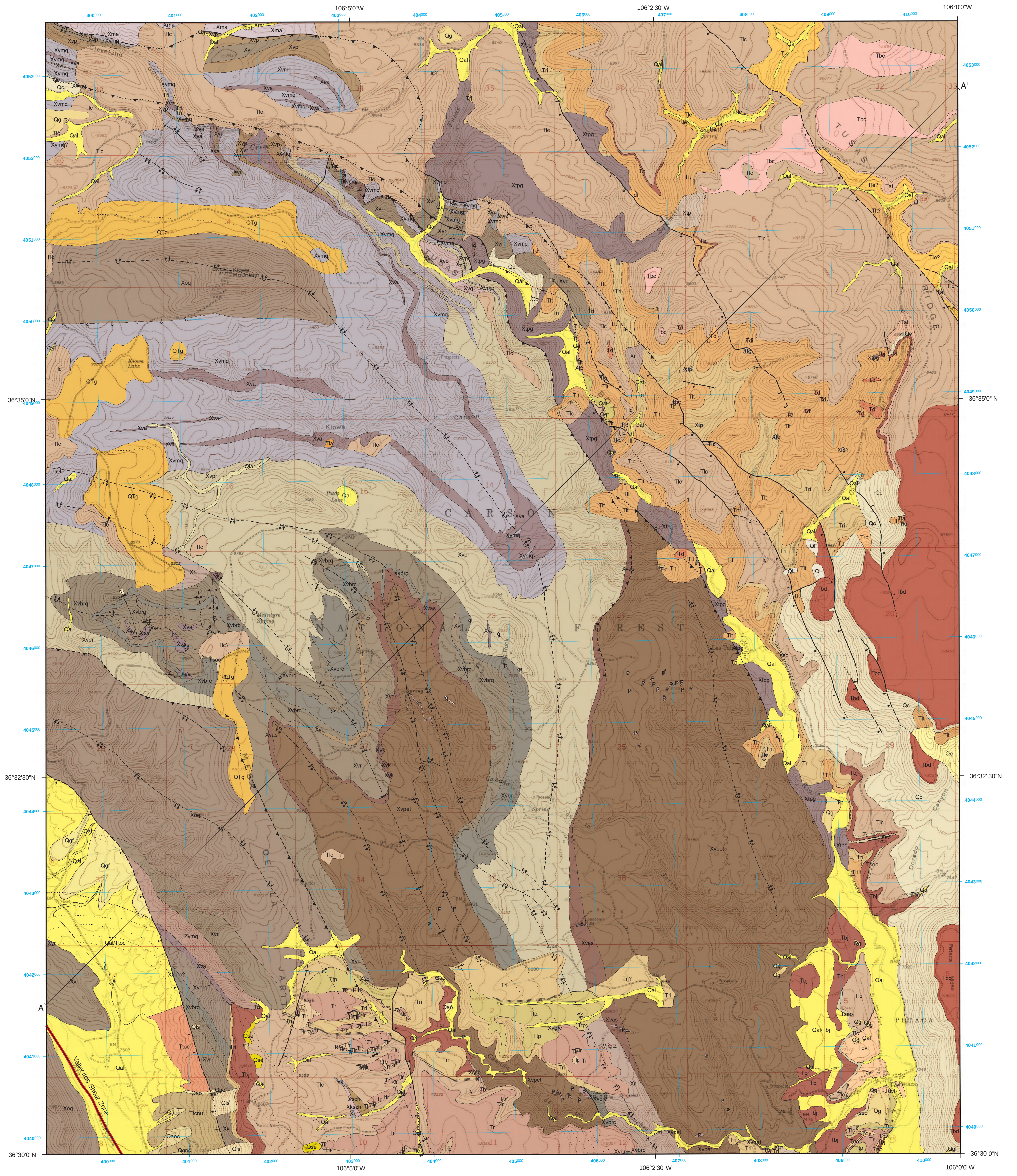
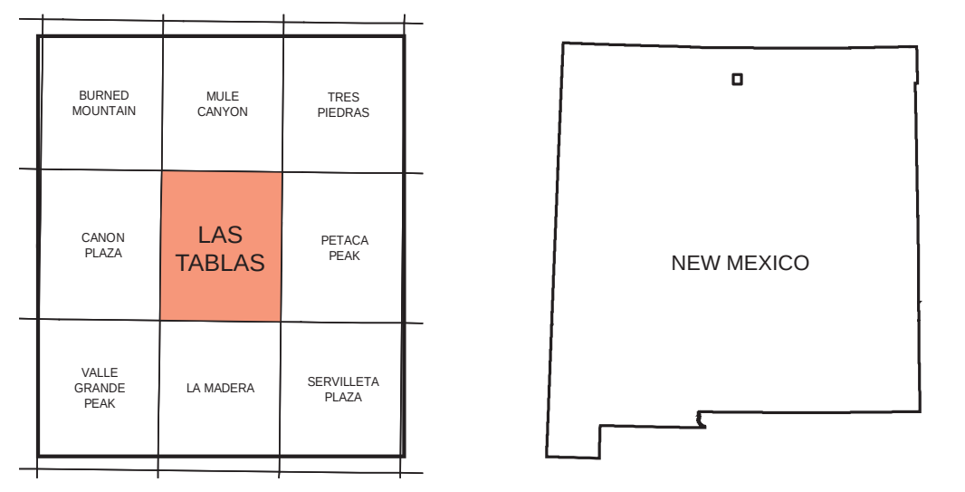
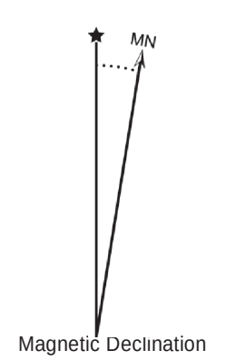
NMBGMR Open-file Geologic Map 200
Last Modified 2013



Base map from U.S. Geological Survey from photographs taken 1962, field checked in 1963.
1927 North American datum, UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in blue

