GEOLOGIC MAP OF THE LAS TABLAS 7.5-MINUTE QUADRANGLE, RIO ARRIBA COUNTY, NEW MEXICO

BY

Scott Aby[1], Karl Karlstrom[2], Daniel Koning[3]
Kirt Kempter[4], and Peter Davis[5]

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[1] Muddy Spring Geology, Box 488 Dixon, NM 87527, scottandlluvia@gmail.com
[2] University of New Mexico, Dept. of Earth and Planetary Sciences, Northrop Hall, MS 032040, Albuquerque, NM 87131-1116, kek1@unm.edu
[3] New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, 801 Leroy Place, Socorro, NM, 87801; dkoning@nmt.edu
[4] 2623 Via Caballero del Norte, Santa Fe, NM, 87505: kempter@newmexico.com
[5] Pacific Lutheran University, Department of Geosciences, 1010 122nd Street South, Tacoma WA, 98447, davispb@plu.edu

LIST OF FIGURES AND TABLES

DESCRIPTION OF MAP UNITS

Explanation of descriptive terms.

Soil Color terms after Munsell (1994); all other colors (e.g. rocks, outcrops) are subjective; strength, sorting, angularity, grain/clast 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

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 **Qaoc** 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. Probably up to 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.

To the north of Kiowa Mountain some of this unit has a pseudo 'blockfield' appearance (with very large, relatively angular clasts and some vague, low, lobate or arcuate 'ridges') that could be the result of periglacial processes. This 'periglacial' material is potentially much younger than the rest of this unit.

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 (see below); 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. Except for the uppermost part of the unit, no clast types confidently correlated with the dacite typifying the 'Plaza member' have been found. At the top of the unit along the southern quadrangle boundary, (where it is incorporated in a landslide) are abundant pebbles of dacite typical of the 'Plaza member' along with subordinate metarhyolite and basalt clasts (the latter likely mixed into this unit during mass-wasting processes). Northward along the outcrop area exposures are totally lacking except for road cuts along state route 111. Even these roadcuts are poor quality outcrops but it is possible that some of this area is underlain by 'pure' Ojo Caliente Sandstone as pebbles are lacking and the sand is lighter colored(?) in this area. 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. Barker stated that, in thin section(?) "Laths of calcic Labradorite fom 0.05 to 1mm in length form 55-60 percent of the rock. Olivine, colorless, or stained brown, is present as equant subhedral grains in amounts from 35-40 percent,...". Butler (1946) named these rocks the Cisneros Basalt for exposures in Cisneros Park (north of the Quadrangle in the NW 1/4 of T29N:R8E). Butler (1946) correlated these rocks with those derived from vents around the Buffalo Buttes (northeast of the Quadrangle) based on their stratigraphic position. Barker (1958) stated that the Cisneros "...ovelies the Cordito member of the Los Pinos formation with a slight angular unconformity.". Based on their outcrop pattern we originally interpreted these as Pliocene(?) lava flows that flowed east and west off of Tusas Ridge (as apparently did Butler). However, a sample has returned an age of 22.77+/-0.52 Ma (Table 1; Peters, 2010). If this age is correct then this basalt was probably extruded during deposition of the Cordito member and has since been exposed by erosion. 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 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). Northeast of Cañada de los Apaches, this unit lies in a similar stratigraphic position as the Trd flow complex, but overlies this flow complex to the south. A buttress unconformity of this gravel with the dacite-rhyodacite can be observed about 0.5 km south of Petaca, on the west road-cut of higway 519. We interpret that after emplacement of the dacite-rhyodacite flows, streams deposited 'Plaza member' sediments in the paleo-topographic low north of the flow, and then prograded southward over the flow. 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. 1-18 m-thick.

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). It is possible that the gray rhyolite represents older blocks from the vent wall, but there is generally a smooth gradation between the red and gray types. Perhaps the gradation and preservation of large, gray rhyolite blocks is due to varying degrees of assimilation of the older (?) gray volcanic rock. No sediment or oxidized, laterally extensive rubble zones occur within the flow complex, and it seems to have been emplaced in a single event. Flows contain almost no indication of hydrothermal alteration.

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.

This gravel lacks the felsic clasts typical of the Cordito Member and is therefore mapped separately even though it lies at the same stratigraphic position as the Cordito Member. Based on grain size (lack of cobbles and boulders) we infer that the source of **Tdvl** was relatively distant compared to the younger volcanic edifice that was the source of the 'Plaza member'. 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) for Canon de Tio Gordito (uncle fatty's canyon) south of Tres Piedras on the Petaca Peak Quadrangle. Apparently the name *C*ordito arose from a misunderstanding.

Poorly-to-moderately well exposed; pinkish, reddish, or purplish; loose-to-moderately strong; moderately-to-poorly sorted; 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.** On the western edge of Mesa de la Jarita, this unit very likely includes unit **Tseo** at its base (see also unit **Tseo** description). In that area ledges of basement-derived gravel (subrounded to subangular, Proterozoic metarhyolite, schist, and pegmatite) mixed with minor Tertiary felsic clasts were observed at the base of the mapped Cordito Member. Near Petaca (and near the abandoned Petaca mica mill in the northeastern La Madera quadrangle) the Cordito Member appears to lie at a similar stratigraphic position as the rhyolite flows (**Tr**). On Mesa de la Jarita **Tlc** overlies **Tri**.and is inset into Proterozoic rocks. 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.

General sediment description is as follows. 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 0.5-5 m-thick.

