

## GEOLOGY OF THE SANDIA CREST QUADRANGLE, BERNALILLO AND SANDOVAL COUNTIES, NEW MEXICO

### SANDIA CREST MAP UNIT DESCRIPTIONS

#### CENOZOIC ERATHEM

##### Neogene (Quaternary and Tertiary) System

##### *Colluvial, landslide, eolian, spring, and anthropogenic deposits*

Thin surficial deposits derived from wind and mass-movement processes, or extensive areas disturbed by open-pit aggregate mining or construction.

- daf** **Disturbed land and artificial fill, undivided (Historic)** – Dumped fill and areas affected by open-pit aggregate mining or construction. Locally mapped where disturbance is areally extensive or geologic contacts are obscured.
- Qca** **Colluvium and alluvium, undivided (Holocene to upper-middle Pleistocene)** – Poorly consolidated, poorly sorted and stratified, fine- to coarse-grained, clast- and matrix-supported gravel derived from a variety of mass-movement hillslope processes, including debris flows, shallow slumps, and creep. May locally include shallow landslide debris. Gravel clasts are typically subangular to subrounded limestone derived from the eastern dip-slope of the Sandia Mountains. Commonly surrounds small unmapped bedrock inliers. Supports distinct vegetative community and associated drainage density, both of which are represented by a distinct tonal pattern on aerial photographs. Differentiated where areally extensive, thick, or obscures geologic contacts. Variable thickness, up to 16 ft (5 m).
- Qsct** **Scree, talus, and colluvium, undivided (Holocene to upper-middle Pleistocene)** – Coarse-grained, angular, clast-supported talus found primarily in first-order hollows on steep, west-facing slopes of the Sandia Mountains.
- Qst** **Travertine (Pleistocene)** – Constructional mounds of travertine typically found around active springs. Variable thickness, between 3-30 ft (1-10 m) thick.

##### *Alluvium*

Divided into stream-valley alluvium, eastern basin-margin piedmont alluvium, and eastern-slope alluvium. Stream-valley alluvium typically contains moderately to well sorted, poorly to well stratified, clast- and matrix-supported deposits associated with modern and late Pleistocene entrenched arroyos across the map area. Eastern basin-margin piedmont alluvium contains generally poorly sorted, poorly stratified, clast- and matrix-supported deposits having angular to subangular clasts of granitic, metamorphic, and minor limestone derived from the western and northern slopes of the Sandia Mountains on the footwall of the Sandia fault (eastern margin of the Albuquerque Basin). Eastern-slope alluvium typically contains very poorly to moderately sorted, clast- and matrix-supported deposits associated with drainages developed on the eastern dip-slope of the Sandia Mountains and headwater region of the Tijeras Canyon drainage.

##### *Stream-valley alluvium*

- QHa** **Youngest stream alluvium, undivided (Historic to Holocene)** – Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) sand, silty to clayey sand, and gravel. Underlies arroyos and is inset against younger stream alluvium (*Qay*). Very weakly developed soils exhibit no pedogenic carbonate at the surface and weak Stage I carbonate morphology at depth. Correlative to geomorphic surface Q8 and Q9 of Connell (1995, 1996). Variable thickness, from 0-20 ft (0-6 m).

**Qay** **Younger stream alluvium, undivided (Holocene to uppermost Pleistocene)** – Poorly consolidated deposits of pale-brown to light-brown (7.5-10YR) sand to sandy clay loam and gravel. Inset against middle piedmont and western-margin alluvium (*Qpm*). Surface is slightly dissected and exhibits weakly developed soils with Stage II carbonate morphology. Remnants of the lower pediment surface (*Qpx3*) are preserved in Juan Tabo Canyon and probably correspond to the basal contact of this unit. Correlative to the geomorphic surface Q8 of Connell (1995, 1996). Variable thickness, from 0-25 ft (0-8 m).

*Eastern-margin piedmont alluvium*

**Qp** **Piedmont and stream alluvium, undivided (Historic to middle Pleistocene)** – *Cross section only.* Undivided deposits of stream-valley (*QHa* and *Qay*) and eastern-margin piedmont alluvium (*Qpm*).