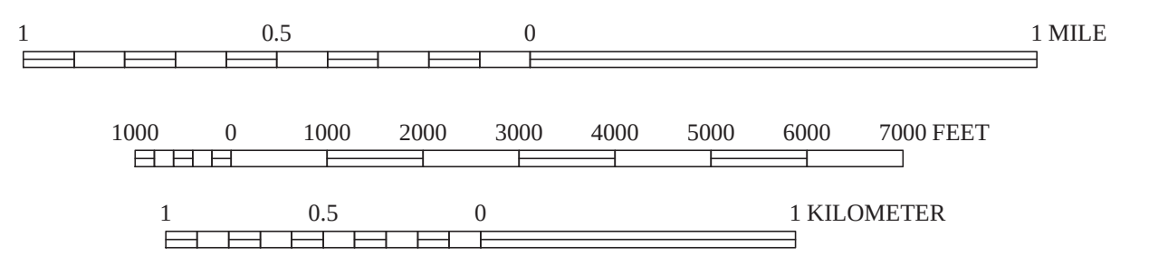


QUADRANGLE LOCATION



Magnetic Declination
03 2008
9º 30' East
At Map Center

1:24,000



CONTOUR INTERVAL 40 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 200

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, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

Geologic map of the Las Tablas quadrangle, Rio Arriba County, New Mexico.

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

http://geoinfo.nmt.edu

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

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.

Map Unit Descriptions

Quaternary

Qal	**Quaternary Alluvium—**Stream channel and valley-floor alluvium, active floodplains, low stream terraces, tributary mouth 'fans', and 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, massive and/or lensoidal; silty sand-to-sandy gravel with rare cobbles/boulders and/or gravelley channel deposits. 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 or tributary (in the case of 'tributary-mouth fans'). Estimated thickness of deposits associated with ephemeral channels is 1-5+ m but is possibly thicker. Thickness in alluvial reaches of perennial streams (Rio Tusas and Rio Vallecitos) is unknown.
Qao	**Older alluvium (upper Pleistocene to Holocene)—**Valley-fill alluvium characterized by abundant sandy gravel and gravelly sand. Clasts are angular to subrounded and poorly-to-very poorly sorted. No exposure available for bedding description. Mapped in the upper reaches of Cañada de los Apaches, where the unit forms terraces and small alluvial fans at the mouths of gullies. Distinction between **Qal** and **Qao** was only made in the southern part of the quadrangle (Figure 3). 2-12 m-thick.
Qaoc	**Older alluvium and colluvium (upper Pleistocene to Holocene)—**Valley-fill alluvium characterized by abundant cobbles and fine boulders, in addition to pebbles. Generally preserved adjacent to steep slopes, so colluvium is very likely present in the unit adjacent to the steep slopes. Found in tributary canyons east of the Rio Vallecitos. Clasts include subrounded Ortega quartzite, basalt, and gray to brownish red rhyolite; minor mylonitized quartzite. Gravel are angular to subrounded and very poorly sorted. Distinction between **Qc**, **Qal** and was only made in the southern part of the quadrangle Estimated 2-10 m-thick.
Qc	**Quaternary Colluvium—**Colluvium is common throughout the quadrangle but is only mapped where it completely obscures relations among older units. Poorly-exposed, light brown, loose-to-friable, poorly-sorted, sub-rounded-to-angular, massive and chaotic gravelly sand and sandy gravel. Composition is determined by units underlying individual colluvial bodies. Much talus and small toreva blocks are included in this unit on the western slopes of the Petaca mesa and Red Mesa. Estimated to be 1-30(?) m thick.
Qfg	**Quaternary fine gravel—**This unit is found in only one exposure at the southeastern corner of the quadrangle. It consists of well exposed, very pale brown (10YR 7/3), friable, moderately well sorted, subrounded/rounded, medium-to-thick bedded sand, sandy gravel and gravelly sand. Clasts are a mixture of Tertiary volcanics (mostly from the Cordito member?) and various Proterozoic rock types. This exposure is easily visible from south of Petaca and could be mistaken for Tertiary units from afar. Possibly up to 60+(?)m thick.
Qgf	**Quaternary gravel fan—**Unexposed, loose, coarse gravel of Proterozoic rock types found only in section 32 T27N:R8E. It is distinguished from the alluvium overlying much of Ttoc to the south by its coarsness. We interpret this gravel as a partially dissected alluvial fan derived from the relatively large drainages to the east and north. Estimated 1-7 m thick
Qse	**Quaternary slopewash and eolian material—**Brown clay, silt, and sand. Interpreted as eolian material that was reworked by sheetflooding.
Ql	**Landslide deposits (Late Pleistocene(?))—**Lobate deposits of sandy and coarse material that moved down steep slopes en-mass by gravity. Typically, disrupted basalt flows are incorporated into the mass-wasted deposit. Gravel are typically a mixture of basalt, Proterozoic clasts, and rhyolite (similar to unit **Tlpc**), but basalt generally dominates. Clast size ranges from pebbles to boulders, with cobbles and boulders being abundant. Local, shallow surface depressions may be present. Estimated 20 m thick.
Qg	**Undifferentiated Quaternary gravel deposits—**Poorly exposed; variably colored; loose; moderately sorted; subangular-to-well rounded; sandy cobble-to-boulder conglomerate and pebbly sand. This unit consists mostly of terrace gravel of the Rio Tusas but also includes relatively large, coarse tributary mouth fans and upland gravels in a few locations and one coarse 'terrace' deposit along Spring Creek. Clast composition dominated by Proterozoic rock types with subordinate Tertiary volcanic clasts locally. Estimated 1-7 m thick.
QTg	**High level, Quaternary and late Pliocene(??) gravel—**Unexposed; loose (except where cemented with soil carbonate, presumably); moderately-to-poorly sorted; subangular-to-rounded; complexly bedded(?); silty-to-sandy(?) conglomerate. In the northwest quarter of the Quadrangle this gravel contains mostly 'Kiowa-mountain type' quartzite (>99% overall) and some vein quartz, rare schist and possibly some Tertiary volcanic clasts, although the later may be only on the surface of the deposit from recent hillslope processes. The relatively small patch of **QTg** in the southern half of the Quadrangle (in center of sections 21 and 28 T27N:R8E) is composed of a mixture of Cordito-type Tertiary volcanic clasts and 'local' Proterozoic clast types. These relations are interpreted as the result of erosion of quartzite from Kiowa Mountain and deposition of this material on a 'geomorphic surface' prior to regional landscape incision. The mixed-clast gravel to the south is interpreted to reflect southward paleoflow and incorporation of Cordito Member clasts and non-quartzite Proterozoic clasts where **QTg** overlies these older units. If this interpretation is sound, then Kiowa Mountain was, prior to regional incision, a Proterozoic highland projecting above a surface of relatively low-relief.

