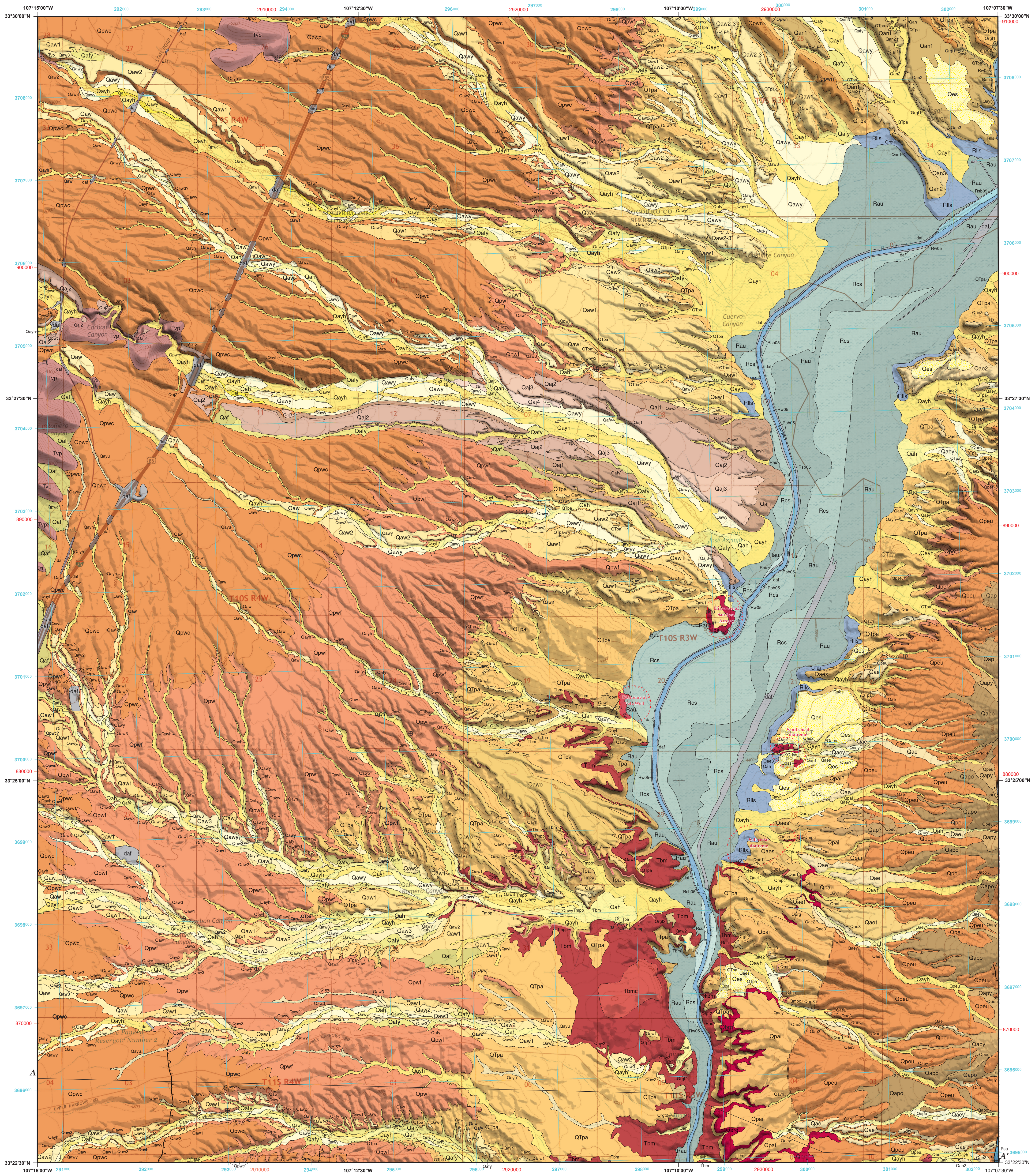
NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A DIVISION OF NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY

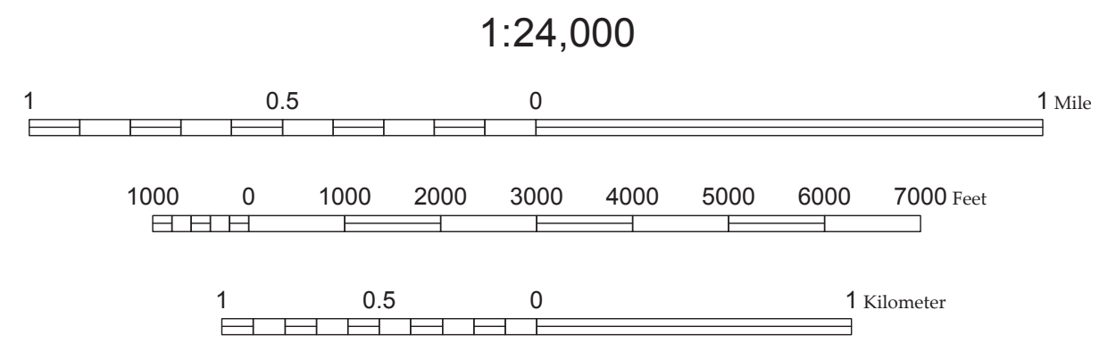
NMBGMR Open-File Geologic Map 270

Last Modified June 2018



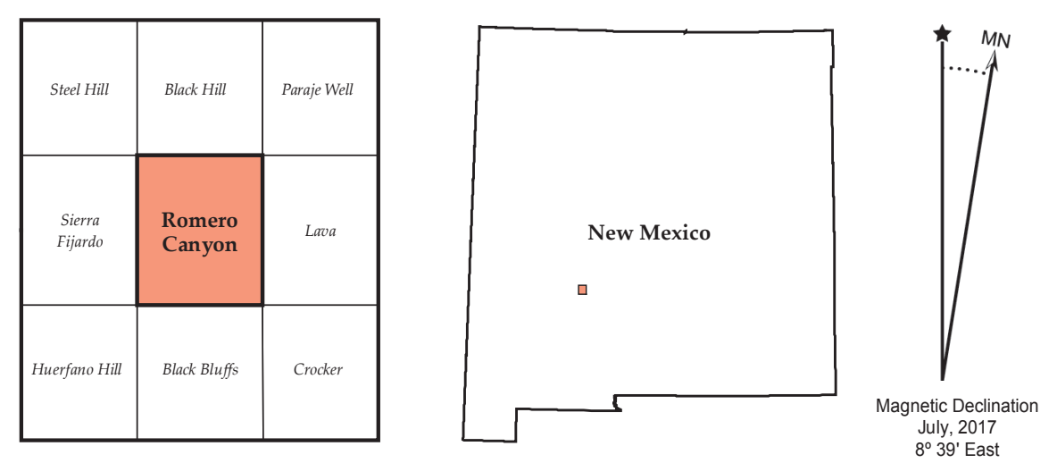
Base map from U.S. Geological Survey 2013.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 13S, shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983 (central zone), shown in red.

