LA JOYA NW 7.5-MINUTE QUADRANGLE

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Description of map units

Geologic units were mapped in the field and using color digital orthophotographs and stereo-pair aerial photographs. Colors are denoted using Munsell notation (Kollmorgen, 1994). Pedogenic carbonate morphologic stages after Machette (1985). Asterisk (*) on map unit symbol denotes units shown only on geologic cross section.

Anthropogenic and surficial deposits

Thin surficial deposits derived from wind and mass-movement processes, or areas disturbed by human activities.

af	Artificial fill and disturbed land (modern) — dumped fill associated with construction of small dams.
Qca	Colluvium and alluvium, undivided (Holocene-Pleistocene) — poorly consolidated, poorly sorted and stratified, fine- to coarse-grained, clast- and matrix-supported, transport-limited deposits derived from a variety of mass-movement hillslope processes, including debris flow, shallow slump and creep. Gravels are typically angular and composition generally reflects local upslope provenance. Differentiated where areally extensive, thick, or obscures geologic contacts. Variable thickness, ranging from 0-5 m.
Qe	Eolian sand and sand dunes (Holocene) — unconsolidated and poorly consolidated, light-brown to light yellowish-brown, moderately to well sorted, fine-to medium-grained sand primarily recognized as laterally extensive sand sheets. Surface supports sparsely to moderately vegetated slopes. Soil development is very weak to nonexistent. Variable thickness, ranging from 0-3 m.
Qae	Eolian sand and alluvium (Holocene-upper Pleistocene) — unconsolidated to poorly consolidated, moderately to well sorted, light reddish-brown to light-brown, fine- to medium-grained sand and silty sand with scattered pebbles that commonly forms a relatively thin, discontinuous mantle over relative flat upland areas. Mapped where areally extensive or thick. Variable thickness, ranging from 0-3 m.

Alluvium of the Rio Puerco

Fluvial deposits associated with modern and former positions of the Rio Puerco. Contains unconsolidated to weakly consolidated sand and mud associated with the gently south-sloping floor of the Rio Puerco Valley. Divided into five units based on geomorphic position and cross-cutting relationships. Valley floor alluvium was deposited primarily by overbank flow of the Rio Puerco and tributaries that flowed down-valley, subparallel to the modern channel. Alluvium accumulated below the valley floor includes paleochannels and overbank deposits and probably is at least 20 m thick. Upstream, the valley fill thickens to 40 m. Inset against the broad valley floor are two alluvial terraces (Qrpt2, Qrpt1). Inset below these are remnants of the Rio Puerco channel (Qrpc2) and active floodplain (Qrpc1). Bryan (1925) and Bryan and Post (1927) attempted to establish when the Rio Puerco incised its valley floor in the 19th century.

Historic photographs of the Rio Puerco channel in the vicinity of the railroad and US-85 bridges (in the adjacent Abeytas quadrangle) show remarkable channel changes during the 20th century from a broad, shallow, braided channel to one trapezoidal silt-sided meandering channel between aggraded tamarisk-stabilized banks (***Qrpc₁*** and ***Qrpc₂***; J. Wall and C. Gorbach, unpublished data). Elliot (1979), Meyer (1989), and Gellis (1991) addressed the possible evolution of the modern Rio Puerco channel through time. Love and others (1982) and Love and Young (1983) described several buried Holocene arroyo channels within the Rio Puerco valley fill upstream from the map area.

