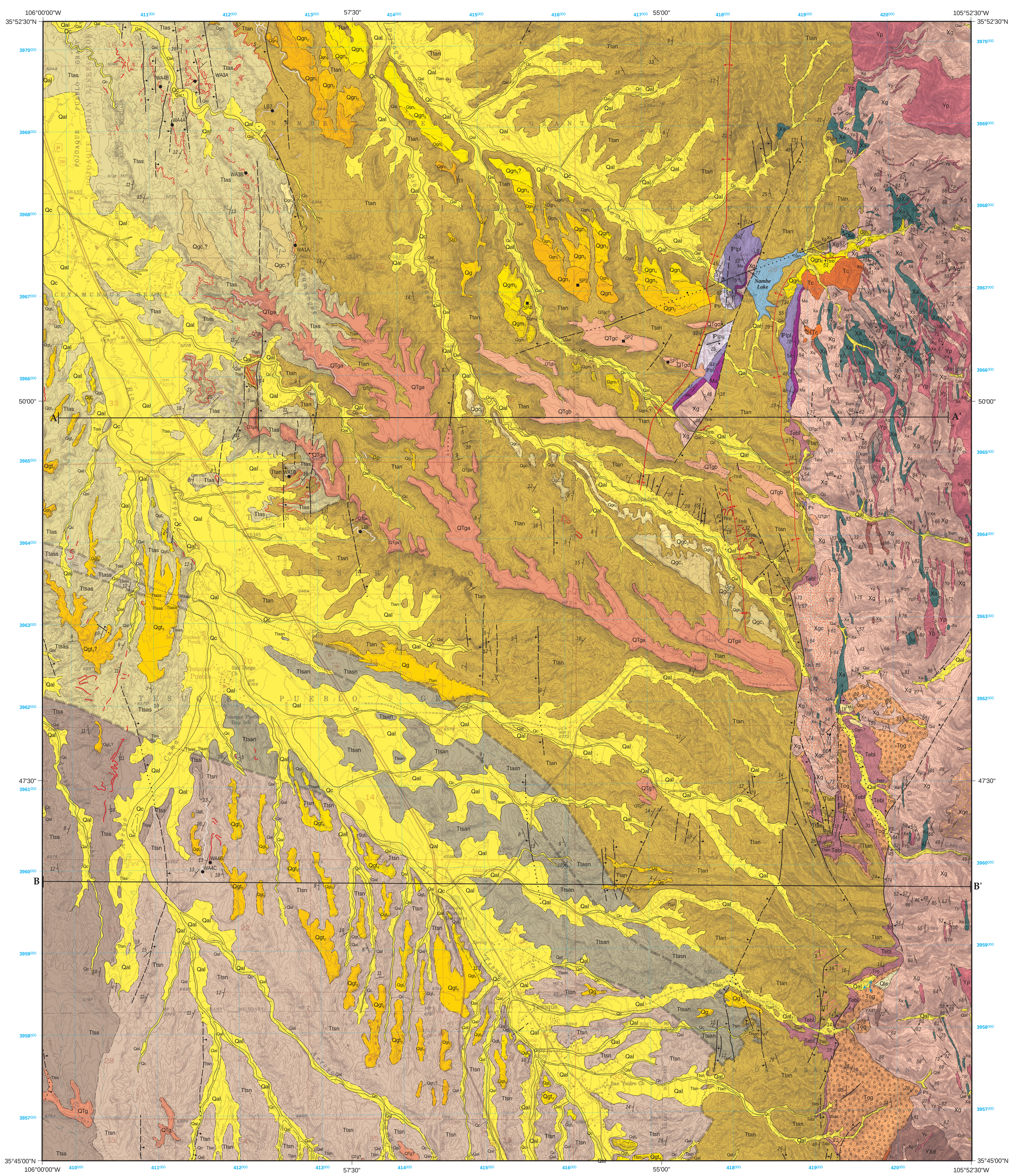
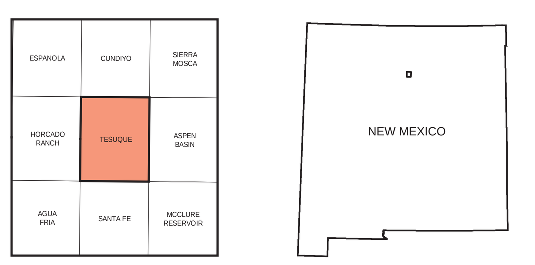


Base map from U.S. Geological Survey 1953, photorevised 1993.
1927 North American datum, Universal Transverse Mercator projectionn.
1000-meter grid, UTM zone 13, shown in blue.



QUADRANGLE LOCATION

MN

Magnetic Declination
January, 2003
10° 08' East
At Map Center

1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

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

[575] 835-5490

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

http://geoinfo.nmt.edu

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 47

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Geologic map of the Tesuque quadrangle, Santa Fe County, New Mexico

February 2003

by

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MAP SYMBOLS

- Location of geologic cross section.
- Geologic contact. Solid where exposed or known, dashed where approximately known, dotted where concealed.
- Gradational geologic contact, location approximately known.
- Normal fault. Solid where well exposed, dashed where poorly exposed or approximated, dotted where covered. Bar-ball on downthrown side. Tic shows dip of the fault plane; arrow shows trend and plunge of slickensides.
- Trace of syncline axial plane.
- Trace of synclinal bend of monocline showing direction of plunge.
- Basalt flow in the lower Nambé Member.
- Tephra beds:
  - Guaje pumice bed, Otowi Member, Bandelier Tuff.
  - Tephra beds of the Skull Ridge Member lithosome A:
    - White fine tephra, undifferentiated.
    - No. 1 white ash
    - Lower light blue ash
    - No. 2 white ash
    - Nos. 2A, 2B, 2C ashes
    - No. 3 white ash
    - No. 4 white ash.
  - Tephra beds of the Nambé Member lithosome A:
    - "Upper" Nambé white ash
    - Nambé white ash (grayish white color on map)
    - Chupadero ash
    - Gabaldon tephra, coarse white ash.
- Strike and dip of bedding.
- Inclined S2 foliation in metamorphic rocks, showing dip. Arrow shows trend and plunge of lineation.
- Breccia.
- Paleocurrent vector measured from clast imbrication; tail of arrow is located at measurement.
- WA4A Tephra sample location and number, collected for geochemical correlation.
- SP3 Exploratory soil pit location and number.

COMMENTS TO MAP USERS

MAP UNITS

(Partial description of units; complete descriptions are found in the accompanying report.)