The Cordito Member on the west rim of Mesa de la Jarita contains clasts of the Amalia Tuff, as does all of the Cordito Member near Petaca. Non-welded Amalia Tuff ('Tuff of Cañada del Agua' (Manley, 1981, and Manley and Wobus 1982)) is found at or very near the base of the Cordito Member in Cañada del Agua, north of Las Tablas. Therefore, the Cordito Member on this quadrangle post-dates the Amalia Tuff. Two samples of Amalia Tuff in Cañada del Agua yielded 40Ar/39Ar ages of 25.06 ± 0.07 and 25.1 ± 0.07 Ma (Smith et al., 2002), so 25.1 Ma provides a maximum age for the Cordito Member in the south. The minimum age of the Cordito Member on the quadrangle is equivalent to the age of the rhyolite flows **Tr**, which are approximately 23 Ma. To the west, where the Cordito Member thickens and may contain younger strata than present on this quadrangle, this unit is interbedded with a 20.7 Ma basalt flow (Manley and Mehnert, 1981). These relations give an overall, approximate regional age range of ~25-~21 Ma. The Cordito is clearly derived from the Latir Volcanic Field based on the presence of abundant silicic volcanic detritus including Amalia Tuff. However, no plutonic rocks from the Latir field are found in the Cordito, although they are abundantly exposed in the Latir Field at present (Lipman and Reed, 1989). Additionally, our observations in the Northern part of the quadrangle indicate that the largest clasts in the Cordito are often fine-to-medium grained 'dacite' that may indicate more proximal contributions of this type of material.

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. Unit may overlie Ritito Formation and underlie Jarita basalt west of Mesa de la Jarita but it is not exposed (or mapped) there. 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. Exposure demonstrating this overlying relation is present to the south near the Burma Trick Tank (La Madera Quad) and in roadcuts along state highway 519 between Petaca and Las Tablas (in sections 19, 30, and 32 T 27N:R9E). Sediment is internally massive and well-sorted. Northwest of Petaca, two medium-thick, tabular beds of fluvially reworked pumice-lapilli occur in the upper part of this deposit, with the higher one directly underlying the Cordito Member of the Los Pinos Formation. Just east of Las Tablas some pumice is also found immediately beneath the Cordito Member. The lowest part of the Cordito member there (and in the lower part of Canada del Agua) also has some orangish beds of fine sand that are nearly identical in hand sample to the characteristic sands of the Chama-El Rito member of the Tesuque Formation (Galusha and Blick, 1971). Some of these beds were mapped by Manley and Wobus (1982) as **"Tsf"** (Santa Fe Group). Except for their color these beds are similar to sand of unit **Tseo** but neither has been examined in detail petrographically. These relations suggest that Tseo has an origin similar to the orange sandstone characteristic of the Chama-El Rito member. Along Forest Road 45 (in section 21, T27N:R8E) there is a relatively thick section exposed in a roadcut. 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. This name is taken from the Mesa de la Jarita and was first used by Butler (1946) in his subdivision of the Los Pinos Formation to describe basalt found below the Cordito member. We therefore *informally* group these basalts into the 'Jarita' based on their position immediately below the Cordito member, based on Butler's (1946) original criteria. Butler (1946) removed these basalts from the "Hinesdale Series" of Atwood and Mather (1932). Manley (1981) eliminated the Jarita Basalt member of the Los Pinos Formation and placed "...flows interbedded in the Los Pinos...within the Hinsdale Formation.". The underlying problem is that the numerous, time-transgressive basalts of central and southern Colorado and northern New Mexico represent a complex, and largely uncharacterized suite of rock. Trading 'Jarita' for 'Hinsdale' is trading one garbage can for another. Even on this quadrangle it is not yet clear how many different basalt types or ages are present. We informally use the term Jarita basalt out of habit, convenience, and the fact that the namesake (Jarita Mesa) is on this Quadrangle. We would suggest that the term Jarita (when rigorously defined) may be a useful starting place in deciphering the history of basaltic volcanism and possibly in untangling the nomenclature of these rocks.

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.

As the above discussion demonstrates, the distribution, history of nomenclature, and correlation of Tertiary basalt in southern Colorado and northern New Mexico is complicated and imperfectly understood. Complete small-scale mapping, many more age dates, and chemical correlations are needed. 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'. As this represents only one analysis and any field classification would label this nearly aphanitic rock as basalt we have not made this change in our description.

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 approximatly 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. Indeed, the very poor exposure of this unit is partly the result of the abundant colluvium generated by the Cordito Member. This unit is restricted to the area northeast of the 'central Proterozoic highlands' (e.g. Barker, 1958, Smith 2004), while the Cordito Member overtopped and buried this highland later in the Oligocene/early Miocene. Approximately 40 m exposed on this quadrangle, thicker to the north.
This unit was originally defined by Butler(1946) in his subdivision of the Los Pinos Formation, which had been defined in northernmost New Mexico and Southern Colorado by Atwood and Mather (1932). Unfortunatley, Butler did not map his own subdivisions on the Las Tablas 7.5 minute quadrangle. He distinguished the Esquibel and Cordito Members mainly on the presence of the Jarita Basalt Member between them. Jarita Basalt is not always present. Barker (1958) mapped rocks in this area as the Biscara member of the Los Pinos Formation. Neither Butler or Barker gave explicit, lithology-based criteria for distinguishing the various members of the Los Pinos. Manley (1981) subsequently abandoned the term Biscara member and grouped rocks mapped as such by Barker mostly into her Esquivel member. We conducted brief reconnaissance to examine the 'type areas' of the Esquivel and Biscara member in Esquivel and Biscara Canyons (Butler, 1946) and along Highway 64 west of Tres Piedras (for the Esquivel Member). All these locations are on the adjacent Mule Canyon Quadrangle to the north. There is very little exposure in Esquivel Canyon but excellent exposures of the Esquivel (and Cordito) are 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 Biscara member is not well exposed in Biscara Canyon but it may in part(?) be equivalent to our Las Tablas Tuff. 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

