





QUADRANGLE LOCATION

Base map from U.S. Geological Survey 1953, from photographs taken 1947, field checked in 1953,

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 guadrangles 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





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> CONTOUR INTERVAL 20 FEET NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources Open-file Geologic Map **141**

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Geologic map of the La Madera quadrangle, Rio Arriba County, New Mexico.

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COMMENTS TO MAP USERS

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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.

1 KILOMETER

DESCRIPTION OF MAP UNITS QUATERNARY EOLIAN AND SLOPEWASH DEPOSITS

Eolian and slopewash deposits (late Pleistocene and Holocene) – Pale brown to light yellowish brown (10YR 6/3-4) and brown to vellowish brown (10YR 5/3-4), silty very fine- to fine-grained sand that mantles flat surfaces and broad topographic depressions. Interbedded locally with minor pebbly sediment. It has a sufficiently long sloping surface to make it susceptible to slope wash processes. May fill topographic depressions in mountainous terrain. 1-5(?) m thick. This unit may overlie older

Eolian and slopewash deposits overlying mixed volcaniclastic sediment of the Tesuque Formation (upper Pleistocene-Holocene and lower-middle Miocene, respectively)

QUATERNARY ALLUVIUM Younger alluvium filling valley bottoms (Holocene) – Light gray to pale brown (10YR 7/2-6/3), poorly bedded sand, gravel, and silty-clayey sand that comprises younger (probable Holocene-age) valley fill. This unit is probably inset below unit Qao. In low- to medium-size drainages, this unit mostly consists of very fine- to medium-grained sand with subordinate coarse- to very coarse-grained sand; local very thin to thick beds of pebbles and cobbles; minor silt and clay that is locally mixed in with the sand (less than ~10% of sediment). In larger drainages, the sediment is likely coarser-grained. Weakly to well consolidated. May possibly be up to 15 m-thick under larger drainages. Older alluvium (upper Pleistocene) – Sandy gravel generally deposited at the mouths of small drainages. Qao is topographically higher than unit **Qay** (i.e., the latter is inset into unit **Qao**); near Vallecitos **Qao** is inset into **Qtp**. Gravel contains wellgraded pebbles, cobbles, and boulders that are subrounded to subangular. Clast composition varies according to source area. Weakly consolidated. Up to approximately 20 m-thick. This unit may overlie older units, as depicted in the following: Older alluvium overlying the Chama-El Rito Member of the Tesuque

Formation (upper Pleistocene and middle Miocene, respectively) Older alluvium overlying interbedded Chama-El Rito Member-Ojo

Caliente Members of the Tesuque Formation (upper Pleistocene-Holocene and middle Miocene, respectively) Older alluvium intercalated with colluvium at the base of steep slopes (middle to upper Pleistocene) – A diamicton composed of silty sandy gravel that includes pebbles through boulders (most to least abundant). Colluvial gravel are very poorly sorted and angular. Alluvium consists of channel fills of gravel to sand exhibiting better rounding than the colluvial gravel. Weakly consolidated. Up to approximately 20 m-thick. Older alluvial fan deposits on south flank of Ortega Mountains (lower to upper Pleistocene and Holocene) – Sandy gravel derived from the Ortega Mountains and deposited as an alluvial fan over unit **Qtv5**. Gravel consists predominately of quartzite. Not exposed. Loose to weakly consolidated. As much as ~60 m-thick. **High-level**, quartzite gravel deposits (Pliocene to lower(?) Pleistocene) – Quartzite-rich sandy gravel on high-level surfaces. Beds are medium to thick, commonly vague, and lenticular(?). Contains poorly sorted, gray, angular to subrounded (mostly subangular to subrounded) quartzite. Other clast types are minor and include Proterozoic gneiss or amphibolite in addition to felsic or intermediate volcanic clasts. Gravel is clast supported and ranges from very fine pebbles to boulders. Unit includes the extensive terrace deposit south of Cañon de los Alamos and east of the Hidden Treasure Mine; this particular deposit is 1-6 m-

La Madera Mountains. Unit is probably mostly fluvial, but colluvium is likely present near bedrock highs. Weakly consolidated. May possibly be as thick as 60 m.

TERRACE DEPOSITS OF RIO VALLECITOS, RIO TUSAS, AND RIO OJO CALIENTE Five terrace deposits along the Rio Vallecitos (**Qtv1-5**) and three deposits along the Rio Tusas (**Qtt1-3**) are sufficiently continuous to correlate along each river. In addition, terrace deposits along these rivers, which join to become the Rio Ojo Caliente, correlate to terrace deposits mapped along the Rio Ojo Caliente (**Qtoc**) in the southern part of this quadrangle and in the Ojo Caliente quadrangle to the south (Koning et al., 2005). Terrace fills generally consist of 2-4 m of sandy cobbles and pebbles. Gravel are clast-supported, subrounded to rounded, poorly sorted, and locally include minor boulders. Clasts include abundant quartile mixed with felsic to intermediate volcanic rocks; Proterozoic schist, gneiss, granite and metavolcanic rocks are minor. Below, the terrace deposits associated with the Rio Vallecitos and Rio Tusas are listed, and their differences and age interpretations briefly discussed. Following the first two letters ("Q" for Quaternary and "t" for terrace deposit), "v" stands for the Rio Vallecitos and "t" stands for the Rio Tusas. The following numbers represent our interpretation of relative age, with 1 being the youngest and higher numbers being successively older). Figure 3 of the accompanying report shows profiles created from the base of each respective terrace deposit, compares these profiles to the modern river level of each respective river, and depicts where the river cuts through solid rock at each channel constriction. In addition, Figure 3 connects work done in this report to terrace profiles of the Rio Ojo Caliente published in the Ojo Caliente quadrangle report (Koning and others, 2005). Much more data has been gathered for terraces of the Rio Vallecitos than for the Rio Tusas, though future mapping in the adjacent Servilleta Plaza quadrangle to the east will provide better deposition and age constraints for terraces of the Rio Tusas. Ages of these terrace deposits are inferred from U-series dating of travertines and other age data published in the Ojo Caliente report.