Pliocene Volcanic Rocks

Tbd	**Dorado basalt (Pliocene)—**Well exposed; 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 Butler (1946). 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. On the Servilleta Plaza Quadrangle these rocks yielded ages of 4.68 +/- 0.10 (base of flows) and 4.13 +/-0.24 Ma (top).

Tertiary Sedimentary and Volcanic Rocks

Ttoc	**Tesuque Formation, unit gradational between the Ojo Caliente Sandstone Member and Chama-El Rito Member (upper middle Miocene)—**Poorly exposed, commonly light reddish, friable; moderately well sorted, subangular-to-subrounded, massive sandstone and pebbly sandstone. Typically covered by colluvium and talus derived from the steep slopes east of Rio Vallecitos. Sand is pink-to-reddish yellow (7.5YR 7/4-6), fine-grained to medium-grained, well-sorted, subangular to subrounded, and consists of quartz and very minor plagioclase, 10-20% orange-stained quartz and potassium feldspar, 3-4% mafics, 0.5-1% felsic-intermediate volcanic grains, and 1-3% red chert or silicified felsic volcanic grains. Contains a trace of scattered, very fine-to-medium pebbles of angular-to-subrounded volcanic clasts (dacite, rhyodacite(?) and rhyolite) and subrounded Proterozoic metarhyolite. These clasts are similar to types found under Mesa de la Jarita. On the La Madera Quadrangle this unit has an inferred age range of ~11-13.5 Ma (Koning et al. 2009). At least 150 m thick.
Tbc	**Cisneros basalt (Miocene)—**Well-exposed, greyish black, strong, aphanitic, vescicular basalt. Rock ranges from dense to vuggy. Vugs are sometimes filled with zeolites(?) and/or calcite. In some hand samples, plagioclase phenocrysts <1mm long form small 'clumps'. Some altered olivine(?) visible in some samples. An age of 22.72 +/- 0.53 for basalt on Jarita Mesa (Table 1), if correct, would make these flows contemporaneous and would indicate that Cordito Member (**Tlc**) deposition was restricted to the northeastern side of the Proterozoic 'core' of the Tusas mountains between ~25 Ma (Amalia Tuff Time) and ~23 Ma. Approximately 15 m thick.
Ttp	**'Plaza member' of the Tesuque Formation (lowest Miocene)—**Poorly exposed; reddish, dark gray, and/or purplish gray; loose-to firm; poorly sorted; subangular-to-subrounded (mostly) and rarely rounded; thin-to-thick(?) bedded; variably carbonate cemented pebbly sand and silty-to-sandy pebble-to-cobble conglomerate. Gravel consists of pebbles, cobbles, and sparse boulders of rhyodacite and dacite. Near the Rio Tusas, minor felsic gravel may be present (generally gray rhyolite). In general, no clasts of rhyolite similar to unit Tlr are observed. Clasts exhibit a phenocryst mineralogy containing: 10-25% alkalic feldspars (0.5-10 mm), trace to 5% quartz (0.5-5.0 mm), 1-10% biotite, and 0-10% hornblende (0.5-4.0 mm). A few clasts composed of schist, metarhyolite, and vein quartz are present in this unit adjacent to Proterozoic bedrock highs. Maximum boulder size of 40 cm (b axis). At a location 600 m south of Petaca, a 2 m-thick interbed of pink (7.5YR 7.4), very fine- to fine-grained sand was observed. This sand is well-sorted, subrounded-to-subangular, and consists of quartz, 15-18% orange-stained quartz and possible potassium feldspar, and 10% mafic grains. Unit is unconsolidated. Thickness 1-18 m.
Tr	**Rhyolite flows (uppermost Oligocene(?) to lower Miocene)—**A flow complex consisting of moderately-to-well exposed red-to-light purple and/or reddish gray-to-gray volcanic flows and flow breccias. By the classification of Le Bas et al. (1986), these rocks are rhyolite (Figure 2). Phenocrysts include hornblende, biotite, sanidine, and quartz. Clasts within flow breccias are subangular and generally 0.1 to 20 cm in size. Local flow banding is 1-4 cm-thick. Flow complex also includes bodies of white rhyolite (unit **Tr**) too small to be mapped at 1:12,000 scale (i.e., less than 10 m-across). Larger bodies of rhyolite within this flow complex were mapped separately and are described in detail below. Flows are extensive and overlie the Cordito Member southwest of Cañada de los Apaches. Only one exposure of this flow, less than 1 km2, is present on the northeast side of this canyon. Near Petaca, this unit typically consists of red-to-light purple, finely brecciated rhyolite. Phenocrysts are composed of 5-30% sanidine and other alkalic feldspars, 0.5-10% hornblende and biotite, and 0 to 7% quartz (mostly </=1%). The sanidine and alkalic feldspars are typically the largest phenocrysts (0.5-10 mm, up to 10-30 mm), whereas quartz is 0.5-7 mm (mostly 0.5-2.0 mm), hornblende ranges from 0.2-9 mm (mostly <5 mm), and biotite is 0.2- 4 mm-long. The reddish volcanic flows seem to have undergone more extensive and finer brecciation than the grayer volcanic flows. These reddish flows comprise virtually all of the unit near the Rio Tusas, whereas both gray and red types are found on Mesa de la Jarita. In the gray dacite on Mesa de la Jarita, locally there are meter-scale blocks that contain megacrysts of sanidine (up to 3 cm long). A sample on this quadrangle (Table 1) returned an age of 23.08 +/- 0.09 Ma. Two samples from the La Madera Quadrangle gave ages of 22.47 +/-0.08 and 22.88 +/-0.07 Ma.