**Qpy** **Younger eastern-margin piedmont alluvium (Holocene to uppermost Pleistocene)** – Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) gravel, sand, and sandy clay loam. Gravel clasts are predominantly cobbles to boulders of angular to subangular granite with minor subrounded limestone. Soils exhibit Stage I to II+ carbonate morphology and few thin clay films. Correlative to the geomorphic surface Q9 of Connell (1995, 1996) Variable thickness, from 0-40 ft (0-12 m).

**Qpm** **Middle eastern-margin piedmont alluvium, undivided (upper to middle Pleistocene)** – Poorly to moderately consolidated deposits of very pale-brown to strong-brown and light-gray (7.5-10YR) gravel, sand, and silty- to clayey-sand. Inset against older eastern-margin piedmont alluvium (*Qpo*) and inset by younger stream alluvium (*Qay*). Gravel clasts are predominantly subangular granite and schist with subrounded limestone, and angular white quartz derived from dikes and veins exposed on the western front of the Sandia Mountains. The slightly to moderately dissected deposit surface exhibits subdued constructional bar-and-swale topography on interflues. Weakly developed soils exhibit Stage II to III+ carbonate morphology and minor to moderate clay film development. Locally divided into an older subunit. Correlative to the geomorphic surfaces Q6-Q7 of Connell (1995, 1996). Variable thickness, estimated from 0-140 ft (0-43 m).

**Qpm1** **Middle eastern-margin piedmont alluvium, older subunit (middle Pleistocene)** – Moderately consolidated deposits of light- to 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. Dissected deposit surface exhibits erosional ridge-and-ravine topography. Subdued bar-and-swale constructional topography is locally preserved on broad weakly dissected interflues. Much of the deposit surface is dissected by arroyos and exhibits erosional ridge and ravine topography. Moderately well developed soils with Stage III+ carbonate morphology and many moderately thick clay films. Correlative to the geomorphic surface Q6 of Connell (1995, 1996).

**QTp** **Old eastern-margin piedmont alluvium, undivided (lower Pleistocene to upper Pliocene(?))** – Moderately consolidated, poorly to moderately sorted and stratified gravel and sand with minor, thin silty-clay interbeds. Gravel clasts are granite with rare limestone. Granite clasts are commonly grussified and deeply pitted. Remnants of upper and lower pediment surfaces (*Qpx1* and *Qpx2*) are locally preserved on Sandia granite (*Ys*) and probably correspond to the stripped base of this piedmont alluvium. Correlative to Tijeras Canyon subunit of the eastern-slope alluvium (*QTpt*). Probably correlative to geomorphic surfaces QT1-Q3 of Connell (1995, 1996), older eastern-margin piedmont alluvium (*Qpo*), or the Suela alluvium (*Qss*) on the northern flank

of the Sandia Mountains (Connell et al., 1995; and Connell, 1997, 1998). Variable thickness, from 0-45 ft (0-14 m).

**Tsla Gravel of Lomos Altos (upper Pliocene)** – Thin gravel lag consisting of subrounded limestone pebbles and cobbles derived from eastern dip-slope of the northern Sandia Mountains. Probably correlative to the Gravel of Lomos Altos on the northern flank of the Sandia Mountains (Connell et al., 1995). May also be equivalent to the Tuerto gravel of Stearns (1953). Approximately 3-30 ft (1-10 m) thick.

#### *Eastern-slope alluvium*

**Qfo Eastern-slope alluvial-fan deposits (middle Pleistocene)** – Poorly sorted and stratified, gravel and sand with minor, thin silty-clay interbeds. Gravel clasts are predominantly limestone with subordinate sandstone. Deposit surface (top) is approximately 100 ft (30 m) above local base level and exhibit modified bar and swale topography. Soils possess Stage II+ to III+ carbonate morphology. Correlative to alluvial fan deposits inset below the Tuerto gravel on the adjacent Sandia Park quadrangle (Ferguson et al., 1996). Probably correlative to eastern-margin piedmont alluvium (*Qpm* or *Qpo*) along western front of Sandia Mountains. Variable thickness but thickens to the east to over 60 ft (18 m).