We also conducted brief reconnaissance of the Los Pinos Formation in its type area along the Rio de Los Pinos (in northernmost New Mexico) and along the Conejos River in southern Colorado (see Atwood and Mather, 1932, Larsen and Cross, 1956). Our observations there indicate that the Los Pinos in that area is distinct from that found on the Las Tablas quad. Along the Rio de los Pinos the Los Pinos formation contains a wide variety of silicic-to-mafic clasts but is dominated by 'dacite' that is distinct in hand sample from that of our Esquivel Member. In other locations there the Los Pinos has abundant clasts apparently derived from the underlying mafic-to-intermediate flows of the Conejos Formation (e.g. Atwood and Mather, 1932; Larsen and Cross, 1956).

*Rocks rich in Plagioclase phenocrysts are commonly termed 'dacite' by us despite the common absence of quartz as is required by most field classifications (e.g. Compton, 1985). This is based on inferences made from regional geochemical work showing that these type of rocks are commonly of dacitic composition.

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. We distinguish the Las Tablas Tuff from the laterally equivalent Esquibel Member by the absence of the plagioclase-rich dacite characteristic of the Esquivel, absence of fluvial bedding (except in 'meggabreccia' blocks derived from fluvial sources), presence of primary ignimbrite matrix texture, and (especially in areas of poor exposure) the presence of the mafic-rich dacite mentioned above.

The origin of this unit is a mystery. It has some characteristics typical of intra-caldera megabreccias but it is not as thick and is not welded --as they typically are. It contains large amounts of rounded fluvial gravels which are found both in large, coherent 'blocks' (which are not apparently dramatically tilted relative to regional bedding attitudes) and also in pipes or dikes that seem to have been injected into a primary ignimbrite matrix. The origin of this fluvial material is also not known but it may be derived from some part of the Los Pinos Formation. Large (10's of meters) blocks of cemented Ritito Conglomerate and possibly Tres Piedras Granite are also found within the Tuff. Some combination of mass movement and ignimbrite emplacement is apparently required to account for the unique characteristics of this unit. 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. Much of the unit lies below the Jarita Basalt, but in the south-central quadrangle it is found interfingering with post-Jarita basalt units (i.e., Cordito Member of the Los Pinos Formation and the Plaza lithosome of the Tesuque Formation). In the northern part of the Quadrangle the unit is found in small patches underlying **Tlc** and in more extensive, thicker sections below **Tlt** and **Tle**. Some large, cemented blocks of this unit are found as 'megaclasts' in unit **Tlt**. On the west edge of Mesa de la Jarita, unit is locally slightly inset (~0.3 m) into the Jarita basalt. In the southern part of the quadrangle **Tri** has interfingering contacts with **Ttp** and **Tlc** and in the east-central part it overlies **Tlt** and underlies **Tlc**. 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.

We use the terminology of Barker (1958) for mapping gravel adjacent to and/or derived from Proterozoic paleo-topographic highs. The Ritito Conglomerate was defined by Barker (on The Canon Plaze Quadrangle to the West) for gravel containing Proterozoic-derived detritus consisting of rounded to subangular pebbles to small boulders of quartzite, amphibolite, and metarhyolite. He describes the unit as weakly cemented with a medium-gray color. We include the well-cemented sandy gravel near Petaca and Las Tablas with the Ritito Conglomerate because of its similar lithology (i.e., Proterozoic clasts that include amphibolite and metarhyolite in addition to quartzite) and stratigraphic position (i.e., overlying, mantling, or laterally adjacent to Proterozoic paleo-topograhic highs). The inclusion of this gravel with the Ritito Conglomerate contrasts with usage and interpretations of Manley and Wobus (1982), who mapped this gravel as El Rito Formation. We disagree with Manley and Wobus (1982) on this issue because: 1) the El Rito Formation gravel is composed almost entirely of quartzite, whereas the clast types on this quadrangle include a diversity of Proterozoic rock types, 2) the matrix of the El Rito Formation gravel is generally red, interpreted to be a result of diagenesis in an Eocene paleoclimate (Logsdon, 1981), whereas the unit in question definitely lacks red color, and 3), the clast types present in the cemented and non-cemented portions of the gravel on this quadrangle are similar and the strong cementation locally continues up-section into the interfingering zone of the Proterozoic-derived gravel with the Cordito Member of the Los Pinos Formation. Maldonado and Kelley (2009) have recently expanded the use of the term Ritito to include rocks previously included in the Abiquiu Formation. As presently used, this term simply implies sediment in north-central New Mexico derived from Proterozoic sources that is not demonstrably equivalent to the Eocene El Rito Formation or of Pliocene or younger age.

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 and 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.

STRUCTURAL GEOLOGY

At least three major generations of penetrative Proterozoic deformation have been identified in the Las Tablas quadrangle. These are identified as D_1, D_2, and D_3, with associated folds F_1, F_2, and F_3, and related axial plane foliations S_1, S_2, and S_3. There is an earlier bedding parallel- foliation with local intrafolial folds of compositional layering (S_0) in some rocks which has been called S1 in other quadrangles (e.g. La Madera Quadrangle). This fabric may represent an early thrust episode, but its extent and geometry are not well known and, for simplicity of nomenclature, this generation is not included here as a penetrative deformation.

