Geologic Map of the Taos Junction Quadrangle, Taos County, New Mexico

By

Daniel J. Koning, Scot Aby, and Keith I. Kelson

May 2007

New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 144

Scale 1:24,000

This work was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP) under USGS Cooperative Agreement 06HQPA0003 and the New Mexico Bureau of Geology and Mineral Resources.

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

The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government or the State of New Mexico.

GEOLOGIC MAP OF THE TAOS JUNCTION 7.5-MINUTE QUADRANGLE, TAOS AND RIO ARRIBA COUNTIES, NEW MEXICO

BY

DANIEL J. KONING[1], SCOTT ABY[2], AND KEITH KELSON[3]

Year 2 of 2 Year STATEMAP Quadrangle

May, 2007

[1] New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801-4796;)

[2] Muddy Spring Geology, Box 488, Dixon, NM 87527

[3] William Lettis & Associates, Inc., 777 Botelho Drive, Suite 262, Walnut Creek, CA 94596

ABSTRACT

Deleted: ¶

The Taos Junction quadrangle covers a sandy area east of the town of Ojo Caliente and includes the eastern margin of the Taos Plateau and the flat-topped, relatively small Mesa Vibora. Surface water is absent on this quadrangle, and groundwater is generally only found several hundred feet deep. One deep aquifer that has been tapped consists of fractured Hinsdale basalts. A distinctive volcaniclastic unit that contains dark gray to purplish gray, coarse-porphyritic dacite has been called the Plaza lithosome by past workers, and was deposited by streams flowing south to southwest from a high-standing volcanic edifice at least 10 km north of this quadrangle. This edifice had sufficient topographic relief to produce bouldery debris flows that traveled into this quadrangle. Gradationally to locally sharply overlying the Plaza lithosome is the fine sand-dominated Chama-El Rito Member of the Tesuque Formation, which in its lower part has coarse channel-fills of similar composition as the Plaza lithosome. The Chama-El Rito Member is gradationally overlain by eolian sediment of the Ojo Caliente Sandstone Member (Tesuque Formation), with a 3-30 m-thick gradational zone between the two members. The Ojo Caliente Sandstone grades laterally northwards into a unit of interbedded fluvial and eolian sand.

Thedr strata in the northwest corner of the quadrangle have experienced offset by a host of generally north-striking, oblique-normal faults. The largest of these faults is the west-dipping Vibora fault zone, along which is concentrated basaltic dikes (4-5 Ma?) and basaltic eruptive centers (4.0-4.5 Ma) that include Mesa Vibora. North of Cañada de los Comanches, these faults are associated with prevalent cementation by silica and calcium carbonate. A graben and syncline has formed between the Vibora fault zone and an east-down, right-oblique fault along the western quadrangle boundary. A horst between the Vibora fault and an east-down fault 0.5-1.0 km to the east is composed of the tuffaceous Plaza lithosome in its upper part. It is likely that the horst and these faults act as barriers to groundwater flow. Groundwater flow flowing southwest down Cañada de los Comanches may be diverted southward along these structures.

Late Miocene through Pliocene sedimentary deposits and volcanic rocks offer clues regarding how tectonic and climatic factors influenced drainages during that time. Overlying the Ojo Caliente Sandstone along the Comanche rim is the sand-dominated, massive and likely bioturbated, gravel-poor Vallito Member of the Chamita Formation; this unit is only 5-21 m thick here. In exposures south of this quadrangle, southeast of Cerro Azul, the Vallito Member is significantly coarser, thicker, and has better bedding than under the Comanche Rim. This contrast in sedimentologic character is probably due to the difficulty of Taos Range-derived, Vallito Member streams in flowing westward against the late Miocene eastward tilt direction as opposed to flowing southwest. Following emplacement of a Servilleta basalt flow in the northeastern part of the quadrangle at 4.6 Ma, there was up to 25 m of deposition of gravelly sediment by two rivers draining the Taos Range. The increase in stream competency is probably related to climatic changes. These two rivers, which were probably merging in the eastern part of the quadrangle, flowed westward towards what is now Mesa Vibora. Eruptions at Mesa Vibora at 4.0-4.5 Ma expelled the gravel previously deposited by these rivers into phreatomagmatic deposits at the base of the mesa. Shortly after the emplacement of a Servilleta Basalt flow in the south, the southern of these two rivers appears to have been pirated elsewhere (probably south into what is now the Rio Grande at Pilar). The northern of the two rivers probably continued to flow here a short time after 3.6 Ma, and then also was diverted elsewhere.