level; generally located in northwestern part of the map adjoining Rio Vallecitos. Loose and weakly consolidated. **Lowest terrace deposit of the Rio Vallecitos (Uppermost Pleistocene)** – Outcrops locally in scattered deposits at ~4.5 and 8 km north (upstream) of the confluence with the Rio Tusas. Its strath is generally less than 1-2 m above the modern Rio Vallecitos. Near Española, terrace deposits 5-12 m above the modern Rio Chama are interpreted to be 12-45 ka in age based on radiocarbon dating and amino-acid ratios of fossil gastropods (Dethier and McCoy, 1993; Dethier and Reneau, 1995, table 1). The unit on this quadrangle may be of similar age or slightly younger. Lowest terrace deposit of the Rio Tusas (Upper Pleistocene) – This was only mapped immediately upstream of the Rio Tusas-Rio Vallecitos confluence. Its strath is not exposed, but is probably a few meters above the modern stream.

modern Rio Vallecitos varies considerably, from 20 m above the river near the confluence with the Rio Tusas to ~3 m above the modern river at ~8 km upstream from the confluence. Upstream from this point no terrace deposits equivalent to it have been recognized, however an undifferentiated terrace deposit approximately 11.5 km upstream from the confluence and ~5 m above the river may be correlative to this unit. Along the length of the river, the height of the terrace above the river generally decreases am, as the gradient of the Rio Valle and others, 2005), which correlates to unit Qt4 of the Lyden quadrangle further south (Koning, 2004). This deposit may also correlate to an extensive terrace deposit near Española that is ~30-39 m above the present-day Rio Chama, which has an inferred age of 70-90 ka based on amino-acid ratios of fossil gastropods (Dethier and McCoy, 1993; Dethier and Reneau, 1995, table 1). **Lower terrace deposit of the Rio Tusas (Upper Pleistocene)** – This represents the lower, relatively extensive terrace deposit mapped along the Rio Tusas. The height of the terrace above the modern river averages between 15-25 m. This unit is correlative to unit Qtv2. Refer to the description of unit Qtv2 for age constraints. Middle terrace deposit of the Rio Vallecitos (Upper to middle Pleistocene) -

Qtv3m south end of the quadrangle, with isolated outcrops inset into canyon walls above the east bank. A clast count of 99 clasts in **Qtv3** gives: 70 quartzite, 19 intermediate to felsic volcanic rocks, 1 granite, 2

vein quartz, 5 quartz-muscovite schist, 1 amphibolite, and 1 possible chert. The height of this terrace above the modern river varies from ~40 m near the confluence with the Rio Tusas to ~20 m near 8 km upstream from the confluence. Locally, there are two or more straths separated by only a few meters, which are noted by putting an u (upper), m (middle), or l (lower) suffix behind the label. Like **Qtv2**, no terrace deposits equivalent to this unit have been mapped upstream of this point, though an undifferentiated terrace deposit \sim 14.5 km upstream from the confluence and \sim 10 m above the modern river may be correlative to this unit. This unit correlates to Qtoc3 of the Ojo Caliente quadrangle, which is correlative to unit Qt3 of the Lyden quadrangle further south (Koning, 2004). Deposits of this height near Española, which also have slightly varying strath elevations, are inferred to be 130-150 ka based on amino-acid ratios of fossil gastropods (Dethier and McCoy, 1993; Dethier and Reneau, 1995, table 1). This terrace projects to about the same elevation as the travertine sites K03-LM4 and K03-LM5 (~85-105 ka) in the Ojo Caliente Upper-middle terrace deposit of the Rio Tusas (Middle Pleistocene) - This terrace deposit is located north of the Rio Tusas in the southern part of the quadrangle. A clast count of 100 clasts gives: 34 quartzite, 44 intermediate to felsic volcanic rocks, 2 granite, 7 vein quartz, 4 basalt, 1 gabbro or diorite, 5 quartz-muscovite schist, 1 amphibolite, 1 quartz-bearing porphyritic silicic rock, and 1 brown-red sandstone. The height of the strath above the modern river is generally ~ 40 m. Refer to the description of Tsgqe Quartzite-rich gravel in basal Santa Fe Group deposits derived from the east of the qua