F_1 folds are macroscopic and mesoscopic tight to isoclinal folds with a well developed axial plane schistosity that forms the dominant fabric in the quadrangle (S1). From north to south macroscopic folds are called: Jawbone Mountain syncline (projected from the north into the cross section), Kiowa Mountain syncline, Posos anticlinourium, Big Rock syncline, MacIntyre Spring anticline (new name), and La Jarita syncline (new name). They have a strong axial plane foliation such that S0 and S1 are commonly subparallel on limbs. S1 –parallel shear zones and thrusts truncate attenuated limbs of F1 folds (similar to Williams, 1989) and initial movement may have been during D1. From north to south, thrusts are: Cleveland Gulch thrust, Spring Creek thrust (Davis et al., 200x0; La Jarita thrust, and Vallecitos thrust (all new names). These structures are interpreted to have formed during the 1.65 Ga Mazatzal orogenic event (Karlstrom and Bowring, 1993).

F_2 folds occur at scales ranging up to macroscopic folds that refold F1 fold axes of the Posos and MacIntyre Springs anticlines and the Kiowa Mountain syncline. But the dominant expression of F2 folds is as mesoscopic folds that refold S1 foliation. This generation is especially clear in the case of refolded stretched pebbles of the Big Rock Conglomerate. In many areas, S2 and S1 are subparallel not identifiable as separate fabrics. F2 folds probably formed in association with top-to-the-northeast directed reverse and dextral shear on the Spring Creek and Cleveland Gulch shear zones. D_2 is constrained to have taken place at about 1.4 Ga based on the presence of ca. 1.43 monazites within syn-S_2 porphyroblasts and the boudinaged and weak deformation of ca. 1.4 Ga pegmatites.

A weak NW- trending crenulation cleavage is locally present, for example in the area of the hinge region of the Posos anticlinorium.

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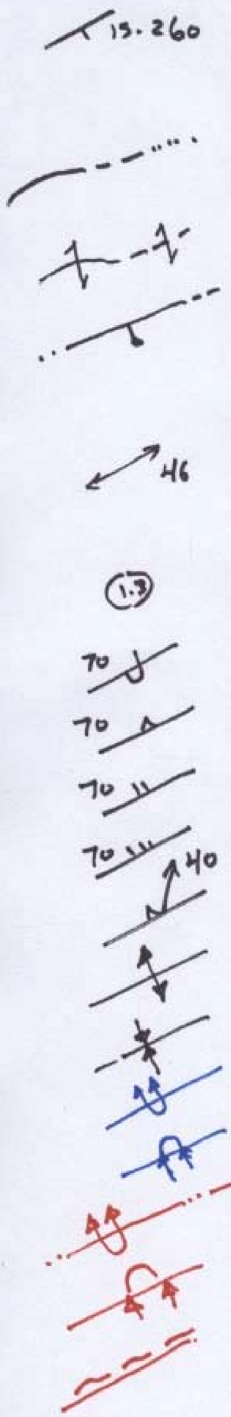
Figure 1.
Explanation of map symbols

Las Tablas Quadrangle Explanation of structural symbols



Strike and dip of bedding (Dip-dip azimuth).

Strike and dip of cross-bedding (Dip-dip azimuth).

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

Laterally Gradational Contact

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

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.

Maximum clast size -visually estimated size in meters of largest boulder. Usually from float.

Overturned Bedding

S' foliation

S'' foliation

S''' Foliation

Plunge of mineral lineation (on S' foliation plane)