INTRODUCTION

Deleted: ¶

The Taos Junction quadrangle covers a sandy area east of the town of Ojo Caliente and southwest of a small collection of houses and a store marking Taos Junction, New Mexico. Highway 285 passes through the northern part of the quadrangle. There are five prominent physiographic features in the area. On the east is the Taos Plateau, whose western edge is called the Comanche rim. This plateau slopes west and is drained by the ephemeral Cañada Embudo and Cañada Comanche in this quadrangle. A relatively low relief, undulating, west-sloping piedmont is found west of the Comanche rim. An unnamed mountain in the northwest corner of the quadrangle rises about 180-270 m above the surrounding piedmont. Cerro Azul rises about 150 m above the piedmont in the southeast corner of the quadrangle. Composed of quartzite, it exhibits a slightly bluish gray color (hence its name). The last feature is an isolated, small, basalt-capped mesa near the central western border of the quadrangle, called Mesa Vibora. Drainages in the western part of the quadrangle are generally dry except after heavy rainfall; these include the southwest-flowing Cañada de los Comanches in the northwest part of the quadrangle and several southwest-flowing drainages on the aforementioned piedmont (including Sandlin and Stevens arroyos south of Mesa Vibora and Cañada las Lemitas in the extreme southwest corner of the quadrangle).

This landscape is underlain by sandy strata that are commonly weakly to moderately consolidated and non-cemented. This results in poor exposure across much of the quadrangle. Cementation is common in strata on the south flanks of the mountain in the northwest corner of the quadrangle, and exposure there is reasonably good.

The Taos Junction quadrangle has escaped attention by most geologists, who opted to study better exposures of the Santa Fe Group to the south and west (e.g., May, 1980 and 1984) or southeast (Steinpress, 1980-1981). The quadrangle lies on a gravity high that has been used to divide the Española Basin to the south-southwest from the San Luis Basin to the north-northeast (Cordell, 1979; Koning et al., 2004).

This quadrangle is uninhabited aside from scattered houses in section 11 of T.24N., R.9E., and the settlement of Taos Junction. Water availability is a limiting factor for further population growth, with most wells having to be drilled several hundred feet or more in order to reach groundwater.

There were three main goals in mapping this quadrangle: 1) document the stratigraphy and geologic structures on this quadrangle that could be influencing the distribution and flow of groundwater; 2) study the Pliocene sediment and volcanic units that cap the Taos Plateau and underlie Mesa Vibora in order to understand their stratigraphic and chronologic relations; and 3) test the hypothesis of Koning et al. (2004, fig. 5) regarding the possible existence of northwest-striking antiform developed during early extension of the Rio Grande rift. After presenting descriptions of the map units, we discuss our findings relative to these three goals.

DESCRIPTION OF MAP UNITS

Grain sizes follow the Udden-Wentworth scale for clastic sediments (Udden, 1914; Wentworth, 1922) and are based on field estimates. Pebbles are subdivided as shown in Compton (1985). The term "clast(s)" refers to the grain size fraction greater than 2 mm in diameter. Clast percentages are based on counts of about 100 clasts at a given locality, except where noted. Descriptions of bedding thickness follow Ingram (1954). Colors of sediment are based on visual comparison of dry samples to the Munsell Soil Color Charts (Munsell Color, 1994). Surficial units are only delineated on the map if estimated to be at least 0.5 m thick. Soil horizon designations and descriptive terms follow those of the Soil Survey Staff (1992) and Birkeland (1999). Stages of pedogenic calcium carbonate morphology follow those of Gile et al. (1966) and Birkeland (1999).

QUATERNARY SLOPEWASH AND EOLIAN DEPOSITS

Qsw **Slopewash deposits (Holocene)** – Very pale brown to yellowish brown (10YR 7/3-6/4) sand and pebbly sand. Sand is fine- to medium-grained, well-sorted, subrounded, and composed of quartz, 15% orange-stained quartz and possible potassium feldspar, 5% mafics, and trace to 1% volcanic grains. Pebble composition and texture similar to that of Cerro Azul quartzite (**Xoq**), **Tatn**, or **Tats**, depending on location. Loose and an estimated 1-2 m-thick.

Qes **Eolian sand and slopewash deposits (Holocene to upper Pleistocene) –** Very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4) to brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4-6) to reddish yellow (7.5YR 6/6) to light brown (7.5YR 6/4), internally massive sand that covers hillslopes, terrace treads, and high-level surfaces throughout the quadrangle (except for the unnamed mountain in the northwest corner of the quadrangle and the steep slopes of Cerro Azul). Sand is fine- to medium-grained, subrounded (mostly) to subangular to well rounded, well sorted, and composed of quartz, 15-20% orange-stained quartz and possible potassium feldspar, 0.5-3% volcanic, and 3-5% mafic grains. Slopewash deposits may include trace to 1% very fine to coarse pebbles. In most places, the upper 1-2 m of this unit is Holocene in age based on a lack of soil development in addition to the presence of a cultural artifact (a 'one-hand mano' or grinding stone) fortuitously spotted at the base of this deposit at one locality. West of the Comanche rim, this unit overlies other loose to weakly consolidated, sandy deposits and its base is difficult to distinguish. Here, these deposits are mapped as "Qes overlying another unit" (see below). We interpret that **Qes** sand is derived from older units **Tsto**, **Tstoc**, and **Tstc** based on grain similarity and its position down-wind from large exposed areas of these units south of the town of Ojo Caliente. Buried soils are locally present, particularly where the sand color is brownish yellow, yellowish brown, or light brown to reddish yellow. These buried soils include a weak calcic horizon (stage I carbonate morphology) overlain by either a Bw or weak Bt soil horizon marked by moderate, coarse to very coarse, prismatic to subangular-subrounded blocky ped structure. Buried soils are generally 50-70 cm-thick and suggest an upper Pleistocene age. Unit is loose to weakly consolidated and generally less than 3 m-thick, although in the west part of the quadrangle it is as thick as 6 m.