Vallecitos in the southern end of the quadrangle. Its strath is generally ~55 m above the modern river but, like the lower two terrace deposits, the height above the river generally decreases upstream; in this case to a minimum of ~35 m near 8 km upstream from the confluence with the Rio Tusas. Also, like the lower units, no terrace deposits equivalent to this unit have been recognized upstream from this point, though an undifferentiated terrace deposit at ~ 11.5 km and ~ 20 m above the modern river level may be equivalent to this unit. This unit probably correlates to unit Qtoc4 of the Ojo Caliente quadrangle to the south (Koning and others, 2004), which is correlative to unit Qt2 of the Lyden quadrangle further south (Koning, 2004). Deposits of this height near Española are inferred to be 130-280 ka based on amino-acid ratios of fossil gastropods (Dethier and McCoy, 1993; Dethier **Qtv5** Upper terrace deposit of the Rio Vallecitos (Lower-middle Pleistocene) – This terrace deposit is the most aerially extensive and laterally continuous of the five terrace deposits of the Rio Vallecitos. A clast count of 151 clasts in **Qtv5** gives: 108 (72%) quartzite, 42 (28%) intermediate to felsic volcanic rocks (mostly felsic), and 1 (0.5%) gneiss. Its strath generally lies ~110 m above the modern Rio Vallecitos and decreases to ~85 m about 8 km upstream from the confluence with the Rio Tusas. Also, like the other units, no terrace deposits equivalent to this unit have been mapped upstream of this point. This unit correlates to unit Qtoc5 of Ojo Caliente quadrangle (Koning and others, 2005), which probably correlates to unit Qt1 in the Lyden quadrangle (Koning, 2004), which has an interpreted age of 600-650 ka.





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Uncorrelated, gravelly terrace deposit alongside of streams (such as the Rio Tusas in th Otg gle) – Composition is variable depending on source area. Most commonly mapped in the Ri Petaca. There, clasts are subrounded and consist of pebbles and cobbles with approximately composed of 10% quartzite and foliated quartzite, 15-20% Proterozoic gneissic metavolcanic are a well-graded mixture of basalt, andesite, dacite, and rhyolite (including clasts of unit **Trq** Terrace deposits of piedmont sediment – Sediment consists of poorly sorted, subangular, s Otp

of the Vallecitos fault. Not described in detail. MIOCENE SEDIMENTARY ROCKS **TESUQUE FORMATION OF SANTA FE GROUP** The Tesuque Formation of the Santa Fe Group was proposed by Spiegel and Baldwin (1963) for Miod pinkish-tan silty arkosic sandstone, deposited in the Rio Grande rift near Santa Fe. Galusha and Blick Formation into several formal members, the pertinent ones for this quadrangle being the Chama-El Ri Members. In contrast to May (1980 and 1984), we have included the volcaniclastic gravel (his Los P with the Chama-El Rito Member as part of the Tesuque Formation. This includes the Plaza lithosome proposed Plaza-Tusas lithosome. The reasons for this change is due to the extreme difficulty in drawin lateral gradation between the volcaniclastic gravel and the orange sand-dominated Chama-El Rito Men as a contact between members. The stratigraphic ideal for the area is to have a single formation-rank t (different from the Tesuque Formation) that includes all early-middle Miocene sediment derived from to be formalized and probably should not be formalized until mapping of the southern Tusas Mountair these are presented in the report, but probably spans the late through early Miocene. Tsto Ojo Caliente Sandstone Member of the Tesuque Formation (middle to upper(?) Mioce eolian sand; massive near base of unit. Sand is generally very pale brown (10YR 8/2-3 to 7/2 medium in grain size, subangular to rounded (mostly subrounded), and well sorted. The sand

orangish grains that includes orange-stained quartz and possible potassium feldspar grains, a canic detritus and mafic grains. Cross-stratification is generally tangential, and beds are lamir nated). Local lenticular grain-flow deposits are present that pinch out towards the sides of trou Unit grades both downward and laterally northward into the Chama-El Rito Member of the T 300 m-thick. Unit is weakly to moderately consolidated and generally non-cemented. It erode Tstoc Interbedded Ojo Caliente Sandstone Member (dominantly) and the Chama-El Rito Mer **Miocene**) – Please see descriptions of the Oio Caliente Sandstone and Chama-El Rito Member gradational contact between the Ojo Caliente Sandstone and Chama-El Rito Member)gradat in the lateral sense). Unit is pinkish to very pale brown, and generally lacks clay or pebble b

Tstco Interbedded Chama-El Rito Member (dominantly) and Ojo Caliente Sandstone Membe Miocene) – Please see descriptions of the Chama-El Rito Member and Ojo Caliente Sandsto gradational contact between the Ojo Caliente Sandstone and underlying Chama-El Rito Mem where pinkish fluvial sand and mud beds are more abundant than very pale brown eolian sedi Tstc Upper Chama-El Rito Member, Tesuque Formation (middle Miocene) – Fluvial deposits minor silt and clay (mostly clay). These are interbedded with subordinate coarser channel de (correlative to unit **Tstvm**). The sand in the finer sediment is generally pink (7.5 YR 7/4) to rein thin to thick (mostly medium to thick), tabular to broadly lenticular beds; these beds are int nally massive, with local gentle cross-lamination. Exposures near Vallecitos have more abun southern part of the quadrangle. In the northeast to central part of the quadrangle, where th

ment (units **Tstvm** and **Tstp**), it is commonly strongly cemented. Unit is 30-50 m-thick Tstvm Mixed, coarse volcaniclastic sediment of Tesuque Formation (middle Miocene) – Grayis pebble-conglomerate and pebbly sandstone. Pink fine sand typical of unit **Tstc** is subordinate nar to lenticular beds. Sand is light gray to pink (7.5YR 7/1-3), fine-to very coarse-grained, sorted, and a volcanic lithic arenite. Gravel are commonly clast-supported, subrounded, very composed largely of felsic volcanic rocks (especially rhyolite and rhyolitic tuff), minor porphy Amalia Tuff is observed but it is minor. Clasts are mostly very fine to medium pebbles, but t and cobbles. Unit is differentiated from unit **Ttpc** in that its volcanic gravel fraction has subeq types that may include clasts of Amalia Tuff. Commonly weakly cemented and moderately t with unit Tstvc of Koning et al. (2005). Unit is interpreted to reflect erosion of the Cordito N In the eastern part of the quadrangle, it both underlies and overlies the Chama-El Rito Member Chama-El Rito Member is less than 6 m-thick and may span into the late Miocene. The sedin

