

### Qay units) typically contain poorly to well sorted, poorly to well stratified, clast- and matrix-supported deposits associated with modern and late Pleistocene entrenched arroyos across the map area. Gravel composition reflects upland lithology. Stream-terrace deposits typically have an elongate planform shape and are associated with major drainages. Western-margin alluvium is delineated west of the inner valley of the Rio Grande (Qam and Qao units) and generally contains poorly to moderately sorted, moderately stratified, and clast and matrix supported deposits derived from uplands underlain by deposits of the Arroyo Ojito Formation (Loma Barbon and Ceja(?) Members). Eastern-margin piedmont alluvium (Qpo and Qpm units) contains generally poorly sorted, poorly stratified, clast- and matrixsupported deposits having angular to subangular clasts of granitic, metamorphic, sandstone, and minor limestone derived from the Stream-valley alluvium Youngest stream alluvium (Historic to Holocene) - Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) sand, silty to clayey sand, and gravel. Boulders are common along the base of Rincon Ridge and northwestern front of the Sandia Mountains. Inset against eastern-margin piedmont alluvium (Qpm2) and stream alluvium (Qay). Underlies modern arroyos that grade westward to the Las Padillas Formation (Qrp, Rio Grande floodplain). Very weakly developed soils exhibit no pedogenic carbonate at the surface and weak Stage I carbonate morphology at depth. Locally subdivided into an older (QHao) deposit on the basis of inset relationships. Forms extensive valley border alluvial fans along the margins of the inner valley of the Rio Grande. These valley border alluvial fans may locally contain hydrocollapsible soils. Geomorphic surface Q9 of Connell (1995, 1996). Variable thickness, up to Younger stream alluvium (Holocene to uppermost Pleistocene) - Poorly consolidated deposits of very pale-brown to light-brown 7.5-10YR) sand to sandy clay loam and gravel. Inset against alluvium of units Qpm and Qam. Slightly dissected surface possesses well-developed constructional bar-and-swale topography. Weakly developed soils exhibit Stage II carbonate morphology and minor clay film development. Associated with broad valley fill units within modern stream valleys that grade to the Las Padillas Formation (Qrp, Rio Grande floodplain). Hibben (1941) reported Rancholabrean mammals (Mastodon and Equus) within this unit near the Village of Placitas (see also Kelley and Northrop, 1975, p. 72-73). Archaic (2-6 ka) projectile points were also reported in this deposit (probably near the deposit base) just north of state highway NM 165, near the Village of Placitas (Bruce Huckle, UNM Maxwell Museum, 1999 written communication). Locally includes undivided stream alluvium (QHa) in narrow arrovos Locally divided into older (Qavi) and vounaer (Qav) subunits on the basis of inset relationships at the southwestern corner of the Bernalillo quadrangle. Spring deposits are locally interbedded within reaches of the Arroyo de San Francisco (notably in Section 15, T13N, R5E). Forms broad valley border alluvial fans along the margins of the inner valley of the Rio Grande. These valley border alluvial fans may locally contain hydrocollapsible Western-margin alluvium Middle western-margin alluvium, undivided (upper to middle Pleistocene) - Poorly consolidated deposits of yellowish-brown to reddish-yellow (7.5-10YR) sand to silty-clayey sand and minor gravel. Gravel is primarily composed of red granite, chert, basalt, and minor gray volcanic rocks recycled from the Arroyo Ojito Formation. Locally well stratified and slightly cemented with calcium carbonate. Inset against older western-margin alluvium (Qao) and is inset by young stream alluvium (Qay). Soil development is variable and possesses Stage II to III carbonate morphology. Delineated west of the Rio Grande, where deposits are associated with broad valley fill units that interfinger with the Los Duranes Formation (Qrd). Correlative to eastern-margin piedmont alluvium (Qpm) and geomorphic Older western-margin alluvium, undivided (middle to lower Pleistocene) - Poorly consolidated deposits of light reddish-brown .5-10YR) sand with pebble to cobble gravel interbeds primarily composed of red granite, chert and basalt recycled from the Arroyo Djito Formation. Unconformably overlies upper Santa Fe Group deposits (QTob, QToc(?)), and the Lomatas Negras Formation (Qrl). Inset by western-margin alluvium (Qam). Unit is poorly exposed and commonly capped by thin veneer of undivided eolian and alluvium (Qae). Soil development is variable and possesses Stage I to III carbonate morphology. Delineated west of the Rio Grande, where deposits are associated with broad valley fill units overlie the Lomatas Negras Formation. Generally correlative to older eastern-margin piedmont alluvium (Qpo) and geomorphic surfaces Q3-Q5 of Connell (1995, 1996). Variable thickness, up to 50 ft (15 m). Eastern-margin piedmont alluvium Younger eastern-margin piedmont alluvium (Holocene to uppermost Pleistocene) - Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) sand, sandy clay loam and gravel. Boulders are common along mountain-front alluvial fans along the flanks of Rincon Ridge and northern Sandia Mountains. Deposit surface is weakly dissected and possesses well developed bar-and-swale topography. Soils possess Stage I to II+ carbonate morphology and few thin clay films. Locally subdivided into older (Qpy1) and younger (Qpý2) subunits on the basis of soil-profile and inset relations. Commonly buries the Edith Formation (Qre) and terminates against the escarpment of the inner valley of the Rio Grande. Geomorphic surface Q9 of Connell (1995, 1996) Variable Middle eastern-margin piedmont alluvium, undivided (upper to middle Pleistocene) - Poorly consolidated deposits of very palebrown to light-brown (7.5-10YR) sand to silty and clayey sand, and gravel derived from the Sandia Mountains. Unconformably overlies the Edith Formation (Qre) and is inset by younger stream alluvium (Qay). Gravel clasts are predominantly subangular metamorphic and porphyritic granite along the western mountain front, and dominated by limestone and sandstone with subordinate granite and metamorphic rocks along the northern flank of the Sandia Mountains. Granite and limestone clasts are moderately to deeply pitted, and schist clasts are locally slightly split. The slightly dissected deposit surface possesses subdued, constructional bar-and-swale topography on interfluves. Weakly developed soils exhibit Stage II to III+ carbonate morphology and minor to moderate clay film development. Locally divided Middle eastern-margin piedmont alluvium, younger subunit (upper to middle Pleistocene) – Moderately consolidated deposits of very pale-brown to strong yellowish-brown (7.5-10YR), poorly to moderately stratified and sorted, silty clay and loamy sand and gravel. Inset against eastern-margin piedmont alluvium (Qpo and Qpm1), and conformably overlies the Menaul Formation

