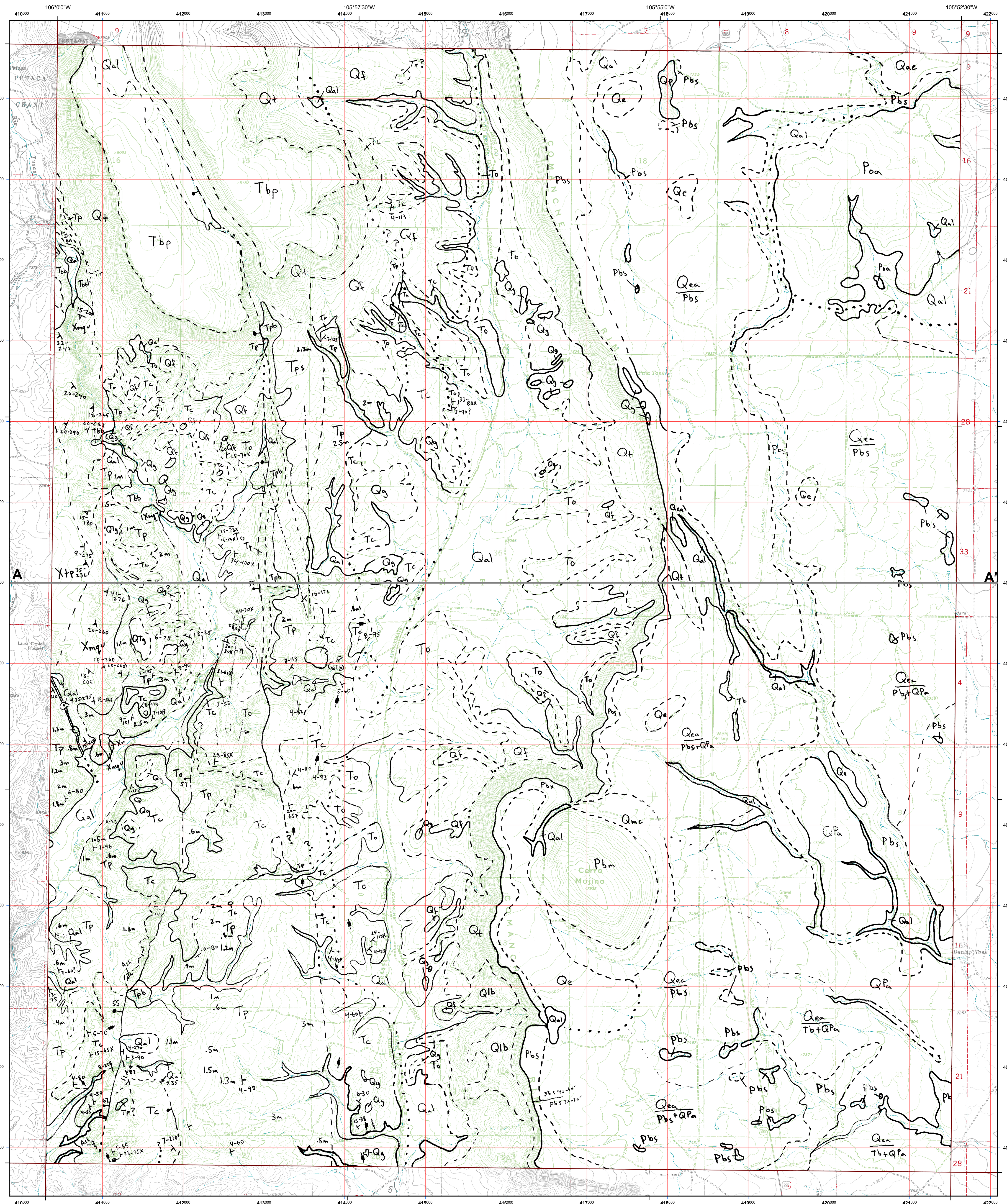
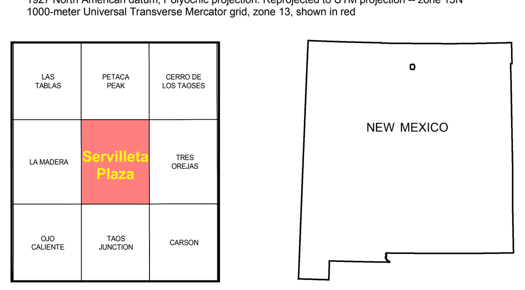
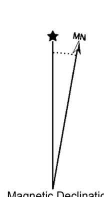


Base map from U.S. Geological Survey 1961, from photographs taken 1958, field checked in 1961.
1927 North American datum, Polyocnic projection. Reprojected to UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in red

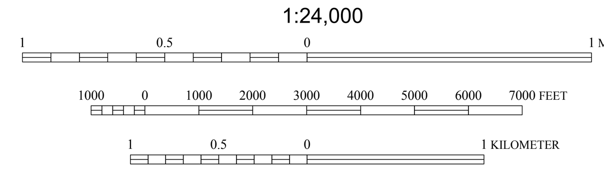


QUADRANGLE LOCATION



Magnetic Declination
April, 2007
9º 33' East
At Map Center

1:24,000



CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geologic map of the Servilleta Plaza quadrangle, Cibola County, NewMexico

May 2008

by
Scott Aby
P.O. Box 488 Dixon, NM 87527

New Mexico Bureau of Geology and Mineral Resources
Open-file Map Series
OF-GM 182

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (Dr. Peter A. Scholle, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

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This and other STATEMAP quadrangles are (or soon will be) available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu/publications/maps/geologic/ofgm/home.html

This draft geologic map is preliminary and will undergo revision. It was produced from either scans of hand-drafted originals or from digitally drafted original maps and figures using a wide variety of software, and is currently in cartographic production. It is being distributed in this draft form as part of the bureau's Open-file map series (OFGM), due to high demand for current geologic map data in these areas where STATEMAP quadrangles are located, and it is the bureau's policy to disseminate geologic data to the public as soon as possible.