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



Contour Interval 20 Feet

North American Vertical Datum of 1988



Magnetic Declination
July, 2017
8° 39' East
At Map Center

Quadrangle Location

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

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 270

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act (Fund Number: G17AC00260), administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (Dr. Nelia W. Dunbar, *Director and State Geologist*, Dr. J. Michael Timmons, *Assoc. Director for Mapping Programs*).

Geologic Map of the Romero Canyon 7.5-Minute Quadrangle, Sierra and Socorro Counties, New Mexico

June, 2018

by
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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 may not be shown due to recent development.

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.

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Description of Map Units

Anthropogenic Deposits

daf **Disturbed ground and artificial fill**—Disturbed ground and uncompacted gravels, sands, and muds associated with gravel pit operations. Only mapped where laterally extensive or concealing underlying geologic features. The deposit thicknesses are <1 to 5 m.

Post-Santa Fe Group Deposits

Eolian Deposits

Qes **Eolian sandsheet deposits**—Isolated areas of relatively thick eolian sand deposits. Sands are well-sorted, rounded, very fine- to fine-grained, and dominantly siliceous, with trace rounded tributary alluvial fine pebbles. Deposits are laminated and have pink to pale brown color (7.5YR 7/3 measured). Deposit thickness is up to 2 m.

Rio Grande Floodplain Alluvium

Rw05 **Water apparent in the 2005 Digital Ortho Quarter Quadrangle (DOQQ) aerial imagery**—Areas of flowing or standing water apparent in 2005 digital aerial imagery.

Rsb05 **Sand bar deposits apparent in the 2005 DOQQ**—Areas of unvegetated sand bars apparent in 2005 digital aerial imagery.

Rcu **Rio Grande channel deposits apparent in the 2005 DOQQ, undivided**—Areas of the floodplain with banded surface textures such as vegetation trends apparent in 2005 digital aerial imagery. Banding only locally exhibits distributary branching. The unit is laterally gradational with the unit **Rcs**.

Rcs **Rio Grande channel splay deposits apparent in the 2005 DOQQ**—Areas of the floodplain with fanning/distributary surface textures such as vegetation trends apparent in 2005 digital aerial imagery. Distributary textures commonly can be traced back to current or former locations of the Rio Grande channel. The unit is laterally gradational with unit **Rcu**.

Rau **Rio Grande floodplain alluvium apparent in the 2005 DOQQ, undivided**—Areas of the floodplain with non-distinct surface textures. Includes areas of the floodplain that have been artificially disturbed by land management activities such that primary surface textures are unrecognizable.

Rlls **Lakeshore sediments**—Loose sands to gravels associated with highstands of Elephant Butte Lake. Sediments are principally reworked from underlying deposits and tributary alluvium. The unit is only mapped where particularly thick or extensive or where masking underlying geologic relationships. Thickness is likely no more than 4 m.

Qrgy **Rio Grande Holocene alluvium, undivided**—Cross-section only. Loose sands, gravelly sands, and muds underlying the Rio Grande floodplain. Up to 30 m thick.

Generic Alluvial Deposits

Channelized Piedmont Deposits

Qar **Recent channelized alluvium**—Unvegetated gravels underlying active drainage channels. Gravels are loose and matrix-poor, in medium-thick, lenticular, trough cross-stratified beds. No notable soil development. Locally distinguished from surrounding historic alluvium by insetting relationships, particularly around I-25. The deposit thicknesses are <1 to perhaps 2 m.

Qah **Historic channelized alluvium**—Poorly or non-vegetated gravels lying along and beneath active drainage channels. Gravels are loose and matrix-poor, commonly in medium-thick, lenticular, often trough cross-stratified beds. Gravel compositions are reflective of upstream exposed materials. No notable soil development. Not uncommon to overtop surrounding **Qay** deposits as thin channel splay or fluvial fan deposits.The deposit thicknesses are <1 to 2 m.

Qayh **Younger and historic channelized alluvium, undivided**—Deposits of historic and younger terrace alluvium that cannot be mapped separately at this scale. Often indicates areas with historic alluvium overtopping younger terrace alluvium. The deposit thicknesses are <1 to 3 m.

Qayu **Younger and slopewash alluvium, undivided**—Alluvial deposits underlying low-gradient, non-channelized, slopewash-dominated drainageways. The deposits are poorly sorted, variably gravelly, variably muddy sands with absent to weakly-developed surface soils. Compositions reflect sediments exposed along hillslopes along the drainage way. The deposit thicknesses are <1 to perhaps 1 m.

Small-scale Fan Alluvium

Qafy **Younger fan alluvium**—Brown sandy pebbles and pebbly sands underlying low-level fan and bajada surfaces emanating from low-order tributary drainages. Gravel and sand compositions are reflective of upstream exposed materials. Fan surfaces typically grade to the younger terrace or historic alluvium levels. Surface soils are weakly-developed, bearing carbonate horizons with no more than Stage I morphology. The deposit thicknesses are <1 to perhaps 2 m.

Qaf **Undivided fan alluvium**—Sandy pebbles and pebbly sands underlying fan and bajada surfaces emanating from low-order tributary drainages and graded to surfaces above the modern arroyo floors. Gravel and sand compositions are reflective of upstream exposed materials. Fan and bajada surfaces typically grade to one of the older terrace levels or to the top of the Palomas, and the source drainage(s) is/are commonly incised into the fan or bajada surface. Surface soils are weakly to well-developed, comparable to those of the older terrace levels. The deposit thicknesses are <1 to perhaps 6 m.

Axial-fluvial (Ancestral Rio Grande) Alluvium

Qrgt2 **Intermediate-level axial-fluvial (ancestral Rio Grande) terrace alluvium**—Loose, siliceous-lithology-rich, variably cobbly, pebble gravels underlying terrace treads along the Rio Grande with tread heights and surface soils comparable to those of **Qaw2**. The deposits are poorly exposed and typically identified by an abundance of siliceous gravels at **Qaw2** terrace levels. Where exposed, the deposits are fining-upwards rounded pebbles with up to 15% cobbles and trace boulders of quartzite and chert with minor felsic-intermediate volcanic rocks, rare granites and basalts, and trace limestones and sandstones, in massive, thick, vague beds. Matrices consist of poorly sorted very fine to very coarse sand grains (fining upwards) of dominantly quartz and siliceous lithics. Where preserved, surface soils consist of Bk horizons with Stage II morphology just below terrace tread surfaces that are 22–24 m above the channel. Additional carbonate occurs as localized phreatic cement along preferential planes. The deposit thicknesses are <1 to 7 m.