sloping constructional piedmont-slope, herein named the Del Agua geomorphic surface, are preserved on the younger subunit (locally mapped as Qpm<sub>2b</sub>) between Del Agua Cañon and Sandia Wash. Geomorphic surface Q7 of Connell (1995, 1996) Middle eastern-margin piedmont alluvium, older subunit (middle Pleistocene) – Moderately consolidated deposits of lightto strong-brown (7.5YR) and very pale-brown to light-gray (7.5-10YR), poorly to moderately stratified and sorted, sand clayey sand and gravel. Inset against older eastern-margin piedmont alluvium (Qpo) and unconformably overlies the Edith Formation (Qre). issected deposit surface exhibits subdued erosional ridge-and-ravine topography. Subdued bar-and-swale constructional topography is locally preserved on broad non-dissected interfluyes. Moderately well developed soils with Stage III+ carbonate morphology Older eastern-margin piedmont alluvium (middle to lower Pleistocene) - Poorly to moderately sorted and stratified gravel and sand with minor silty-clay mixtures. Granite clasts are commonly grussified or deeply pitted, schist clasts are typically split, and limestone clasts are moderately to deeply pitted. Map relationships suggest that deposits are inset against the gravel of Lomos Altos (Tsla) and are truncated by a buried escarpment formed during deposition of the Edith Formation. Locally divided into four subunits. Variable Older eastern-margin piedmont alluvium, youngest subunit (middle Pleistocene) - Poorly exposed cobble gravel overlying a strath along the southern margin of Las Huertas Creek. Inset against older eastern-margin piedmont deposits (Qpo3). Deposit is Older eastern-margin piedmont alluvium, younger subunit (middle Pleistocene) - Moderately consolidated deposits of pale to dark brown (7.5-10YR) clay loam to silty clay loam and cobble to boulder gravel. Gravel clasts are dominated by limestone, netamorphic rocks, and sandstone along the northern flank of the Sandia Mountains. Poorly exposed, inset against older eastern margin piedmont alluvium (Qpo)), and overlies a formerly broad, northwest-sloping pediment surface cut on Santa Fe Group and older rocks. The western margin of unit is truncated by a buttress unconformity that probably formed during deposition of the Edith Formation (Qre). Deposit surface is slightly dissected, exhibits subdued bar-and-swale topography. Soils are moderately developed and exhibit weak Stage III carbonate morphology and many to continuous, thick clay films. Geomorphic surface Q5 of Connell Older eastern-margin piedmont alluvium, middle subunit (middle to lower Pleistocene) - Poorly to moderately sorted and moderately consolidated deposits of brownish-yellow to yellowish-brown (10YR) gravel and sandy clay loam. Gravel clasts are predominantly granite, metamorphic, and subordinate limestone. Locally contains grussified granite and split metamorphic clasts ery poorly exposed and mostly buried by eastern-margin piedmont alluvium (Qpy and Qpm) on the hangingwall of the Rincon fault (NW1/4, Section 12, T12N, R5E). Soils are strongly developed and locally exhibit Stage III to IV carbonate morphology.

> Upper Santa Fe Group Western basin-margin deposits (Arroyo Ojito Formation)

moderately cemented, yellowish-brown to yellowish-red and reddish-brown (5-10YR), fine-grained silty sandstone with interbedded mudstone and scattered, lensoidal, weakly to well cemented, cobbly to bouldery sandstone interbeds. Gravel clasts are predominantly subangular red granite, subrounded basalt and light-gray tuff, and minor sandstone derived from the northwestern margin of the Albuquerque Basin and eastern slope of the Sierra Nacimiento. Named after a succession of reddish-brown sandstone, gravel and mudstone exposed just north of Loma Barbon. A primary airfall lapilli tuff (Locality B-1, SE1/4, SW1/4, NW1/4, Section 10, T13N, R3E), present about 10 ft (3 m) below Ceja(?) Mémber deposits (QToc(?)), yields a <sup>40</sup>Ar/<sup>39</sup> Ar date of 6.82±0.04 Ma (NMGRL 8925, W.C. McIntosh, 1998, written communication) and is tentatively correlated with the Peralta Tuff Member of the Bearhead Rhyolite. A recycled subrounded rhyodacite(?) clast (Locality B-4) yields an 40Ar/39 Ar date of 4.59±0.21 Ma (NMGRL 9136, W.C. McIntosh, 1998, written communication). Interfingers with, and is overlain by axial-fluvial deposits (QTsa), which are exposed east of the inner valley of the Rio Grande. Correlative deposits (unit QTst of Cather and Connell, 1998) are overlain by the basalt of Santa Ana Mesa' (Tbsa). Locally includes thin, discontinuous lenses of unit QTsa along the margins of the inner valley of the Rio Grande. Estimated hydraulic conductivity is poor to moderate. Base is not exposed but is at least 425 m Syntectonic colluvial wedge unit (upper Miocene to Pliocene) - Reddish-brown to orange-brown (5-10YR) sandstone and mudstone associated with the hanging wall of the Luce fault (Section 11, T13N, R03E). Pinches out east of the Luce fault and is interpreted to be an intra-formational colluvial wedge associated with fault movement within the Loma Barbon Member (QTob). Axial-fluvial deposits (ancestral Rio Grande)