After this map has undergone scientific peer review, editing, and final cartographic production adhering to bureau map standards, it will be released in our Geologic Map (GM) series. This final version will receive a new GM number and will supercede this preliminary open-file geologic map.

DRAFT

New Mexico Bureau of Geology and Mineral Resources
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NEW MEXICO STATEMAP

COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology and Mineral Resources. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government.

Explanation of descriptive terms.

Soil Color terms after Munsell (1994); all other colors (e.g. rocks, outcrops) are subjective; strength, sorting, angularity, grain size, and hand-sample descriptive terms after Compton (1985); sedimentary terms generally after Boggs (1995). Queries (?) after descriptors indicate uncertainty, generally due to lack of exposure in loose units.

Quaternary Rocks

Qe Holocene and late Pleistocene(?) silty eolian and slopewash(?) deposits

Unexposed; very pale brown-to-light yellowish brown (10 YR 7/4-6/6);loose; moderately well-to-moderately poorly sorted, subangular-to-rounded; massive(?); silty fine sand. This unit covers small parts of the area above (east of) the Commanche Rim and is interpreted as a mixed eolian and 'slopewash' unit derived by local reworking of material supplied by the dominant Southwest winds (and possibly by more local weathering/erosion of underlying units). Almost certainly some of the sand supplied in this way is derived from older tertiary units west of the Commanche Rim. This unit appears to be part of a mantle of 'desert loess' that covers relatively stable parts (e.g. isolated uplands, stream terraces) of many landscapes across northern New Mexico. Age is inferred from landscape position and a cultural artifact found beneath sandier deposits in a similar landscape position on the Taos Junction Quadrangle (Koning et al, 2007)

Qp 'playa' deposits

Thin; unexposed; grey (2.5YR 6/1-possibly gleyed?), friable, well sorted (bimodal), very thinly bedded(?) silty clay with occasional subangular, fine, quartzose (?) sand grains. Unit found only in one shallow, closed depression in the north central part of the quadrangle. It is apparently formed by occassional ponding/evaporation of rainwater that has winnowed fine material from nearby Tbs and Qea.

Qal

Stream channel and valley-floor alluvium,active floodplains, low stream terraces and tributary mouth 'fans'; as well as isolated 'upland' alluvial deposits (Holocene and latest Pleistocene?)-Poorly exposed; light gray-to-pale brown (10YR 7/2-6/3); loose; poorly to well-sorted; rounded-to-subangular; thin-to-thick bedded or massive; silty sand to sandy gravel with rare boulders. Light-brownish silty sand, gravelly sand, and sandy gravel with minor gravel, mud and silt underlies modern ephemeral channels. Gravel is generally poorly-to-moderately sorted, subangular to subrounded pebbles. Sand is generally coarse- to very coarse-grained, poorly to moderately sorted, and subrounded to subangular. Coarsness, sorting, and composition of Qal is controlled by which Tertiary unit is drained by an individual channel. Alluvium west of the 'main central drainages' (called Canada de los Commanches in southern half of Quad and unnamed tributary of Rio Tusas in northern half) is commonly pebbly due to input from the Plaza member while that to the east is more sandy (and better sorted) due to erosion of the Ojo Caliente Sandstone. Estimated thickness of deposits associated with ephemeral channels is 1-5+ m but is possibly thicker. Thickness in alluvial reaches of the Rio Tusas is unknown.

Qlb

Quaternary landslide deposits with intact blocks of Tertiary basalt flow(s) (late Pleistocene to Holocene?) Quaternary landslide deposits with intact blocks of Tertiary basalt flow(s); abundant, subangular-to-angular basalt blocks; and common pebble-to-small boulders of Tertiary volcanic clasts (silicic-to-intermediate), vein quartz, granite, quartzite, epidote and mica schist. All the non basalt clast types are believed to be derived from Pliocene (?) sub-basalt alluvium. This alluvium is only well exposed in one spot (416977 :4036363) and is not shown on the geologic map. Qlb is mapped in slope deposits west of the Commanche Rim only where Toreva blocks are clearly distinguishable.

Qt

Quaternary talus deposits (Pleistocene and Holocene?).

Unexposed; loose; very poorly sorted; subrounded-to-angular; unbedded (?); characterized by ubiquitous subangular-to-angular basalt blocks and common pebble-to-small boulders of Tertiary volcanic clasts (silicic-to-intermediate), vein quartz, granite, quartzite, epidote and mica schist. Some of the non-basalt clast types are believed to be derived from Pliocene (?) sub-basalt alluvium. This Pliocene alluvium is only well exposed in one spot (416977 :4036363-see discussion under Servilleta Basalt description) and is not shown on the geologic map. Small areas of sandy-to-silty fines between coarse boulders are common-to-rare. As mapped this unit includes some small basalt 'blockfields'.

Qg

Undifferentiated Quaternary gravel deposits. Unexposed, commonly buff-to-brownish, loose, poorly sorted, subangular-to-well rounded, basalt-rich conglomerate and sandy conglomerate.

Along the Rio Tusas at the north of Servilleta Plaza some Qg deposits are clearly 'terrace gravels' of the Rio Tusas as reflected by the presence of well rounded cobbles and pebbles of Dorado basalt, and Precambrian clast types derived from units exposed along the Rio Tusas to the north. These terrace gravels are limited in extent and are often buried by a veneer of relatively fine (sandy and/or silty) material.