CENOZOIC

Quaternary

Qc — **Modern channels (streams and arroyos) and associated active floodplain alluvium (Holocene)** — Tan, poorly-sorted, gravelly sand and silt. Most deposits occur within 2 m elevation of the present channel. Floodplain may contain vegetation. Only channels >3 m in width are identified on map. Thickness unknown.

Qal — **Alluvium, undifferentiated (Pleistocene? - Holocene)** — Tan, poorly-sorted sand and silt, with minor amounts of subrounded gravel (mostly granite and granitic gneiss); surface soils may have been inflated by addition of eolian material. Grades to 2-10 m above modem channel (base level) of current main¬stem stream (Rio Tesuque or Rio Nambé). Unit includes at least four undifferentiated terraces, such as the inhabited and cultivated terraces along the Rio Tesuque, Rio en Medio, and Rio Chupadero. Alluvial deposits, estimated <2 m thick, are not included within this map unit. Likely equivalent to *Qal* of the Santa Fe quadrangle geologic map by Kottlowski and Baldwin (1963). Thickness is unknown, but estimated to be less than 25 m on the basis of regional well logs.

Qls — **Landslide deposits (Pleistocene)** — Unconsolidated, disturbed sediment consisting of angular to subangular granitic clasts and sand.

Qg — **Gravel, undifferentiated (Pleistocene)** — Dominantly subrounded gravel and tan sand with lesser silt. Gravel clasts are dominantly pinkish granite and granitic gneiss (70%), with some quartz and quartzite and sparse limestone, amphibolite, and quartz-mica schist. Clasts are as much as 0.4 m in diameter and generally smaller than the *QTg* gravel deposits. A 1-2 m thick silt deposit, which has largely been pedogenically altered, overlies the gravels and is attributed to eolian dust influx. Deposits are set into existing valleys (most commonly the south and west side) and unconformably overlie the gently dipping beds of the Tesuque Formation. Unit is sufficiently isolated to make correlation to other gravel deposits or to ancestral stream difficult. *Qg* deposits are not correlative to one another. Deposits typically 2-10 m thick.

Gravel of the ancestral Rio Nambé (Pleistocene) — Gravel deposits inset into the southwestern flanks Rio Nambé drainage basin:

- **Qgn_5** — **Lowermost terrace of the ancestral Rio Nambé (middle to upper(?) Pleistocene)** — Terrace tread is approximately 30-45 m above modem channel. 4-10 m thick.
- **Qgn_4** — **Lower terrace of the ancestral Rio Nambé (middle to upper(?) Pleistocene)** — Terrace tread is approximately 45-56 m above modem channel. 2-10 m thick.
- **Qgn_3** — **Middle terrace of the ancestral Rio Nambé (middle Pleistocene)** — Terrace tread is approximately 60-73 m above modem channel. Deposit may correlate to Qt2 Rio del Oso terrace of Dethier and Demsey (1984) with an estimated age of 160 ka. 2-3 m thick.
- **Qgn_2** — **Upper terrace of the ancestral Rio Nambé (middle Pleistocene)** — Terrace tread is approximately 75-83 m above modem channel. 2-5 m thick.
- **Qgn_1** — **Uppermost terrace of the ancestral Rio Nambé (lower Pleistocene)** — Terrace tread is approximately 85-92 m above modem channel. Includes a well-developed soil with a 0.5 m-thick Bt horizon and a 1 m thick Stage II calcium carbonate horizon (Borchert and Wisniewski, unpublished). Soil age is estimated to be >330 ka using the method outlined in Machette (1982, using a constant dust influx rate of 0.25 g cm^{-1} ka^{-1}). Actual age may be significantly older, since observations of soil profile horizon suggest at least two soil-stripping events. 2-10 m thick.

Gravel of the ancestral Rio en Medio (Pleistocene) — Gravel deposits inset into the southwestern flanks Rio en Medio drainage basin:

- **Qgm_2** — **Lower terrace of the ancestral Rio en Medio (upper(?) Pleistocene)** — Terrace tread is approximately 24-31 m above modem channel. Includes a well-developed soil with a 0.52 m thick Bt horizon and a 0.5 m thick Stage II calcium carbonate horizon (Borchert and Wisniewski, unpublished). Soil age is estimated to be >120 ka using the method outlined in Machette (1982, using a constant dust influx rate of 0.25 g cm^{-1} ka^{-1}). Actual age may be significantly older, since observations of soil profile horizon suggest at least two soil-stripping events. This deposit may correlate to *Qt2* Rio del Oso terrace of Dethier and Demsey (1984) with an estimated age of 160 ka. 2-6 m thick.
- **Qgm_1** — **Upper terrace of the ancestral Rio en Medio (middle to upper Pleistocene)** — Terrace tread is approximately 43-61 m above modem channel. 2-8 m thick.

Gravel of the ancestral Rio Chupadero (Pleistocene) — Gravel deposits inset into the southwestern flanks Rio Chupadero drainage basin:

- **Qgc_2** — **Lower terrace of the ancestral Rio Chupadero (late(?) Pleistocene)** — Terrace tread is approximately 22-28 m above modem channel. This deposit may correlate to the *Qt3* Rio del Oso terrace of Dethier and Demsey (1984), whose age is estimated to be 51 ka. 1-5 m thick.
- **Qgc_1** — **Upper terrace of the ancestral Rio Chupadero (middle to late Pleistocene)** — Terrace tread is approximately 36-49 m above modem channel. 2-5 m thick.

Gravel of the ancestral Rio Tesuque (Pleistocene) — Gravel deposits inset into the southwestern flanks Rio Tesuque drainage basin:

- **Qgt_5** — **Lowermost terrace of the ancestral Rio Tesuque (upper(?) Pleistocene)** — Terrace tread is approximately 20-28 m above modem channel. 1-4 m thick.
- **Qgt_4** — **Lower terrace of the ancestral Rio Tesuque (middle to upper Pleistocene)** — Terrace tread is approximately 30-35 m above modem channel. This deposit may correlate to the *Qt3* Rio del Oso terrace of Dethier and Demsey (1984), whose age is estimated to be 51 ka. 1-5 m thick.
- **Qgt_3** — **Middle terrace of the ancestral Rio Tesuque (middle to upper Pleistocene)** — Terrace tread is approximately 45-55 m above modem channel. 2-5 m thick.
- **Qgt_2** — **Upper terrace of the ancestral Rio Tesuque (middle Pleistocene)** — Terrace tread is approximately 60-65 m above modem channel. 2-6 m thick.
- **Qgt_1** — **Uppermost terrace of the ancestral Rio Tesuque (middle Pleistocene)** — Terrace tread is approximately 75-85 m above modem channel. 2-8 m thick.