Qrgt1 **High-level axial-fluvial (ancestral Rio Grande) terrace alluvium**—Loose siliceous sands, pebbly sands, gravels, and trace clay beds underlying high-level tributary alluvial deposits (**Qan1**, **Qaw1**) and overlying consolidated and variably cemented **QTpa** deposits. Sands are dominantly well-sorted, rounded, and fine- to medium-grained, coarser-grained and poorer-sorted where mixed with gravels, and occurring in prominently trough cross-stratified lenticular beds up to 70 cm thick. Gravels are dominantly rounded fine to medium pebbles of quartzite, granite, chert, felsic to intermediate volcanics, limestone, and sparse foliated metamorphic rocks and "red bed" clastic sedimentary rocks. Clay beds are thin- to medium-planar to undulatory-tabular beds with internal planar laminations; clay also occurs as trace mudballs. Sand colors are pink to very pale brown to light-gray (measured at 7.5YR 7/3, 10YR 7/4, and 10YR-2.5Y 7/1) with local redoximorphic coloration; clay beds are light-reddish-brown (measured at 5YR 6/4). The preserved deposit thicknesses are <1 to 4 m.

Western (San Mateo Mountains) Piedmont Alluvium

Western Piedmont Generic Terrace and Tributary Fan Alluvium

Qawy **Younger western piedmont terrace alluvium**—Brown sandy pebbles and pebbly sands underlying low-level terrace treads with weakly-developed surface soils. Terrace treads are up to 2 m above nearby channels and are a constituent of the modern arroyo floors. Soil development is characterized by A-Av/Bw/Bk surface soils with carbonate horizons of weak or discontinuous Stage I morphology. Matrices are free of clay films, with a measured color of 7.5YR 4/4. The deposit thicknesses are <1 to 2 m.

Qaw **Older western piedmont terrace alluvium**—Brown to reddish-brown gravels and sandy gravels underlying discontinuous terrace treads and tributary fan surfaces overlooking modern arroyo floors with weakly to well-developed surface soils. Usually assigned to one of three subunits. Where the undivided map unit is used, the deposit may reflect the characteristics of any combination of the subunits.

Qaw3 **Low-level older western piedmont terrace alluvium**—Brown to reddish-brown gravels and sandy gravels underlying low-level terrace treads and tributary fan surfaces with weakly developed surface soils. Terrace treads are 1–3 m above nearby channels and typically discontinuous. Soil development is characterized by A/Bwt/Bk surface soils with carbonate horizons of Stage I-I+ to weak, discontinuous Stage II morphology; clay in Bwt horizons are sparse, very fine to fine films on pebbles. Matrix colors were measured at 7.5YR 4/4-5/4. The deposit thicknesses are <1 to 2 m.

Qaw2 **Intermediate-level older western piedmont terrace alluvium**—Reddish-brown to brown or yellowish-red gravels and sandy gravels underlying intermediate-level terrace treads with moderately developed surface soils. Terrace treads and tributary fan surfaces are from 1 to locally 13 m above nearby channels, increasing downstream, with particularly high treads where the channel has breached the basalt of Mitchell Point. Soil development is characterized by A/Bwt-Bt/Bk surface soils with carbonate horizons of Stage II to weak, discontinuous Stage III morphology; clay in B(w)t horizons increases downstream from sparse very fine to fine films on gravels to rare fine to medium films and bridges between sands. Matrix colors were measured at 7.5YR-5YR 5/4-4/4, 2.5YR 4/4, and 5YR 5/6. The deposit thicknesses are <1 to 2 m.

Qaw2-3 **Low- to intermediate-level older western piedmont terrace alluvium**—Units **Qaw3** and **Qaw2**, undivided. The map unit is used where the two cannot be mapped separately at this scale.

Qaw1 **High-level older western piedmont terrace alluvium**—Reddish-brown to brown gravels, sandy gravels, and sands underlying high-level terrace treads and tributary fan surfaces with well-developed, but partially stripped, surface soils. Terrace treads are 3–18 m above nearby channels, increasing downstream, with particularly high treads where the channel has breached the basalt of Mitchell Point. Soil development is characterized by Bk-K horizons at or just below the tread surface, with carbonate horizons of Stage III to locally III+ (plugged horizon without overlying laminae) morphology, and any previously overlying A and/or B horizons stripped by erosion. Clay occurs below the surface soil as sparse very fine to fine films on gravels. Matrix colors were measured at 5YR-7.5YR 5/4. Sand beds are only found along the Rio Grande inner valley, and consist of light-brown (measured at 7.5YR 6/4) variably muddy very fine grains of mainly quartz and volcanic lithics in thick, planar-tabular beds with vague internal planar stratification, which interbed with lenticular gravel beds. The deposit thicknesses are <1 to 20 m.

Qawo **Older valley-margin western piedmont fan alluvium**—Reddish-yellow to reddish-brown pebble gravels underlying high-level tributary fan surfaces with stripped surface soils. Gravels are poorly sorted, fine to coarse pebbles with minor (<10%) cobbles. Matrices consist of variably clayey sands; sands are poorly sorted angular to subrounded very fine to very coarse grains; clay occurs as rare to common, fine to coarse bridges between sand grains and lesser gravel coats. Beds are medium to thick, massive to cross-bedded, and lenticular. Phreatic carbonate cement occurs along preferential bedding and cross-bedding planes. Fan surfaces are 16 to 40 m above nearby channels, increasing downstream, with particularly high surfaces where channels have breached the basalt of Mitchell Point. The surface soils are stripped. The deposit thicknesses are <1 to 8 m.

Nogal Canyon Alluvium

Qan3 **Low-level older terrace alluvium of Nogal Canyon**—Light-brown sandy gravels and gravelly sands underlying low-level terrace treads and tributary fan surfaces with weakly to moderately developed surface soils. Terrace treads are 5–8 m above the nearby active channel, generally increasing downstream. Soil development is characterized by A/Bw/Bk surface soils with carbonate horizons of up to Stage II morphology. A matrix color was measured at 10YR 6/4. The deposit thicknesses are <1 to 5 m.

Qan2 **Intermediate-level older terrace alluvium of Nogal Canyon**—Light-brown gravels and sandy gravels underlying intermediate-level terrace treads and tributary fan surfaces with moderately developed surface soils. Terrace treads are 8–13 m above the active channel, generally decreasing downstream. Soil development is characterized by A/Bwt/Bk surface soils with carbonate horizons of Stage II morphology; clay in Bwt horizons occurs as rare fine to medium films on gravels. A matrix color was measured at 7.5YR 6/4. The deposit thicknesses are <1 to 2 m.