**Qpf Eastern-slope pediment-alluvial fan complex (middle Pleistocene)** – Alluvial fan deposits that overlie broad, northeast-sloping pediment surfaces cut on older sedimentary rocks. Correlative to piedmont-alluvial fan complexes (unit *Qpf*) on the adjacent Sandia Park quadrangle (Ferguson et al., 1996). Variable thickness, ranging from 10-20 ft (3-20 m).

**QTpt Old eastern-slope alluvium, Tijeras Canyon unit (lower Pleistocene to upper Pliocene(?))** – Moderately consolidated, poorly to moderately sorted and stratified gravel and sand. Poorly exposed. Gravel locally overlies reddish-brown silty sand. Inset against upland gravel (*QTug*) and recognized at southwestern corner of map area, within the San Antonio Arroyo drainage (major tributary to Tijeras Arroyo). Probably correlative to old eastern margin piedmont alluvium (*QTp*). Approximately 3-10 ft (1-10 m) thick.

**QTug Upland gravel (middle Pleistocene to upper Pliocene(?))** – Well rounded, poorly stratified gravel lag deposits that mantle a low-relief upland erosion surface (pediment) approximately 330 ft (100 m) above local base level. May be correlative to the Tuerto gravel of Stearns (1953), or to the gravel of Lomos Altos along the northern flank of the Sandia Mountains (Connell et al., 1995). Correlative to unit *QTug* on the adjacent Sandia Park quadrangle (Ferguson et al., 1996). Thickness is generally less than 3 ft (1 m).

#### *Upper Santa Fe Group*

**QTsp Eastern basin-margin piedmont deposits, undivided (lower Pleistocene to Miocene)** – *Cross section only.* Poorly to moderately 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. Buried by eastern-margin piedmont alluvium (*Qpm*). Conglomerate clasts are predominantly composed of subangular granite with minor subrounded limestone schist, and angular white quartz (derived from dikes and veins exposed in the Sandia Mountains). 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 west across basin-margin faults and interfingers with fluvial deposits of the ancestral Rio Grande to the west (Connell et al., 1998; Connell, 1997). Thickness is variable, from about 2000-7000 ft (610-2135 m).

## Paleogene-Cretaceous Systems

- KTu Lower Tertiary and Cretaceous sedimentary rocks, undivided (Paleogene-Cretaceous)** – *Cross section only.* Undivided lower Tertiary and Cretaceous deposits that may include the Unit of Isleta No. 2 (Lozinsky, 1994), Galisteo Formation, and Menefee Formation.

## TERTIARY IGNEOUS UNITS

- Tmi Mafic or intermediate dike (upper Oligocene?)** – Generally deeply weathered mafic to intermediate, steeply dipping, north trending dikes. These are probably correlative to an Oligocene mafic to intermediate dike exposed on the northern flank of the Sandia Mountains (Connell et al., 1995).

## MESOZOIC ERATHEM

### Upper Cretaceous

- Kmf Menefee Formation, undivided** – *Cross section only.* Gray, 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 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 1200 ft (205 m to 365 m) due in part to post-depositional erosion.
- Kpl Point Lookout Sandstone** – *Cross section only.* 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. Unit thickness ranges from about 240 ft (73 m) near Placitas, to 315 ft (96 m) in the Hagan embayment.
- Kmu Mancos Shale, upper member** – *Cross section only.* Medium- to dark-gray to olive-gray shale, and silty shale, with less abundant very fine to fine-grained, locally gypsiferous sandstone. This unit is an upper tongue of the lower member of the Mancos Shale (*Kml*). Thickness is variable, but ranges from about 240 ft (73 m) west of Placitas, to 360 ft (110 m) in the Hagan embayment.
- Khd Hosta-Dalton Sandstone** – *Cross section only.* Drab, yellow-gray to yellow-tan, very fine- to medium-grained, weakly cemented sandstone with olive-brown sandstone lenses. Unit thickness ranges from 210 ft (64 m) near Placitas to 370 ft (112 m) in the Hagan embayment.
- Kml Mancos Shale, lower member** – *Cross section only.* Lithology is similar to the upper Mancos Shale (*Kmu*) 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. Unit thickness is highly variable regionally and across the study area, ranging from 850 ft (260 m) west of Placitas to 1850 ft (565 m) in the Hagan embayment.
- Kd Dakota Formation** – *Cross section only.* Medium-bedded, pervasively silica-cemented, medium-grained, yellowish-gray to orange-yellow quartz arenite. Unit thickness ranges from 75 ft (23 m) west of Placitas, to less than 25 ft (8 m) in the Hagan embayment.