Some Qg deposits east of the Rio Tusas are composed of Precambrian clasts mixed with basalt, rhyolite and dacite clasts derived from erosion of Tertiary units. These are clearly 'terrace gravels' of the Rio Tusas. These terrace gravels grade away from the stream to the east with Qf deposits and may underlie Qf in places.

A cluster of three small Qg deposits inset into Pbs along the Commanche Rim are composed of clasts typical of Tertiary deposits to the west (as opposed to clasts typical of the Taos Range) and may therefore represent a 'proto-Canada de los Commanches'.

In rare instances along foothills west of the Canada de los Commanches a few slate pebbles are found in Qg deposits. The most likely source of these slate clasts is the Precambrian Big rock conglomerate (Koning et al., 2007). Deposits along the main central drainage both north and south of the Canada de los Commanches divide seem to contain basalt clasts from the Petaca mesas, indicating through-going drainage at some time in the quaternary and piracy of the headwaters (northern half of 'main central drainage') by the Rio Tusas since that time.

Qf Quaternary alluvial fan deposits.

Unexposed, loose (except where cemented by soil carbonate), poorly sorted, subangular-to-rounded, thin-to-thick bedded(?), commonly basalt-rich, sandy gravel-to-boulder conglomerate. Coarse material composed of basalt (up to 95%+), dacite, rhyolite (including Amalia tuff), vein quartz, and quartzite (sometimes mica-rich). This unit is derived from erosion on the slopes of the Petaca Mesas and is composed of a variable mixture of the clasts contained in the units underlying those mesas. On the southwestern side of the Petaca Mesas this unit contains a higher percentage of Precambrian clast-types due to the greater extent of Precambrian outcrop in that area and possibly interfingering of 'Rio Tusas' gravel with fan deposits. The distinction between Qf and Qt (upslope) and between Qf and Qg is somewhat arbitrary in some cases and is based on greater rounding of clasts away from their source and/or a break in slope at the base of Qt or Qf.

QTg

Unexposed; buff-to-brown(?); loose (except where cemented with soil carbonate, presumably); moderateley-to-poorly sorted; subangular-to-rounded; complexly bedded(?); silty-to-sandy conglomerate containing basalt, dacite, rhyolite, quartzite, vein quartz, and Tres Piedras Granite, and Vadito group(?) schist clasts. This unit has a limited aerial extent on this quadrangle and is found mainly at an elevation of about 7120' near the western quad boundary. This deposit overlies Tertiary units (Tp and Tc) just east of the Proterozoic/Tertiary contact here and seems to have been deposited by streams that were following this contact due to the contrast in erodability of the two older rock types. There may be a separate, slightly lower (~7080') primary deposit of essentially identical gravel just east of the main deposit or this lower material may have been derived by hillslope erosion of the higher gravel.

<u>**Qea**</u>
Tb Eolian and/or alluvial deposits overlying Servilleta Basalt (Holocene-to Pliocene?)
Poorly exposed; buff to light, loose-to-carbonate-cemented; moderately-to-poorly sorted; subangular-to subrounded; complexly bedded and interbedded silty sandstone and sandy siltstone with common-to-rare lenses and beds(?) of sandy gravel composed of clasts of basalt, silicic-to-intermediate volcanics, vein quartz, granite, epidote, and amphibolite. Stage III+ carbonate soils are exposed in cuts along the old railroad grade east of highway 285. (Although these carbonate soils are not well indurated they are greater than 2 m thick and very varbonate rich.) Clasts exposed at surface vary are nearly 100% basalt .

<u>**Qea**</u>
Tb+QPa Eolian and/or alluvial deposits overlying Servilleta Basalt and Tertiary alluvium(Holocene-to Pliocene?).
Poorly exposed; buff to light brown, loose-to-carbonate-cemented; moderately-to-poorly sorted; subangular-to subrounded; complexly bedded and interbedded silty sandstone and sandy siltstone with common-to-rare lenses and beds(?) of sandy gravel composed of clasts of basalt, silicic-to-intermediate volcanics, vein quartz, granite, epidote, and amphibolite. Clasts exposed at surface vary from 95%+ basalt to 100% non-basalt types. This reflects a complex of processes that have mixed locally-derived alluvial material and eolian sand (and silt?) derived mostly from the west.

Qmc Cerro Mojino colluvial apron
Unexposed, buff-to brown(?), loose-to-carbonate cemented, very poorly-to moderateley sorted(?), well-rounded to angular, basalt-rich colluvium derived from Cerro Mojino. This unit is likely formed from a combination of Servilleta Basalt weathered and eroded from Cerro Mojino and eolian material blown onto Cerro Mojino and reworked by erosion. Some of the eolian material is reworked Ojo Caliente Sandstone that has blown up the Commanche Rim.

QPa
Tertiary alluvium overlying Servilleta Basalt (Pleistocene and Pliocene?)
Poorly exposed; grayis, purplish, and buff to light brown; loose-to-carbonate-cemented; moderately-to-poorly sorted; subangular-to subrounded; complexly bedded sandy gravel and gravelly sand with subordinate muddy and/or silty lenses. The sole exposure of this unit is in a gravel pit in the NE quarter of Section 11 T25N:R10E (east of Cerro Mojino). This exposure is a mixture of conglomerate and sandy/silty lenses/beds. Gravel clasts include silicic volcanics, granite, basalt, quartzite, gabbro, amphibolite, epidote, and vein quartz. This unit represents mixing of debris derived from local and regional erosion of Servilleta basalt and alluvial material from the Taos (and possibly Tusas) mountains.