Qan1 **High-level older terrace alluvium of Nogal Canyon**—Brown to reddish-yellow gravels and sandy gravels underlying high-level terrace treads and tributary fan surfaces with well-developed, but partially stripped, surface soils. Terrace treads are 16–24 m above the active channel, generally decreasing downstream. Soil development is characterized by Bk-K horizons at or just below the tread surface, with carbonate horizons of Stage III morphology, and any previously overlying A and/or B horizons stripped by erosion. Clay occurs below the surface soil as rare very fine to fine films on gravels and bridges between sand grains. Matrix colors were measured at 7.5YR 5/4-6/6. Deposit thicknesses are <1 to 15 m.

San Jose Arroyo Alluvium

Qaj4 **Low-level older terrace alluvium of San Jose Arroyo**—Light-yellowish-brown gravels and sandy gravels underlying low-level terrace treads and tributary fan surfaces with weakly developed surface soils. Preserved terrace treads are 1.5–7 m above nearby channels, increasing downstream, with tread height projecting into the arroyo floor upstream. Soil development is characterized by A/Bk surface soils with carbonate horizons of Stage I morphology. Terrace deposits are poorly exposed, poorly sorted, subrounded pebbles with <1–1% cobbles in loose, unstructured tabular beds with matrices of very poorly sorted very fine to very coarse sands. A matrix color was measured at 10YR 6/4. The deposit thicknesses are ≤1 m.

Qaj3 **Low-intermediate-level older terrace alluvium of San Jose Arroyo**—Yellowish-red gravels and sandy gravels underlying low-intermediate level terrace treads and tributary fan surfaces with weakly developed surface soils. Terrace treads are 6–9 m above the nearby channel, increasing downstream. Soil development is characterized by A/Bw/Bk surface soils with carbonate horizons of Stage I+ to II morphology. Clay occurs in the sandy matrix as detrital aggregates, but no films were observed. A matrix color was measured at 5YR 4/6. Gravels are dominantly fine pebbles, with trace gravel up to 1 m diameter boulders, in thick massive tabular beds up to 60 cm thick. The deposit thicknesses are <1 to 5 m.

Qaj2 **High-intermediate-level older terrace alluvium of San Jose Arroyo**—Yellowish- red gravels and sandy gravels underlying high- and intermediate-level terrace treads and tributary fan surfaces with moderately developed surface soils. Terrace treads are 11–34 m above the nearby channel, decreasing downstream. Surface soils are poorly exposed, but appear to bear carbonate horizons with Stage II+ to locally III morphology. Clay occurs in the sandy matrix as detrital aggregates, but no films were observed. Matrix colors were measured at 5YR 4/6-5/6. Gravels are dominantly pebbles with rare (<3%) cobbles and trace boulders. The deposit thicknesses are <1 to 6 m.

Qaj1 **High-level older terrace alluvium of San Jose Arroyo**—Gravels, sandy gravels, and sands underlying high-level terrace treads and tributary fan surfaces. Terrace treads are 16–23 m above the nearby channel, generally decreasing downstream. Terrace deposits are poorly exposed, and no evidence of preserved surface soils was identified; surface soils are potentially stripped. Gravels are dominantly pebbles with rare cobbles and trace boulders. Sand beds are only found along the Rio Grande inner valley, and consist of light-brown variably muddy very fine grains of mainly quartz and volcanic lithics in thick, planar-tabular beds with vague internal planar stratification, which interbed with lenticular gravel beds. The deposit thicknesses are <1 to perhaps 20 m.

Eastern (Fra Cristobal Mountains) Piedmont Alluvium

Eastern Piedmont Terrace Alluvium

Qaey **Younger eastern piedmont terrace alluvium**—Grayish-brown to brown sandy pebbles and pebbly sands underlying low-level terrace treads with weakly-developed or absent surface soils. Terrace treads are up to 1 m above nearby channels, and are a constituent of the modern arroyo floors, commonly exhibiting bar-and-swale microtopography. Soil development is weak to absent; maximum surface soil development is characterized by A/Bw/Bk horizonation with carbonate horizons of weak or discontinuous Stage I morphology. The deposit thicknesses are <1 to perhaps 2 m.

Qae **Older eastern piedmont terrace alluvium**—Grayish-brown to brown to yellowish-brown gravels and sandy gravels underlying discontinuous terrace treads and tributary fan surfaces overlooking modern arroyo floors with weakly to well-developed surface soils. Usually assigned to one of three subunits. Where the undivided map unit is used, the deposit may reflect the characteristics of any combination of the subunits.

Qae3 **Low-level older eastern piedmont terrace alluvium**—Brown to light-brown gravels and sandy gravels underlying low-level terrace treads and tributary fan surfaces with weakly developed surface soils. Terrace treads are 1–3 m above nearby channels and typically discontinuous. Soil development is characterized by A/Bw/Bk surface soils with carbonate horizons of Stage I morphology. Matrix colors were measured at 7.5YR 5/4. The deposit thicknesses are <1 to 2 m.

Qae2 **Intermediate-level older eastern piedmont terrace alluvium**—Grayish-brown to locally reddish-yellow gravels and sandy gravels underlying intermediate-level terrace treads and tributary fan surfaces with moderately developed surface soils. Terrace treads are 3–40 m above nearby channels, increasing downstream and northward, with particularly high treads along the inner valley of the Rio Grande. Soil development is characterized by A/Bwt/Bk surface soils with carbonate horizons of Stage II-II+ to locally III morphology; clay in reddish-yellow Bwt horizons occurs as rare very fine bridges between sands. The deposit thicknesses are <1 to 6 m.

Qae1 **High-level older eastern piedmont terrace alluvium**—Yellowish-brown gravels and sandy gravels underlying high-level terrace treads and tributary fan surfaces with well-developed, but partially stripped, surface soils. Preserved terrace treads are 4–30 m above nearby channels, increasing downstream and northward. Soil development is characterized by Bk-K horizons at or just below the tread surface, with carbonate horizons of Stage III to locally III+ (plugged horizon without overlying laminae) morphology, and any previously overlying A and/or B horizons stripped by erosion. Matrix colors were measured at 10YR 5/4. The deposit thicknesses are <1 to about 10 m.