Tlr	**LeucoRhyolite (uppermost Oligocene to lower Miocene)—**Light gray-to-tannish white-to-chalky white rhyolite that also occurs as meter-scale 'pods' in the flow complex mapped as **Trd** (see above). Outcrop weathers to a white color. These pods were mapped where larger than about 10 m across in order to assess the spatial distribution of the leucorhyolite within the **Tr** flow complex. The light-gray and tannish-white rhyolite are fresh, whereas chalky white rhyolite appears to be related to gas-phase alteration. Generally, the chalky white rhyolite appears near the outer margin of a 'pod'. Contains 12-20% smoky quartz phenocrysts (0.5-2.0 mm-long), 0.5-8% chatoyant (iridescent blue) sanidine (0.5-1.0 mm-long), and a trace biotite. Rock contains a trace to 0.5% (locally as much as 8%) xenoliths of a rhyolite(?) (up to 13 mm-long) and rhyolite of unit Tr (1-28 mm-long). On the La Madera Quadrangle this rock returned ages of 25.05 +/-0.06 Ma and 24.93 +/-0.25 Ma. These ages are roughly the same as the age of the Amalia Tuff (Smith et al., 2002), but as **Tlr** was heated (to 'ductile' temperatures) during incorporation into **Tr** these ages may not reflect original cooling.
Tdvl	**Lower, dacitic volcaniclastic unit (uppermost Oligocene?)—**Poorly exposed, light-colored, friable-to-firm, poorly-to-moderately sorted, subangular-to-subrounded, planar laminated, very thin-to-medium tabular bedded, and locally cross stratified. Moderately-to-strongly carbonate(?) cemented sandy conglomerate and gravelly sandstone. This unit underlies and intercalates with **Tr** rhyolite flows within 2 km of Petaca. This sediment grades laterally westward into the Cordito Member. West-northwest of Petaca, the gravel assemblage of this sediment generally consists of light-colored (light-pink to creamy-tan to gray to white), commonly altered pebbles of dacite that generally differs from the darker tones of the 'Plaza member' dacite described above. Southwest of Petaca, clasts are similar to those observed in the 'Plaza member', and this unit is distinguished from Ttp by its stratigraphic position under the rhyodacite flows of units **Tr/Tlr**. The gravel consists predominately of dacite (containing hornblende +/- biotite), with subordinate felsite clasts. Locally, the gravel contains 4-5% of a black vitrophere(?). Gravel is comprised of very fine-to-very coarse pebbles (local, sparse fine-to-coarse cobbles) that are poorly-to-moderately sorted; dacitic clasts are subrounded to angular, and felsite clasts are subrounded. The sand fraction consists of fine-to-very coarse-grained sand composed of quartz, potassium feldspar, plagioclase, and minor biotite and hornblende. Grains are subrounded to angular (mostly subangular) and poorly-to-moderately sorted. Sand may be tuffaceous (1-20% tuff in the matrix). Moderately to strongly cemented. 15-25 m thick. The age of this unit ranges from 23-25 Ma, based on the interpreted ages of interfingering units (i.e., Tlc and Tr/Tlr).
Tlc	**Cordito Member, Los Pinos Formation (uppermost Oligocene-late miocene)—**The Cordito Member was named by Butler (1946). Poorly-to-moderately well exposed, pinkish, reddish, or purplish, loose-to-moderately strong, moderately-to-poorlysorted, subrounded-to-subangular, thin-to-thick tabular-to-lensoidally bedded, weakly-to-strongly cemented, sandy conglomerate and gravelly sandstone dominated by felsic gravel clasts with subordinate intermediate composition clasts (Manley, 1981). Where exposed, matrix is usually light-colored. This unit overlies the Jarita Basalt and older slopewash and eolian deposits (**Tseo**) and generally underlies the rhyolite flows (**Tr**) where the later are present. It also has laterally gradational contacts with **Ttp**, **Tri**, and **Tdvl**. Unit interfingers with the Ritito Conglomerate (unit **Tri**) in upper Cañada de los Apaches. Where exposed in upper Cañada de los Apaches, there are vague, thin-to-medium, tabular beds. Gravel are clast or matrix supported. Clasts are mostly subrounded (minor rounded to angular to subangular), moderately-to-poorly sorted, and range from pebbles to boulders (mostly pebbles and cobbles). Boulders up to 3 m are found in the northern quadrangle with largest clasts in any one area usually being dacite. Clasts are dominated by a blue-to-gray-to reddish brown, commonly flow-banded rhyolite; there is also subordinate reddish crystalline rhyolite (with quartz and sanidine), minor reddish brown rhyolite, and minor (1-10%) welded ash-flow tuff. The latter includes Amalia Tuff (1-2% of gravel fraction). Trace to 10% of gravel is hornblende-bearing, gray to pink dacite. Trace to 1% Proterozoic clasts, including quartzite. Adjacent to Proterozoic topographic highs, gravel includes 10-50% Proterozoic metamorphic clasts. Sand is very pale brown (10YR 8/2) to light brownish-gray (10YR 6/2) to pinkish-white (5YR 8/2), fine-to very coarse-grained, moderately-to-poorly sorted, subangular-to-subrounded, and composed of quartz, plagioclase, sanidine(?) and variable amounts of felsic volcanic grains. Locally present are meter-scale intervals of slightly silty (5-8%), very fine- to very coarse-grained sand. Locally, minor laminae of pinkish white-to-very pale brown (7.5-10YR 8/2) siltstone and very fine-grained sandstone are interbedded within coarser strata. These fine beds are most common near the base of the section in the north (see also **Tseo** description). Minor tuff in the matrix. Locally indurated by silica, where it forms prominent ledges, thickness is 0.5-5 m.
Tat	**Amalia Tuff (late Oligocene)—**The Amalia tuff on this quadrangle is a moderately well exposed, slightly friable-to-moderately strong, very light tan to dirty buff, grey, or whitish, weakly-to moderatley welded ash-flow tuff. In some spots the tuff is strongly cemented with silica. Contains distinctive smokey quartz and sanidine crystals. The sanidine here are often not chatoyant (iridescent blue) as is usually the case in the better welded part of the tuff. ~25Ma (Smith et al., 2002). Approximately 10-15 m thick.