Qbo — **Guaje pumice bed of the Otowi Member, Bandelier Tuff (lower Pleistocene; *ca.* 1.61 ± 0.01 Ma (Izett and Obradovich, 1994)** — White pumice clasts generally less than 1 cm long with rare clasts as much as 7 cm long derived from the Valles caldera. Pumice includes quartz and sanidine phenocrysts. Lies within upper 3 m of a 4-12 m fill terrace, *QTga*, and is visible from Hwy 285/84 in the cliffs east of Camel Rock Casino (T18N, R9E, Sec. 2; Plate 1). Constrains age of *QTga* as late Pliocene to early Pleistocene. 1-1.5 m thick.

Late Pliocene to early Pleistocene

Stream gravel (late Pliocene to early Pleistocene) — Nearly flat-lying, bedded, sub-rounded to subangular gravel and sand (with some silt) unconformably overlying the gently dipping Tesuque Formation. Basal unit is commonly rusty yellow, subrounded gravel with tan sand and silt. Clasts are dominantly pinkish granitic gneiss (40-60%) and granite (10-20%), with some quartzite (10-30%), limestone (5-15%), amphibolite <10%), and schist <10%). Limestone clasts are present in greater number and larger size at high elevations close to the mountain front. The gravel varies from 2 mm to 80 cm in diameter and is commonly imbricated to the east. These coarse-grained, fluvial deposits are overlain by 1+ m of silt and fine sand, which we attribute to eolian deposition. Deposits are divided into *QTga-c* based on their interfluve position and not by clast composition:

- **QTg** — Gravel units of small aerial extent in interfluve positions. Deposits range from 2-18 m thick.
- **QTga** — Fill terrace. Caps the interfluve south of Rio Chupadero. Includes the 1.61 Ma Guaje Pumice bed of the Otowi Member of the Bandelier Tuff (Qbo, age from Izett and Obradovich, 1994) within the upper 3 m of the fill terrace. Well exposed behind the Camel Rock Casino (T18N R9E, Sec. 3) and along County Road 592, where it underlies the Vista Redondo subdivision. As much as 18 m thick.
- **QTgb** — Fill terrace. Caps the interfluve south of Rio en Medio. As much as 20 m thick.
- **QTgc** — Fill terrace. Caps the interfluve south of Rio Nambé. As much as 15 m thick.

Tertiary

Tesuque Formation

Proposed by Baldwin (1963), the Tesuque Formation consists of relatively arkosic sandstone and silty sandstone intercalated with variable gravelly channel-fills and subordinate mudstone and siltstone. Strong cementation is not common and its characteristic colors are tan to pink, with minor reddish brown. Galusha and Blick (1971) subdivided the Tesuque Formation in the eastern Española Basin into three stacked members (listed in ascending order, but note the Pojoaque Member is not present on this quadrangle): the Nambé, Skull Ridge, and Pojoaque Members. Later, Cavazza (1986) subdivided the Tesuque Formation into two lithosomes (lithosomes A and B) based on composition, paleocurrents, and provenance considerations; note that lithosome B is not exposed on this quadrangle. Following up on this approach, Koning et al. (2004) recognized another lithosome, called lithosome S, in the Santa Fe area. The map units on the Tesuque quadrangle reflect a combination of the nomenclature of both Cavazza (1986) and Galusha and Blick (1971), with primary emphasis on the former.

Lithosome A interfingers and grades laterally southward into lithosome S (described below). Smith (2000b) and Kuhle and Smith (2001) have interpreted correlative sediment to the north as alluvial slope deposits. Lithosome A is subdivided into the Skull Ridge and Nambé Members, following Galusha and Blick (1971). [description modified from Koning and Read, 2010].

Lithosome A, Tesuque Formation, Santa Fe Group (upper Oligocene to middle Miocene) — Pink-tan alluvial slope deposits composed of sandstone, silty-clayey very fine- to medium-grained sandstone, and subordinate mudstone; these are intercalated with minor, coarse-grained channel-fills. Colors of the sandy sediment range from very pale brown, light yellowish brown, pink, to light brown (most common to least common). Sandstone outside of the coarse channel-fills is generally very fine- to medium-grained, mostly moderately to well consolidated, weakly cemented, and in very thin to thick (mostly medium to thick), tabular beds. Coarse channel-fills consist of medium- to very coarse-grained sandstone, pebbly sandstone, and sandy conglomerate. The coarse channel-fills are clast-supported, weakly to strongly cemented by calcium carbonate, and ribbon- to lenticular-shaped. The proportion of coarse channel-fills increases near (within 5 km) the modern mountain front, where gravelly sediment dominates. Conglomerate includes pebbles with minor cobbles. Clasts are poorly to moderately sorted, subrounded to angular (larger clasts are rounded to subrounded), and composed of granite with trace to 5% quartzite, 1-5% amphibolite, and minor intraformational clasts of cemented sandstone. Sand is subangular to subrounded, moderately to well sorted, and arkosic.

Ttas — **Lithosome A, Skull Ridge Member of the Tesuque Formation, Santa Fe Group (middle Miocene)** — Pinkish, interbedded sandstone and siltstone, with lenses of conglomerate and mudstone. Sedimentary structures include cross bedding, ripple lamination, channel scour-and-fill, and bioturbation (burrows). Distinguished from other members by its numerous tephra layers. Approximately 200-230 m (650-750 ft) thick (Galusha and Blick, 1971).

Tephras of the Skull Ridge Member in lithosome A

The Skull Ridge Member contains as many as 37 ash beds whose color, texture and thickness may vary laterally. Tephra beds are thicker than original ash fall as a consequence of fluvial reworking of the ash. Some pure fallout ash may locally remain at the base. Four prominent, white tephra horizons, labeled as the No. 1, 2, 3, and 4 white ashes by Galusha and Blick (1971), are specified on the map where identified. The "lower light blue", a useful horizon marker between the No. 1 and No. 2 white ashes, is also identified. All other white tephra are marked as "undifferentiated white tephra."