ial) and is not a factor in delineating the transitional facies (Cather 199

Travertine and spring deposits (middle Pleistocene to Pliocene) - Light-gray nodular to massive limestone interlayered with mudstone. Prominent outcrop at the northern tip of the Cuchilla de San Francisco (Sections 14 and 15, T13N, R5E) where deposits overlie and interfinger with Santa Fe Group eastern basin-margin piedmont deposits (QTsp<sub>cs</sub>) on the hangingwall of the San Francisco fault. Spring deposits are locally present along depositional contacts and faults. Variable thickness, up to 50 ft (15 m) thick. Suela Alluvium (lower Pleistocene) - Moderately consolidated and weakly cemented deposits of brown, very pale-brown to white (7.5YR-2.5Y) sandy loam, sand and subrounded to subangular cobble to pebble gravel overlying remnants of extensive, relatively smooth, northwest-sloping pediment surface that cuts across the trace of the Placitas fault. Gravel clasts contain abundant subrounded to subangular limestone, granite, sandstone, and metamorphic rocks. Limestone clasts are typically pitted, and granite clasts are locally grussified. The basal contact is unconformable along the northern flank of the Sandia Mountains, but becomes conformable with the underlying axial-fluvial deposits (QTsa) northwest of the Escala and Lomos faults. The deposit surface (top) forms a broad, northwestsloping constructional surface herein named the Las Huertas geomorphic surface. The Las Huertas geomorphic surface is commonly buried by thin veneer of light-brown eolian sand, diverges downstream of Las Huertas Creek, between about 110-165 ft (34-50 m), and is underlain by moderately to strongly developed soils exhibiting III+ carbonate morphology. In the map area, the Las Huertas geomorphic surface is interpreted to mark the end of upper Santa Fe Group deposition and the initiation of Quaternary incision by the Rio Grande. Bar-and-swale topography is absent and soils exhibit Stage III+ carbonate morphology, and very few thin silica and clay films. Overlies Bandelier Tuff-bearing piedmont and fluvial deposits (QTsp<sub>cs</sub> and QTsa) and is thus, younger than about 1.1 Ma. Gravel of Lomos Altos (upper Pliocene) - Well consolidated deposits of very pale-brown to brown (10YR-2.5Y), sandy clay loam, sandy loam and subrounded to subangular, limestone-dominated, cobble to pebble gravel overlying remnants of a formerly broad pediment cut on Santa Fe Group eastern basin-margin piedmont deposits (Tspuc, Tspc) on Lomos Altos. The basal contact is about 260-328 ft (80-100 m) above local base level, is inset against Santa Fe Group piedmont deposits (Tspuc), and is recognized on the footwalls of the Lomos, Escala, and southern Valley View faults. Soils are strongly developed, partially stripped and exhibit Stage IV+ carbonate morphology. Unit may be equivalent to the Tuerto gravel of Stearns (1953) or the gravel of Lookout Park of Smith and Kuhle (1998a). Correlative deposits west of the Escala fault are probably buried beneath the Suela alluvium (Qss) and piedmont deposits of unit QTspcs. Piedmont deposits, undivided (lower Pleistocene to Miocene) – Subhorizontally stratified to slightly east-tilted, reddish-brown to yellowish-brown and very pale-brown (7.5-10YR) conglomerate, gravelly sandstone, and sandstone with subordinate siltstone and rare mudstone. Conglomerate clasts are predominantly composed of subangular limestone, metamorphic rocks, with minor granite and sandstone. Clast imbrications indicate generally west to southwest paleoflow. Includes unit Tsp on cross section. May be correlative with piedmont-slope and alluvial fan deposits of the Sierra Ladrones Formation (Machette, 1978) exposed at the southern margin of the Albuquerque Basin. Thickens to the east and interfingers with axial-fluvial deposits (QTsa) to the west. Moderate to low estimated hydraulic conductivity. Thickness is variable and estimated to range from 3,000-7,000 ft (915-2,135 m) thick. Divided into four subunits Piedmont deposits, conglomerate subunit – Predominantly conglomerate (conglomerate:sandstone ratio is greater than 2) with subordinate sandstone and very rare mudstone interbeds. Conglomerate clasts contain pebbles, cobbles, and boulders of lithologies similar to clasts in underlying Santa Fe Group eastern basin-margin piedmont deposits (QTsp<sub>cs</sub>). Sandstone is coarse to very coarse and typically crossbedded or horizontally laminated. Matrix-supported conglomerate is common and interpreted to represent debris Piedmont deposits, conglomerate and sandstone subunit – Sub-equal conglomerate and sandstone. Conglomerate is typically poorly sorted and clast supported, consisting primarily of pebbles and cobbles of Paleozoic limestone, sandstone, siltstone, and chert, and Proterozoic granite, gneiss, phyllite, and schist. Proterozoic detritus becomes more abundant in the southern part of the quadrangle. Sandstone is horizontally laminated or trough crossbedded, moderately to poorly sorted, and commonly pebbly. Mudstone is rare. Volcanic ash (Locality P-2) is present near the top and may be correlative to the Bandelier Tuff (Dunbar, 1997 personal communication). On the basis of stratigraphic position (e.g., stratigraphically above recycled lower Bandelier Tuff clasts

**Piedmont deposits, sandstone subunit** – Sandstone (conglomerate:sandstone ratio is less than 0.5), with subordinate siltstone. Sandstone is mostly horizontally laminated with subordinate trough and planar crossbedding. Conglomerate occurs in shallow, lenticular beds, is mostly clast supported, and consists dominantly of pebbles of Paleozoic sedimentary rocks and Proterozoic