Tseo	**Older slopewash and eolian deposits (upper Oligocene)—**Very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4); friable; moderately-to-well sorted; subrounded; massive or medium-to-thin bedded; clayey-silty very fine-to fine-grained sand. Based on low slopes above the basalt there, it is inferred that locally this unit may also overlie the Jarita basalt on the poorly exposed, western rim of Mesa de la Jarita. Sediment is internally massive and well-sorted. The unit contains some Proterozoic clasts there. This unit is interpreted as eolian sediment subjected to reworking (and some local addition of clasts) by slopewash and/or fluvial processes. A possibly suspect date on the Jarita basalt on Mesa Jarita of 22.72 Ma (see **Tbj** description and Table 1) indicates that unit **Tseo** was being deposited at that time as the unit seems to both overlie and underlie that basalt. A basalt dated at 24.92 +/- 0.34 Ma south of Petaca on the La Madera quadrangle seems to be equivalent to the basalts underlying **Tseo** north of Petaca, giving a maximum age of ~25 Ma. 2-15(?) m thick.
Tjb	**'Jarita' basalt (upper Oligocene)—**All basalt interbedded with pre-Pliocene Tertiary sediment (except the Cisneros basalt) is mapped as 'Jarita' basalt. A recent date of 22.72+/-.53 (22.19-23.25 Ma) (from the Jarita Mesa just south of the southern Quad boundary) is mostly younger than a dated, overlying unit (**Tr** 23.08 +/- 0.09 or 22.09-23.17Ma). However, if the older part of the basalt age range is correct then these two units (**Tbj** and **Tr**) may have been deposited in rapid succession with a pulse of **Tlc** depositon between them. The 'Jarita' basalt mapped in Canada del Agua is below the Amalia Tuff which is well dated at ~25 Ma (Smith, et al., 2002). Therefore, if the above date on the Mesa Jarita sample is correct then the 'Jarita' basalt as used by us (and Butler, 1946) spans an age range of at least 2 million years. Using a recent geochemical analysis (Figure 2, Table 2) and the classification scheme of Le Bas et al., (1986) the Basalt on Mesa Jarita is classified as a 'basaltic andesite'. The Jarita basalt as thus defined consists of multiple stacked basalt flows on the Mesa de la Jarita, and thinner sections possibly representing individual flows on the eastern half of the quadrangle. No interbedded, epiclastic sediment deposits have been observed. Basalt overlies slopewash and eolian deposits (unit Tseo), fluvial/colluvial gravel (**Tri**), tuff (**Tlt**), and Proterozoic basement; and underlies the Cordito Member (**Tlc**), slopewash and eolian deposits (unit **Tseo**), and fluvial/colluvial gravel (**Tri**). Basalt that outcrops on Mesa de la Jarita, differs somewhat from basalt mapped near Petaca. The basalt on Mesa de la Jarita is characteristically gray to dark gray, in tabular, 1-8 m-thick flows, vesicular, contains abundant plagioclase laths 0.05-0.1 mm-long, locally displays vesicle pipes, and is non-to-weakly altered. Calcite may locally fill vugs. On the west rim of Mesa de la Jarita, the top of the basalt exhibits up to 6 m of relief, largely due to inferred laterally discontinuous lava flows. The basalt near Petaca commonly exhibits greenish-gray to maroon colors that likely are due to minor hydrothermal alteration; hydrothermal activity of basalt near Petaca is also supported by ubiquitous vug-fills of calcium carbonate, possible zeolite, and trace amounts of small geodes containing calcium carbonate precipitates. The basalt near Petaca is light gray to dark gray (2.5Y 6/1; 7.5YR 4-5/1; fresh-color) and largely aphanitic, but has a trace of green pyroxene(?) and other mafics; vesicles are 0.5-7.0 mm-wide. The top of this basalt near Petaca seems to have ~2 m of relief. Just south of Petaca, on the La Madera quadrangle, this basalt yielded an age of 24.92 +/- 0.34 Ma (Koning et al., 2009).
Tle	**Esquivel Member of Los Pinos Formation (upper(?) and middle(?) Oligocene—**Very poorly exposed, grayish/brownish(?), loose-to-moderately friable, subrounded-to-subangular, medium-to-thick tabular bedded, moderately cemented pebbly-to-cobbly sandstone and tuffaceous sandstone. Clast types are dominated by grayish, blackish, reddish or brownish dacite. The sole, natural exposure so far found is approximately 0.5 km NW of Sawmill spring on the north side of the 'west fork' of Sawmill canyon. One very shallow channel (?) in this natural exposure appears to trend ~210 degrees, indicating southwestern paleoflow. In general this unit is identified by a sudden increase in the proportion of dacite clasts in float below the felsic-clast-rich float of the Cordito Member. A zone of 'mixed' Esquivel/Cordito float is almost always found near the contact. There are excellent exposures of the Esquivel (and Cordito) found in roadcuts along highway 64 west of Tres Piedras. The Esquivel there always contains distinctive, plagioclase-rich 'dacite' clasts which we have used to distinguish the Esquivel from unit **Tlt** on the Las Tablas Quadrangle. These 'dacite' clasts contain 15-50 % snow-white-to glassy-white (sometimes greenish or pinkish) plagioclase phenocrysts that range in size from <1mm-1.5 cm and usually have 3-10% mafics (Biotite +/- amphibole). These clasts are distinct from dacites found in the Las Tablas Tuff, which are finer-grained and usually less porphyritic (even when dacites in **Tlt** and **Td** have as much Plagioclase the phenocrysts are much 'duller'). The Esquivel is fluvially bedded in all exposures we have seen. The Esquivel Member, as mapped, is laterally equivalent to the Las Tablas Tuff, but the upper part may have overlain **Tlt** locally(?). The older parts of **Tle** are therefore likely ~ 28.3 Ma (see **Tlt** description) and the youngest part, underlying **Tlc/Tla** is >~25Ma