Ashes were identified in the field generally by stratigraphic context (especially in relation to other non-white ashes) rather than internal characteristics (e.g. mineralogy). Galusha and Blick (1971) use the No. 1 white ash to mark the contact between the Skull Ridge and the Nambé Members. In absence of the No. 1 white ash, the contact between the Skull Ridge and Nambé Members is not stratigraphically identifiable; hence where the No. 1 white ash is covered or not present in the Tesuque quadrangle (approximately 90% of the quadrangle), the basal contact has been approximated (dashed on the map) using local bedding orientation. Magnetostratigraphy (Barghoorn; 1981), biostratigraphy (Tedford and Barghoorn; 1993), and ^{40}Ar/^{39}Ar geochronology (McIntosh and Quade, 1995; McIntosh, unpub. in Kuhle, 1997, Izett and Obradovich, 2001) establish the age of the Skull Ridge between 14.5 and 16 Ma (middle Miocene).

White tephra, undifferentiated – White to very light-gray, vitric tephra. May include quartz, sanidine, biotite, hornblende, and/or pyroxene. Variably indurated and weathered. 0.3-3.3 m thick.

No. 1 white ash, 15.86 ± 0.03 Ma (Perkins, *personal communication*, by tephra-stratigraphic correlation, in Kuhle, 1997) – Blocky white, fine-grained, vitric, stuctureless tephra. Includes sparse quartz and lithic fragments. Base weathers to bentonite locally. Constitutes the contact between the Skull Ridge and Nambé Members. Visible from U.S. Hwy. 285/84 north of Camel Rock Casino (T19N, R9E, Sec. 34). 1-2 m thick.

Lower light blue ash – White, fine-grained tephra. Typically capped by a 0.2-0.5 m-thick, cemented sandstone ledge. Visible from U.S. Hwy. 285/84 north of Camel Rock Casino (T19N, R9E, Sec. 34). 0.2-0.5 m thick.

No. 2 white ash, 15.5 ± 0.07 Ma (Izett and Obradovich, 2001) and 15.59 ± 0.07 Ma (MacIntosh, *personal communication*, in Kuhle, 1997) – White, fine-grained, vitric tephra. Contains quartz, sanidine, plagioclase, and little biotite. Occurs 41 m (stratigraphic distance) above the No. 1 white ash. Encircles the base of a hill east of U.S. Hwy. 285/84, 1.5 km northwest of Camel Rock Casino (T19N, R9E, Sec. 34). 0.2-0.8 m thick.

Ashes slightly above the No. 2 white ash (Nos. 2A, 2B, or 2C of Galusha and Blick, 1971) – Thin ashes that lie within 7-10 m above the No. 2 white ash. Not described.

No. 3 white ash, 15.4 ± 0.08 Ma (Izett and Obradovich, 2001) – White, fine-grained, vitric, structureless tephra. Locally found stratigraphically below a highly bioturbated bed. Occurs 58 m (stratigraphic distance) above the No.1 white ash. Crops out east of Cuyamungue (T19N, R9E, Sec. 34). 0.4-1.0 m thick.

No. 4 white ash, 15.3 ± 0.05 Ma (Izett and Obradovich, 2001) and 15.42 ± 0.06 Ma (MacIntosh and Quade, 1995) – White, fine-grained, vitric, structureless tephra. Contains quartz, sanidine, plagioclase, and sparse biotite. Occurs 157 m (stratigraphic distance) above the No. 1 white ash. Crops out approximately 5 m below a distinct blue ash (T19N, R9E, Sec. 21).

Ttan — **Lithosome A, Nambé Member of the Tesuque Formation, Santa Fe Group (upper Oligocene to lower Miocene)** — Light gray, tan and pinkish, coarse-grained sandstone interbedded with conglomerate, siltstone, and sparse claystone layers. The upper section is tan and pink silty sandstone with more mudstone than in the lower and middle sections. Galusha and Blick (1971) named the upper 120 m the "fossiliferous part" of the member. The section is well exposed in an arroyo with a road east of Rio Tesuque (T18N, R9E, section 12).

The reddish brown, coarse-grained, lower-middle 305-345 m (1000-1100 ft) section (called the 'lower conglomeratic portion' by Galusha and Blick, 1971, depicted in cross section B-B' as *Ttanc*) varies in grain size, sorting, and rock fragment composition. Outcrops exhibit 80-90% poorly-sorted, sub-angular, arkosic sandstone and conglomerate in beds as much as 40 cm thick; clasts are commonly 2-10 cm (and as much as 35 cm) in diameter and composed of granite and granitic gneiss. A distinctive interval in the lower-middle section commonly overlies outcrops of the Bishop's Lodge Member (now of the Espinaso Formation). It consists of angular to sub-rounded, moderately sorted, medium to coarse-grained, quartz-rich (60-75%) gravelly sandstone and sandy conglomerate; this interval is commonly cemented by a white, calcium-carbonate-rich matrix and bedded on the cm to dm scale. This cemented interval crops out discontinuously in many places in the Tesuque quadrangle and is reminiscent of quartz grus visible on modern transport-limited granite or granite gneiss hill slopes. 400-450 m thick (Galusha and Blick, 1971); 500-550 m thick from the cross sections.

Tephras of the Nambé Member in lithosome A

Multiple white and gray tephra exist within the Nambé Member. As many as three white tephras have been identified. The upper tephra was called the Nambé Ash by Galusha and Blick (1971). The lower tephra is herein named the Chupadero Ash, because of its locality within the Chupadero valley (T18N, R9E, Sec. 1); it may possibly correlate with an ash dated by Izett and Obradovich (2001) at 16.4 ± 0.13 Ma.

White ash, undifferentiated – White tephra that was not described in detail. Variably indurated and weathered. 0.3-1 m thick.

"Upper" Nambé white ash – A white, fine ash bed located 10-13 m stratigraphically above the Nambé white ash and lithologically similar to it. Located near the northern quadrangle boundary (T19 N, R9E, Sec. 15 and 22).

Nambé white ash – White, fine-grained, vitric, structureless tephra. Contains quartz, sanidine, plagioclase, and sparse biotite. 0.6-1.2 m thick. Located approximately 35 m (stratigraphic distance) below the contact between the Nambé and Skull Ridge Members.

Chupadero ash – A white, fine ash located in the Chupadero valley (T18N, R9E, Sec. 1).

Gabaldon tephra – A 0.2-100 cm-thick, white tephra bed consisting of fluvially reworked coarse ash and fine lapilli; the latter consists of felsic (latite?) clasts. Tephra is mixed with subordinate arkose sand. Located approximately 18 m (stratigraphic distance) above the basal contact (below which lies the Bishops Lodge Member of the Espinaso Formation). ^{40}Ar/^{39}Ar analyses on sanidine crystals returned an age of 25.52 ± 0.07 Ma (Koning *et al.*, 2013).