Member is commonly around 30 m-thick. Tstvm-Tstsp Mixed unit within the lateral gradational zone of the coarse, mixed volcaniclastic with the more monolithic, dacitic Plaza lithosome of the Tesuque Formation (middle M mation in the northeast part of this quadrangle, this unit is demarcated for the sediment found coarse volcaniclastic sediment on the northwest (unit **Tstvm**) with the Plaza lithosome (**Tstp**) marked by a mixture of felsic volcanic rocks (primarily rhyolite and tuffs) with coarse plagiou 30 m-thick. . Tstp Plaza lithosome of Tesuque Formation (middle Miocene) – Gravish channel complexes of sandstone. Very thin to medium (minor thick), lenticular to broadly lenticular to planar beds

nel fills (mostly broadly lenticular); local cross-stratification is present but is not characteris pebbles with minor cobbles and boulders. Pebbles are clast- to matrix-supported, subrounde rounded), moderately to poorly sorted, and composed of greater than 65% dark gray to purpli coarse plagioclase phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts up to clude rhyolite and other volcanic rocks similar to that found in unit **Tstvm**. Paleoflow indica . Tstpt Plaza-Tusas lithosome of Tesuque Formation (middle Miocene) – Generaly a white light stone and sandy pebble congolmerate. Beds are commonly medium to thick and tabular to b Cross-stratification or clast imbrication is not common. Gravel may include minor (1-10%) very coarse, subangular to subrounded, moderately sorted, and consist of gray to pink to whit phenocrysts (up to 2 mm-long) and 2-15% biotite + hornblended phenocrysts up to 4 mm-lon grained, subangular, poorly to moderately sorted, and consists of the aforementioned dacite

quartz and 1-10% subhedral biotite and hornblende. Unit may have up to 20% tuff in the matu eruptive debris flows. Unit differs from Tstp by its clast composition, whiter color, and more and commonly well-cemented. At least 100 m-thick. **Tuffaceous debris-flow deposits (lower Miocene)** – Pebble-cobble breccia composed of subblack, porphyritic dacite. Matrix is pinkish white sand with abundant tuff, dacite grains, hornl solidated. Generally less than 6 m-thick. Tsgqw Quartzite-rich gravel in basal Santa Fe Group deposits derived from western and centra **Miocene**) – Sandy coarse gravel and subordinate sand and pebbly sand. Relatively thin, bould

Ortega quartzite near the top of southern Mesa de la Jarita were also included in this unit. G non-exposed. Best exposures are found in and near the lower part of the Cañon de los Alamo broadly lenticular to tabular beds. Gravel consist of well-graded pebbles through cobbles an clast- to matrix-supported, subrounded to rounded, poorly to very poorly sorted, and dominat ite with subordinate Proterozoic meta-volcanic clasts and amphibolite. Paleoflow indicators southeast to south flow direction. Sand is white (2.5Y 8/1) to pink (7.5YR 8/3), mostly fineto subangular, poorly sorted, and composed of quartz and 10% possible feldspar and up to 10 cemented. Unit clearly interfingers and grades eastward into volcaniclastic sediment of the as 60 m-thick. gravel and subordinate sand and pebbly sand in lower Cañada de los Alamos. It is in very thi

ticular beds. Gravel consists of quartzite, foliated quartzite, minor Proterozoic clasts, and min in unit Tstpt. Gravel is pebble- to cobble-size, with 10-15% boulders; largest clast is 80 cm-le general southwest paleoflow direction. Sand is light gray to white (2.5-5Y 8/1-2), fine- to ver subangular, moderately to poorly sorted, and consists of quartz and plagioclase with 3-8% vo grains. Generally weakly to moderately consolidated and non-cemented, with 1-5% scattered interfingers with units Tstpt and Tlpce. Unit is overlain by Tstpt. Approximately 60 m-thick Tlpce Cordito Member of Los Pinos Formation in eastern stream system (Oligocene to lower I 5/4) pebbly sandstone and subordinate sandy conglomerate. Pebbly sandstone beds are plan Conglomerate beds are thin to medium and lenticular. Gravel includes pebbles and minor co subangular and poorly sorted. Clasts consist mostly of welded tuff, non-welded tuff, rhyolite 1-3% Proterozoic gneisses. Sand is mostly medium- to very coarse-grained, moderately sorted

Correlation of map units with respect to age.