## Upper Jurassic

- Jm Morrison Formation, Salt Wash Member** – Light tan to yellowish white, massive, friable sandstone exposed only in a highly fractured fault-bounded block of Mesozoic rocks just south of the Jaral fault and Rincon Ridge. Exposed thickness is approximately 85 ft (26 m) compared to an estimated thickness of 216 ft (66 m) for the Salt Wash Member exposed near Placitas (see Van Hart, 1999). Total Morrison Formation thickness varies regionally, ranging from about 850 ft (260 m) near Placitas, to 780 ft (240 m) in the Hagan embayment.

## Middle Jurassic

- **San Raphael Group** – Locally includes the Summerville (*Js*), Todilto (*Jt*), and Entrada (*Je*) Formations as recently defined by Lucas et al. (1995) and Lucas and Anderson (1997). Exposed only within a highly fractured fault-bounded block of Mesozoic rocks located just south of the Jaral fault and Rincon Ridge (see Van Hart, 1999). Total estimated San Raphael Group thickness in this fault block is 128 ft (39 m).

- Js San Raphael Group, Summerville Formation** – Purple-gray, red-brown, and green-gray mudstone interbedded with tan, gray, and greenish-gray, very fine grained sandstone. These rocks are assigned to the Summerville Formation based on stratigraphic position (previously called the Recapture Shale Member of the Morrison Formation--see Lucas et al., 1995; and Lucas and Anderson, 1997). Estimated exposed thickness is 50 ft (15 m).

- Jt San Raphael Group, Todilto Formation (Luciano Mesa Member)** – A thinly laminated, petroliferous, dark-gray, micritic limestone. Fossils are not recognized, but laminations are probably algal in origin. The overlying Tonque Arroyo Member appears to be absent in this area (Van Hart, 1999). A very small outcrop of this important stratigraphic marker is overlain by the Summerville Formation, underlain by the Entrada Formation, and is approximately 3 ft (1 m) thick.

- Je San Raphael Group, Entrada Formation** – Variably colored, very fine to fine-grained, weakly cemented, crossbedded, eolian, quartz sandstone with coarser grained components. These rocks are very poorly exposed south of the Jaral fault. The lower contact with the Chinle Group (**TRc**) is disconformable. Estimated local thickness of 75 ft (23 m).

## Upper Triassic

- TRc Chinle Group, undivided (probably Petrified Forest Formation)** – Mudstone with lenticular beds of lavender-gray sandstone; mudstones are reddish-brown to orange-tan in the upper part, and purple to reddish-brown in the lower part; also locally contains limestone-pebble conglomerate lenses. Exposures confined to limited outcrop just south of the Jaral Fault and near the Village of Cañoncito (on the southeastern corner of the map). Total Chinle Group thickness is about 1300 ft (400 m).

- TRcz Chinle Group, Agua Zarca Formation** – The only distinct sub-unit of the Chinle Group recognized during this study (differentiated near the Village of Cañoncito). It is a tan- to light-grayish pink, resistant, thin- to medium-bedded quartz arenite and feldspathic arenite. The lower contact with the underlying Moenkopi Formation (**TRm**) is disconformable. The unit is about 350 ft (105 m) thick.

## Middle and Lower Triassic

**Trm Moenkopi Formation** – A recessive-weathering, dark red, micaceous shale, silty shale and thin-bedded feldspathic sandstone. The unit is about 200 ft (60 m) thick.