Qrp	Rio Puerco valley alluvium, undivided (Historic-middle Pleistocene) — Pale-brown and reddish-brown, unconsolidated sand, pebbly sand, silt and clay underlying most of the floor of the Rio Puerco valley. Interfingers with units ***Qae*** and ***Qvy*** at valley margins. Generally corresponds to unit Pfa of Pearce and Kelson (2004). Thickness decreases downstream from more than 40 m thick north of the study area to 20 to 30 m thick near the confluence with the Rio Grande. Locally divided into three channel subunits and two terrace subunits:
$Qrpc_3$	Rio Puerco valley alluvium, modern channel deposits (Historic) — Unconsolidated pale brown, medium sand, silt, and clay within the active channel of the Rio Puerco. Lowest and youngest inset valley alluvium. Thickness varies.
$Qrpc_2$	Rio Puerco valley alluvium, modern channel deposits (Historic) — Unconsolidated pale brown, medium sand, silt, and clay within the active channel of the Rio Puerco. Generally modified from units W35, Rsb35, and Rcs35 (i.e., the channel in 1935) of Pearce and Kelson (2004) using 1996-vintage digital orthophotography. Thickness varies.
$Qrpc_1$	Rio Puerco valley alluvium, Modern channel and scroll-bar deposits (Historic-upper Holocene) — Unconsolidated, light brown sand and silty clay deposits interpreted as former Rio Puerco channels; recognized on aerial photography and generally corresponds to units Hcs, Hcb, and Hsb of Pearce and Kelson (2004). Scroll-bars are marked by arcuate vegetation such as tamarisk. Thickness ranges up to 4 m.
$Qrpt_2$	Rio Puerco valley alluvium, younger inset terrace deposits (Holocene) — Unconsolidated pale brown silty clay at top (20-60 cm), and underlain by medium sand, silt, and clay; deposit top sits approximately 1.5 m above the active channel of the Rio Puerco. Fine-grained upper beds suggest occasionally inundation by floods. Thickness ranges from 4 to 6 m.
$Qrpt_1$	Rio Puerco valley alluvium, older inset terrace deposits (lower Holocene to upper Pleistocene) — Unconsolidated to poorly consolidated pale brown, medium sand, silt, and clay. Unit sits approximately 2-3 m above the active channel of the Rio Puerco. Thickness ranges from 5 to 7 m.

Stream-valley alluvium

Tributary stream-valley alluvium associated with modern and Pleistocene entrenched tributary valleys. Deposits typically contain poorly to well sorted, poorly to well stratified, clast- and matrix-supported sediment that is inset against the Santa Fe Group and older rocks.

Qa	Active alluvium, modern deposits (modern-Holocene) — light-brown (7.5YR

	6/4), unconsolidated, poorly to moderately sorted, medium- to coarse-grained sand and pebbly to bouldery sand occupying modern arroyos that grade to the floor of the Rio Puerco and Rio Grande valleys. No pedogenic development or carbonate cement. Base is not exposed, but deposit is estimated to range from 1 to 3 m in thickness.
Qvy	Younger alluvium, undivided (Holocene-upper Pleistocene) — brown (7.5YR 4/4) pebble gravel associated with broad valley fill units within modern stream valleys and valley border fans that grade to the Rio Puerco floodplain. Weak soil development with Stage I pedogenic carbonate morphology. Locally divided into older subunit (***Qayo*** based on inset relationships).
	Intermediate alluvium (middle Pleistocene) — inset by younger stream-valley alluvium (***Qvy***). Locally divided into four subunits based on inset relationships and surface morphology.
Qvm4	Intermediate alluvium, youngest subunit (middle Pleistocene) — brown (7.5YR 5/4), weakly consolidated pebble gravel, pebbly sand with Stage II pedogenic carbonate morphology; poorly exposed and generally less than 3 m thick.
Qvm3	Intermediate alluvium, intermediate subunit (middle Pleistocene) — brown (7.5YR 5/4-5/6), weakly to moderately consolidated pebble gravel, pebbly sand, and medium- to coarse-grained sand with Stage III pedogenic carbonate morphology; poorly exposed. Thickness ranges from 1 m to over 8 m thick.
Qvm2	Intermediate alluvium, older subunit (middle Pleistocene) — brown, moderately consolidated pebble gravel, pebbly sand, and medium- to coarse-grained sand with Stage III pedogenic carbonate morphology; poorly exposed. Thickness ranges from 1 m to over 3 m thick.
Qvm1	Intermediate alluvium, oldest subunit (middle Pleistocene) — brown, moderately consolidated pebble gravel, pebbly sand, and medium- to coarse-grained sand with Stage III pedogenic carbonate morphology; poorly exposed and strongly modified by erosion. Thickness ranges from 1 m to over 3 m thick.
Qvo	Older alluvium, undivided (middle Pleistocene) — poorly exposed pebble to cobble gravel on high ridge-tops. Unconformably overlies moderately to slightly tilted strata of the Popotosa and Sierra Ladrones formations. Locally exhibits stripped soils with Stage III+ pedogenic carbonate morphology. Unit is inset by intermediate alluvium (***Qvm***). Gravels are dominated by 10-20% boulders of quartz and light-colored granite, with locally abundant schist. Gravels up to 60 cm in maximum diameter. Deposit top about 70-115 m above local base level. Approximately 15 m thick.
Qg	Ridge-capping gravel (Pleistocene) — cobble and small boulder lags on ridge tops. Probably remnants of older and intermediate alluvium (***Qvo***, and ***Qvm***).
Qu*	Alluvium, undivided (Holocene-Pleistocene) — undivided units ***Qa***, ***Qvy***, ***Qvm***, and ***Qvo***. Cross-section only.