#### Piedmont deposits, conglomerate subunit - Conglomerate (conglomerate:sandstone ratio of 2) with subordinate sandstone. Mudstone is absent. Conglomerate is mostly clast supported, although matrix-supported deposits are locally present. Clast content varies upsection. Phaneritic early Tertiary volcanic clasts derived from the Espinaso Formation (Te) are present near the base of the section exposed along the southern end of the Cuchilla de Escala (Locality P7), with Paleozoic and Proterozoic detritus dominating upsection. Volcanic pebbles and cobbles are absent at Lomos Altos (Locality P8). **Piedmont deposits, conglomerate and sandstone subunit** – Subequal sandstone and conglomerate. Mudstone is rare. Sandstone is medium to very coarse-grained and is typically horizontally laminated or trough crossbedded. Conglomerate is mostly clast supported and consists largely of Paleozoic limestone, sandstone, siltstone, and chert with subordinate Proterozoic lithologies. Piedmont deposits, sandstone subunit - Sandstone (conglomerate:sandstone ratio is less than 0.5), with subordinate siltstone. Sandstone is mostly horizontally laminated with subordinate trough and planar crossbedding. Conglomerate occurs in shallow, lenticular beds, is mostly clast supported, and consists dominantly of pebbles of Paleozoic sedimentary rocks and lesser amounts of Proterozoic crystalline rocks. Siltstone is massive to faintly laminated and forms tabular to broadly lenticular beds. Piedmont deposits, siltstone and mudstone subunit — Subequal siltstone and mudstone, with rare sandstone. Volcanic and intrusive rocks Canjilon Tuff (upper Pliocene) - Oval-shaped tuff-breccia diatreme that intrudes east-tilted sandstone of the Loma Barbon Member (QTob), just south of Santa Ana Mesa. Generally dips 50° or less towards the center of the diatreme; bedding is subvertical near faults. ontains numerous basalt dikes and brecciated basalt dikes, flows and plugs, where mappable, that are differentiated as basalt and basaltic breccia beds of the Canjilon Tuff (Tvcb). Contains a circular tuff ring near the center of diatreme. Map of diatreme interior is simplified from Kelley and Kudo (1978). Basalt and basaltic breccia beds - Locally brecciated basalt flows and feeder dikes interlayered within the Canjilon Tuff (Tvc). Yields a K-Ar date of 2 61+0 09 Ma (Kudo et al. 1977) and 40Ar/39 Ar dates of 2 14+0 66 Ma and 2 52+0 43 Ma (Locality B-2 and B-3; NMGRL 9132 and 9131, respectively, W.C. McIntosh, 1998, written communication). Basalt of Santa Ana Mesa (upper Pliocene) — Tholeiitic flood basalt with modal affinities to alkali olivine basalt (Kelley and Kudo, 1978, p. 9). Locally, a thin (0-13 ft or 0-4 m thick), discontinuous basaltic tuff locally underlies the base (Spiegel, 1961, Cather and Connell, 1998). Bachman and Mehnert (1978) report a K-Ar date of 2.5±0.3 Ma. In the adjoining San Felipe quadrangle, Cather and Connell (1998) report <sup>40</sup>Ar/<sup>39</sup> Ar dates of 2.24±0.22 to 1.77±0.21 Ma (NMGRL 8926, 8927, 8928) for this unit. Variable thickness between 20-40 ft (6-12 m) along southern margin of Santa Ana Mesa. Mafic or intermediate dike (upper Oligocene) - A single, approximately 4,000 ft (1,250 m) long, northeast-trending mafic to intermediate dike, about 0.6 mi (1 km) north of the village of Placitas (San Antonio de las Huertas Grant). Unconformably overlain by Santa Fe Group eastern basin-margin piedmont deposits (Tsp<sub>c</sub>) and yields a <sup>40</sup>Ar/<sup>39</sup> Ar date of 30.9±0.5 Ma (NMGRL 3183, W. C. McIntosh, 1995, written communication) Paleogene System Espinaso Formation (Oligocene) - Cross section only. Unit comprises the remnants of widespread, coarse-grained, volcaniclastic aprons that accumulated adjacent to volcanic vent complexes of the Ortiz Mountains. Consists primarily of upward-coarsening or crudely stratified tuffaceous sandstone, conglomerate, and debris-flow deposits. Variable thickness, up to 4,265 ft (1,300 m). Diamond Tail and Galisteo Formations, undivided (Oligocene to upper Paleocene) - Cross section only. Unit consists of red to white mudstone, sandstone, and conglomerate deposited within fluvial channels and broad floodplains in an early Tertiary basin between Albuaueraue and Santa Fe, New Mexico. Previous workers (Stearns, 1953; Kelley and Northrop, 1975; and Menne, 1989) have mapped Galisteo Formation in the area (NE1/4 of Section 36, T13N, R4E); however, relatively poor exposures, faulting, and ambiguous textural and stratigraphic relationships preclude differentiation on the map. Variable thickness, up to 4,250 ft (1,295 m). Mesozoic Erathem **Upper Cretaceous** Menefee Formation, undivided — Contains three informal members: a lower member (324 ft or 99 m thick), the Harmon Sandstone (140 ft or 43 m thick), and an upper member (740 ft or 225 m thick). Upper and lower members are similar and contain, in order of abundance: aray, tan to orange tan, cross-bedded, and laminated to thick-bedded siltstone and sandstone: dark-gray to olive-gray and black shale; dull, dark-brown to shiny black lignitic coal; and maroon to dark-brown iron concretions. The upper member has a greater abundance of shale, carbonaceous material, ironstone, thicker coal seams, and lenticular beds of calcareous sandstone. The light-gray to buff or aray-tan Harmon Sandstone is a medium arained, well-sorted, auartz sand with cross-beddina and limonite staining. Thickness of the Harmon Sandstone is variable and thins to at least 73 ft (22 m) in the Hagan embayment east of Placitas. The lower contact between the Menefee Formation and the Point Lookout Sandstone (Kpl) is interfingering and gradational. Total unit thickness varies regionally from 680 ft to 1,200 ft (205 m to 365 m) due in part to post-depositional erosion. Point Lookout Sandstone — Gray-tan to light-tan and drab-yellow, very fine- to fine-grained, massive, quartz sandstone with limonitic sandstone lenses and interbedded thin gray shale. The unit is weakly cemented and a prominent ridge and ledgeformer. Both upper and lower contacts are interfingering and gradational. Unit thickness ranges from about 240 ft (73 m) near Placitas, to 315 ft (96 m) in the Haaan embayment. Mancos Shale, upper member - Medium to dark-gray to olive-gray shale, and silty shale, with less abundant very fine to finegrained, locally gypsiferous sandstone. This unit is an upper tongue of the lower member of the Mancos Shale (Km) and forms valleys and covered slopes between the more resistant Point Lookout Sandstone (Kpl) and Hosta-Dalton Sandstone (Khd). The unit produces poor quality, high sulfate ground water. Upper and lower contacts are gradational. Thickness is variable and difficult to measure due to cover but ranges from about 240 ft (73 m) west of Placitas, to 360 ft (110 m) in the Hagan embayment. Hosta-Dalton Sandstone - Drab, yellow-gray to yellow-tan, very fine to medium-grained, weakly cemented sandstone with olivebrown sandstone lenses. The unit is a moderate ridge- and ledge-former. Upper and lower contacts are gradational. Unit thickness ranges from 210 ft (64 m) near Placitas to 370 ft (112 m) in the Hagan embayment (where it contains a considerable amount of siltstone and fissile shale that does not exist in the Placitas area). **Mancos Shale**, lower member — Lithology is similar to the upper Mancos Shale $(Km_u)$ with subequal proportions of olive-brown to gray to black shale and laminated to interbedded, olive-brown to gray, very fine grained sandstone, siltstone, and shale. Selenite and white to yellow gypsum are interbedded throughout the unit. The dark gray shale typical of the lower section intertongues with the underlying sandstone of the Dakota Formation (Kd) and the upper contact is gradational. Unit thickness is highly variable regionally and across the study area, ranging from 850 ft (260 m) west of Placitas to 1,850 ft (565 m) in the Hagan embayment. Thickness near the Village of Placitas is intermediate Dakota Formation — Medium-bedded, pervasively silica-cemented, medium-grained, yellowish-gray to orange-yellow quartz arenite. hin interbeds of dark-gray lower Mancos Shale (Kmi) are common. Sandstones are well cemented and weather to angular and blocky ridges. Unit thickness ranges from 75 ft (23 m) west of Placitas, to less than 25 ft (8 m) in the Hagan embayment. Upper Jurassic Morrison Formation, undivided - Three members are commonly recognized in northern New Mexico but are not differentiated in this map area. In descending stratigraphic order, the members are: the Jackpile Sandstone, the Brushy Basin Shale, and the Salt Wash Sandstone (the Westwater Čanyon Sandstone of former usage, Lucas et al., 1995). The uppermost Jackpile Sandstone is a distinctive gray-white, kaolinitic, fine- to medium-grained sandstone with a thickness of about 70 ft (21 m) near Placitas. The Brushy Basin member is a gray, green, and maroon mudstone and shale, with interbedded and intercalated gray to tan sandstone. Thickness is about 240 ft 73 m) near Placitas. The Salt Wash Sandstone is a gray to yellow-buff, medium-grained and weakly cemented sandstone, with a unit thickness of 215 ft (66 m) near Placitas. The Recapture Shale member has been redefined by Lucas et al. (1995) as the Summerville Formation of the upper San Raphael Group (Lucas and Anderson, 1997). However, due to poor exposure in the study area, it remains undifferentiated from the Morrison Formation. The Summerville Formation is approximately 325 ft (100 m) thick and consists of purplegray, red-brown, and green-gray mudstone interbedded with tan, gray, and greenish-gray, very fine grained sandstone. Total thickness of the Morrison and Summerville formations combined is relatively uniform regionally, ranging from about 850 ft (260 m) near Placitas to 780 ft (240 m) in the Hagan embayment. Middle Jurassic Todilto Formation, undivided — Two members are commonly recognized in north-central New Mexico (Lucas et al., 1995), but are not differentiated in the map area. In descending stratigraphic order, the two members are the Tonque Arroyo Member and Luciano Mesa Member. The Luciano Mesa Member is a medium-gray to olive-gray, laminated, fetid, micritic limestone. Dark-brown to black carbonaceous mud is interbedded with limestone laminations near the base and gypsum interlayers are present from the middle to the top of the limestone member. The Tongue Arrovo Member is locally present as a white avpsum bed. Upper and lower contacts are sharp. The unit is included in the middle San Raphael Group of Lucas and Anderson (1997). Thickness of the Luciano Mesa Member ranges from 5 ft (1.5 m) southwest of the Village of Placitas, to about 20 ft (6 m) just east of the Cuchilla de San Francisco. Where present, the Tonque Arroyo member is as much as 45 ft (14 m) thick. Total unit thickness is up to 65 ft (20 m). Entrada Formation - Variably colored, very fine- to fine-grained, weakly cemented, crossbedded, eolian, quartz sandstone with Je coarser-arained components. Near Placitas, the Entrada Formation is characterized by three distinct units differentiated by color: a lower unit (75 ft or 23 m) of pale reddish-brown to grayish-pink sandstone, a middle unit (15 ft or 4.5 m) of gray-green sandstone, and an upper unit (30 ft or 9 m thick) of grayish-yellow or light-tan sandstone. Due to the local dip of 20° to 30°, the Entrada Formation forms round, nonvegetated slopes rather than the cliffs and ledges typical of other localities. Included in the lower San Raphael Group of Lucas and Anderson (1997). The contact with the underlying Chinle Group (ħcp) is disconformable. Total unit thickness ranges from about 120 ft (37 m) near Placitas, to 71 ft (22 m) in the Hagan embayment. Upper Triassic Chinle Group, undivided Petrified Forest Formation and Correo Sandstone - Predominantly reddish-brown mudstone interbedded Ћср with thin subordinate sandstone and limestone-pebble conglomerate. The formation is only partially exposed near Placitas due to faultina. hickness and lithologic descriptions presented here are from the Hagan embayment. Although three informal subunits are recognized near Placitas that are distinct hydrostratigraphic units, they are not differentiated at the surface. The upper unit is a thick reddish-brown mudstone, overlain by relatively thin intervals of reddish-orange siltstone and a reddish-brown to tan coarse sandstone (Correo Sandstone equivalent according to Picha, 1982). The middle unit consists of medium-grained moderately cemented sandstone interbedded with minor mudstone. The lower unit is a reddish-brown to purple to greenish-gray mudstone interbedded with silty to fine-grained sandstone. Gypsum and limestone-conglomerate lenses, characteristic of the Petrified Forest Formation, are pervasive throughout the unit. The lower contact with the underlying Agua Zarca Formation ( $\pi_z$ ) is gradational and interfingering. The formation varies regionally in thickness from about 1,300 ft to 1,650 ft (400 m to 500 m), and in the Hagan embayment is measured at 1,590 ft (485 m), Picha (1982). Chinle Group, Agua Zarca Formation — Medium-grained, tan to white and light grayish-pink, thin- to medium-bedded quartz arenite and feldspathic arenite with minor interbedded reddish-brown mudstone. Interbedded mudstone is similar to the Petrified Forest Formation (Ācp). The sandstone is dominant and is very well cemented with silica, forms major ridges, and typically is highly fractured. The lower contact with the underlying Moenkopi is disconformable. The total unit thickness near Placitas is 220 ft (67 Middle and Lower Triassic Moenkopi Formation - Laminated to thick-bedded, maroon-brown, micaceous, fine-grained sandstone and siltstone intercalated with minor reddish-brown mudstone. Sandstones and mudstones are moderately to weakly cemented and locally friable with generally low porosity. Both upper and lower contacts are unconformable and regional thickness varies significantly. The unit is poorly exposed in he Placitas area and thickness ranges from at least 45 ft (14 m) near the Village of Placitas to 100 ft (30 m) in the Hagan embayment. Paleozoic Erathem Upper Permian San Andres Formation — Light gray to tan, thin- to medium-bedded limestone with interbedded grayish-white sandstone, similar to the Glorieta Formation (Pg), at the base. The limestones are well indurated, have a high fracture porosity, and are locally cavernous. The lower contact with the Glorieta Formation is gradational. Unit thickness ranges from about 80 ft (24 m) near Placitas to 130 ft (40 m) in the Hagan embayment. Glorieta Formation — White to grayish white, massively bedded, well-indurated, medium-grained, quartz arenite. In some localities, Pg