Tlt	**Las Tablas Tuff (Oligocene)—**White to light-gray, poorly-welded tuff with 25-35% phenocrysts of plagioclase, sanidine, and minor amounts of biotite and pyroxene (?). Pumices are typically less than 1 cm in length and relatively nonvesicular. Locally, reworked deposits of the tuff exhibit planar and trough cross-bedding. Roadcuts on the road up the Rio Tusas at Las Tablas exhibit contorted 'bedding' that seems to indicate soft-sediment deformation. Massive landslide and debris-flow deposits are incorporated into the tuff, including angular volcanic breccias and sedimentary conglomerates. Many of these “megabreccia” lenses were previously mapped as deposits of Conejos Formation, El Rito (our Ritito) Formation, and Esquibel Member (Manley and Wobus, 1982) or as the Biscara member of the Los Pinos Formation (Barker, 1958). Typically, these sedimentary and volcanic lenses are choatically enveloped in a tuff matrix, which can include abundant rounded sedimentary cobbles, boulders, and xenocrysts of volcanic sand. A wide range of volcanic lithologies, ranging from basalt to rhyolite, are included in the megabreccia lenses. The most characteristic clast type is a ligh-colored, brownish-to-tan or reddish intermediate composition rock ('dacite' and/or andesite) with ~8-20%, 0.3-5 mm long phenocrysts of amphibole +/- biotite. In some spots sparse rhyolite similar to that of unit Trb is found within the Tuff. Locally, Proterozoic boulders, ranging from 1 to 5 meters across, and angular blocks of consolidated Ritito conglomerate also occur within the tuff. A preliminary age of ~28.3 Ma has been obtained from this unit (Bill Macintosh, personal communication, 2010) is equivalent to the age of both unit **Td** (Table 1), the Fish Canyon Tuff of Colorado, and older parts of the Latir Volcanic field. Approximately 200 m thick.
Trb	**Tertiary Rhyolite breccia—**Light gray, fine-grained rhyolite breccia. Rhyolite clasts are aphyric and angular, ranging in size from 1 to 5 cm across. The matrix and clasts appear to be of the same composition, and the breccia is matrix supported. The unit overlies the Ritito conglomerate and predates at least parts of the Las tablas tuff as clasts of this rhyolite(?) are found within some parts of the tuff. This unit was found in only one location (near the south boundary of section 17 T27N:R9E) but Butler (1946) noted a 'rhyolite breccia' 70 feet (20m) thick in the 'southeast tributary of Dorado canyon.' (apparently on the Petaca peak Quadrangle(?). He also noted that a similar rhyolite breccia 'underlies basalt east of Servilleta Plaza.'.
Td	**Tertiary Dacite (Oligocene)—**Light-purple, medium-gray, reddish, and blackish; strongly porphyritic dacite (?) intrusions and/or flows with 35-55% phenocyrsts of plagioclase, orthoclase (?), biotite, hornblende, and minor quartz. Crystal size varies from medium-to-coarse grained, exhibiting strong variations in phenocryst size and content. This unit appears to intrude the Las Tablas Tuff along Cañada del Agua. Auto-brecciated horizons are common. Locally, horizontal columnar jointing and finer-grained chill margins occur along the intrusive contact. However, some of Td may reprent lava flows that are contemporaneous or slightly predate(?) emplacement of **Tlt**. Some outcrops of Td apparently (assuming all rocks mapped as **Td** are time-equivalent) project above **Tlt** level and were buried by **Tlc**. One outcrop of this unit yielded an age of 28.28 +/- 0.09 Ma (Table 1).
Tri	**Ritito Conglomerate (lower(?)Oligocene through lower Miocene)–** Sandy conglomerate adjacent to Proterozoic bedrock highs; minor pebbly sandstone. Very thin-to-thick, tabular to lenticular bedding; locally cross-stratified (laminated to very thin- to medium-bedded foresets). Sediment consists of pebbles and cobbles, with minor boulders, in a sand matrix. Maximum clast sizes in unit beneath Jarita basalt on steep, western slopes of Mesa de la Jarita: 25-37 cm x 20-35 cm (a and b axes). Gravel are clast-to-matrix supported and locally imbricated. Gravel composition is dominated by variable amounts of Proterozoic detritus: porphyritic metarhyolite, schist, schistose metarhyolite, amphibolite, granite and vein quartz, with clast composition varying according to source area. Gravel derived from local sources. No to trace quartzite observed within 3 km of southern quadrangle border, except where the unit overlies Jarita basalt flows. Clasts are poorly-sorted-to-very-poorly sorted and angular-to-subrounded (mostly subangular). Sand is gray (7.5YR 6/1) to light yellowish brown (2.5Y 6/3) to pinkish white (7.5YR 8/2) to very pale-brown (10YR 8/2) to pink (7.5YR 7/4) to reddish-yellow (7.5YR 7/6), fine-to-very-coarse-grained (mostly coarse-to-very coarse-grained), angular-to-subrounded, poorly-to-moderately sorted, and consists of quartz, feldspar, Proterozoic-derived lithics, and up to 10% muscovite. Friable-to strong. Cementation is variable (none to strong). Unit is strongly cemented in all exposures in the northeastern half of the Quadrangle. Around Mesa de la Jarita, the deposit is generally non-cemented, but locally there are some beds a 1-2 m-thick intervals that are strongly cemented. Minimum age of about 23 Ma constrained by interpreted ages of interfingering/overlying units (**Ttp**,**Tr**). Older parts of unit are at least 28.3 Ma based on age of unit **Td**, but maximum age is not well constrained. Up to 80+ m thick.