Qaes **Sandy older alluvium**—Pink to yellowish-brown variably clayey sands with interbedded lenticular gravels inset into surrounding Palomas-age deposits and underlying younger post-Palomas alluvial deposits. Sands are poorly sorted; clayey, silty, or clean; very fine- to fine-grained; and rounded, of dominantly quartz, lesser siliceous lithics, and trace limestone and volcanic lithics, occurring in poorly exposed, uncemented, medium-thickness planar tabular beds. Clays occur as detrital chips; no pedogenic films were observed. Matrix colors were measured at 7.5YR-10YR 5/4 and 7/3. The deposit thicknesses are <1 to locally 20 m.

Eastern Piedmont Mountain Front Fan Alluvium

Qap **Eastern piedmont mountain front fan alluvium, undivided**—Gravels and sandy gravels underlying alluvial fan surfaces along the western foot of the Fra Cristobal Mountains. Gravels are poorly sorted subrounded pebbles to boulders of varying proportions of mainly limestones and granites with lesser foliated metamorphic rocks, quartzites, sandstones, and rhyolites; proportions vary with lithologies exposed in the nearby mountains. Sands are poorly sorted, very fine to very coarse grains of quartz and lithics of compositions comparable to the gravels. Surface soils vary from no development to A/Bw/Bk horizonation, with Bk horizons exhibiting up to Stage II+ morphology. Where insetting relationships, surface textures, or exposed soils and map scale permit differentiation of older and younger subunits, **Qap** is subdivided into a younger **Qapy** and older **Qapo**. The deposit thicknesses are <1 to at least 6 m.

Qapy **Younger eastern piedmont mountain front fan alluvium**—Gravels and sandy gravels underlying alluvial fan surfaces along the western foot of the Fra Cristobal Mountains with surface or soil evidence indicating a younger subunit age. Sedimentologic characteristics like those of unit **Qap**. Surface soils vary from no development to A/Bw/Bk horizonation, with Bk horizons exhibiting up to Stage I+ morphology. Surfaces commonly exhibit bar-and-swale microtopography, and are inset below surfaces capping nearby **Qapo** deposits. The deposit thicknesses are <1 to at least 6 m.

Qapo **Older eastern piedmont mountain front fan alluvium**—Gravels and sandy gravels underlying alluvial fan surfaces along the western foot of the Fra Cristobal Mountains with surface or soil evidence indicating an older subunit age. Sedimentologic characteristics like those of unit **Qap**. Surface soils consist of A/Bw/Bk horizonation, with Bk horizons exhibiting Stage I+ to Stage II+ morphology. Surfaces may exhibit subdued bar-and-swale microtopography, and lie above inset surfaces capping nearby **Qapy** deposits. The deposit thicknesses are <1 to at least 6 m.

Santa Fe Group, Palomas Formation Deposits

Axial-fluvial (Ancestral Rio Grande) Facies of the Palomas Formation

Qpai **Interbedded axial-fluvial and piedmont deposits of the Palomas Formation**—Light-gray Rio Grande-derived variably pebbly sands interbedded with eastern piedmont sands and gravels. Axial sands consist of moderately to poorly sorted, subrounded to rounded, fine to coarse sands of dominantly quartz with minor feldspars and rare chert and volcanic lithics. Axial pebbles, generally sparse, are of quartzite, chert, rhyolitic and intermediate volcanics, and gravel reworked from the eastern piedmont. Beds are thin to medium, lenticular, trough cross-stratified, and uncemented. A matrix color was measured at 2.5Y 7/2. Eastern piedmont sediments are like those described for unit **Qpeu**. This map unit is used where poor exposures and/or map scale prevents mapping piedmont and axial deposits separately. Thickness as much as about 25 m.

QTpa (QTpa) **Axial-fluvial facies of the Palomas Formation**—White to pink to very pale-brown, trough cross-stratified, locally concretionary, variably pebbly siliceous sands/sandstones. Sands are moderately to poorly to well-sorted, subangular to rounded, very fine to very coarse grains of dominantly quartz with minor crystalline siliceous lithics, minor basaltic lithics, and trace each of felsic to intermediate volcanic lithics, chert, feldspars, black ferromagnesian lithics, and detrital clay aggregates, in thin to medium, lenticular beds. Color measurements of 7.5YR-10YR 7/2-7/4 and 8/1-8/2 are common, with local reddish-yellow colors (5YR-7.5YR 6/6) beneath unit **Qpwn**. Clayey mud/mudstone beds are generally traced in abundance but are locally common. Gravels are up to 15% of beds, mainly pebbles with trace cobbles, poorly to moderately sorted, mainly subrounded to well-rounded, and consist of common felsic to intermediate volcanic rocks, variable quartzites and granites, rare cherts and basalts, and trace clastic sedimentary rocks. Cementation is highly localized, and exposures are poor. Base unexposed; unit thickness is at least 60 m.

Tpa **Axial-fluvial facies of the Palomas Formation underlying Pliocene volcanics**—Axial-fluvial variably pebbly sands/sandstones like those of **QTpa**, with age constrained to Pliocene by overlying or cross-cutting igneous rocks.

Western Piedmont Facies of the Palomas Formation

Qpwc **Dominantly gravelly western piedmont deposits of the Palomas Formation**—Yellowish-red to pink, variably cobbly pebble conglomerates with rare sandy conglomerates to sandstones. Gravels are dominantly poorly sorted, subangular to rounded, fine to coarse pebbles with rare cobbles and trace boulders in medium to very thick (max 1.5 m thick), commonly cross-stratified (tangential and trough), matrix-poor (<5%), lenticular beds; locally, cobbles are common (up to 25%), or matrix is more abundant (up to 15%). Gravel are mainly phenocryst-poor rhyolites with absent to rare plagioclase±pyroxene andesitic porphyries, absent to rare quartz-feldspar rhyolitic porphyries, and trace fine-grained limestones. Matrices are poorly sorted clayey fine to very coarse sands; sands are dominantly rhyolitic lithics with lesser but common feldspars and quartz. Clay typically occurs as common medium to coarse films that coat gravels and bridge sand grains; cobbly and sandy beds typically bear less abundant and/or finer clays. Matrix colors were measured at 5YR 5/4-5/8 and 7/4. Unit bears very local buried soils with Bt and Bk horizons with up to Stage II morphology. The lower contact is placed where conglomerates become >50% of exposures. On-quad unit thickness varies from <1 to at least 40 m.