Pliocene Volcanic Rocks
Introduction
We take all volcanic rock names for rocks of the Taos Plateau Volcanic Field (those east of the Commanche Rim) from Lipman and Mehnert (1979) where possible. The rocks capping the Petaca Mesas were called Dorado basalt by Barker (1958). All other mafic, aphanitic volcanic rocks on this Quadrangle are designated basalt based on field criteria. The term 'dacite' has been used to describe the plagioclase-rich clasts in the 'Plaza member' (Tp) in this area (e.g. Ingersoll et al, 1990; Koning et al., 2007) even though these casts do not often contain obvious quartz as required by some field classifications {e.g. Compton (1985)}. We retain this designation for all porphyritic-aphanitic rocks with obvious plagioclase phenocrysts in a semi-aphanitic matrix.

Tbx basalt(?) flow west of Cerro Mojino (Pliocene?)
Well exposed, black, very strong, vesicular-to- non-vesicular, aphanitic basalt(?). A field description would designate this rock as basalt but it has superficial similarities to the Servilleta Plaza Quad vent which has been designated olivine andesite by Lipman and Mehnert (1979) and pyroxene dacite by Appelt (1998). This flow appears to have flowed around Cerro Mojino and would then be < ~4.3 Ma. The base of this basalt is everywhere covered in talus but it is at least 18 m thick, slightly thicker than the Servilleta basalts (Pbs) along the Commanche Rim. Its flow morphology suggests that it was more viscous at eruption than Pbs. This rock can be distinguished in hand sample by its aphanitic texture and strength (hand samples are hard to break with a hammer).
Sample submitted for dating at NMBGMR lab September 2007

Pbm Cerro Mojino basalt (Pliocene ~4.3 Ma)
Poorly exposed, grey-to-dark grey, moderateley strong, porphyritic-apahnitic, vesicular-to-non vesicular, grey-to-brown weathering, plagioclase-rich basalt. The basalt of Cerro Mojino has the dikytaxitic texture characteristic of all Servilleta basalts, of which it is one example (Lipman and Mehnert, 1979). The term dikytaxitic describes the association of plagioclase crystals in these rocks with small vescicles/voids. Plagioclase crystals are more abundant and larger than 'average' Servilleta basalt. This fact gives these rocks a decidedly 'sparkly' appearance on fresh faces. No outcrops are available to describe the internal structure of this basalt. Lipman and Mehnert (1979) suggested that Cerro Mojino may be a structural dome. We do not see any evidence of structural deformation in the area but it is possible that such evidence is obscured by younger flows. I would suggest that the topographic relief of Cerro Mojino may also be the result of its higher crystal content relative to typical Servilleta Basalt or to a lower eruption temperature. Appelt (1998) dated a single sample at 4.32 +/- 0.03 Ma.
Sample submitted for dating at NMBGMR lab September 2007

Poa 'Servilleta Plaza Quad Vent' olivine andesite(?) (Pliocene ~4.5)
Poorly exposed, dark grey-to-black, moderately strong-to strong, porphyritic-aphanitic, vesicular-to-non vesicular, grey-weathering olivine andesite. Olivine crystals up to ~1.5 mm are rare to common in hand samples. Red cinders of scoria rare to ubiquitous in float on slopes. An eroded cinder cone is present just off the eastern quad boundary. Lipman and Mehnert (1979) named the edifice composed of this lava the 'Servilleta Plaza Quad Vent' and identified it as an 'olivine andesite'. Appelt (1998) dated two samples that he referred to as 'pyroxene dacites' to 4.69 +/- 0.06 Ma and 4.27 +/- 0.11 Ma. He further noted that this eruption was one of several small pyroxene dacite eruptions that are clustered in time with the volumetrically larger pyroxene dacite eruptions that produced Tres Orejas, Guadalupe Mountain, and several large edifices in the Questa/Red river area (Appelt 1998 p. 38). This flow is in contact laterally with Pbs across an arroyo in the northeast part of the map area but relative age relations are not clear there.
Sample submitted for dating at NMBGMR lab September 2007

Pbs Pliocene Servilleta Basalt (Pliocene, ~4.6 Ma)
Well exposed, grey-to-dark grey, moderateley strong, porphyroapahnitic, vesicular-to-non vesicular, grey-to-brown weathering basalt. Cumulative thickness > 30m near the eastern quadrangle boundary but <10m at the Commanche Rim. This thickness usually appears to be composed of at least two flows and or cooling units that are usually separated by a zone of relatively more vesicular basalt.

A single good exposure of the base of these flows is found at 416977 4036363 (another poor exposure exists in the south part of section 31 T26N:R10E). This good exposure reveals a spectacularly baked carbonate soil(?) beneath the lava. Parts of the upper 20 cm are oxidized to bright (5YR) red colors colors. The upper surface of the 'soil' is composed of highly vesiculated and oxidized silty material apparently produced by boiling away of soil moisture. The upper meter of sediment appears to have dewatered producing soft sediment deformation under the weight of overlying lava. The soil is developed in sandy alluvial material that has sparse pebbles of Tertiary silicic and intermediate volcanic rocks, quartzite, and a few large angular basalt(?) clasts. These later, angular mafic clasts include some that are superficially similar to the lava of the Servilleta Plaza Quad Vent (Poa) and another greenish, olivine-rich rock not familiar to the author from any outcrops. In other locations the talus (Qt) developed below Pbs contains abundant, rounded clasts that may be derived from coarser parts of this same sub-basalt alluvium.

Appelt (1998) dated a single sample of Servilleta basalt at 4.63 +/- 0.09 Ma along the Commance Rim on the adjacent Taos Junction Quadrangle to the south.

