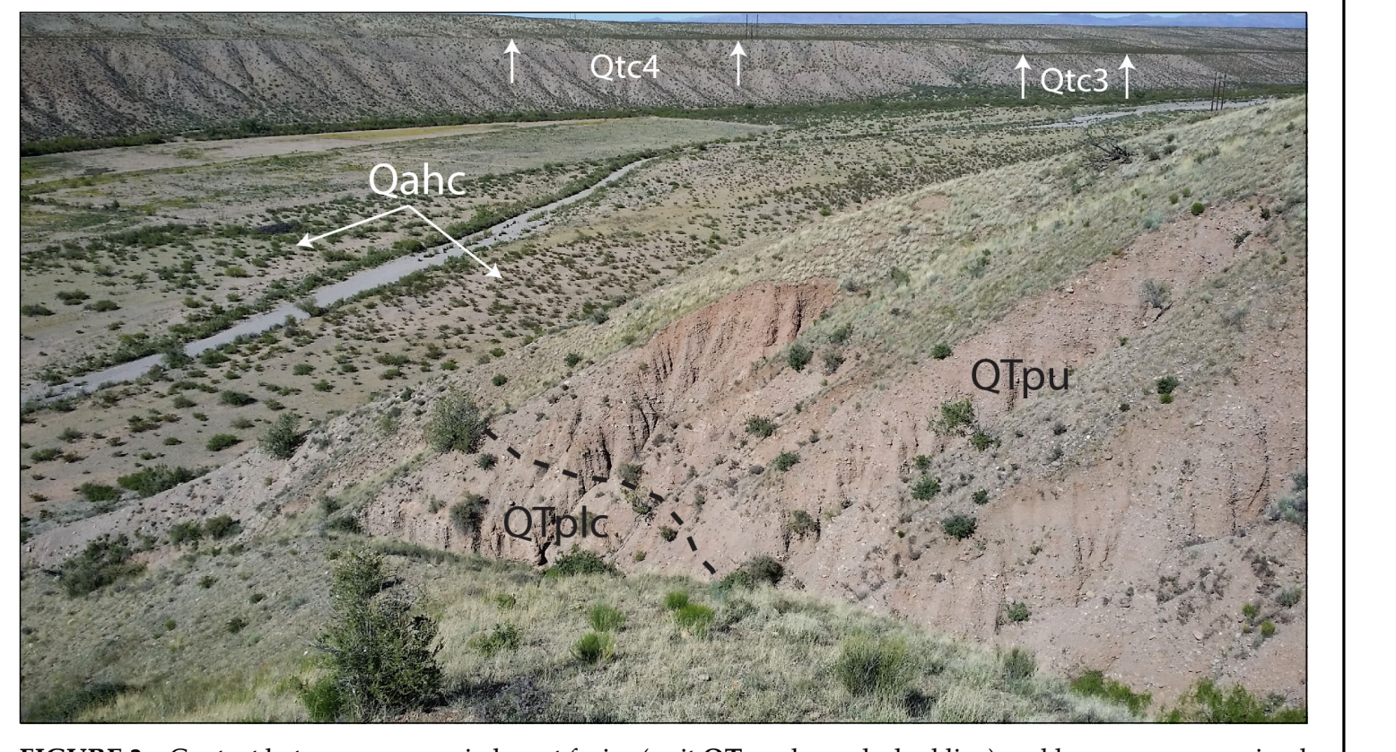


FIGURE 3—Contact between upper piedmont facies (unit **QTpu** above dashed line) and lower, coarse-grained piedmont facies of the Palomas Formation (unit **QTplc**, below). Contact may be sharp and scoured or planar to gradational over ~3–5 m. Cuchillo Negro Creek flows through middle ground (looking downstream toward east-northeast). Historical alluvium (unit **Qahc**) and middle to late Pleistocene terrace deposits (units **Qtc4** and **Qtc3**, treads above white arrows) are also shown. Sec. 25, T. 12 S., R. 6 W.

Geologic Cross Section