Qpwf **Dominantly sandy western piedmont alluvium of the Palomas Formation**—Pinkish-gray to light-brownish-gray variably muddy sands/sandstones with local gravelly sandstone and conglomerate channel-fills. Sands are dominantly moderately to poorly sorted and very fine- to fine-grained, with rare medium to coarse grains in lenticular channel fills, and consist of common volcanic lithics and quartz, rare to common potassium feldspar, and rare plagioclase in medium to thick beds that are massive and tabular to cross-stratified and lenticular. Gravels are poorly to moderately sorted, mainly pebbles with rare cobbles and trace boulders, of fine-grained rhyolites to subequal rhyolites and plagioclase±pyroxene porphyry andesites, with additional trace fine-grained limestones. Gravelly channel-fills occur as medium to thick (up to 40 cm thick), lenticular, massive, or cross-stratified beds, and constitute 0–50% of exposures, with abundance increasing upsection. The unit bears buried soils marked by Bw, Bt, and/or Bk horizons with up to Stage II+ morphology that become increasingly common upsection. Unmodified colors were measured at 7.5YR-10YR 6/2-7/3, and buried soil colors are as strong as 5YR 4/6-6/4. The basal contact with unit **QTpa** is interbedded, while the upper contact with **Qpwc** is locally irregular. Overall unit thickness is <1 to as much as 80 m.

Qpwn **Gravelly deposits along Nogal Canyon of the Palomas Formation**—Yellowish-red pebble conglomerates. Gravels are dominantly poorly sorted, subrounded, coarsening-upsection fine to coarse pebbles with rare cobbles in thick, vaguely-defined lenticular to tabular, locally cross-stratified, commonly matrix-poor beds. Sand matrix is as much as 20% of beds at the base, decreasing upsection; cobbles generally are <10% of beds. Gravel are mainly phenocryst-poor rhyolites with less common (up to 20%) plagioclase±pyroxene andesitic porphyries. Matrices are poorly sorted, clayey, subangular to rounded, medium- to very coarse-grained sands of quartz and volcanic lithics. Clay occurs as common to ubiquitous medium to coarse films that coat and bridge between grains. Matrix color was measured at 5YR 5/6. The deposits are as much as 15 m thick.

Eastern Piedmont Facies of the Palomas Formation

Qpeu **Upper gravel-dominated deposits of the eastern piedmont of the Palomas Formation**—Pink to brown and locally yellowish-red variably sandy gravels/conglomerates and rare sands/sandstones. Gravels consist of poorly sorted subrounded pebbles, rare cobbles, and trace boulders of varying proportions of mainly limestones and granites with lesser foliated metamorphic rocks and quartzites and trace sandstones; clast lithologies vary with the bedrocks exposed upstream. Matrix materials and sand beds consist of poorly sorted very fine to very coarse grains of quartz and lithics, with variable cementation by clay, carbonate, or sparry calcite. Lenticular beds are thin to medium and commonly cross-stratified. The unit grades laterally into **Qpai** in the southern part of the field area, and overlies **QTpa** and **Qpef** in the northern part. The unit thickness is up to at least 40 m.

Qpef **Upper sand-dominated deposits of the eastern piedmont of the Palomas Formation**—Light-yellowish-brown to pink to reddish-yellow variably muddy sands/sandstones with lesser gravelly sandstone and conglomerate channel-fills. Sands are poorly sorted, dominantly very fine- to fine-grained, with rare medium to coarse grains, of common quartz and lesser siliceous and granitic lithics, in medium-thickness, generally massive planar tabular beds and less common lenticular cross-stratified beds. Gravels in rare channel fills are poorly to moderately sorted, mainly pebbles with rare cobbles, of mainly granite with lesser foliated metamorphic rocks, quartzite, and trace limestone. Channel-fills occur as medium-thickness, lenticular, massive or cross-stratified beds, and constitute up to 50% of exposures and commonly <10% of exposures. Matrix colors were measured at 7.5YR-10YR 6/4-8/3 and 5YR 6/6. The unit thickness is <1 to as much as 40 m.

QTpae **Eastern piemont and axial deposits of the Palomas Formation, undivided**—Cross-section only. Undivided interfingering eastern piedmont conglomerates and sandstones and axial pebbly sandstones, likely including intercalated volcanic rocks. Exposures to the north and south of the cross-section line suggest axial deposits may extend to within 600 m of the basin-bounding fault along the base of the Fra Cristobal Mountains. Unit thickness unconstrained.

Igneous Rocks Intercalated with or Intruding Palomas Formation Deposits

Volcanics Along The Narrows

Qbrg **Basalt of the Rio Grande**—Dark-gray xenolithic fine-porphyry basalt. Phenocrysts are rare and commonly weathered to reddish replacement minerals; unweathered crystals consist of olivine, pyroxene, and plagioclase. Weathered faces commonly exhibit pale gray "spots" up to 2 mm across. Flow bears trace upper mantle to lower crustal xenoliths; Warren (1978) reports a xenolith suite of pyroxenites, granulites, olivine megacrysts, and lherzolites. The unit thickness is <1 to about 20 m.

Qbc **Basaltic cinder**—Dark reddish-brown to black scoriaceous pyroclastics. Dominantly aphanitic lapilli to bombs with trace fine-pyroxene phenocrysts up to 1 mm across. Base unexposed; thickness is <1 to at least 20 m.

Salt Cedar Diatreme

Qdsc **Salt cedar diatreme**—Commonly foliated pink tuff and lesser lapilli-tuff. Beds are principally coarse basaltic ash with as much as 35% vesicular dark gray basaltic lapilli and lesser fine ash, with as much as 20% accidental lithics of siliceous sand grains and trace pebbles of granite, quartzite, and xenolith-bearing basalt. Finer ash grains (<1 mm across) are variably degraded to pale yellowish-brown clays. Beds are medium-thickness, undulatory to massive, with foliations generally dipping toward the center of the outcrop extent. Ash color was measured at 10YR 7/2. The diatreme is inset into surrounding **QTpa** in outcrop and inferred to cross-cut unit **Tbm**. The exposed width of the diatreme is up to about 790 m.

Qmpc (Qmpc) **Salt cedar outflow pyroclastics**—Pink to light-brown, variably fluvially-reworked, accidental lithic-rich basaltic tuff. Ash is mainly coarse grains of variably weathered, vesicular basaltic material, with trace basaltic lapilli up to 15 cm across also present, in thin undulatory to tabular beds with weak internal cross-stratification. Accidental lithics and additional material incorporated by reworking consist mainly of fine siliceous sand grains. Ash colors were measured at 7.5YR 7/2-7/3 and 6/4. Thickness trends suggest **Qmpc** forms a thin, laterally-restricted ejecta ring around unit **Qdsc**. Although not exposed in outcrop, **Qmpc** appears to lie stratigraphically below unit **Qbrg**. Unit thickness is <1 to locally about 10 m.

Mitchell Point Volcanics

Tbm **Basalt of Mitchell Point**—Dark gray fine-porphyry basalt. Fine (<1 mm across) phenocrysts are common (up to 30% of fresh faces) and consist of pyroxene, plagioclase, and olivine, with trace coarser phenocrysts up to 4 mm across. The unit intercalates with **QTpa** in outcrop. ^{40}Ar/^{39}Ar age of 3.0 Ma (Table 1). The unit thickness is <1 to 35 m.