Tbp Basalts of the Petaca Mesas (Dorado basalt) (Pliocene?)
Well exposed; blue, bluish grey-to-black; strong; aphanitic; vesicular-to-non vesicular; quartz-bearing; brown-weathering basalt. Quartz is found as semi-euhedral crystals and in lens-shaped 'bodies' up to ~2cm long and apparently elongated transverse to flow. These lenses are superficially similar to fiame in shape. These rocks were called Dorado Basalt by Barker (1958). Some parts of these rocks are flow-banded and this banding leads to the production of abundant 'platy' debris which is characteristic of material derived from these mesas. These rocks have not been radiometrically dated to our knowledge but they are in a similar topographic position to the Pliocene Servilleta Basalts of the Taos Plateau.
Sample submitted for dating at NMBGMR lab September 2007

Tertiary Sedimentary and Volcanic Rocks

To

Ojo Caliente Sandstone of Tesuque Formation

Poorly-to-moderately-well exposed; very pale brown (10YR 8/2-3 to 7/3 and 7/4), loose-to friable; well and moderately well sorted; subrounded-to-rounded; thickly-to-very thickly bedded and cross-bedded; quartz-rich, uncemented-to moderately well carbonate-cemented sandstone. The Ojo Caliente Sandstone was deposited by large-scale (~1-7m) eolian sand dunes in a sand sea (erg) that stretched from near Espanola in the south and Dixon in the east, and at least as far north as Taos and as far west as Abiquiu . Cross-bedding indicates that the dominant wind direction at the time of deposition was from the southwest, as it is today. In adjacent areas (Koning et al., 2007) one or more transitional units between the Chama-El Rito Member of the Tesuque Formation and the Ojo Caliente Sandstone have been mapped. On this map I have restricted the Ojo Caliente to the 'classic' eolian part of the strata that are cross-bedded on a large scale and well sorted. These strata are universally lighter colored than the underlying Chama-El Rito Member which here includes all strata that show any evidence of fluvial origin such as tabular bedding or lenses and stringers of coarse sand and/or granules. Koning et al., (2007) have interpreted the age as between ~13.4-11.0 Ma based on interbedding relations of To with various ash beds regionally. The top of this unit is buried beneath Pbs flows but it appears to be at least ~400 m thick. Bedding attitudes are not available in the eastern half of the outcrop area and this thickness estimate may be exaggerated if dips shallow to the east.

Zones of enhanced cementation and small scale shear that have been referred to as 'sand deformation band faults'. These features are fairly common in the Ojo Caliente but only those that are exposed over fairly long (>~75m) distances are shown on the map. These 'band faults' appear to accommodate distributed strain in the Ojo Caliente and (to a lesser degree) the sandier parts of the Chama-El Rito Member. They are best developed immediateley west of the main N-S fault east of Servilleta Plaza, and they run parallel to a 'grain' in these rocks that is visible on air and orthophotos. Sub-vertical, calcite-filled (and ocassionally opalized), cm-scale fractures (see map) are fairly common in exposures of the Ojo Caliente and Chama-El Rito and also run parallel to this 'grain'.

Tc
Chama-El Rito Member of Tesuque Formation (middle Miocene)
Poorly-to-well exposed; pink (7.5YR 7/3-4) to reddish yellow (7.5YR 6/6); loose-to-slightly friable; moderately-well-to-well sorted; subangular-to-subrounded; massive-to-planar laminated (rarely cross-bedded), thin-to-thick bedded and sometimes lensoidal; quartz-rich silty sandstone-to-sandstone.
Sand is composed of quartz, feldspars, volcanic lithics, and mafic grains. The lower few meters of this unit locally contains conglomerate beds and lenses as well as isolated pebbles of Plaza member clasts, but the unit is otherwise almost all sandstone on this quadrangle. The orangeish color of the Chama-El Rito has proved characteristic in distinguishing it from the overlying Ojo Caliente Sandstone. This member is at least 75 meters thick but thickness may be variable. Koning et al., (2007) have interpreted the age as between 13.4-15 Ma based on interbedding relations of Tc with various ash beds and other sedimentary deposits regionally.

An interbedded, white volcanic ash found in two places in the lower few meters of this unit in the southwestern part of the quadrangle was submitted for dating at NMBGMR lab September 2007.

Tp
'Plaza member' of Los Pinos Formation
Poorly exposed; pinkish, greyish, white, and purplish; loose-to-friable; poorly-to-very poorly sorted (sometimes bimodal and sometimes with dramatically 'outsized' clasts); subrounded-to-rounded; thinly-to-thickly bedded; massive-to-planar laminated; rarely inversely-graded; dacite-rich silty-to-sandy pebble-to-boulder conglomerate and pebbly-to-bouldery silty sandstone. We here introduce the informal designation 'plaza member' to replace earlier use of the term 'plaza lithosome'. This informal member is characterized by the dominance of dacite clasts that range from red, blue, black, purple, pink, marron, and brown colors. The Plaza member is rarely exposed, but float of this unit is distinct due to the presence of abundant dacite pebbles and a characteristic purplish color of the regolith overlying it. On this quadrangle these dacites are rich in plagioclase phenocrysts and individual plagioclase up to 7 cm long are occasionally seen within dacite clasts. Occasional inverse grading, very poor sorting, and the presence of large boulders protruding from the top of thin beds into overlying strata both indicate that debris flow processes were important during Plaza deposition. The basal few tens(?) of meters of this unit are lighter colored and the matrix is finer grained than avarage Tp so that it has a 'chalky' appearance (but is not calcite cemented). The Plaza member is ~30 m thick where it laps onto Proterozoic rocks in the western part of the map area. To the east of Servilleta Plaza proper it is at least 150 m thick (including Tpb) but the base is cut out by a fault here. This unit is older than the Chama-El Rito Member and younger than basal Tertiary basalts (Tbb) in the map area and is therefore roughly between 15 and 27 Ma.
Samples of interbedded units Tpb and Tr have been submitted for dating and will eventually provide direct age constraints
.