Anticline

Syncline

Overturned anticline- F1

Overturned syncline- F1

Overturned anticline- F2

Overturned syncline- F2

shear zone and ductile thrust

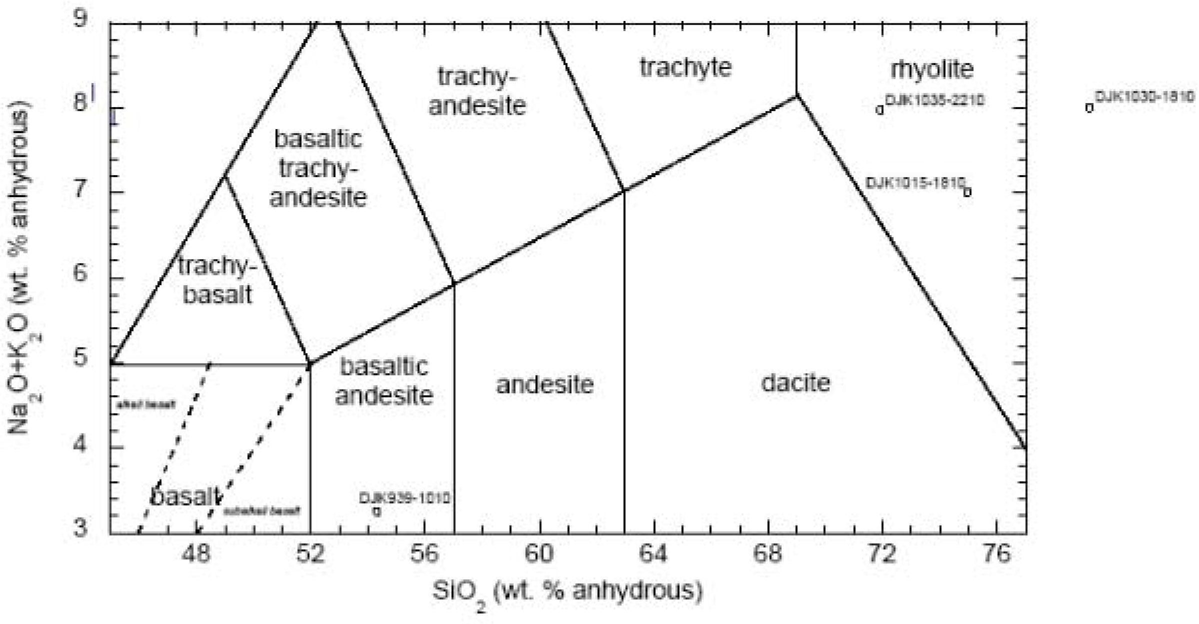