Middle and lower Santa Fe Group, undivided

Eastern-basin margin piedmont deposits

Piedmont deposits, undivided (lower Pliocene(?) to Miocene) - Cross section only. Slightly to moderately tilted, well consolidated,

and well cemented, sandstone and limestone-dominated conglomerate, sandstone, and mudstone derived from the Sandia Mountains

and eastern-basin margin. Deposits are generally better cemented and more steeply dipping than overlying upper Santa Fe Group

eastern basin-margin piedmont deposits (QTsp, QTsp<sub>c</sub>, QTsp<sub>cs</sub>, QTsp<sub>s</sub>, and QTsp<sub>sm</sub>). May be correlative to piedmont-slope and alluvia

fan deposits of the Sierra Ladrones or Popotosa formations (Machette, 1978) exposed at the southern margin of the Albuquerque Basin.

(see Cather, 1997) and clast composition.

Estimated thickness is approximately 9,840 ft (3,000 m). Locally divided into five mappable subunits based on dominant deposit texture

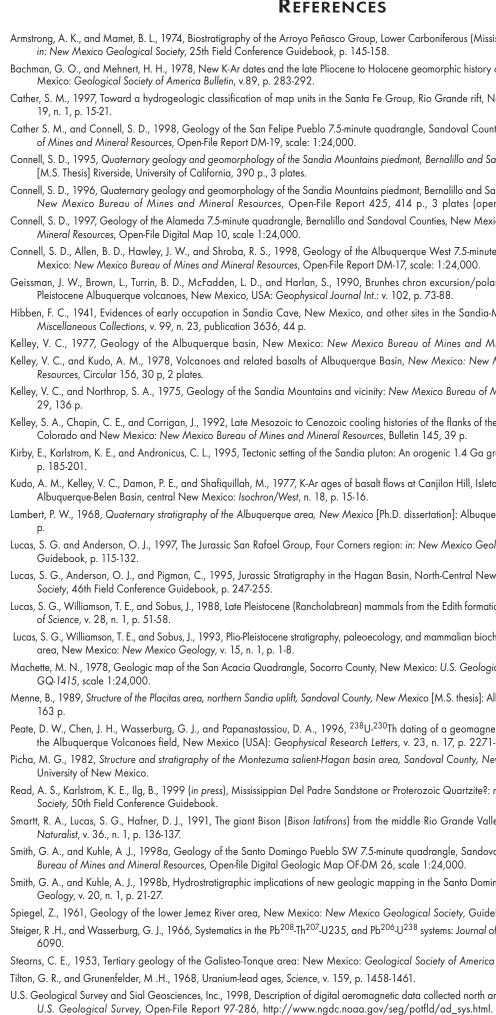
Piedmont deposits, limestone-bearing conglomerate subunit - Well consolidated and cemented, limestone-dominated gravel