## PALEOZOIC ERATHEM

### Upper Permian

**Ps San Andres Formation** – Light gray and less commonly tan colored, medium- to thick-bedded limestone. The limestones are mostly micrites or skeletal wackstones, commonly with some component of quartz sand. The San Andres Formation is interbedded with the Glorieta Formation (*Pg*) with a total upper Permian (*Ps* and *Pg*) thickness of approximately 400 ft (120 m).

**Pg Glorieta Formation** – White and pink (along the contact with the underlying Yeso Formation), massive or plane-bedded to low-angle planar cross-stratified quartz arenite. Locally, the sandstones are extensively bioturbated by *Macaronichnus*, and near the contact with Yeso Formation they are feldspathic. The sandstones are typically well sorted, but a thin, feldspathic quartz-pebble conglomerate occurs just below the base of the lowermost San Andres Formation limestone in the Arroyo Armijo area along the boundary between Sandia Park and Sandia Crest quadrangles. Interbedded with the San Andres Formation with each sandstone bed generally less than 30 ft (10 m) thick.

### Lower Permian

**Pa-y Abo and Yeso Formations, undivided** – The lower two lithostratigraphic units of the Permian represent a red-colored feldspathic to quartzose siliciclastic sequence that, because of generally poor exposure, was mapped as a single unit throughout the study area. The *Yeso Formation* is a reddish to pink or tan-colored, medium- to thin-bedded, feldspathic sandstone, shale and silty shale with interbedded massive or laminated micritic gray or tan limestone (*Pyc*) near the top. The sandstones are typically cross-stratified and/or cross-laminated and virtually identical to those within the underlying Abo formation except that, rarely, salt hopper casts and molds are present. The *Abo Formation* is a red and locally tan-colored (particularly near the base), medium- and thin-bedded arkose and feldspathic sandstone interbedded with red, micaceous siltstone and shale, commonly with green reduction spots. The lowermost arkoses are typically lighter-colored and coarser-grained than the younger feldspathic sandstones, and at least one of them is strongly bioturbated (*Macaronichnus*). The sandstones are cross-stratified (typically trough and wedge-planar geometries) and the finer grained rocks are commonly ripple cross-laminated. In addition, mud-chip clasts and plant debris are common. The upper contact with the Yeso Formation (*Py*) is conformable but difficult to distinguish in the field. The lower contact with the Madera Formation (*IPm*) is gradational with interbedded limestone and reddish-brown mudstone. The top of the lowermost laterally continuous and relatively thick limestone bed is chosen as the Madera Formation contact. Total thickness for the Abo and Yeso formations combined is approximately 1300 ft (400 m).

**Pyc Yeso limestone** – Intervals of massive or algal/cryptalgal-laminated limestone within the upper part of the Yeso Formation. The limestones are typically micritic, fenestral fabrics are commonly preserved, and they contain abundant quartz sand. Differentiated where possible east of the Village of Canoncito. Generally less than 16 feet (5 m) thick.

## Upper and Middle Pennsylvanian

**IPm Madera Formation, undivided** – Two informal members, an arkosic limestone and a gray limestone, are recognized but not differentiated. The upper arkosic limestone is a gray, greenish-gray, olive-gray, tan and buff-brown fossiliferous limestone (comprises slightly more than half of member) interbedded with intervals of sub-arkosic sandstone and mudstone. The limestone is thinly to thickly bedded and massive, with sparsely disseminated chert. Sandstones and mudstones vary from reddish-brown to maroon to greenish-gray and gray, are commonly lenticular, and often laterally discontinuous. Arkosic sandstones are typically coarse- to medium-grained and often contain granules and pebbles. The lower gray limestone is a gray, ledge-forming, cherty limestone separated by thinner and less resistant intervals of light-brown, pale greenish-brown, tan, greenish-gray, and gray, argillaceous limestone. The upper and lower members are respectively generally correlative to the Wild Cow Formation and Los Moyos Limestone (Formation) of the Madera Group of Myers and McKay (1976). These informal member names are used because the units were lithostratigraphically defined on the Sedillo (Read et al., 1998) and Tijeras (Karlstrom et al., 1999) 7.5-minute Quadrangles rather than biostratigraphically defined and may therefore not strictly correlate with the units defined by Myers and McKay (1976). The Madera Group nomenclature was abandoned because of the gradational contacts between members and the difficulty of distinguishing these contacts in the field. Total thickness is approximately 1320 ft (402 m) near Cedro Peak to the southeast (Myers and McKay, 1976) and 1260 ft (385 m) on the Crest of Montezuma (Picha, 1982) to the north (consistent with thickness estimates based on map relationships in the study area).