Lithosome S of the Tesuque Formation, Skull Ridge Member (upper Oligocene(?) to middle Miocene) — Pebbly sandstone channel-fill deposits and fine sandstone and mudstone floodplain deposits associated with a large drainage exiting the Sangre de Cristo Mountains near the modern Santa Fe River. Lithosome S is recognized by its clast composition (35-65% granite, 3-40% Paleozoic clasts, 5-30% quartzite, including a distinctive black quartzite, and 1-8% chert), reddish color (particularly compared to the browner, distal alluvial slope facies of lithosome A), and high-energy-flow deposits in very broad, thick channel complexes that possess very thin to medium, planar to lenticular internal bedding. Channel-fill conglomerate is commonly clast-supported, poorly to moderately sorted, and mostly subrounded (but granitic clasts may be subangular). The sand fraction is arkosic and is composed of quartz, 10-30% potassium feldspar, trace to 7% yellowish Paleozoic siltstone, sandstone, or limestone grains, and trace to 5% chert and dark quartzite grains. Channel-fill sand is commonly light brown (7.5YR 6/3), fine- to very coarse-grained, poorly to well sorted, and subrounded to subangular. Cementation of channel-fills is variable. Finer-grained strata of lithosome S are in very thin to medium, tabular beds with horizontal-planar to wavy laminations; locally, this sediment is structureless. Overbank sediment consists of light brown to reddish yellow and pink to very pale brown siltstone, very fine- to coarse-grained (generally fine-grained) sandstone, and silty to clayey sandstone. Within the fine sediment are local very thin to medium, lenticular channel-fills. There are also variable amounts of reddish brown to yellowish red to light reddish brown mudstone and sandy mudstone. Lithosome S interfingers and grades northwards into lithosome A. Lithosome S is subdivided into the Skull Ridge and Nambé Members, following Galusha and Blick (1971). [description modified from Koning and Read, 2010].

Ttss — **Lithosome S, Skull Ridge Member of the Tesuque Formation, Santa Fe Group (lower to middle Miocene)** — Sediment as described above. Unit overlies the inferred, approximate projection of White Ash No. 1. Approximately 200-230 m (650-750 ft) thick (Galusha and Blick, 1971).

Ttsn — **Lithosome S, Nambé Member of the Tesuque Formation, Santa Fe Group (late Oligocene to early Miocene)** — Sediment as described above. This unit gradationally overlies a 350(?) m-thick tongue of lower lithosome A sediment. Approximately 380-400 m thick.

Ttsas — **Gradational zone between lithosomes S and A of the Skull Ridge Member, slightly more lithologically similar to lithosome S (upper to middle Miocene)** — Fine-grained lateral gradation between lithosomes A and S; unit is laterally closer to lithosome S than lithosome A; predominantly fine sandstone, silty sandstone, and mudstone. Approximately 200-230 m (650-750 ft) thick, similar to the thickness of the Skull Ridge Member to the north.

Ttsan — **Gradational zone between lithosomes S and A of the Nambé Member, slightly more lithologically similar to lithosome S (upper Oligocene to lower Miocene)** — Fine-grained lateral gradation between lithosomes A and S; unit is laterally closer to lithosome S than lithosome A; predominantly fine sandstone, silty sandstone, and mudstone. Approximately 380-400 m thick.

Ttass — **Gradational zone between lithosomes S and A of the Skull Ridge Member, slightly more lithologically similar to lithosome A (upper to middle Miocene)** — Fine-grained lateral gradation between lithosomes A and S; unit is laterally closer to lithosome A than lithosome S; predominantly fine sandstone, silty sandstone, and mudstone. Approximately 200-230 m (650-750 ft) thick, similar to the thickness of the Skull Ridge Member to the north.

Ttasn — **Gradational zone between lithosomes S and A of the Nambé Member, slightly more lithologically similar to lithosome A (upper Oligocene to lower Miocene)** — Fine-grained lateral gradation between lithosomes A and S; unit is laterally closer to lithosome A than lithosome S; predominantly fine sandstone, silty sandstone, and mudstone. Approximately 380-400 m thick.

Ttnb — **Basalt in the lower Nambé Member (upper Oligocene to lower Miocene(?))** — Dark-green to dark gray, weathered, olivine basalt with a coarse-crystalline texture. Vesicles and calcite amygdules are concentrated near the top of the flows. Outcrops tend to weather spheroidally. Five separate basalt flows have been identified in a relatively unaltered outcrop in an arroyo north of the Chupadero fire station. Basalt is overlain by a 1-2 m greenish siltstone within the lower Nambé Member. Basalt crops out near faults in several locations northeast of the Rio Chupadero, close to the mountain front. May be correlative to a basalt dated at 24.9 ± 0.6 Ma (K-Ar age-determination by Baldridge et al., 1980; sample UAKA-77-80) located 5 km east-northeast of Nambé Pueblo. 1-3 m thick.

Tcb+Tte — **Cieneguilla basanite flows interbedded with lithosome E, Tesuque Formation (Oligocene)** — Cieneguilla basanite flows interbedded with sandstone and pebbly sandstone of lithosome E of the Tesuque Formation (Koning and Read, 2010; Koning and Johnson, 2006). The flows correlate in part with the basalt in the lower Nambé Member (unit *Ttnb*). They consist of gray, porphyritic, mafic volcanic rocks -- probably basanite but may also include nephelinite and basalt. Cuttings from correlative strata in the Yates No. 2 La Mesa well, located 8.1 km southwest of the southwestern corner of this quadrangle, indicates that these flows contain a dark groundmass composed of fine-grained pyroxene and plagioclase; phenocrysts include clinopyroxene, iddingsite-replaced olivine, and plagioclase (Myer and Smith, 2006, unit 2). These cuttings also indicate that the sand is grayish in color and composed of altered basalt, variable percentages of latite, and 1-5% greenish, granular grains of unknown composition. Very fine to fine sand has minor quartz and lesser (about 3%) potassium feldspar and granitic grains. Sand grains are very fine- to very coarse, poorly sorted, and angular to subrounded. Note that some of the sand grains are likely slough from strata higher in the well. Locally there are minor (10-15%) very fine pebbles of basalt. At least one tuff interval. Description of volcaniclastic sediment is from observations of the Yates No. 2 La Mesa well cuttings (Daniel Koning and David Sawyer, unpublished data). Cross section B-B' only.