Tbmc **Cinder of Mitchell Point**—Black to locally dark reddish-brown, commonly vesicular, basaltic bombs and lapilli with local irregular bands of solid basalt. Bombs and solid basalt bear rare (up to 5%) phenocrysts of plagioclase. Siliceous sands and trace siliceous pebbles commonly mix with and mantle basaltic material at the surface. The deposit base is unexposed; thickness is perhaps as much as 55 m.

Tmpp (Tmpp) **Pyroclastics of Mitchell Point**—Pinkish-white to very pale brown, variably fluvially-reworked pyroclastics underlying and interfingering with the basalt of Mitchell Point. Primary pyroclastic deposits are planar- to undulatory-tabular laminated to thinly-bedded lapillistone to lapilli-tuff consisting of variably-weathered, dark gray, vesicular basaltic lapilli with minor to subequal (10–50%) basaltic ash (variably degraded to clay) and rare (up to 2%) accidental siliceous sands and pebbles. Fluvial reworking is apparent in the enrichment of siliceous sands and pebbles; thoroughly reworked beds consist of basalt pebble-bearing sandstones and sandstones dominated by basaltic lithic grains. Individual outcrops may bear no reworked beds or be all reworked. Matrix colors were measured at 7.5YR 7-8/2 and 10YR 7/4-8/3. The deposit thickness is <1 to 4 m.

Miscellaneous Diatremes

Qdss **Sand sheet diatreme**—Light-yellowish-brown, basaltic-lapilli tuff and lesser coarse tuff with common accidental lithics. Lapilli consist of black to very dark-gray, scoriaceous, basaltic clasts; ash is basaltic material variably weathered to pale yellowish clays. Accidental lithics are principally siliceous sand grains with lesser feldspar grains and trace fine, siliceous pebbles. Beds are thin to medium, generally well-foliated, and typically tabular in outcrop. Ash color was measured at 2.5Y 6/3. The exposed width of the diatreme is up to about 390 m.

Tdpw **Diatreme of Pete Well**—Light-brown to pink, juvenile-pyroclastic material with abundant incorporated siliceous sands and lesser pebbles. Pyroclastic material is dominantly ash that is commonly degraded to clays that bridge and envelope coarser juvenile and incorporated material; 5–25% of outcrops are angular to subangular, dark gray to black, vesicular and amygdule-bearing basaltic lapilli up to 10 cm across. Abundant rounded fine- to medium-grained siliceous sands, rare (up to 5%) rounded siliceous and granitic pebbles, and trace pale brown clayey mudballs are thoroughly incorporated in and supported by the ash matrix. Exposures are typically massive and form a rounded blocky outcrop, with local vague planar-tabular foliations. Ash color was measured at 7.5YR 6/4 and 7/3. The exposed width of the diatreme is up to 330 m.

Tdsj **Diatreme of San Jose Arroyo**—Prominently foliated pinkish-gray to pink, juvenile-pyroclastic material with common incorporated siliceous sands. Foliations are undulatory to tabular and defined by a very thin (1–3 cm thick) layering. Layers are dominantly ash with up to 50% accidental lithics of siliceous sand grains and up to 5% lapilli. Approximately 10% of beds are 30 to 60% lapilli. Lapilli are variably weathered black to yellowish-brown subangular basaltic material up to 15 cm across. Ash color was measured at 7.5YR 7/2. Trace rounded siliceous pebbles are also present. The exposed width of the diatreme is 380–490 m.

Pre-Santa Fe Group Rocks

Oligocene Volcanics

Tvp **Vicks Peak Tuff**—Light gray, weathering pale brown to black, phenocryst-poor, well-foliated, generally pumice-rich rhyolitic ignimbrite. Phenocrysts are <1–1% of faces and are mainly <1 mm-across (locally up to 3 mm-across) sanidines. Pumices constitute 5–35% of faces and are commonly strongly flattened, and are also commonly granular-textured from recrystallization. Concentrically-laminated spherulites as much as 8 cm across are 0 to locally 15% of outcrops. ^{40}Ar/^{39}Ar age estimated to be 28.4 Ma (Table 1). The unit base is unexposed; the unit thickness is at least 80 m.

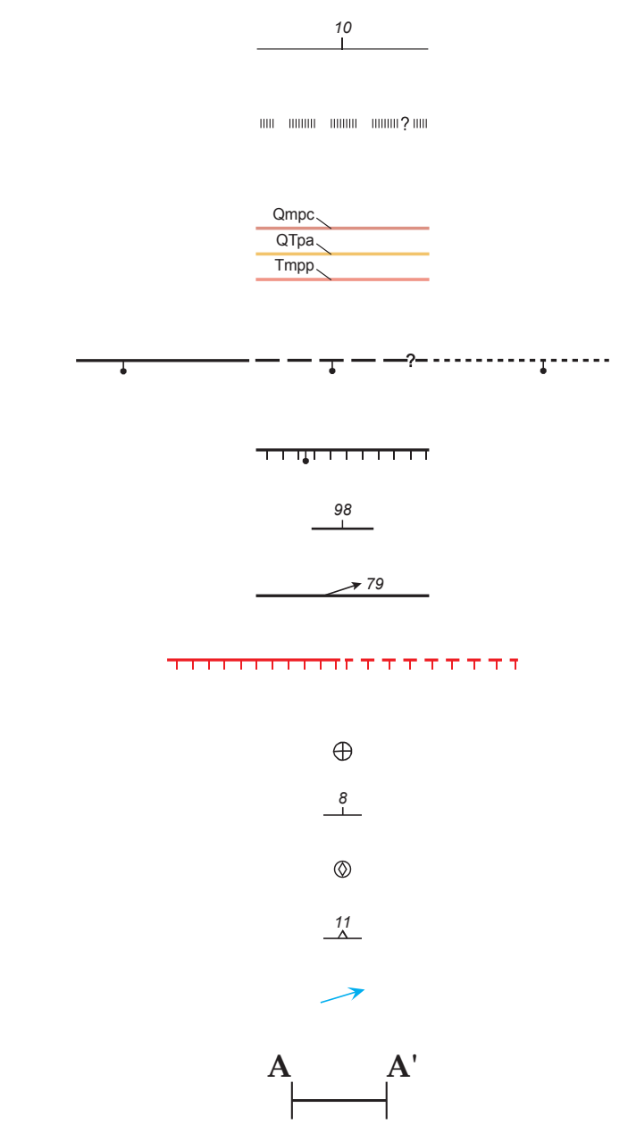
Permian System

Psa **San Andres Formation**—On this quadrangle, the San Andres consists of highly fractured, medium-gray, granular limestone. Thin arcuate traces of sparry calcite may be replaced fossils; Cserna (1956) reported small gastropod fossils in the San Andres in the Fra Cristobal Mountains. Thickness unconstrained on this quadrangle; Nelson et al. (2012) estimate a maximum thickness of 160 m within the Fra Cristobal Mountains.