**IPms Madera Formation, sandstone and arkose beds** – Sandstones and arkosic sandstones, mapped as marker units where possible. Up to approximately 60 ft (18 m) thick.

**IPmc Madera Formation, massive limestone beds** – Prominent ledge forming limestone beds, mapped as marker units where possible. Up to approximately 40 ft (12 m) thick.

**IPs 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, ledge-forming limestone. The lower contact is unconformable with the Arroyo Peñasco Group (*Ma*) or Proterozoic crystalline rocks. Limestone in the Sandia Formation is distinct from limestone in the overlying Madera Formation as they are typically thinner-bedded, clast-supported, greenish, and contain abundant siliciclastic material. Approximately 170 ft (50 m) thick.

## Mississippian

**Ma Arroyo Peñasco Group, Espiritu Santo Formation** – The locally thin and discontinuous Espiritu Santo Formation unconformably overlies Proterozoic basement. Generally only the basal Del Padre Sandstone Member is present, but the limestones, dolomites, and limey mudstones of the unnamed upper member are preserved in places north of Sandia Peak. Microfossils from these carbonate rocks near Placitas and other areas indicate an Osagean age (Armstrong and Mamet, 1974). No other formations within the Arroyo Peñasco Group have been recognized in the map area. The thickest section and best exposure of the Arroyo Peñasco Group in the region of the Sandia Mountains is on the west slope of the Crest of Montezuma east of Placitas (Armstrong and Mamet, 1974; Connell et al., 1995). The Del Padre Sandstone is a distinctive sedimentary quartzite and quartz-pebble conglomerate that is generally very white and extremely well lithified. The

silicified finer-grained varieties of quartzite from the Del Padre Sandstone are easily mistaken for metamorphic rocks but have no apparent foliation and have visible rounded grains on weathered or broken surfaces. Additionally, these quartzites and associated quartz pebble conglomerates are only seen along the Great unconformity between Proterozoic basement and the Pennsylvanian Sandia Formation. Mineralized faults and fractures containing barite-flourite-galena and quartz are often seen in these rocks. Some of these structures apparently do not extend above the Sandia Formation and are therefore interpreted as the result of pre-Madera Formation deformation. The age of the mineralization is unknown. These rocks were previously considered Proterozoic metasediments (see Kelley and Northrop, 1975) and some clearly are metamorphic based on recent thin section study (Read et al., 1999). However, based stratigraphic position, the lack of foliation, and on study of several thin sections, the bulk of the rocks mapped as Arroyo Peñasco Group are sedimentary rocks that did not experience the high-grade metamorphism typical of Proterozoic supracrustal rocks in this area. Generally less than 50 ft (15 m) thick where preserved.

## PROTEROZOIC ERATHEM

### Mesoproterozoic igneous rocks

- Yp Pegmatite and aplite dikes** – Dikes, pods, and lenses ranging from <1 in to >50 ft (<30 cm to >15 m) in thickness and perhaps up to 2600 ft (800 m) in length; interpreted to be coeval with the Sandia granite (Ys).
- Ys Sandia granite** – Mainly megacrystic biotite monzogranite to granodiorite–K-feldspar megacrysts, up to several cm long, are commonly aligned in a magmatic foliation; contains numerous ellipsoidal enclaves of microdiorite, fine-grained granite, and gabbro (interpreted to be mingled mafic magmas), and xenoliths of quartzite and mafic metavolcanic rock. Pegmatites, aplites, and quartz veins are ubiquitous. Various dates are available: U-Pb zircon plus sphene 1455±12 Ma (Tilton and Grunefelder, 1968, recalculated by Steve Getty, unpublished); U-Pb zircon of 1437±47 Ma (Steiger and Wasserburg, 1966, recalculated in Kirby et al., 1995); U-Pb zircon of 1446±26 Ma (Unruh, unpublished data); <sup>40</sup>Ar/<sup>39</sup>Ar from hornblende is 1422±3 Ma and from muscovite is 1423±2 Ma (Kirby et al., 1995); apatite fission track dates range from 14±4 Ma at low elevation to 30±5 Ma at high elevation (Kelley et al., 1992).