PROTEROZOIC IGNEOUS AND METAMORPHIC ROCKS

MESOPROTEROZOIC ROCKS

Yqv	**Quartz veins—**Light gray to white and composed of bull quartz. Lacks large crystals and relatively massive in appearance. Veins are up to 6 m in width. Mapped as lines labeled "qv."
Ya	**Aplite—**fine grained pink to white sugary textured aplite
Yp	**Pegmatite—**Potassium feldspar + quartz + plagioclase+muscovite+ biotite pegmatite. Large books of muscovite up to 5-cm in diameter. Occurs as dikes, sills, and pods 1-30 m-wide cutting metasedimentary and metavolcanic rocks. Not strongly foliated, but dikes and sills are variably boudinaged and folded. U-Pb zircon dating places age of crystallization at ~1400 in adjacent La Madera Quadrangle Ma (Koning et al., 2007). Locally mined for muscovite. This district has been called the Petaca Pegmatite district and was extensively explored in the early 1900’s (refs).

PALEOPROTEROZOIC ROCKS

Xtpg	**Tres Piedras granite—**Granitic gneiss consisting principally of quartz, feldspar, biotite, and muscovite. Orangish on weathered surface and has a granular texture. Locally contains garnet up to 1 mm diameter in the matrix and up to 5 mm in muscovite-rich lenses. This unit intrudes rocks of the Vadito Group. Contact with neighboring schist units is difficult to discern. Early U-Pb zircon dating placed age of crystallization at 1650 Ma (Maxon, 1976). More recent U-Pb dating of a sample in the Tusas Box in the northern part of the map area places the age at 1700 ± 9, with a related pegmatite dated at 1693 ± 11 (Davis et al.,)

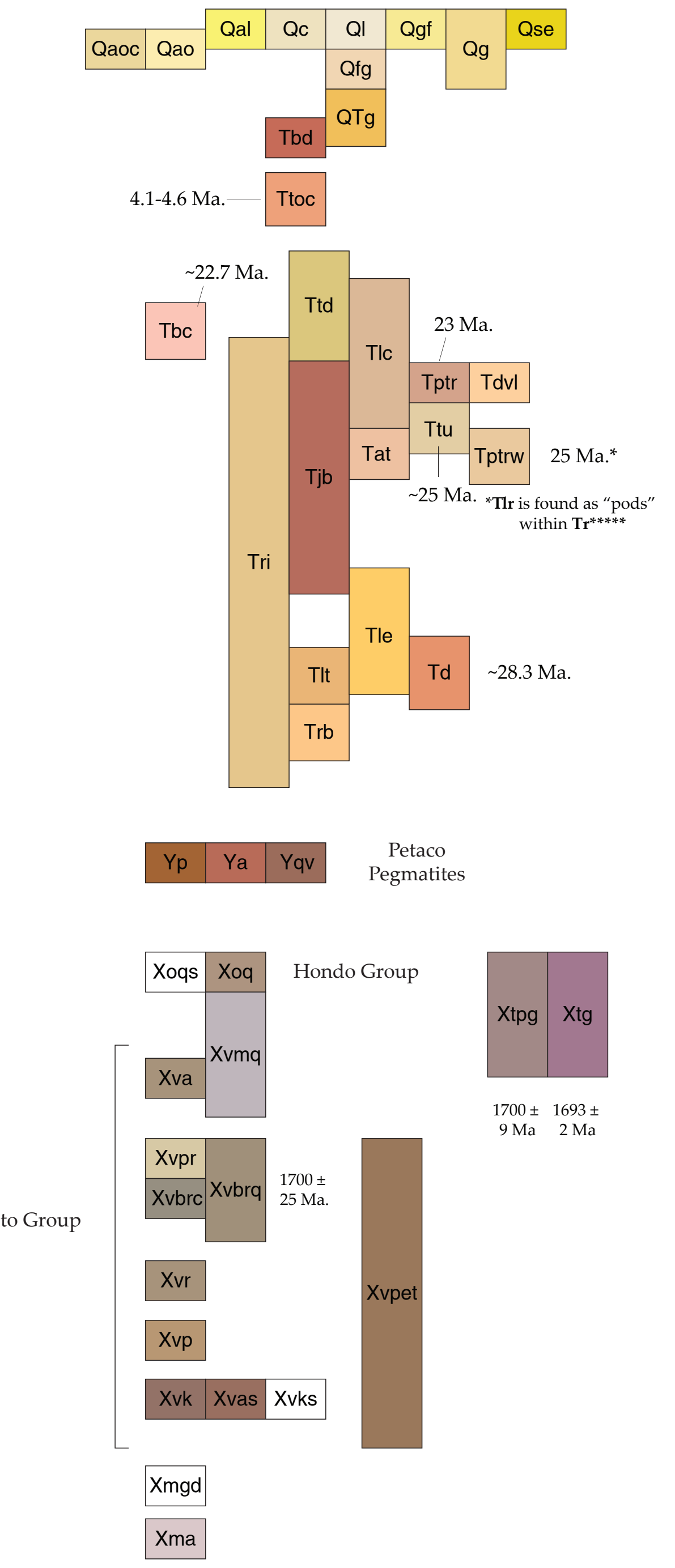
Hondo Group (Includes Ortega Quartzite and associated units)

Xoqs	**Aluminous schist—**Interlayers within Ortega Quartzite, locally contains kyanite, andalusite, and sillimanite. This unit was previously mapped as qka in the La Madera quadrangle (Bingler, 1965)
Xoq	**Ortega Quartzite—**Coarse-grained, gray to white vitreous cross-bedded quartzite consisting mostly of quartz with minor amounts of muscovite, kyanite, and layers of hematite. Viridine-bearing quartzites occur in the lower Ortega Quartzite on Kiowa Mountain and is a regionally continuous marker horizon.

Vadito Group (Includes associated metasedimentary and metavolcanic rocks)