Figure 2. Plot of geochemical Samples on Alkali/Silica plot of Le Bas et al., 1986

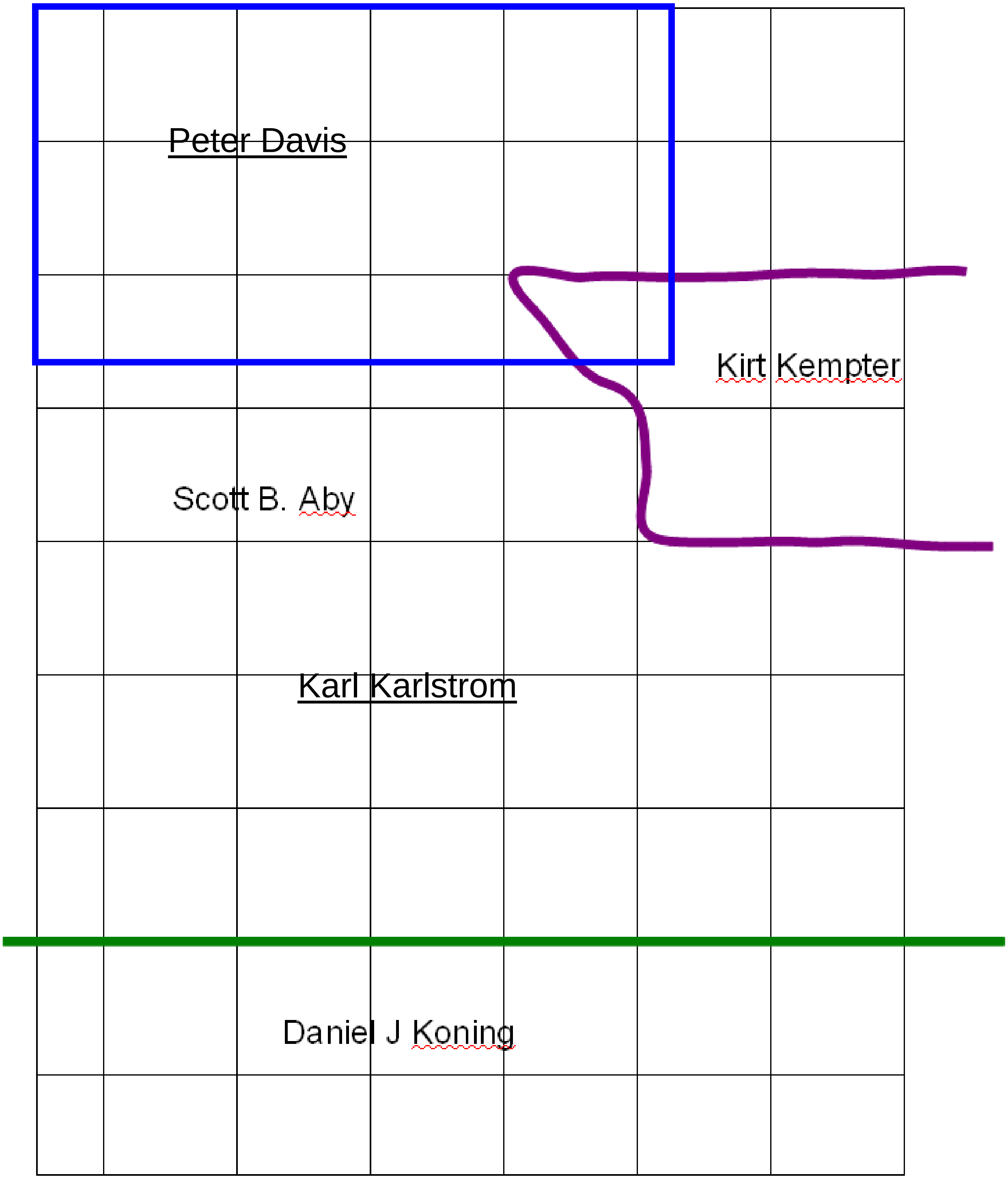
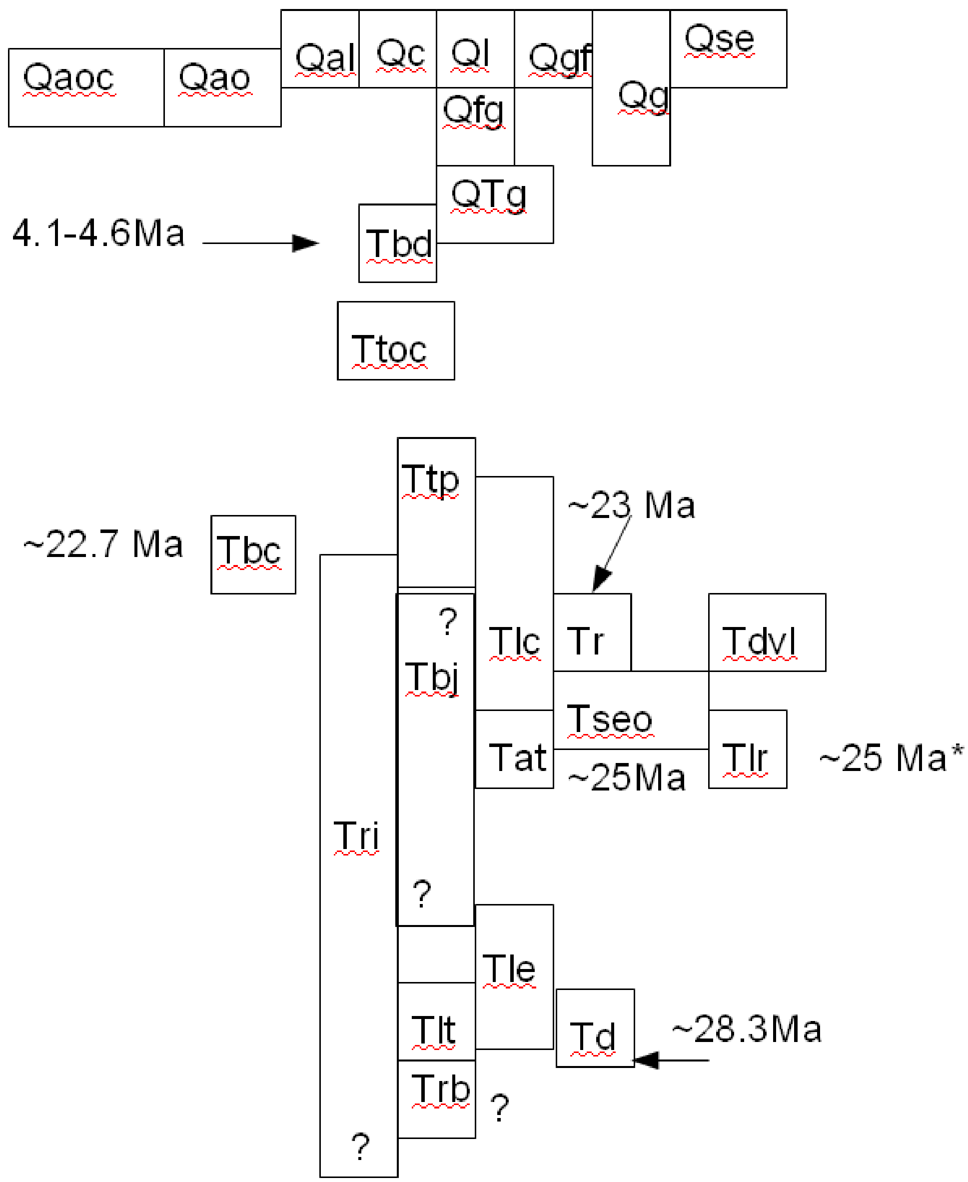