Santa Fe Group

Deposits of the Santa Fe Group were divided into three lithostratigraphic units and locally subdivided based on textural criteria according to Cather (1997). The Popotosa Formation (lower Santa Fe Group) represents the lowest unit of the Santa Fe Group and records unroofing of the Ladron Mountains with the lower part of the formation being dominantly volcaniclastic and the upper part containing granitic detritus (Bruning, 1973). The Popotosa Formation typically has moderately steep westward stratal tilts, towards the Ladron Mountains (Bruning, 1973). In fault contact in the map area, but typically overlain by Sierra Ladrones Formation in angular unconformity (Bruning, 1973; Machette, 1978; Asher-Bolinder, 1988). The Ceja Formation (upper Santa Fe Group) was recognized by Connell et al. (2001) and Love et al. (2001) east of the Loma Blanca fault. They originally correlated these deposits to the Arroyo Ojito Formation, but subsequent work in the northwestern part of the Albuquerque basin suggests that Ceja Formation is a better correlation (Connell, 2006). The Ceja Formation was mapped as piedmont-slope and alluvial-flat deposits east of the axial-fluvial member on the adjacent San Acacia quadrangle (see Machette, 1978). The Sierra Ladrones Formation (upper Santa Fe Group) represents the youngest and highest unit of the Santa Fe Group and was originally defined on the adjacent San Acacia quadrangle by Machette (1978).

Ceja Formation

Tc	<u>Ceja Formation (Pliocene)</u> — light-brown to very pale-brown (7.5YR 6/4-5/4 to 10YR 8/2), moderately sorted, very fine- to medium-grained (vfL-mL) sandstone with well sorted, ledge-forming ledge forming sandstone and pebbly sandstone interbeds. Contains subordinate to minor amounts of light reddish-brown (5YR 6/3) slightly calcareous mudstone. Coarse-grained intervals represent less than 15% of unit. Gravels contain abundant rounded chert and intermediate volcanic pebbles with sparse sandstone and very sparse, scattered oyster (*Pycnodonte)* shells (probably recycled from Cretaceous deposits). The presence of abundant rounded chert and southerly paleoflow directions suggest correlation to the Ceja Formation. Locally trough cross-stratified with southeasterly paleoflow direction. Beds are typically subhorizontal or slightly tilted. Overlain by stream-valley alluvium. Base not exposed, but unit is probably more than 100 m thick.

Ceja-Sierra Ladrones Formation transition

QTsct	<u>Transitional deposits, Ceja and Sierra Ladrones formations (Pliocene)</u> — reddish-brown (5YR 5/4) mudstone and medium- to coarse-grained (mL-cU) pebbly sandstone; coarse-grained beds are approximately 10-20% of unit and contain abundant angular to subangular volcanic, granitic, and schistose pebbles and cobbles; float on slopes locally contain 2-10% rounded black to brownish-yellow polished chert pebbles. Conglomeratic beds are locally trough cross-stratified, and cross-stratification indicates southward and eastward paleoflow directions. Unit is poorly exposed and generally forms slopes with medium bedded cemented intebeds of angular pebbly sandstone; interfingers with Sierra Ladrones piedmont deposits to west. Eastern exposures truncated by Loma Blanca fault. Probably interfingers with axial-fluvial deposits of Sierra Ladrones Formation to east. Base not exposed, but unit is at least 25 m in thickness.

Sierra Ladrones Formation

Deposits of the Sierra Ladrones Formation (upper Santa Fe Group) were originally defined by Machette (1978) for deposits on the adjoining San Acacia quadrangle (to south). Base of formation is not exposed on map area, but Cather et al. (1994) report approximately 470 m to south in the Silver Creek quadrangle. Unit is commonly divided into a piedmont member and an axial-fluvial member. The piedmont member is locally subdivided into three textural facies using the scheme of Cather (1997). Beds of the Sierra Ladrones Formation are typically subhorizontal. In the study area stratal tilts of the axial-fluvial member dip up to 14ºNW.