### Paleoproterozoic metamorphic rocks

- Xqs Quartz-rich pelitic schist** – Quartz-muscovite schist and quartz-chlorite schist locally interlayered with amphibolites, mafic metavolcanics, and calc-silicates; commonly contains aluminosilicates.
- Xcs Calc-silicate and calc-pelite** – Lenticular calc-silicate bodies interlayered with quartz-rich pelites (Xqs).
- Xgn Banded granitic gneiss** – Isolated screens (and xenoliths) of banded biotite-rich granitic gneiss intruded by the Sandia Granite in Madera Canyon as well as larger outcrops in Barrow Canyon beneath the Paleozoic-Proterozoic unconformity. May be correlative with pelitic gneiss or the Cibola granite exposed on the Sandia Park Quadrangle (Ferguson et al., 1996).



## MAP SYMBOLS

Line of geologic cross section

Geologic contact—Solid where exposed; dashed where approximately located; dotted where concealed; queried where inferred.

Fault—Showing dip with arrow showing trend and plunge of slickenlines where measurable; solid where exposed; dashed where approximately located; dotted where concealed; ball-and-bar on downthrown side of normal fault, teeth on upthrown side of reverse fault (combination of reverse fault teeth and bar-and-ball indicates interpretation of normal reactivation of a reverse fault); upthrown (U) and downthrown (D) used where fault dip is unknown.

Strike and dip of joint surface

Strike and dip of bedding, ball indicates that younging is known.

Horizontal bedding

Strike and dip of  $S_1$  foliation, arrow indicates trend and plunge of lineation defined by elongate minerals and stretched grains.

Strike and dip of  $S_2$  foliation

Strike and dip of magmatic foliation in granite defined by alignment of mafic enclaves.

Strike and dip of magmatic foliation in granite defined by alignment of megacrysts.

Strike and dip of pegmatite dikes and veins.

Brecciated rocks

Prospect

Axial trace of anticline

Axial trace of syncline

Axial trace of the anticlinal hinge of monocline

Water-supply well, including well number assigned by the New Mexico Office of the State Engineer.

Exploratory or groundwater monitoring well, including abbreviation. *HD-1* and *HD-2* data from Geohydrology Associates (1993); *SHO3* and *SHOCH* and data from G. Hall (unpubl. data, 1998).

***Qpx1*** Upper pediment surface — Broad, relatively low relief erosional surface on Sandia granite (*Ys*). Surface projects to the basal contact of eastern-margin piedmont alluvium (*Qpo*) and is provisionally correlated to geomorphic surfaces Q2-Q3 of Connell (1995, 1996).

- Qpx2*** Middle pediment surface – Broad, relatively low relief erosional surface on the Sandia granite (*Ys*). Surface is topographically lower than pediment surface of unit *Qpx1* and correlated to the base of older eastern-margin piedmont alluvium (*Qpo*). Provisionally correlated to geomorphic surfaces Q4-Q5 of Connell (1995, 1996).
- Qpx3*** Lower pediment surface – Exposed erosional surface between Sandia granite (*Ys*) and overlying younger stream alluvium (*Qay*). Probably correlative to geomorphic surface Q8 of Connell (1995, 1996).

### **DISCLAIMER INSERT**

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 are based on 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. Several different scales of mapping were incorporated into this map; therefore, the user should be aware of significant variations in map detail. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

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Cross sections are constructed based upon the interpretations of the authors made from geologic mapping, and available 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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