Figure 3. Mapping responsibilities

Tertiary rocks: Scott Aby, Dan Koning, Kirt Kempter

Precambrian rocks: Karl Karlstrom, Peter Davis

Figure 4.
Correlation of Tertiary Units of the Las Tablas Quadrangle



*Tlr is found as 'pods' within Tr

Figure 5.
Correlation of Precambrian units
of the Las Tablas Quadrangle

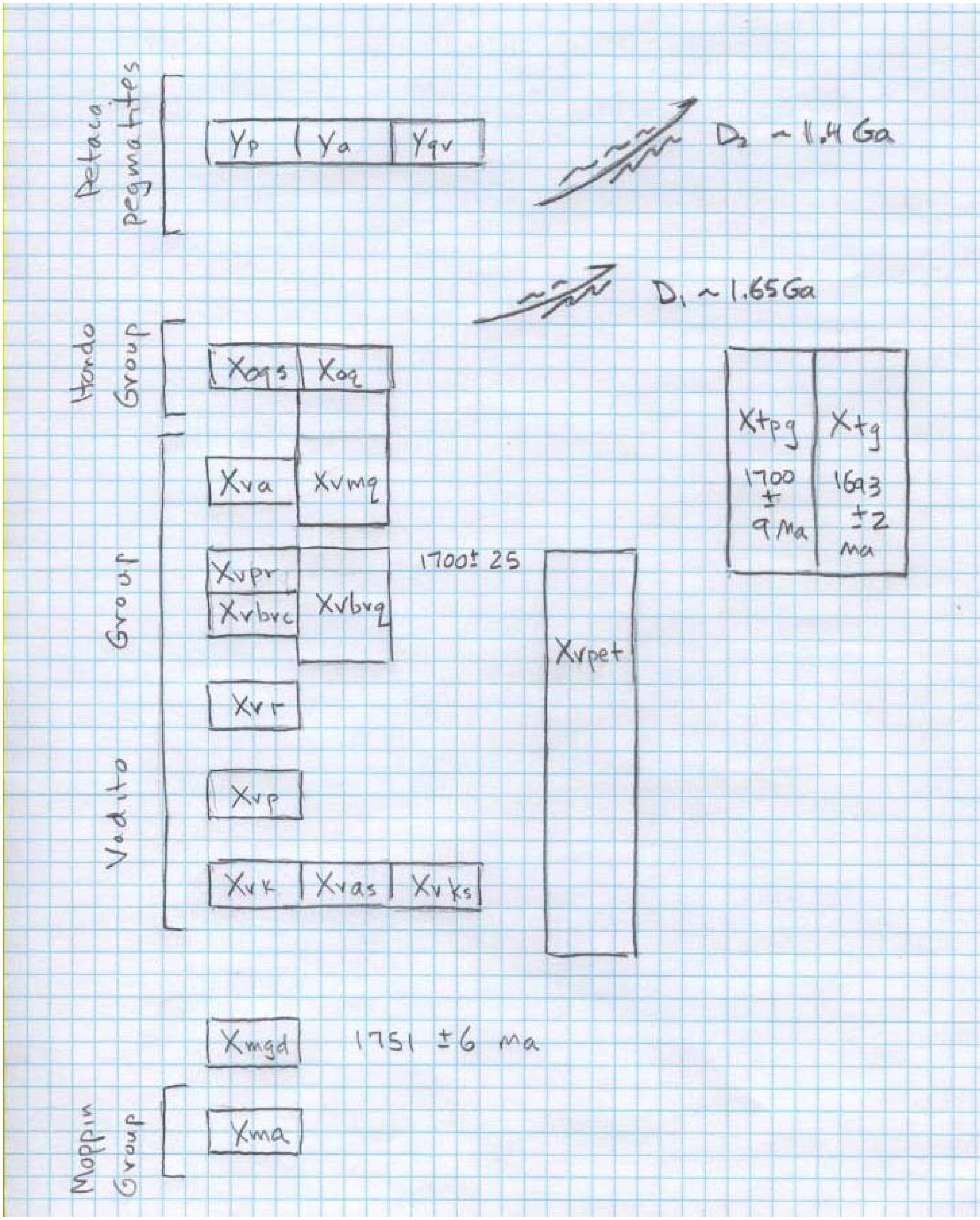


Table 1. Geochronologic samples from Las Tablas and La Madera Quadrangles

Sample #	General location	UTM coordinates (NAD 27; zone 13) Easting	Northing	Date collected	Field description /classification of sample	Material Analysed	Assigned Age (Ma)	Unit
GTM-1188	West edge of Mesa de la Jarita, about 200m south of southern quad boundary	402346	4038636	11/14/2008	basalt	Groundmass concentrate	**22.72 +/-0.53**	**Tbj Jarita Basalt**
L1L	NE corner of Quad	409490	4052900	6/17/2008	basalt	Groundmass concentrate	**22.77+/-0.52**	**Tbc Cisneros Basalt**
L6Q	NE quarter of section 12 T27N:R8E	407222	4049858	7/11/2008	'Dacite' with obvious, clean crystals	Biotite	**28.28+/-0.09**	**Td Tertiary dacite**
GTM-1078	Ne quarter of section 10 T26N:R8E	403281	4040366		Pinkish to light purple Rhyolite	Biotite	**23.08+/-0.09**	**Tr Tertiary rhyolite**

All information from Peters, L. 2010 40Ar/39Ar geochronology results from Las Tablas quadrangle:
New Mexico Geochronology Research Laboratory (NMGRL), Internal Report # NMGRL-IR-675.

Table 2. Geochemical analysis of samples from Las Tablas Quadrangle

	DJK101 5-1810	DJK939 10100	DJK103 0-309C	DJK103 5-2210
Date	6-Mar-10	7-Mar-10	7-Mar-10	7-Mar-10
UTM coord	403394 m E	401605 m E	403661 m E	402945 m E
(NAD27)	4039729 m N	4039989 m N	4040706 m N	4040998 m N
Unnormalized Major Elements (Weight %):				
SiO2	72.57	54.28	75.13	70.65
TiO2	0.369	1.582	0.207	0.422
Al2O3	12.17	14.49	10.23	13.80
FeO*	2.15	10.65	1.22	2.46
MnO	0.042	0.164	0.091	0.038
MgO	0.66	6.37	0.12	0.83
CaO	1.89	8.96	0.21	2.07
Na2O	3.44	2.94	3.29	3.96
K2O	3.35	0.33	4.32	3.82
P2O5	0.123	0.175	0.019	0.139
Sum	96.78	99.93	94.84	98.19
Normalized Major Elements (Weight %):				
SiO2	74.99	54.31	79.22	71.95
TiO2	0.381	1.583	0.218	0.430
Al2O3	12.58	14.50	10.79	14.06
FeO*	2.22	10.66	1.28	2.50
MnO	0.043	0.164	0.096	0.039
MgO	0.68	6.37	0.12	0.84
CaO	1.95	8.97	0.22	2.10
Na2O	3.56	2.94	3.47	4.04
K2O	3.46	0.33	4.56	3.90
P2O5	0.127	0.176	0.020	0.141
Total	100.00	100.00	100.00	100.00
Unnormalized Trace Elements (ppm):				
Ni	9	119	0	11
Cr	13	208	4	16
Sc	5	24	2	5
V	37	168	5	43
Ba	1427	168	94	1064
Rb	85	6	79	97
Sr	394	253	18	425
Zr	128	85	315	136
Y	18	23	62	15
Nb	16.0	8.6	25.6	16.0
Ga	17	19	19	17
Cu	11	46	0	12
Zn	37	109	87	43
Pb	21	1	20	23
La	45	10	34	50
Ce	61	20	86	64
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
sum tr.	2370	1282	913	2085
in %	0.24	0.13	0.09	0.21
sum m+tr	97.01	100.06	94.93	98.40
M+Toxides	97.05	100.10	94.95	98.43

Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.