NMBGMR Open-file Geologic Map 141 Last Modified 9 May 2007

Uncorrelated, gravelly terrace deposit alongside of streams (such as the Rio Tusas in the northeast part of the quadran- gle) – Composition is variable depending on source area. Most commonly mapped in the Rio Tusas drainage near the town of Petaca There, clasts are subrounded and consist of pebbles and cobbles with approximately 3-5% houlders. Gravel there is		Last Modified 9 May 2
composed of 10% quartizite and foliated quartizite, 15-20% Proterozoic gneissic metavolcanic rocks, 25% vein quartiz, and the rest	Tlpcw	Cordito Member of Los Pinos Formation in western stream system (Oligocene to lower Miocene) - Light gray sandy con-
are a well-graded mixture of basalt, andesite, dacite, and rhyolite (including clasts of unit Trq) Terrace deposits of piedmont sediment – Sediment consists of poorly sorted, subangular, sandy gravel shed from the footwall of the Vallecitos fault. Not described in detail.		glomerate to gravelly sandstone. Beds are very thin to thick and broadly lenticular; subordinate trough cross-stratification and tangential cross-stratification. Gravel consists of pebbles and cobbles that are clast-supported, poorly sorted, and subrounded. Clasts include felsic volcanic rocks (i.e., rhyolite and ryholitic tuffs that include the Amalia Tuff), dacite-rhyodacite, and hy-
MIOCENE SEDIMENTARY ROCKS E FORMATION OF SANTA FE GROUP		pabyssal intrusive rocks in varying proportions. Clasts are poorly sorted and subrounded. Sand is fine- to very coarse-grained, poorly sorted, subrounded, and lithic-rich. Locally as much as 10-15% tuffaceous matrix. Unit differentiated from Tlpce by the presence of gray banded rhyolite. Well-cemented and tilted more steeply than Miocene volcaniclastic units. Unconformably
uque Formation of the Santa Fe Group was proposed by Spiegel and Baldwin (1963) for Miocene basin fill sediment, primarily		overlain by unit Tdrd ; the latter appears to have filled valleys eroded into Tlpcw . Possibly as much as 100 m-thick west of the
tan silty arkosic sandstone, deposited in the Rio Grande rift near Santa Fe. Galusha and Blick (1971) later subdivided the Tesuque	The series of	Rio Vallecitos; unit is thinner east of the Rio Vallecitos (commonly 6-30 m-thick).
on into several formal members, the pertinent ones for this quadrangle being the Chama-El Rito, and Ojo Callente Sandstone s. In contrast to May (1980 and 1984) we have included the volcaniclastic gravel (his Los Pinos Formation) that interfingers	Tipcw-1	- Unit found west of Rio Vallecitos and generally not well-exposed. Interbedding and general composition is inferred by observ-
Chama-El Rito Member as part of the Tesuque Formation. This includes the Plaza lithosome of Ingersoll et al. (1980) and our		ing variations in clast compositions of surficial (colluvial) gravel.
d Plaza-Tusas lithosome. The reasons for this change is due to the extreme difficulty in drawing a formation-rank contact in the	Тео	Older eolian and slopewash deposits (Oligocene) – Light yellowish brown (10YR 6/4) to very pale brown (10YR 7/3) very
radation between the volcaniclastic gravel and the orange sand-dominated Chama-El Rito Member. We prefer to treat this contact		fine- to fine-grained sand. Generally found between the basalt flows and the Cordito Member of the Los Pinos Formation, but
tact between members. The stratigraphic ideal for the area is to have a single formation-rank term for the Abiquiu embayment of from the Tesuque Formation) that includes all early-middle Miocene sediment derived from Tusas Mountains. But this has yet		too thin to map there. We only map this unit where it overlies basalt northeast of the confluence of Rio Vallecitos and Canon de los Alamos, where it is perhaps 6.8 m-thick. There, this sand is silty (estimate 3-10% silt) and contains 1-10% scattered, medium
malized and probably should not be formalized until mapping of the southern Tusas Mountains is completed. Age control for		to very coarse sand of Proterozoic or basaltic detritus. In general, the sand is gesubrounded to subangular, well sorted, and is
e presented in the report, but probably spans the late through early Miocene.		probably of quartz with 10% possible Kspar and 7-10% mafic grains). Weakly consolidated to loose and non-cemented. Mostly
Ojo Caliente Sandstone Member of the Tesuque Formation (middle to upper(?) Miocene) –Extensively cross-laminated	-	2-3 m-thick between the basalt flows and Cordito Member (Tbf and Tplcw).
eolian sand; massive near base of unit. Sand is generally very pale brown (10YR 8/2-3 to 7/3 and 7/4), upper-fine to upper- medium in grain size, subangular to rounded (mostly subrounded), and well sorted. The sand is composed of quartz with a 15%	Tr	Ritito Conglomerate (Oligocene) – Sandy conglomerate composed exclusively of locally derived Proterozoic clasts. Found only in Cañada de los Tanques east of South Petaca. Gravel are subangular to subrounded, poorly sorted, and consists of well
orangish grains that includes orange-stained quartz and possible potassium feldspar grains, and 8-15% (generally 8-12%) vol-		graded pebbles, cobbles, and boulders. Conglomerate is indurated by silica cement. Clast imbrications indicate a southeast-
canic detritus and mafic grains. Cross-stratification is generally tangential, and beds are laminated to very thin (mostly lami-		directed paleoflow. Unit is overlain by a few meters of very pale brown to light gray (10YR 7/2-3), silty very fine- to medium-