QTsp	Sierra Ladrones Formation, undivided piedmont deposits (Pliocene-lower Pleistocene(?)) — very pale-brown to light reddish-brown (10YR 7/3, 7.5YR 6/3-6/4, 5YR 6/4), weakly cemented, poorly sorted, fine- to very coarse-grained (fL-vcU) sandstone, conglomeratic sandstone, and mudstone; with scattered ledge-forming, well cemented, conglomeratic sandstone interbeds. Gravel is mostly <4 cm diameter and ranges up to 11-12 cm maximum diameter (3-4 cm intermediate diameter) and composed of intermediate volcanic, limestone, granite, greenstone, red volcanic, schist/gneiss, angular quartz, sandstone (2%), and chert pebbles. Beds typically have shallow dips, except near faults; poorly exposed; base not exposed, but probably overlies Popotosa Formation with angular unconformity. Divided into four units using textural scheme of Cather (1997).
QTspc	Western-margin piedmont deposits, conglomeratic deposits (Pliocene-lower Pleistocene(?)) — conglomerate with subordinate sandstone (conglomerate: sandstone ratio greater than 2:1). Conglomerate is mostly clast supported, although matrix-supported deposits are also present.
QTspcs	Western-margin piedmont deposits, conglomeratic sandstone deposits (Pliocene-lower Pleistocene(?)) — poorly sorted, conglomeratic sandstone with sparse mudstone (conglomerate:sandstone ratio between 2:1 and 1:2). Conglomerate is mostly clast supported. Sandstone is medium to very coarse and is typically horizontally laminated or trough cross bedded. Typically found between conglomeratic (***QTspc***) and sandstone (***QTsps***) facies.
QTsps	Western-margin piedmont deposits, sandstone deposits (Pliocene-lower Pleistocene(?)) — sandstone with subordinate mudstone (conglomerate:sandstone ratio less than 1:2). Sandstone is mostly horizontally laminated with subordinate trough and planar cross bedding. Conglomerate occurs in shallow, lenticular beds, is mostly clast supported.
QTsts	Sierra Ladrones Formation, transitional deposits (Pliocene-lower Pleistocene(?)) — interfingered axial-fluvial member deposits (***QTsa***) and piedmont deposits (***QTsp***). Reddish-brown (5YR 5/4), thinly bedded, very fine- to fine-grained (vfL-fU) sandy mudstone containing 10-20 cm thick bioturbated zones. Conglomerate:sandstone ratio generally less than 1:2. Transitional deposits are defined as the zone of overlap between the *western* outcrops of axial river deposits and the *easternmost* outcrops of piedmont sandstone and conglomerate.
QTsa	Sierra Ladrones Formation, axial-fluvial member (Pliocene) — very pale-brown to light-brown (10YR 7/3 – 7.5YR 6/3), moderately to well sorted, cross-stratified sandstone with sparse light olive-green mudstone and thin pale-yellow (2.5Y 8/4) fine-grained sandstone (vfL-fU) interbeds.

	Conglomerate:sandstone ratio less than 1:2. Sparse pebbly sandstone beds contain sparse rounded orthoquartzite and locally abundant subangular granite. Granite is interpreted to be derived from Ladron Mountains. Interbedded with light-gray to very pale-brown (10YR 7/1-8/2) weakly to moderately cemented sandstone and claystone. Interfingers with piedmont deposits (***QTsp***). Probably Pliocene in age.
QTspe*	Sierra Ladrones Formation, eastern-basin piedmont member (Pliocene) — Interpreted deposits derived from eastern margin of basin, underlies and probably interfingers with Ceja Formation. Probably contains granitic and volcanic detritus. Cross section only.

Popotosa Formation

Beds in the Popotosa Formation typically have steeper dips (~9-20º) than in the Sierra Ladrones Formation. Stratal dips in the Popotosa Formation increase to 45º in the adjacent Ladron Peak quadrangle (see Read et al., 2007). The Popotosa Formation is divided into a piedmont-slope member and a fluviolacustrine (playa-lake) member. Piedmont deposits range from 820 to 1860 m in thickness. The playa-lake deposits are approximately 700 m in thickness.