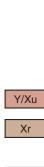
capping the top of Lomos Altos. Recognized by an abrupt increase in limestone clasts. Approximately 40 ft (12 m) thick.

a greenish-yellow silty mudstone, 2 to 3 ft (60 to 90 cm) thick, occurs near the top of the formation. The sandstone is extremely well cemented with silica, is often strongly fractured, and forms prominent ridges and ledges. The lower contact with the Yeso Formation (Py) is disconformable and sharp. Unit thickness varies from about 50 ft (15 m) near Placitas to 35 ft (11 m) in the Hagan embayment. Lower Permian Yeso Formation, undivided — Two members of the Yeso Formation are recognized but not divided in the map area: the San Ysidro Member, and the underlying Meseta Blanca Member. The San Ysidro Member is a friable, orange-brown, laminated to thickly bedded, silty to fine-argined sandstone and interbedded siltstone with minor clay-rich and limestone layers. A moderately cemented coarse sandstone occurs at the base. The Meseta Blanca Member is lithologically distinct and consists of a light-orange to gray-white, mediumto coarse-argined, moderately cemented sandstone. Picha (1982) mapped an informal lower Yeso member as a separate unit in the Hagan embayment (Pyl) that is similar to the San Ysidro Member. The lower contact with Abo Formation (Pa) is conformable, but is commonly difficult to discern because of similar lithologies. Total thickness is 680 ft (207 m) in the Hagan embayment. Yeso Formation, lower member — Informal lower sandstone member of the Yeso Formation is lithologically similar to the San Ysidro Member (as described above). Differentiated east of the Cuchilla de San Francisco (see Picha, 1982 Abo Formation - Predominantly a reddish-brown mudstone alternating with grayish-white to light-orange lenticular beds of mediumto coarse-grained sandstone. The Abo Formation is distinguished from the Yeso Formation (Py) based primarily on a slight color change from orange-brown to reddish-brown and a higher proportion of coarser-grained orange or white sandstone. The sandstone is locally conglomeratic and arkosic in the lower part. The lower contact with the Madera Formation (IPm) is gradational and interfingering, with about 20% limestone units interbedded in reddish-brown mudstone over the lower 80 ft (25 m). The top of the lowermost laterally continuous and relatively thick limestone bed is chosen as the Madera Formation contact. Unit thickness on Cuchilla de San Francisco is 1.070 ft (325 m). Picha (1982) Upper and Middle Pennsylvanian Madera Formation, undivided — An informal upper arkosic limestone member and a lower gray limestone member of the Madera Formation are recognized, but not differentiated in this study area. The upper arkosic limestone member is gray, greenish-gray, olivegray, tan, and buff-brown fossiliferous limestone (57% of upper member) interbedded with intervals of subarkosic sandstone and mudstone. Limestone is thinly to thickly bedded and massive with sparsely disseminated chert. Sandstones and mudstones vary from

coarse- to medium-grained and commonly contain granules and pebbles. The lower gray limestone member is a gray, ledge-forming, cherty limestone separated by thinner less resistant intervals of light-brown, pale greenish-brown, tan, greenish-gray, and gray argillaceous limestone. A distinct 7 ft (2 m) thick interval of medium- to coarse-grained, green, subarkosic sandstone lies 160 ft (50 m) below the top of the lower gray limestone member and provides a marker for the lower unit. The top of the lower gray limestone member is placed at the top of the uppermost cliff-forming limestone exposed on the western rim of the Crest of Montezuma (referred to locally as Montezuma Mountain) and is also approximately coincident with the top of Cuchilla Lupe. The upper arkosic limestone member is approximately 615 ft (187 m) thick and the lower gray limestone member is approximately 645 ft (197 m) thick. Total unit thickness is 1,260 ft (385 m) on the Crest of Montezuma (Picha, 1982). Sandia Formation — Consists of a variety of lithologies including, in descending stratigraphic order: interbedded brown claystone and gray limestone, massive gray limestone, and a lower olive-brown to gray, subarkosic, fine- to coarse-grained sandstone. The contact with overlying Madera Formation (IPm) is chosen at the base of the lowest thick limestone ledge. The lower contact is unconformable with the Arroyo Peñasco Group, where present, or Proterozoic basement. Sandia Formation limestones are distinct from the Madera ormation limestones as they are typically thinner-bedded, clast-supported, greenish, and contain abundant siliciclastic material. Unit is 193 ft (59 m) thick on the Crest of Montezuma.

reddish-brown to maroon to greenish-gray and gray and are lenticular and laterally discontinuous. Arkosic sandstones are typically





Ха

Xms

Xas

Xss







## Mississippia

Arroyo Peñasco Group, Espiritu Santo Formation, undivided (locally includes the Log Springs Formation) — These are the oldest sedimentary rocks in the area and rest unconformably on a relatively planar surface of Proterozoic basement. The Espiritu Santa Formation is composed of a basal member, the Del Padre Sandstone, and an unnamed upper member. Mississippian exposures are discontinuous with the thickest section in the vicinity of the Sandia Mountains found on the west slope of the Crest of Montezuma (generally only the basal Del Padre Sandstone is recognized). The Del Padre Sandstone, about 6 ft (2 m) thick, is a distinctive quartz cobble conglomerate overlain by a very coarse-grained, green and purplish-brown sandstone. Stromatalitic limestones, about 30 ft (10 m) thick, are above the basal Del Padre Sandstone followed by limey mudstones, dolomites and minor wackestones. Microfossils found above the Del Padre Sandstone member indicate an Osagean age (Armstrong and Mamet, 1974). Undulose extinction and sutured quartz grain boundaries in thin sections of the basal conglomerate suggest a pre-Pennsylvanian tectonic history (Read et al., 1999). Unconformably overlying the Espiritu Santo Formation, on the west slope of the Crest of Montezuma, are fluvial red shales and siltstones of the Log Springs Formation (6 - 10 ft or 2 - 3 m thick) that are not differentiated from the Arroyo Peñasco Group. The total measured thickness of the Arroyo Peñasco Group is 73 ft (22 m) on the west slope of the Crest of Montezuma (Armstrong and Mamet, 1974). **P**ROTEROZOIC **E**RATHEM