Tps
Silicic clast-dominated part of Tp
Unexposed, silicious clast-rich part of the Plaza member. This unit overlies Tpb and forms a tongue within Tp. Silicious (felsic) clasts include grey-to-blueish banded rhyolite and Amalia Tuff which are characteristic of Tpc elsewhere (e.g. Koning et al, 2007). The position of this unit immediately above Tpb suggests that emplacement of this flow altered drainage patterns so that rhyolitic clasts were deposited where dacitic clasts of Tp had previously been deposited. A small area of Tr which consists mostly of white-to-cream colored, crystal-rich tuff is found immediately above Tps and suggests that silicic volcanic activity again altered drainage patterns in such a way as to again exclude silicic clasts from this area. Some clasts within unit Tps are similar to those found in the older unit Tpc, and this unit may reflect continued Tpc deposition or erosion of Tpc at this time.
A small, ~5m thick stream-bed exposure of silicious breccia(?) is found interbedded with Tp near 413050 4031810. The relation of this bed to Tps is unknown but clast types are similar to those seen in float in the mapped area of Tps. Age is equivalent to upper part of Tp (~15-20 Ma?)

Tpb
Basalt flow (and possible plug) interbedded in Plaza member
Well-exposed; black-to grey; strong; vescicular basalt. Some parts (both at the base and within the basalt) are autobrecciated and oxidized to red colors indicating multiple flows and/or flow lobes. The isolated exposure of basalt in the southeast quarter of Section 16 T25N:R9E contains some autobrecciated basalt and rare breccia of sandstone (To?) and basalt, while the overall outcrop pattern is suggestive of an intrusion. This possible plug is at a similar stratigraphic position to the flow(s) of Tpb found to the north but has not been otherwise correlated to these rocks.
Sample of flow submitted for dating at NMBGMR lab September 2007

Tr Tertiary Rhyolite and Rhyodacite(?)

Rhyolite, rhyodacite, and possibly dacite? Rocks are generally divisible into maroon dacite/rhyodacite flows and white-to-cream colored, quartz and sanidine-rich Tuff. These two rock types are often found adjacent to each other at a similar stratigraphic level but exposures do not allow detailed interpretation of their relations. Found directly overlying Tpc, Tj, and Proterozoic rocks and interbedded in Tp. Tuff contains chatoyant (irridescent blue) sanidine crystals ('moonstones') characteristic of the Latir Volcanic Field. Thickness is between 40 and 50 m. A sample of "... rhyolite welded tuff {interbedded in the Los Pinos Formation}collected west of Petaca yielded a potassium-argon age of 25.9 +/- 1.8 Ma.." Bingler (1968). Petaca is just north of the Quad Boundary, but the relation of Tr to this dated tuff is unknown at present.

Sample of tuff found between Tps and Tp southeast of the Petaca Mesas submitted for dating at NMBGMR lab September 2007. Since unit Tps underlies Tr and contains clasts of welded Amalia Tuff this Tuff interbedded in Tp must be <~25 Ma.

Tpc Cordito Member of Los Pinos Formation

Well exposed; black, tan, reddish, and/or brownish; slightly friable-to-strong; moderately well-to- poorly sorted; angular-to-rounded, medium-to-thick bedded; massive-to-weakly cross bedded and sometimes lenticular; sandy pebble-to-cobble conglomerate and very coarse sometimes pebbly sandstone and granule conglomerate. Clasts are generally over 95% silicic volcanic rocks including many varieties of rhyolite and rhyolitic tuff including Amalia Tuff, gray-to-blueish flow-banded rhyolite, white-to-creamy rhyolitic tuff, and black and/or red flow banded rhyolite. Coarse sandstone and granule conglomerate comprises the lowest few(?) meters of this unit (immediately above Tbb) on this quadrangle. This interval is composed of >99% angular-to-subrounded quartz and sanidine crystals including chatoyant sanidine ('moonstone') characteristic of rhyolite tuffs of the Latir Volcanic Field including the Amalia Tuff. This part of the unit may represent fairly near-source reworking of unwelded parts of the Amalia Tuff. The Cordito Member exposed on this quadrangle is younger than Tbb.

Tbb Basal Tertiary basalt flow(s)

Gray-to-black, strong-to-very strong, usually vesicular-to-vuggy olivine basalt. Olivine crystals are generally <1.5 mm and compose a few percent by volume of this rock. This basalt fills paleotopography developed in Proterozoic rocks and represents the oldest Tertiary unit on this quadrangle. Found in both thin (5-15m), isolated patches and a thick (~200') section along the Rio Tusas near the western quad boundary beneath both Tr and Tpc. Similar basalts in this area have retuned ages between 27 and 22 Ma. {Lipman and Mehnert, 1979; Baldridge et al., 1980.) Lipman and Mehnert (1975) included all basalts in this region to the Hinsdale Series, whereas earlier workers had mapped these basalts (along with two other types of basalt) as the Jarita Member of the Los Pinos Formation (e.g. Barker, 1958). Detailed maps of the entire area must be made before relations among the basalts can me accurately defined.

Proterozoic Igneous and Metamorphic Rocks

PALEOPROTEROZOIC ROCKS

Identification, description, and division of Proterozoic rocks follows that of Koning et al., 2007 for the adjacent La Madera Quadrangle. Thanks to Dr. Karl Karlstrom for advice and identification of samples.