nated). Local lenticular grain-flow deposits are present that pinch out towards the sides of trough cross-bedds (0.5-1.0 cm-thick).		grained sand. This sand is in turn overlain by the thick basalt flows of unit Tbf . This conglomerate is in a similar stratigraphic
Unit grades both downward and laterally northward into the Chama-El Rito Member of the Tesuque Formation. Probably 200- 300 m-thick Unit is weakly to moderately consolidated and generally non-cemented. It erodes relatively easily to form rounded		position as the Ritito Congiomerate in the Las Tablas quadrangle to the north (Barker, 1958). Unit IF is less than 15 m-thick.
hills.		LOWER MIOCENE AND OLIGOCENE VOLCANIC ROCKS
Interbedded Ojo Caliente Sandstone Member (dominantly) and the Chama-El Rito Member, Tesuque Formation (middle	Trq	Quartz-bearing, porphyritic rhyolite bodies within dacite-rhyodacite flows (lower Miocene) - Distinctive, white to
Miocene) – Please see descriptions of the Ojo Caliente Sandstone and Chama-El Rito Member. This unit is mapped as part of the		brownish or grayish white, porphyritic rhyolite with 10-25% quartz phenocrysts (brownish gray color and 0.2-2.0 mm-long). The
in the lateral sense). Unit is pinkish to very pale brown, and generally lacks clay or pebble beds		and quartizite up to 2 cm-long. Occurs as pods or small intrusions within unit Tdrd or more rarely alongside of unit Tdrd . We
Interbedded Chama-El Rito Member (dominantly) and Ojo Caliente Sandstone Member, Tesuque Formation (middle		preliminarily interpret that these bodies reflect mixing of two somewhat immiscible magmas (this rhyolite and the dacitic-
Miocene) – Please see descriptions of the Chama-El Rito Member and Ojo Caliente Sandstone. This unit is mapped as part of the		rhyodacitic magma of Tdrd proper), which were both extruded, but more work is needed to test that interpretation.
gradational contact between the Ojo Caliente Sandstone and underlying Chama-El Rito Member. Here, it is assigned to strata	Tdrd	Dacite and rhyodacite flows (lower Miocene) –Reddish brown to gray to pinkish gray volcanic flows and and flow breccia
Upper Chama-El Rito Member, Tesugue Formation (middle Miocene) – Fluvial deposits of predominately fine sand and		also minor quartz (in the rhyodacite, where it is up to 3 mm) $3-5\%$ hornblende plus biotite phenocrysts (< 2 mm). Generally this
minor silt and clay (mostly clay). These are interbedded with subordinate coarser channel deposits of volcanic gravel and sand		unit is indurated. Eroded detritus of this unit is interpreted to comprise, in part, the Plaza lithosome, clasts of which have been
(correlative to unit Tstvm). The sand in the finer sediment is generally pink (7.5 YR 7/4) to reddish yellow (5-7.5YR 6-7/6), and		dated at 21-23 Ma by the K-Ar method (Ekas et al., 1984). Unit includes minor beds of unit Tstp . Individual flows are generally
in thin to thick (mostly medium to thick), tabular to broadly lenticular beds; these beds are internally planar-laminated or inter-	Tdudu	1-3 m-thick. Exposed cumulative thickness is 1-25, perhaps as much as 60 m-thick in the subsurface.
southern part of the quadrangle. In the northeast to central part of the quadrangle, where this unit overlies volcaniclastic sedi-	Turuu	described in unit Tdrd , but inclusions of Trg were not differentiated.
ment (units Tstvm and Tstp), it is commonly strongly cemented. Unit is 30-50 m-thick	Tat	Amalia(?) Tuff (upper Oligocene) – Reddish welded tuff with flattened pumice, less than 1% mafic grains, and containing mi-
Mixed, coarse volcaniclastic sediment of Tesuque Formation (middle Miocene) – Grayish channel-fill complexes of sandy		nor crystals of blue, irredescent sanidine crystals. Near-vertical and overlain by gently east-dipping rhyodacite and dacite flows
pebble-conglomerate and pebbly sandstone. Pink fine sand typical of unit Tstc is subordinate to minor. Laminated to thin, pla- ner to lanticular hads. Sand is light gray to pink (7 5 VP 7/1 3) fine to very coarse grained subangular to subrounded poorly.		of unit Trdd. $\sqrt[5]{Ar}$ Ar dating of the Amalia Tuff in the Latir volcanic field has returned an age of 25 Ma (Zimmerer et al., 2007), and $\sqrt[40]{Ar}$ dating of the Amalia Tuff in the Tusas Mountains also returned an age of 25 Ma (Smith et al. 2002).
sorted, and a volcanic lithic arenite. Gravel are commonly clast-supported, subrounded, very poorly to moderately sorted, and		Greater than 30 m-thick.
composed largely of felsic volcanic rocks (especially rhyolite and rhyolitic tuff), minor porphyritic dacite, and minor granite.	Tbf	Basalt flow (Oligocene) – Gray to dark gray to black, olivine-bearing basalt that generally weathers reddish brown or brown;
Amalia Tuff is observed but it is minor. Clasts are mostly very fine to medium pebbles, but there are also minor coarser pebbles		olivine phenocrysts are up to 1 mm long and occupy trace to 10% of the rock; basalt is commonly vesicular. Individual flows are
types that may include clasts of Amalia Tuff. Commonly weakly cemented and moderately to well-consolidated. Correlates		cording to Lipman and Mehnert (1975 and 1979): Baldridge et al. (1980): probably 24-27 Ma on this quadrangle.
with unit Tstvc of Koning et al. (2005). Unit is interpreted to reflect erosion of the Cordito Member of the Los Pinos Formation.		
In the eastern part of the quadrangle, it both underlies and overlies the Chama-El Rito Member. The sediment that overlies the	PROTE	CROZOIC IGNEOUS AND METAMORPHIC ROCKS
Chama-El Rito Member is less than 6 m-thick and may span into the late Miocene. The sediment underlying the Chama-El Rito Member is commonly around 30 m-thick	MESOP Yn	Pegmatite – Potassium feldspar + quartz + plagioclase+muscovite+ biotite pegmatite. Large books of muscovite up to 5-cm in