## **Mesoproterozoic** Pegmatite and aplite dikes – Dikes, pods, and lenses ranging from <1 in. up to >50 ft (<3 cm to >15 m) in thickness and up to 1 mi.

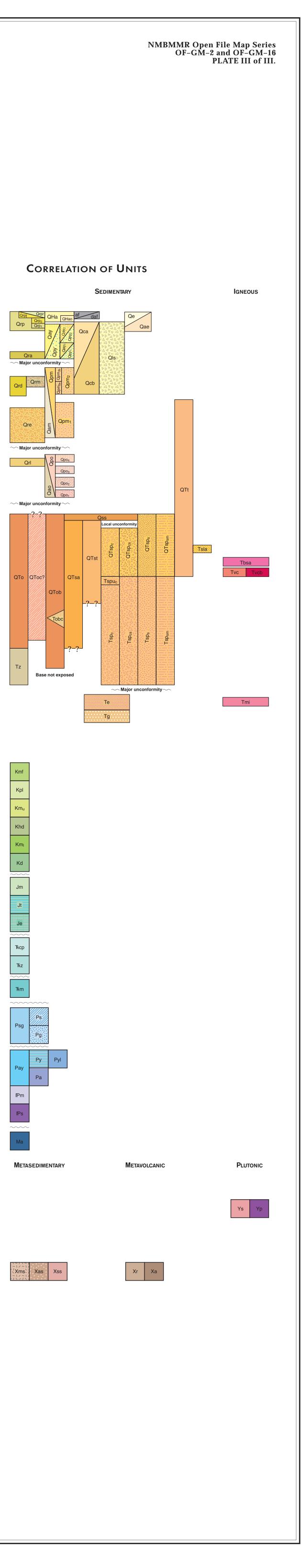
.6 km) in length; interpreted to be coeval with the Sandia granite (Ys). Sandia granite — Mainly megacrystic biotite monzogranite to granodiorite. K-feldspar megacrysts, up to ~1 in. (3 cm) long, are commonly aligned in a magmatic foliation. Contains numerous ellipsoidal enclaves of microdiorité, fine-grained granite, and gabbrc (interpreted to be mingled mafic magmas), and xenoliths of quartzite and mafic metavolcanic rock. Pegmatite and aplite dikes (Yp), and quartz veins are ubiquitous. Various radioisotopic dates are available: U-Pb-zircon+sphene yields an age of 1,455±12 Ma (Tiltor and Grunenfelder, 1968, recalculated by S. Getty, unpublished); U-Pb-zircon yields an age of 1,437±47 Ma (Steiger and Wasserburg, 1966, recalculated in Kirby et al., 1995); U-Pb-zircon yields an age of 1,446±26 Ma (Unruh, unpublished data); 40Ar/39Ar data yield an age of 1,422±3 Ma from hornblende and 1,423±2 Ma from muscovite (Kirby et al., 1995); apatite fission track dates range from  $14\pm 4$  Ma at low elevation to  $30\pm 5$  Ma at high elevation (Kelley et al., 1992).

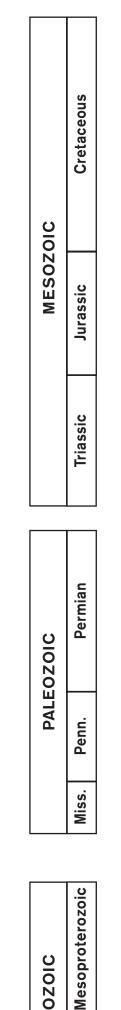
Paleoproterozoio Meso/Paleoproterozoic rocks, undivided – Cross section only.

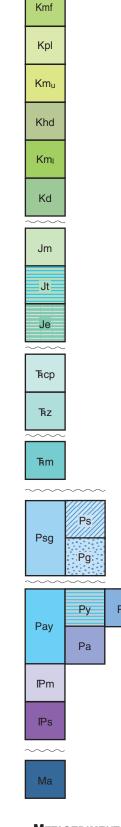
Metarhyolite – Multiply deformed, fine-grained, quartz-muscovite schist with distinctive fine-grained quartz porphryoclasts (eyes) interpreted to be relict quartz phenocrysts). These rocks are exposed in the core of the Crest of Montezuma monocline beneath the Arroyo Peñasco Group (Ma) and bounded by the East Las Huertas fault to the west. Amphibolite and amphibole-biotite schist – Massive green amphibole-plagioclase schist with lensoidal bodies of calc-silicate and alc-pelite interlayered with amphibolite and metapelite. Protolith is interpreted to be volcanic. Mica schist and phyllite – Quartz-muscovite schist and phyllite with local andalusite porphyroblasts, commonly crenulated. Andalusite-biotite schist – Pelitic andalusite and biotite schist, locally contains chlorite.

Sillimanite-biotite schist and gneiss – Pelitic sillimanite and biotite schist and gneiss, locally contains K-feldspar.

Epoch Chro 1.8 Ma – not showr 23.7 Oligocen 36.6 Eocene 57.8







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