Xtp
Tres Piedras granite – Tan-to-orange, strong-to-slightly friable, granular granitic gneiss consisting principally of quartz, feldspar, biotite, and muscovite. Orangish on weathered surfaces relative to other Proterozoic rocks. Contact with Xmqu is gradational over many (tens?) meters.

Rocks of the Vadito Group

Xmqu
Micaceous quartzite – Variably colored, thinly laminated, schistose, micaceous quartzite. Mica content is varible (~5-50%) over short distances. Consists of quartz, muscovite, biotite, hematite, and epidote. Identified in the field by granular texture and absence of feldspar.

Xr
Metarhyolite – Greyish/greenish-to-tan, schistose metarhyolite, consisting principally of quartz, feldspar, muscovite, and opaques. Identified by presence of quartz "eyes" and ribbons, some of which are zoned and may have originally been lithopysae (Karlstrom personal communication2008). This unit is found in only one small outcrop along the Servilleta Plaza road.

Synoptic Summary of Geologic History

Proterozoic rocks are limited to the Tres Piedras granite and 'schists' of the Vadito Group. These rocks have been regionally metamorphosed and deformed by at least three phases of stress likely related to continental accretion events (Koning et al. 2007). Prior to Tertiary deposition, a topography with at least tens, and likely hundreds of meters of relief was developed on this Precambrian terrane. This relief may have (likely did?) develop in response to uplift associated with the Laramide Orogeny, which may also have provided the energy necessary to erode older Tertiary (and Paleozoic/Mezozoic?) rocks from this area.

Initial Tertiary deposition on this quadrangle consisted of extrusive basaltic volcanism (Tbb) which partly filled paleotopography. This mafic volcanism was followed, possibly after a substantial hiatus, by deposition of largely rhyolitic, volcaniclastic debris of the Cordito Member (Tpc) by generally southward flowing streams. Volcanic activity 'migrated' into the map area with the deposition of silicic tuff and silicic-to-intermediate flows of unit Tr, which overlies the Cordito Member in the northwestern part of the quad. However, intermediate volcanism of the "Plaza center" to the north (Ingersoll et al., 1990) and mafic volcanism as represented by basalt interbedded in the Plaza member (Tpb) to the south must have preceded the silicic volcanism of Tr as Tr overlies parts of the dacitic and silicic volcaniclastics eroded from the Plaza center to form the Plaza member (both Tp and Tps). Filling of paleotopography by the Plaza member may have allowed unit Tr to flow directly onto the Cordito member in the nortwestern part of the map area.

Deposition of mostly intermediate clasts of the plaza member both preceded and followed deposition of unit Tr and the interbedded basalt of Tpb, indicating that mafic and silicic volcanism were roughly coeval during this period. The complex relations of all these early Miocene (and late Oligocene?) units indicate that a complex topography with substantial relief existed throughout this interval of time. Drainage evolution was effected by emplacement of mafic and silicic flows within the map area and was almost certainly effected by construction of the Plaza Center and resultant isostatic effects.

A substantial change in depositional environment in the map area is demonstrated by the deposition of the fine sands of the Chama-El Rito Member above the Plaza member. The medium-to thick bedded fine sands and rare granules of the Chama-El Rito appear to have formed by fluvial reworking of eolian material from the south and southwest (based on the attitude of cross beds in eolian parts of the Chama-El Rito). Regionally, paleocurrent indicators show that Chama-El Rito streams flowed south and southwest, and the silt and rare granules/pebbles found in this rock may therefore have been derived from the north and northeast. The Chama-El Rito member and the Plaza member interfinger regionally (e.g. Koning et al., 2007), but on this quad the Chama-El Rito everywhere overlies the Plaza, indicating that this sandy depositional system somehow displaced the coarser system associated with the Plaza member in the map area.

I have chosen to restrict the Ojo Caliente Sandstone to the 'purely' eolian strata that are cross-bedded on meter + scale and relatively well sorted ('dune-field sands'), however, the Chama-El Rito and Ojo Caliente are clearly intimately related sedimentary sequences. In many locations regionally the Chama-El Rito contains significant proportions of conglomerate beds, but on the Servilleta Plaza Quadrangle gravelly beds are restricted to the lower few meters overlying the Plaza member. Eolian cross-bedding within the Chama-El Rito Member and the difficulty sometimes encountered in distinguishing the two rock types near their contact both indicate a progressive change in the depositional system with time toward a dominance of eolian processes.

Aside from a single ash layer found low in the Chama-El Rito, volcanic activity is absent from the record during Chama-El Rito and Ojo Caliente deposition. Sometime after deposition, the map area was tilted to the east between 10 and 6 degrees. Due to the difficulty in obtaining attitude data with sufficient accuracy, it is not clear if this tilting was syn or post-depositional. However, general concordance of dip magnitude across the main faults in this area indicate that faulting post-dates tilting. Slight (1-2 degrees) apparent tilting of Servilleta Basalts further indicates that tilting has continued during the Pliocene and Quaternary(?). The basalts capping the Petaca Mesas are offset between 90 and 120 meters (depending on interpretation of the base of the basalt and possible mass movements), and older Tertiary units are offset approximately the same amount across this same fault to the south. This indicates that faulting, at least on this maiin fault, has occurred mostly in the late Miocene and Pliocene.

The Petaca Mesa Basalt (Tbp) is apparently the oldest of the post-tilting basalts, but his relation is not yet confirmed by radiometric dates. Ages of volcanic rocks east of the Commanche Rim are similar (within errors for individual dates and the range of dates for the Servilleta Plaza Quad Vent), and cluster around 4.5 Ma, some of the older ages for rocks of the Taos Plateau Volcanic Field (Appelt, 1998; Lipman and Mehnert, 1979). After deposition of the rocks of the Taos Plateau Volcnic Field, alluvial material from the Taos Range/Latir Volcanic Field was deposited east of the Commanche Rim (Unit QPa).