tsp Mixed unit within the lateral gradational zone of the coarse, mixed volcaniclastic unit of the Tesuque Formation	- P	diameter. Occurs as dikes, sills, and pods cutting metasedimentary and metavolcanic rocks. Not strongly foliated, but dikes and sills
with the more monolithic, dacitic Plaza lithosome of the Tesuque Formation (middle Miocene) – Found in the Tesuque For-		are variably boudinaged and folded. U-Pb zircon dating places age of crystallization at ~1400 Ma (Lanzirotti, personal comm. to
mation in the northeast part of this quadrangle, this unit is demarcated for the sediment found in the lateral transition between		Lombardi, 1997).
marked by a mixture of felsic volcanic rocks (primarily rhyolite and tuffs) with coarse plagioclase-bearing, porphyritic dacite. 2-	Xtp	Tres Piedras granite – Granitic gneiss consisting principally of quartz, feldspar, biotite, and muscovite. Orangish on weathered
30 m-thick.	1	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
Plaza lithosome of Tesuque Formation (middle Miocene) – Grayish channel complexes of sandy conglomerate and pebbly		lenses. This unit intrudes rocks of the Vadito Group. Contact with neighboring schist units is difficult to discern. U-Pb zircon dating
nel fills (mostly broadly lenticular): local cross-stratification is present but is not characteristic of the unit. Gravel consists of	Hondo (Group (Includes Ortega Quartzite and associated units)
pebbles with minor cobbles and boulders. Pebbles are clast- to matrix-supported, subrounded to subangular (mostly sub-	Xqs	Aluminous schist – Interlayers within Ortega Quartzite, locally contains kyanite, and sillimanite. This unit was previ-
rounded), moderately to poorly sorted, and composed of greater than 65% dark gray to purplish, porphyritic dacite (with >10%		ously mapped as qka in the La Madera quadrangle (Bingler, 1965),
coarse plagioclase phenocrysts up to 8 mm-long and less than 10% biotite + hornblende phenocrysts). Remainder of clasts in-	Xq	Ortega Quartzite – Coarse-grained, gray vitreous cross-bedded quartzite consisting mostly of quartz with minor amounts of mus-
rangle are generally to the southwest.		tutes the base of this quartizite and is aregionally continuous marker horizon.
Plaza-Tusas lithosome of Tesuque Formation (middle Miocene) – Generaly a white light gray (10YR 7/1-2, 8/1) pebbly sand-	Vadito G	Group (Includes associated metasedimentary and metavolcanic rocks)
stone and sandy pebble congolmerate. Beds are commonly medium to thick and tabular to broadly lenticular (some lenticular).	Xmqu	Micaceous quartzite – Grayish white to greenish white thinly laminated micaceous quartzite. This unit is schistose, ranges from
Cross-stratification or clast imprication is not common. Gravel may include minor $(1-10\%)$ cobbles. Pebbles are very fine to very coarse, subangular to subrounded moderately sorted, and consist of grav to pink to white dacite that have <10% feldspar		Locally contains trough crossbeds. This unit is most likely correlative to Xmg in the Qio Caliente Quadrangle (Coning and others
phenocrysts (up to 2 mm-long) and 2-15% biotite + hornblended phenocrysts up to 4 mm-long. Sand is fine- to very coarse-		2005). Represents a gradational transition from Vadito to Hondo groups
grained, subangular, poorly to moderately sorted, and consists of the aforementioned dacite with minor (~25%) feldspar and	Xr	Metarhyolite – Brick red to light pink schistose to massive metarhyolite, consisting principally of fine-grained quartz, feldspar,
quartz and 1-10% subhedral biotite and hornblende. Unit may have up to 20% tuff in the matrix. Interpreted as possibly syn-		muscovite, and opaques. Has distinctive quartz "eyes" and ribbons. This unit is likely correlative to the Cerro Colorado metarhyo- lite and the Arroyo Rancho metarhyolite (Bishon, 1997) found in the Oio Caliente quadrangle, as well as to the Burned Mountain
and commonly well-cemented. At least 100 m-thick.		metarhyolite (Barker, 1958), and unit fs of Bingler (1965). The Cerro Colorado metarhyolite has been dated at ~1.70 Ga based on
Tuffaceous debris-flow deposits (lower Miocene) – Pebble-cobble breccia composed of subangular clasts of biotite-rhyolite or		zircons (Lanzirotti personal communication 1996 to Bishop, 1997). Interpreted by several workers to have originally been ash flow
black, porphyritic dacite. Matrix is pinkish white sand with abundant tuff, dacite grains, hornblende, and trace biotite. Well con-	Va	tuffs (Just, 1937; Jahns, 1946; Treiman, 1977)
Ouartzite-rich gravel in basal Santa Fe Group deposits derived from western and central parts of the quadrangle (lower	ла	sedimentary rocks. Consists of hornblende, plagioclase feldspar, as well as chlorite and actinolite: grades into areas rich in tourma-
Miocene) – Sandy coarse gravel and subordinate sand and pebbly sand. Relatively thin, bouldery terrace deposits composed of		line. Foliation defined by inter-layered amphibole and plagioclase feldspar-rich layers. Primary textures are absent, but may include
Ortega quartzite near the top of southern Mesa de la Jarita were also included in this unit. Generally weakly consolidated and		both metabasaltic flows and hypabyssal intrusive sills and dikes. These layers are also widespread in the Ojo Caliente and Las Tab-
non-exposed. Best exposures are found in and near the lower part of the Canon de los Alamos. There, sediment is in thick, broadly lenticular to tabular beds. Gravel consist of well-graded pebbles through cobbles and 15-25% houlders. Gravel are	Xc	las Quadrangles (Coning and others, 2005; Williams, 1987). Big Rock Conglomerate – Stretched and folded nebble metaconglomerate layer interbedded with the aluminous schists, varies