Xvmq	**Vadito micaceous quartzite—**Tan, grayish white to greenish white micaceous and feldspathic quartzite. This unit is schistose, ranges from fine-to-medium grained with mica content varying between 10-30%. Consists of quartz, muscovite, K-spar, biotite, hematite, and epidote. Locally contains trough crossbeds. This unit is correlated to **Xmq** in the Ojo Caliente Quadrangle (Koning and others, 2005) and Xmqu in the La Madera Quadrangle (Koning et al., 2007). It is interpreted to be a meta-arkose to meta-litharenite of dominantly fluvial origin (because of the trough cross bedding and immature composition) that represents a gradational transition from the micaceous quartzites of the Vadito Group (**Xvmq**) to the quartzarenties of the Hondo Group.
Xva	**Vadito Amphibolite—**Foliated to massive amphibolite that occurs as pods, dikes, and continuous layers that are interbedded with micaceous quartzites (**Xvmq**) in the Kiowa Mountain syncline. Consists of hornblende, plagioclase feldspar, as well as chlorite and actinolite; grades into areas rich in tourmaline. Foliation defined by inter-layered amphibole and plagioclase feldspar-rich layers. Primary textures are rare but include amygdaloidal textures. Unit is interpreted to include both metabasaltic flows and hypabyssal intrusive sills and dikes.
Xvpr	**Vadito Posos Metarhyolite (new name)—**Yellowish orange to orangish tan to pinkish gray in color. Weathers to an orange-reddish orange color. Fine grained foliated metarhyolite containing fine-grained quartz, plagioclase, K-feldspar, muscovite, and iron oxides, with rare biotite, epidote, and garnet. Has distinctive embayed quartz and microcline mm-scale phenocrysts and ribbons. Dark and orange patches on foliation surfaces may represent deformed pumice clasts. Ash flow layering locally preserved and mapped as primary layering (bedding symbol). This unit is correlative to the Cerro Colorado metarhyolite and the Arroyo Rancho metarhyolite (Bishop, 1997), as well as to the Burned Mountain metarhyolite (Barker, 1958). The Cerro Colorado metarhyolite has been dated at ~1.70 Ga based on zircons (Lanzirotti personal communication 1996 to Bishop, 1997); Burned Mountain metarhyolite also has a ~ 1.70 Ga age (Silver, unpublished). This unit has been interpreted by several workers to have originally been ash flow tuffs (Just, 1937; Jahns, 1946; Treiman, 1977). The unit is texturally heterogeneous with interlayers of schistose layers. Unit grades into micaceous quartzites (**Xvmq** and **Xvbrq**), schistose metarhyolites (**Xvsr**), and foliated parts of the Tres Piedres granite (**Xtpg**) making unique identification in many areas difficult.
Xvbrc Xvbrq	**Vadito Big Rock Conglomerate and Quartzite—**Stretched and folded pebble metaconglomerate (**Xvbrc**) interbedded with micaceous quartzite and aluminous schists (**Xvbrq**) , conglometate varies from clast-supported to matrix-supported and occurs in lenses within quartzite. Clasts include bluish-grayish quartzite and vein quartz (egg-shaped, up to 10 cm), highly stretched felsic volcanic clasts (up to 15 cm long), and chert (moderately ellipsoidal shapes). Clasts are typically flattened and elongated in the main foliation plane (S1). The matrix of the conglomerate varies from quartzite, to quartz-muscovite schist, to metarhyolite. The quartzites contain trough cross bedding. This unit likely correlates with to the conglomerate exposed near Big Rock and in the Ojo Caliente and La Madera Quadrangles. The gradational relationship and the location of trough cross bedded micaceous quartzites both above and below lead to the interpretation that the conglomerate forms channels in a fluvial deposit. Gradation of quartzites to rhyolite and rare occurance of rhyolite as matrix to pebbles suggests the fluvial channel conglomerate was deposited adjacent to rhyolitic calderas.
Xvr	**Vadito Metarhyolite—**Similar to Posos rhyolite and Petaca schist but stratigraphically underlying the Big Rick conglomerate and quartzite. Fine-grained foliated rhyolite containing quartz, plagioclase, K-feldspar, muscovite, and iron oxides, with rare biotite, epidote, and garnet. Locally has distinctive embayed quartz and microcline mm-scale phenocrysts and ribbons. Dark and orange patches on foliation surfaces may represent deformed pumice clasts. Ash flow layering locally preserved and mapped as primary layering (bedding symbol). The unit is texturally heterogeneous with interlayers of schistose layers. Unit grades into micaceous quartzites and aluminous schists (**Xvbrc**, **Xvbrq**, **Xvps**, **Xvas**, **Xvpet**) making unique identification in many areas difficult.
Xvp	**Vadito Pelitic Schist—**Pelitic schist containing porphyroblasts of staurolite, garnet, chloritoid, and aluminum silicates
Xvk	**Vadito Kyanite Schist—**Lenticular knobs and ridges up to 40 m high of distinctive kyanite-quartz schist in a zone that can be mapped for about 5 km in the Posos anticline area. Kyanite rock contains up to 25 weight percent Al and have been mined for Al (Bingler, 1965); it is low in K, Na, Ca, and Fe. Outcrops contain cm-scale knobby quartz pods with fine grained kyanite and occasional quartz - kyanite with coarse fibrous kyanite; local lenses of staurolite schist. Grades into sericite-rich mica schist (**Xvas**) and schistose metarhyolite. Quartz-kyanite pods and connecting sericite layers are interpreted to be hydrothermally leached rhyolite that later was further altered during shear zone development along the hydrothermally weakened zones (Simmons, 1999).
Xvas	**Vadito Aluminous Schist—**White micaceous schists made up of quartz, plagioclase, and sericite/muscovite. This unit is gradational with kyanite schists and with micaceous quartzite and schistose metarhyolite. The aluminous schist is interpreted to be the product of fluid alteration and leaching of rhyolite both during hydrothermal activity associated with volcanism and during shearing (Simmons, 1999). Individual layers of schist vary in thickness from tens of centimeters to meters wide.
Xks	**Knobby Schist—**Quartz-feldspar-muscovite schist that has a knobby or bumpy microtopography because of very fine to medium, somewhat flattened, megacrysts (former pebbles?) composed of potassium feldspar and quartz. The feldspar and quartz megacrysts are subhedral to anhedral, 1-20 cm long (mostly 1-10 mm), and comprise 35-50% of the rock. Pink to pinkish-gray to light -gray fresh color, and orangish weathered color. We interpret a protolith of muddy-pebbly sand. Interbedded in this unit are metarhyolite flows that contain potassium feldspar phenocrysts.
Xvpet	**Vadito Petaca Schist—**Quartz-feldspar-mucscovite +/- biotite schist. Tan to light tan to very light tannish white to light gray to light grayish white in color, locally slightly greenish tan-white; common yellow to orangish tan weathered color. Grains are generally <0.5 mm in diameter (mostly 0.1-0.3 mm); 1-5% biotite grains. Very localized garnet minerals. Foliation generally planes spaced 0.5-2 mm, and up to 10 mm. Locally, foliation planes are folded. Unit hosts pegmatites and quartz veins in the area around the Petaca pegmatite mines. Unit is heterogeneous and grades into Vadito ryolites **(Xvr)**, into micaceous quartzites (**Xvmq**), schistose metarhyolites of the Petaca Schist (**Xvps**), and foliated parts of the Tres Piedres granite (**Xtpg**), making unique identification in many areas difficult.

Correlation Diagram



*Tlr is found as “pods” within Tr*****