Espinaso Formation

Tebl — **Bishop's Lodge Member of the Espinaso Formation (upper Oligocene to lower Miocene(?))** — Light gray to white, tuffaceous (?) siltstone and sandstone with gray pumiceous, porphyritic (plagioclase and pyroxene), and andesitic to latitic clasts. Pumice clasts reached 45 cm, whereas latite rock clasts are as much as 18 cm in diameter. At the type-section near The Bishop's Lodge within the Santa Fe quadrangle, Smith (2000) has distinguished at least two volcaniclastic intervals that are each 10-60 m thick: an older, coarser-grained interval that includes latitic and pumaceous clasts and a finer-grained upper interval.

The member differs from the Nambé Member by the presence of volcanic clasts and its characteristically whitish-gray, fine-grained sandy silt. The contact with the pinker, more granitic Nambé Member is interfingered and locally both sharp and gradational, likely because the sediment of a volcanic apron was shed intermittently and mixed with sediment derived from the mountains to the east. Fine-grained material (tuffaceous sand and silt) that contains few volcanic pebbles, but may include volcanic granules or small pumice lapilli, have been included in the Bishop's Lodge Member, as well as fine-grained siltstones exhibiting the characteristic light-gray Bishop's Lodge Member color. The Bishop's Lodge Member crops out discontinuously, close to the mountain front (e.g. west and south of Pacheco Canyon road and along the National Forest Boundary in Secs. 17 and 22, T10N, R8E) and commonly fills valley floors. Smith (2000) reported a 30.45 ± 0.16 Ma tephra age (^{40}Ar/^{39}Ar date on biotite,) from within the member. Although this member was named by Baldwin (1963), who included it within the Tesuque Formation, Galusha and Blick (1971) call the member the Picuris Formation. Ingersoll, et al. (1990) consider it contemporaneous with deposition of the upper Abiquiu and middle Picuris Formations, which are late Oligocene to early Miocene age. Typically 2-25 m thick.

Tc — **Colluvium (Oligocene? to lower Miocene?)** — Buff and yellowish poorly-exposed, limestone boulder-rich deposit overlying basal Nambé Member adjacent to the contact between the basement rock and basin fill. Probably >10 m thick.

Tog — **Older gravels (Eocene to lower Oligocene)** — Limestone- and granite-bearing pebbly sandstone and conglomerate that underlies the Bishops Lodge Member (Espinaso Formation) at and north of Santa Fe. At the mouth of Pacheco Canyon, 10-30 m of limestone-rich gravel overlies the Bishops Lodge Member and is assigned to this unit. Beds are commonly medium thicknesses and tabular to lenticular. Clasts are subangular to subrounded, commonly clast-supported, moderately to poorly sorted, and consist of pebbles with varying amounts of cobbles (but cobbles are generally subordinate). Clasts are composed of granite, granitic gneiss, and yellowish Paleozoic limestone and siltstone. Sand is light yellowish brown to light gray, mostly medium- to very coarse-grained, subrounded to subangular, poorly to moderately sorted, and arkosic in its upper part. Strong cementation is common. [modified from Koning and Read, 2010].

This unit correlates to a >400-m section of limestone-rich strata below the Bishop's Lodge Member that Smith (2000) included in the Nambé Member. Following Koning and Read (2010), we have elected to informally call this interval as an "older gravel unit (*Tog*)," in part because the lower part of this unit may be correlative with the Laramide-age Galisteo Formation. At least three distinct intervals, whose heterogeneity are perhaps influenced by local basin characteristics (such as drainage basin size, location within drainage basin, and proximity to faults) are present in the *Tog* unit near its basal contact with the basement rock. One is a 25+ m exposure of a quartz-rich interval visible in the footwall along a near-vertical fault surface (State Plane coordinates: x=605000, y=1732000). The fault juxtaposes the quartz-rich strata in the footwall against pink, arkosic, gravelly, sub-angular sand and silt beds in the hanging wall; the hanging wall arkosic beds interfinger with the light gray, tuffaceous, volcaniclastic Bishop's Lodge Member. The second interval comprises a very light tan sandstone and/or siltstone, which does not contain volcanic clasts but may represent a mixing of volcanic ash with granitic source material. The strata are rich in limestone (25-40% limestone cobbles) and more visible in the Tesuque quadrangle as lag deposit than in outcrop. The third interval is a pink to dark reddish brown, coarse, angular sand and gravel much like the 'lower-middle' unit of the Nambé Member described previously. >400 m thick (Smith, 2000).

PALEOZOIC

Pennsylvanian

IPlpu — **La Pasada Formation – upper part (Desmoinesian)** — Gray, fossiliferous limestone (weathering buff to tan) with some gray shale and red to maroon, subrounded, sandstone and conglomerate. This unit is well exposed in an unnamed drainage 0.5 km south the Nambé Lake Dam (northwest comer of T19N, R10E, Sec. 32). Sutherland and Harlow, 1973 (pp. 109-114) mapped a thrust fault at the base of this unit that explains the missing Atokan part of the La Posada Formation. However, this contact is interpreted here as a disconformity because there is no clear evidence for a fault contact. Approximately 30-50 m thick.

IPlpl — **La Pasada Formation – lower part (Morrowan)** — Gray, highly fossiliferous limestone (weathering buff to tan) with some green to black mudstone, gray, green and buff shale, and green, red, maroon and brown, poorly sorted sandstone and conglomerate. Overlies the Arroyo Peñasco Group (Mississippian) along western boundary of Nambé Lake (T19N, R10E, Sec. 29). Outcrops may include Arroyo Peñasco Group locally at base. Approximately 60 m thick.

Mississippian

Ma — **Arroyo Peñasco Group** — Predominantly gray, crinkly-laminated dolomitic limestone (~0.5 m-thick beds) interbedded with lesser amounts of platy mudstone, blocky limestone, and reddish sandstone. Basal unit is a greenish, very fine to fine-grained, silty sandstone. Unconformably overlies the Proterozoic rocks west of Nambé Lake Dam. Approximately 12 m thick.

PROTEROZOIC

YXu — **Proterozoic undifferentiated** — Strongly foliated granitic gneiss with lesser amounts of amphibolite, quartzite, and quartz-muscovite schist (likely Paleoproterozoic). Cross sections only.