clast- to matrix-supported, subrounded to rounded, poorly to very poorly sorted, and dominated by quartzite and foliated quartz-	. 240	from weathering-resistant clast-supported lenses to long, matrix-supported lenses. Clasts include bluish-grayish quartzite, vein
ite with subordinate Proterozoic meta-volcanic clasts and amphibolite. Paleoflow indicators (from clast imbrication) indicate a		quartz, black shaley pebbles, volcaniclasts (up to 10 cm diameter), and chert (ellipsoidal shapes). Clasts are typically flattened and
southeast to south flow direction. Sand is white (2.5Y 8/1) to pink (7.5YR 8/3), mostly fine- to very coarse-grained, subrounded to subangular, poorly sorted, and composed of quartz and 10% possible foldspar and up to 10% mafie minorals. Locally strongly		elongated in the main foliation plane. The matrix of the conglomerate varies from quartzite, to quartz-muscovite schist, to metarhy-
cemented. Unit clearly interfingers and grades eastward into volcaniclastic sediment of the Plaza lithosome (Tstpc). As much	Xas	Aluminous schists – Grayish brown to greenish brown fine-grained schists of varying compositions and bearing various aluminous
as 60 m-thick.		phases including garnet, staurolite, kyanite, sillimanite, and alusite, and cordierite. Principle minerals include quartz, plagioclase,
Quartzite-rich gravel in basal Santa Fe Group deposits derived from the east of the quadrangle (lower Miocene) – Sandy		biotite, and muscovite. Accessory minerals include ilmenite, epidote, magnetite, tourmaline, apatite, monazite, and chlorite. Locally
ticular beds. Gravel consists of quartizite, foliated quartizite, minor Proterozoic clasts, and minor dacite clasts similar to that seen		quence of rhyolites, tuffs, and reworked volcanic rocks. Individual layers of schist vary in thickness from tens of centimeters to
in unit Tstpt. Gravel is pebble- to cobble-size, with 10-15% boulders; largest clast is 80 cm-long. Clast imbrication indicates a		meters wide. This unit has members that are likely correlative to qmps, qb, qp, and qbk of Trieman, 1977). The aluminous schists
general southwest paleoflow direction. Sand is light gray to white (2.5-5Y 8/1-2), fine- to very coarse-grained, subrounded to	X 7	are mapped as separate units Xk, Xst, Xcd, and Xs in the Ojo Caliente Quadrangle (Coning and others, 2005).
subangular, moderately to poorly sorted, and consists of quartz and plagioclase with 3-8% volcanic grains and 8-12% mafic grains. Generally weakly to moderately consolidated and non-computed with 1-5% scattered, strongly computed bads. Unit	AS	reiuspating senist – Light pink schist distinguished from unit Xms by the presence of feldspar. Consists of quartz, muscovite, feld- spar and some iron oxides. This unit is not recognized in the Qio Caliente Quadrangle to the south: this unit and Xms are managed
interfingers with units Tstpt and Tlpce . Unit is overlain by Tstpt . Approximately 60 m-thick or greater.		instead as Xms and Xbs.
Cordito Member of Los Pinos Formation in eastern stream system (Oligocene to lower Miocene) – Reddish brown (2.5YR	Xms	Mica schist – White to grayish-green fine-grained quartz-mica schist. Includes quartz-muscovite-biotite schist and gneiss. Consists
5/4) pebbly sandstone and subordinate sandy conglomerate. Pebbly sandstone beds are planar and laminated to very thin-thin.		primarily of quartz and muscovite. Accessory minerals include epidote, hematite, retrograde chlorite, and garnet. This unit is likely correlative to unit ams of Bingler (1965)
subangular and poorly sorted. Clasts consist mostly of welded tuff, non-welded tuff, rhvolite, 25-35% dacite and rhodacite. and	Xmql	Lower micaceous quartzite – Coarse-to-fine-grained grayish-blue, micaceous quartzite. Consists of quartz. muscovite. biotite and
1-3% Proterozoic gneisses. Sand is mostly medium- to very coarse-grained, moderately sorted, subrounded to subangular, and	•	hematite. Distinguished from unit Xmqu by recognized stratigraphic position (Lombardi, 1997), lower overall mica content, and
consists of approximately subequal quartz, plagioclase, and felsic volcanic grains. Matrix may have up to 15% tuff. Commonly		absence of greenish layers. This lower quartizite has not been recognized in nearby areas, however this sediments that make up this guartizite may have sourced from the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) and may areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas in the lower metachyolite unit (Xm) (Lemberdi 1007) areas
strongry cemented. Approximately 60 m-tmck or greater.		quartize may have sourced from the lower metarnyonte unit (Arp) (Lombardi, 1997) and may previously been grouped together with Xrp.
	Xrn	Porphyritic metarhyolite – Foliated euhedral feldspar metarhyolite, consists mostly of quartz, plagioclase, microcline, and musco-

, plagioclase, microcline, and muscovite in the matrix and contains large pink feldspar and quartz phenocrysts ("quartz eyes" of Lombardi, 1997). This unit appears reddish-orange both on fresh and weathered surfaces, and is exposed as rounded, poorly layered outcrops with a rough, knobby, weathering surface. Accessory minerals include magnetite and apatite. Feldspar phenocrysts are up to 1 cm in diameter and are euhedral. This unit is likely correlative to unit fsg of Bingler (1965). More schistose layers of this unit are mapped separately from this unit in the Ojo Caliente quadrangle (unit Xrs of Koning and others, 2005).



INDEX MAP OF AUTHOR MAPPING AREAS