Regional incision began sometime in the Quaternary and led to the end of fluvial/alluvial deposition above the Commanche Rim and development of drainages west of the Rim. The oldest preserved unit recording this incision is QTg gravel preerved near the Proterozoic/Tertiary contact near the western quad boundary. Younger Quaternary gravel (Qg) deposits are not extensively preserved below this level but they seem to record intermittent incision and lateral migration of trunk streams within a context of overall denudation. No substantial fill terraces are recognized. Extensive 'alluvial fans' were developed south and east of the Petaca mesas, their preservation likely due to the abundance of coarse debris shed from the mesas themselves. Talus slopes developed below basalt (Tbp, Pbx, and Pbs) as the more easily eroded Tertiary sediments beneath tehm were washed away and topography was inverted. Very complex eolian, fluvial, and slopewash processes have presumably operated throughout this incision and evidence of these processes is seen today in some small dunes (especially 'coppice' dunes seen developed around vegetation), and in the actively evolving arroyo systems both above and below the Commanch Rim. Eolian activity has probably been enhanced by the ready supply of 'pre-sorted' eolian sand available from erosion of the Ojo Caliente Sandstone.

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Servilleta Plaza Quadrangle Legend

7-90 **Strike and dip of bedding** (Dip-dip azimuth).

70-90X **Strike and dip of cross-bedding** (Dip-dip azimuth).

70-90 **Strike and dip** of mineral lineation in Proterozoic rocks (Dip-dip azimuth).

Contact-solid where well located, dashed where approximately located or partially concealed, dotted where inferred or covered by alluvium, queried where uncertain.

Normal Fault-solid where exposed and/or well located, dashed where approximately located, dotted where inferred or buried, queried where uncertain. Ball-and-bar on downthrown block. Number indicated magnitude of dip

55

Air Photo lineament (fault?)

240 **Bidirectional paleocurrent indicator**-paleoflow direction inferred from azimuth of channel margins. Arrow indicates inferred direction of flow based on interpretation of source area; number indicates azimuth of channel margin or average of several channel margins.

50 **"Sand deformation band fault"** -zones of shear and cementation in Ojo Caliente Sandstone that accommodate distributed strain. Commonly near vertical, tick mark and number indicate dip direction and magnitude where measurable. Sense of offset not determined. These 'band-faults' produce small topographic highs due to enhanced cementation relative to surrounding rock. Only those exposed over multiple tens of meters are shown and undoubtedly many more exist than were observed.

Sub-vertical, calcite-filled fracture sets – calcite-filled fractures commonly 1-2 cm wide, exposed for several meters and found in sets with individual fractures 10s of cm apart. Probably pervasive throughout Tertiary strata but only seen in good outcrops with fortuitous orientations. Mapped examples are representative but not comprehensively surveyed.

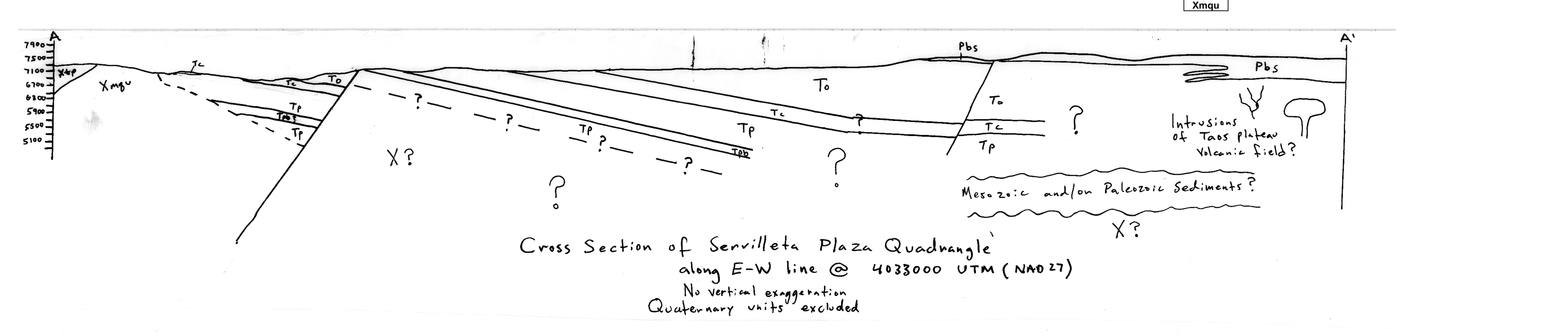
3m **Maximum clast size in Plaza member**-visually estimated size in meters of largest boulder in Plaza member of Los Pinos Formation. Almost always from float as this unit is poorly exposed.

Ash bed in Chama-El Rito Member of Tesuque Formation.

Gouge zone along fault.

<u>Stratigraphic Correlation chart for Servilleta Plaza Quadrangle</u>

Age	Units					
Pleistocene and/or Holocene	Qt	Qal	Qe	Qlb	Qmc	
Pleistocene	Qg	Qf				
Pliocene and /or Pleistocene	QTg				Qea/Pbs	Qea/Pbs +Qpa
Pliocene and latest Miocene	Pbs	Pbm	Poa	Pbx	Pbp	
	Unconformity					
Miocene	To					
Miocene	Tc					
Miocene and late Oligocene(?)	Tp	Tpb	Tr			
	Tpc					
	Tbb					
Proterozoic	Unconformity					
	Xtp					
	Xmqu					



Cross Section of Servilleta Plaza Quadrangle along E-W line @ 4028000 UTM (NAD 27)
No vertical exaggeration
Quaternary units excluded