Cataclastic Rocks

sbr **Silicified breccia**—Silicified breccia lying along the basin-bounding fault at the base of the Fra Cristobal Mountains. Breccia shows evidence of multiple periods of brecciation and silicification. Breccia clasts are angular, pale gray silicified material generally <6 cm across; the nature of the protolith is obscured by heavy silicification. Clasts are surrounded and often supported by ubiquitous reddish-brown siliceous cement (jasper). Clasts and cement are cross-cut by rare thin mineralized fractures and veins of black, bulbous oxides and sparry calcite. The unit extends off-quadrangle eastward, grading into solid rock over several tens of meters.

Explanation of Map Symbols



Contact—Identity and existance are certain, questionable where queried. Location is accurate where solid (bold tic marker, where present, indicates a location where the contact is particularly well exposed), approximate where dashed, concealed where dotted.

Inclined geologic contact—Showing dip value and direction.

Gradational contact—Identity and existance are certain, questionable where queried. Location is approximate.

Key bed—Map units noted pinch out into single bed in exposure.

Normal fault—Identity and existance certain; location approximate where dashed, concealed where dotted. Where queried, identity and existance questionable; location approximate where dashed, concealed where dotted. Bar and ball on downthrown side.

Scarp on normal fault—Identity and existence certain, location accurate.

Minor inclined fault, showing dip value and direction.

Lineation on fault surface, showing bearing and plunge.

Rim of volcanic crater–Hachures point into crater—Identity and existence certain, location accurate where solid and concealed where dotted.

Horizontal bedding.

Inclined bedding—Showing strike and dip.

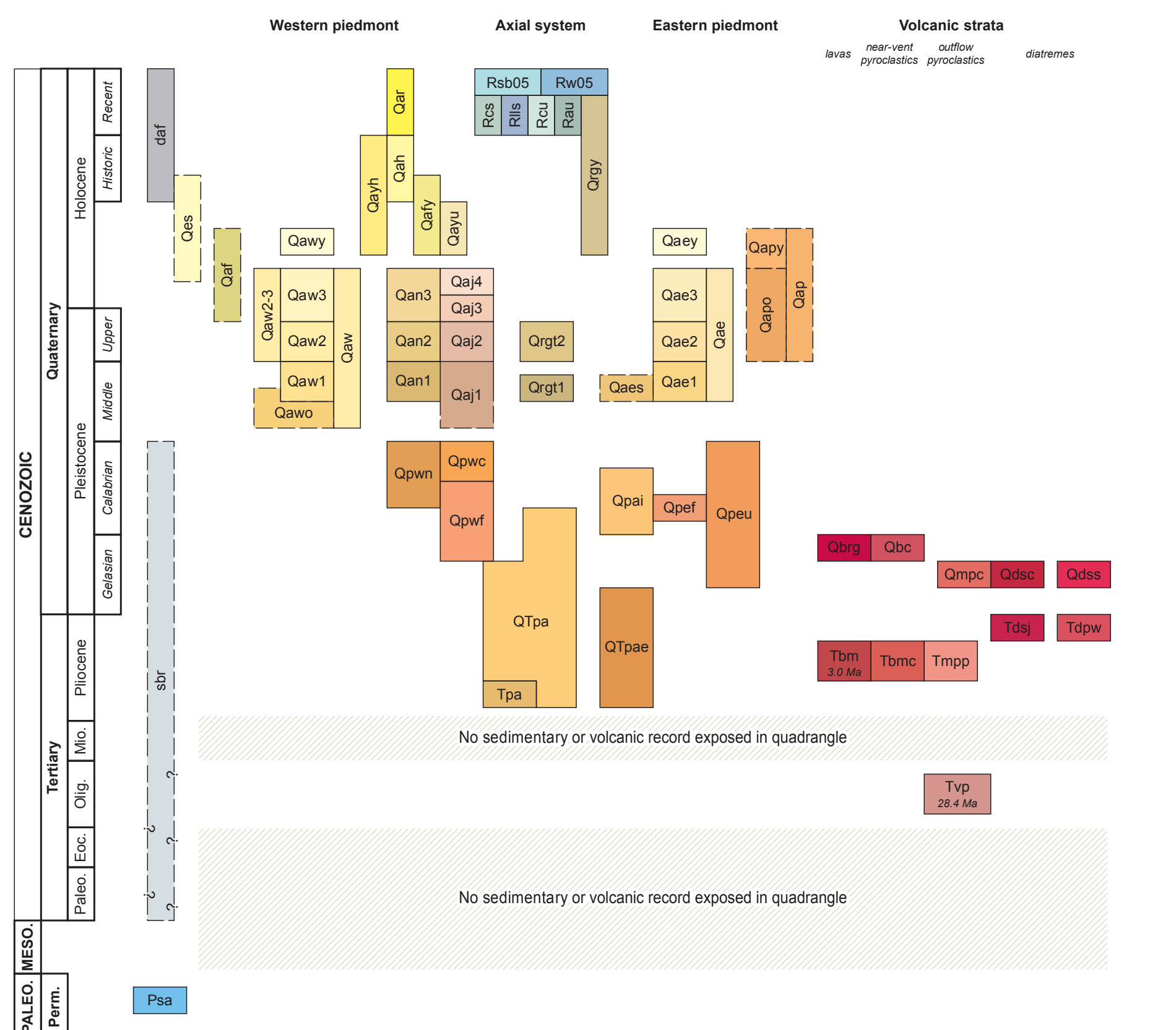
Horizontal flow banding, lamination, layering, or foliation in igneous rock.

Inclined flow banding, lamination, layering, or foliation in igneous rock.

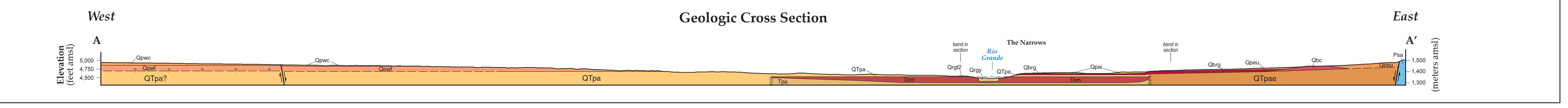
Fluvial transport direction.

Location of geologic cross section.

Correlation of Map Units



Geologic Cross Section



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