Yp — **Pegmatite (Middle (?) Proterozoic)** — Very coarse-grained, anhedral to subhedral pink, locally perthitic K-feldspar, light gray to clear-gray quartz, and locally variable amounts of either muscovite or biotite. Muscovite is much more common. Crystals range up to 6 or more cm across. Some bodies contain abundant anhedral to euhedral bipyramidal magnetite crystals. Red garnet is rare. Some exposures reveal K-feldspar and quartz intergrown in graphic textures several tens of cm across. These rocks form thin veins less than a meter wide to thick dikes and irregularly shaped bodies. The pegmatites tend to erode into coarse debris that commonly mantles slopes and creates the illusion of a much thicker body. Hence in many areas contacts are difficult to identify and dashed contacts on the map should be regarded as best guesses.

YXd — **Diorite (Middle (?) Proterozoic)** — Medium-grained, equigranular, non-foliated intrusive rocks containing roughly equal parts amphibole, biotite, and plagioclase, with subordinate quartz. Exposures are poor and rock weathers into sandy grus-covered slopes in the extreme southeastern corner of the Tesuque 7.5' quadrangle. Weathers dark green.

Xg — **Fine- to medium-grained granite—"Embudo Granite" (Early Proterozoic)** — Locally heterogeneous, predominantly fine-to medium-grained granite. This equigranular rock contains pink K-feldspar, light gray plagioclase, clear-gray quartz, and minor biotite (1-3%). Many exposures are light tan to pink and contain coarser-grained muscovite crystals and a preponderance of K-feldspar over plagioclase. The coarse muscovite is probably not primary, but was likely created during metamorphism by the reaction between K-feldspar and quartz. The excess(?) K-feldspar suggests that some of these rocks may have undergone addition of potassium during an episode of potassium metasomatism. The axial plane of rare isoclinal folds are sub-parallel to S2. The dominant foliation, S2, and stretching lineation, L2 (indicated on the map), may represent a secondary tectonic fabric, overprinting an earlier tectonic stress history (with an associated Sl and Ll). The Embudo granite has been dated by Register and Brookins (1979) in the Nambé Falls area at 1,412 and 1,372 Ma and in Pacheco Canyon at 1,534 and 1,492 Ma.

Miller, *et al.* (1963) described a separate gneissic variety as well as a coarse-grained variety and a quartz-dioritic phase. Mapping has shown that the gneissic variety grades into rock where foliation is weak to nonexistent and is clearly recognizable as fine-grained granite. Hence, the gniessic and fine-grained rocks are probably the same granite. Exposed very locally south of Rio Nambe is a medium-gray, strongly foliated, fine- to medium-grained rock containing very little recognizable K-feldspar and abundant (~10%) biotite. This rock, though not mapped separately, is adjacent to a large band of quartz-muscovite schist/quartzite. The rock may be equivalent to the quartz diorite variety described by Miller, *et al.* (1963). However, they interpret the variety as having originated from the partial assimilation of amphibolite, but here the rock is not immediately in contact with any amhibolite.

Map unit *Xg* may be equivalent to 'tonalite' mapped in the northeast part of the Chimayo 7.5' quadrangle (Koning, 2003). This unit contains some areas that are coarse-grained.

Xgc — **Coarse-grained granite – "Embudo Granite" (Early Proterozoic)** — Coarse-grained granite containing obvious pink K-feldspar phenocrysts up to about 1.5 cm across. Biotite is abundant (5-10%) and is characteristically fresh, anhedral, and relatively large (1-3 mm) compared to biotite crystals in the fine-grained granite (map unit *Xg*). This unit, as mapped, is everywhere foliated. Miller, *et al.* (1963) describe a coarse-grained variety of the Embudo granite. However, at the time of their study, few accurate age-dates were available and the significance of the later pulse of ~1.4 Ga plutonism was not fully recognized. Hence, it is possible that this coarse-grained granite may either be part of the early Proterozoic Embudo pluton or it may be a younger ~1.4 Ga intrusion. Comparison of these exposures with granites to the east may help to resolve this problem.

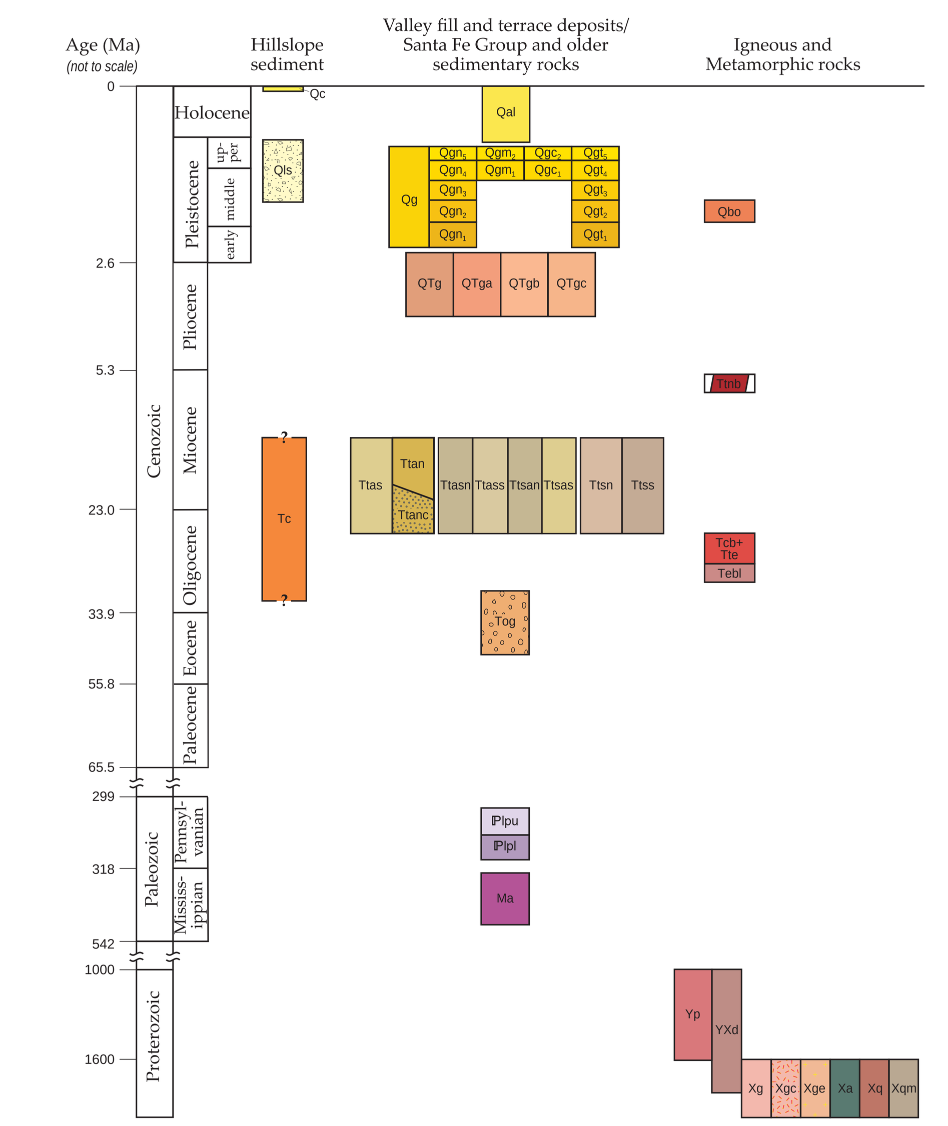
Xge — **Medium- to coarse-grained, equigranular granite – "Embudo Granite" (Early Proterozoic)** — This unit is tentatively separated from map unit *Xg* on the basis of homogeneous and apparently widespread (at least locally) exposures on the high, steep face on the north side of Pacheco Canyon, in the southern part of the Tesuque 7.5' quadrangle. Here it approaches coarse-grained, is equigranular, and forms very bold cliffs with subangular to rounded, bouldery outcrops.