Tppc	Popotosa Formation, fanglomerate of Ladron Peak (upper Miocene) — brown to light-brown (7.5YR 6/3-5/3) well consolidated, pebble to cobble conglomerate and pebbly sandstone. Conglomerate:sandstone ratio of greater than 2:1. Conglomerate is commonly clast supported, crudely imbricated, and poorly sorted. Typically poorly exposed, but locally can form steep walls and ledges. Gravel is 2- to 10-cm diameter with scattered large cobbles and small boulders. Gravels contain mostly angular to subangular red granite, quartzite, schist, subrounded limestone and sparse gray volcanic tuff. Pebble imbrications indicate easterly to southeasterly paleoflow direction. Correlative to the fanglomerate of Ladron Peak (Bruning, 1973); over 500 ft (150 m) thick.
Tppcs	Popotosa Formation, piedmont deposits conglomeratic sandstone, (Miocene) — conglomeratic sandstone (conglomerate:sandstone ratio between 2:1 and 1:2). Conglomerate is mostly clast supported and poorly exposed. Sandstone is fine- to very coarse-grained and horizontally stratified or locally trough cross-stratified. Mudstone is sparse. Pebble imbrications indicate eastward paleoflow direction. Interfingers with conglomeratic sandstone (unit Tppc) and sandstone (Tps). Gravels are dominated by granitic and metamorphic rocks. Locally contains abundant volcanic detritus, especially low in unit.
Tpps	Popotosa Formation, transitional piedmont/basin-floor deposits (Miocene) — sandstone with subordinate mudstone (conglomerate:sandstone ratio less than 1:2). Sandstone is mostly horizontally laminated with subordinate trough and planar cross bedding. Interfingers with and includes thin transition (10-30 m) with basin-floor deposits of unit ***Tpl***. Interpreted as distal piedmont deposits.
Tpl	Popotosa Formation, basin-floor (fluviolacustrine) deposits (Miocene) — reddish-brown (5YR 5/3) mudstone with local 1-2 m thick, light greenish-gray (5GY 7/1) mudstone interbeds, and very sparse thinly bedded sandstone interbeds. Sandstone:mudstone ratio less than 1:2. Sandstone ranges from very fine- to medium-grained and is present as sparse, think tabular beds.

	Conglomeratic beds are sparse or not present. Gypsum is common. Interfingers with units ***Tpps*** and ***Tppcs***. In fault contact with Sierra Ladrones Formation. Interpreted as deposits in a playa-lake. Base not exposed in map area; Bruning (1973) estimated thickness of about 700 m.
Tpp*	Popotosa Formation, piedmont deposits, undivided (Miocene) — undivided units ***Tppc***, ***Tppcs***, ***Tpps***. *Cross-section only*.
Tppg*	Popotosa Formation, granite-bearing piedmont deposits, undivided (Miocene) — granite-bearing piedmont deposits. *Cross-section only*.
Tppv*	Popotosa Formation, volcanic-bearing piedmont deposits, undivided (Miocene) — volcanic-bearing piedmont deposits. *Cross-section only*.

Older rocks

Older sedimentary and crystalline rocks depicted in geologic cross section.

Tlu*	Laramide sedimentary and volcanic rocks, undivided (Eocene-Oligocene) — includes volcanic rocks of La Jara Peak Basaltic Andesite, La Jencia Tuff, Hells Mesa Tuffs, Spears Formation, and Baca Formation (Osburn and Chapin, 1983). Oligocene volcanic rocks are approximately 330 m thick. Volcaniclastic deposits of the Spears Formation are about 200 m thick. The underlying Baca Formation is about 60 m thick. *Cross-section only*.
Mz*	Mesozoic sedimentary rocks, undivided (Cretaceous and Triassic) — includes sedimentary rocks of the Cretaceous Tres Hermanos Formation and Mancos shale. Also includes undivided Triassic rocks. Estimated thickness is approximately 130 m. *Cross-section only*.
Pz*	Upper Paleozoic sedimentary rocks, undivided (Mississippian-Permian) — includes Caloso and Kelly formations, Sandia Formation, Madera Group, Abo and Yeso Formations, and other Permian deposits. Estimated thickness is at least 330 m. *Cross-section only*.
XY*	Proterozoic crystalline rocks, undivided (Mississippian-Permian) — includes plutonic and metamorphic rocks. *Cross-section only*.

Symbols

▲▲▲	Piedmont conglomerate marker bed (***QTsp***).
□	Location of Ceja Formation deposits (***Tc***).
▲	Location of piedmont-slope deposits (***QTsp***).
●	Location of axial-fluvial deposits (***QTsa***).
x→ ●→ ▪→	Azimuth of paleocurrent vector, filled circle denotes observation from pebble imbrications; x denotes observation from channel orientation or cross-stratification.
┬┬┬┬┬┬┬┬ **(2)**	Topographic scarp; numbers denote approximate height (in meters)
70—┴—............**?**	Trace of fault (red); dashed line denotes approximate location; dotted where concealed; queried where inferred.
⊕	Horizontal bedding
—┴—**12**	Strike and dip of inclined bedding

LA JOYA NW 7.5-MINUTE QUADRANGLE
UNIT CORRELATION

**asterisk denote units shown in cross-section only*