NiO	11.8	151.0	0.0	13.5
Cr2O3	19.6	303.3	5.3	22.7
Sc2O3	6.9	36.0	3.5	7.4
V2O3	54.0	247.1	7.2	63.7
BaO	1593.0	187.9	104.6	1188.3
Rb2O	93.0	6.7	86.0	106.2
SrO	466.3	299.2	21.5	502.3
ZrO2	172.2	114.5	425.2	184.1
Y2O3	22.2	28.7	79.1	19.2
Nb2O5	22.9	12.3	36.6	22.9
Ga2O3	22.4	25.9	25.0	23.3
CuO	13.8	58.0	0.0	15.3
ZnO	45.8	136.4	108.6	54.4
PbO	22.7	1.2	21.9	25.1
La2O3	52.4	12.0	39.5	58.1
CeO2	74.9	24.3	106.0	78.9
ThO2	12.6	0.7	10.4	14.0
Nd2O3	37.2	14.2	59.5	35.0
U2O3	5.3	2.4	3.1	5.2
Cs2O	0.0	0.0	0.0	0.0
As2O5	0.0	0.0	0.0	0.0
W2O3	0.0	0.0	0.0	0.0
sum tr.	2749	1662	1143	2439
in %	0.27	0.17	0.11	0.24

	Map unit	Rock name*
DJK1015-1810	Tr	Rhyolite
DJK939-1010	Tjb	Basaltic andesite Tjb
DJK1030-1810	Ttr	High silica rhyolite Tt
DJK1035-2210	Tr	Rhyolite Tr

*Based on classification of Le Bas et al. 198

Table 3. Geochronoloigic and thermochronologic data from Las Tablas Quadrangle and vicinity

Sample		Age	Error 2 sigma	UTM-E NAD 83	UTM-N NAD 83	comments	interpretation	Reference
U-Pb zircon and preliminary monazite								
		1755	20			Maquinita Granodiorite	crystallization age	Silver, 1984
73		1751	6	130399614	4054902	Maquinita Granodiorite	crystallization age	Davis, 2002
74		1700	9	130404263	4052337	Tres Piedres Granite	crystallization age	Davis, 2002
		1700	25			Burned Mountain rhyolite	crystallization age	Silver, 1984
26		1693	2	130398366	4056002	Tusas Granite	crystallization age	Davis, 2002
85		1693	11	130404036	4051421	Tres Peidres pegmatite	crystallization age	Davis, 2002
56		1660		130399827	4054181	Mopin metavolc.- monazite age	metamorphic age	Davis, unpublished
79		1490		130403924	4051362	monazite age	age of pegmatite and/or metamorphic age	Davis, unpublished
Ar-Ar hornblende								
PD-176		1614	4	130398781	4055944	farthest N of Spring Creek thrust	Metamorphic age-- cooling through ~ 500 C	Davis, 2002
PD-54		1585	10	130400669	4054232	1 km N of Spring Creek thrust	mixed age-- no geologic significance	Davis, 2003
KT02-7		1484	5	130403996	4051572		cooling through ~ 500 C	Davis, 2004
PD-81		1475	3	130402266	4052260	of Spring Creek thrust	cooling through ~ 500 C	Davis, 2005
PD- 70		1436	5	130401875	4052444	S of Spring Creek thrust	cooling through ~ 500 C	Davis, 2006
KT02-12		1391	3	130402606	4053648		cooling through ~ 500 C	Davis, 2007
KT02-13		1390	3	130401788	4052403		cooling through ~ 500 C	Davis, 2008
KT02-10		1364	3	130402195	4053642		cooling through ~ 500 C	Davis, 2009
KT02-9		1358	3	130402195	4053695		cooling through ~ 500 C	Davis, 2010
PD-62		1324	3	130399041	4054469	1 km N of Spring Creek thrust	cooling through ~ 500 C	Davis, 2011
KT96-8		1314	3	130398945	4054253		cooling through ~ 500 C	Shaw et al., 2005
KT96-5		715	1	130401696	4052313		disturbed spectrum-- no geologic significance	Shaw et al., 2005
	average h=	1430	excluding 715 age					
Ar-Ar micas- m=muscovite; b= biotite								
KT02-11	b	1359	2	130402435	4053673		cooling through ~ 300 C	Davis, 2011
PD-70	b	1344	2	130401875	4052444	S of Spring Creek thrust	cooling through ~ 300 C	Davis, 2012
KT02-16	m	1338	2	130398881	4054012		cooling through ~ 350 C	Davis, 2013
KT02-5	m	1336	2	130404167	4052273		cooling through ~ 350 C	Davis, 2014
KT02-16	b	1329	2	130398881	4054012		cooling through ~ 300 C	Davis, 2015
KT02-15	m	1327	2	130401822	4052452		cooling through ~ 350 C	Davis, 2016
KT96-15	m	1325	7	130402558	4052081		cooling through ~ 350 C	Davis, 2017
KT02-14	m	1321	2	130401747	4052438		cooling through ~ 350 C	Davis, 2018
PD-201	m	1302	2	130403413	4051631	S of Spring Creek thrust	cooling through ~ 350 C	Davis, 2019
KT96-9	b	1294	8	130398996	4055013		cooling through ~ 300 C	Shaw et al., 2005
KT02-8	b	1263	2	130403996	4051572		cooling through ~ 300 C	Shaw et al., 2005
PD-81	b	1230	2	130402266	4052260	S of Spring Creek thrust	cooling through ~ 300 C	Davis, 2011
KT02-15	b	1227	3	130401822	4052452		cooling through ~ 300 C	Davis, 2012
	ave b age=	1292						