Xa — **Amphibolite (Early Proterozoic)** — Amphibole-rich gniess, biotite schists, and all gradations in between. Outcrops are rather heterogeneous and contain highly variable amounts of amphibole, feldspar (mostly plagioclase), biotite, and quartz. Biotite schists commonly contain abundant light gray feldspar and quartz, and are approximately granodioritic in composition. The biotite schists generally appear slightly lighter gray than the dark greenish gray amphibolites. Amphibolites range from fine-grained to relatively coarse-grained and contain tabular subhedral amphibole phenocrysts locally up to 1 cm long, that appear as though they formed both during and after metamorphism. The percentage of feldspar is highly variable. Some rocks contain only amphibole and quartz. The amphibolites and biotite schists together may have originally been either intermediate to mafic igneous rocks or intermediate-composition pelitic rocks, or both.

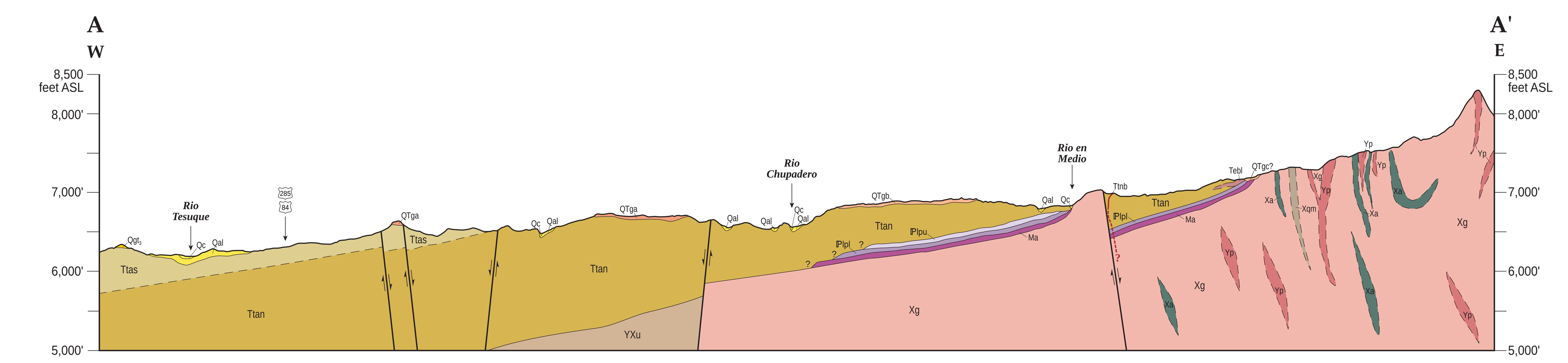
Xq — **Quartzite (Early Proterozoic)** — These discontinuous, lens-shaped bluish gray exposures are composed of quartz and thin laminae of darker iron oxides. No bedding is obvious. Exposures are foliated.

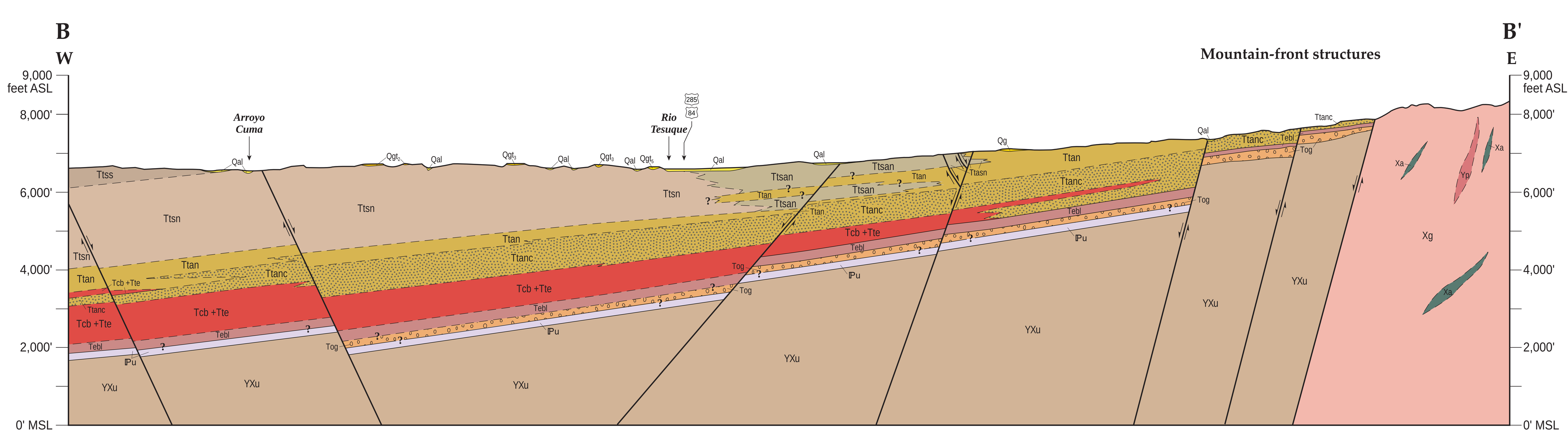
Xqm — **Quartz-Muscovite Schist (Early Proterozoic)** — Composed of quartz and medium- to coarse grained muscovite. Commonly strongly foliated. This unit was likely a sedimentary protolith that contained abundant quartz and finer material that included some clay.

CORRELATION OF MAP UNITS



GEOLOGIC CROSS SECTIONS





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