Qes **Qao**	**Eolian sand and sandy slopewash deposits overlying older alluvium (Holocene-upper Pleistocene and Pleistocene, respectively) –** See description for **Qes** above and description for **Qao** below.
Qes **Qao-Ttso**	**Eolian sand and sandy slopewash deposits overlying older alluvium and the Ojo Caliente Sandstone Member of the Tesuque Fm (Holocene-upper Pleistocene, Pleistocene, and middle Miocene, respectively) –** See description for **Qes** above and descriptions for **Ttso** and **Qao** below. Mapped where very poor exposure on low hills precludes mapping of the Qao/Tsto contact (in most places, we would speculate that **Tsto** probably occupies the lower 5-25% of the hillslope).
Qes **QTae**	**Eolian sand and sandy slopewash deposits overlying Plio-Pleistocene alluvium and eolian deposits (Holocene-upper Pleistocene and Plio-Pleistocene, respectively) –** See description for **Qes** above and description for **QTae** below.
Qes **QTae-Tatn**	**Eolian sand and sandy slopewash deposits (Holocene-upper Pleistocene) overlying Plio-Pleistocene alluvium and eolian deposits in addition to probable Pliocene, gravelly alluvium from the Taos Range north of Taos –** See description for **Qes** above and descriptions for **QTae and Tatn** below. Mapped east of the Comanche rim in areas where very poor exposure precludes differentiation of units **QTae** versus **Tatn**.
Qes **Tscv**	**Eolian sand and sandy slopewash deposits overlying sand of the Vallito Member of the Chamita Formation (Holocene-upper Pleistocene and middle-upper Miocene, respectively) –** See description for **Qes** above and description for **Tscv** below.
Qes **Tsto**	**Eolian sand and sandy slopewash deposits overlying sand of the Ojo Caliente Member of the Tesuque Formation (Holocene-upper Pleistocene and middle-upper Miocene, respectively) –** See description for **Qes** above and description for **Tsto** below.
Qes	**Eolian sand and sandy slopewash deposits overlying sand of**

Tstoc **mixed and interbedded Ojo Caliente and Chama-El Rito Members of the Tesuque Formation (Holocene-upper Pleistocene and middle Miocene, respectively) –** See description for **Qes** above and description for **Tstoc** below.

Qes
Tstc
Eolian sand and sandy slopewash deposits overlying sand of the Chama-El Rito Member of the Tesuque Formation (Holocene-upper Pleistocene and middle Miocene, respectively) – See description for **Qes** above and description for **Tstc** below.

Qec **Eolian fine sand in coppice dunes (Holocene) –** Pale brown (10YR 6/3), fine- to medium-grained sand (mostly lower-medium) that forms coppice dunes around juniper and pinon trees (dune height is less than a meter and generally 20-70 cm). Sand is well-sorted, subrounded, and composed of quartz, 15% orange-stained quartz and possible potassium feldspar, 3-5% mafic grains, and 0.5% volcanic grains. Soil of unit is very poorly developed and interpreted to be Holocene-age. Loose and poorly exposed.

Qsc **Eolian sand ramps intercalated with colluvium on the flanks of Cerro Azul (Pleistocene) –** Light yellowish brown (10YR 6/4), fine- to medium-grained sand with minor pebbles to boulders of quartzite from Cerro Azul. Internally massive and weakly consolidated. Sand is well-sorted, subrounded, and composed of quartz, 15% orange-stained quartz and possible potassium feldspar, 1-3% volcanics, and 3-8% mafic grains. Erosion of this deposit has produced a gravel lag on its surface. At foot of this deposit are slopewash deposits (**Qsw**, described above) consisting of sand and pebbly sand eroded from the surface of this deposit.

Qedu **Undivided eolian sand in various dune forms (Holocene) –** Light yellowish brown (10YR 6/4), fine to coarse-grained sand in various dune forms. Surface is characterized by circular to irregular, hummock-shaped dunes adjacent to bowls. Dunes consist of aggradaded eolian sand and attain heights of 50 cm to 3 m and widths of 10 to 40 m; the bowls are of comparable width. Coppice dunes (<1 m-tall) are also locally present. Dunes support a moderate density of grasses, junipers, and pinons and appear to be stabilized. Sand is subrounded to rounded, well-sorted, and composed of quartz, 15% orange-stained quartz and possible potassium feldspar, 2-3% felsic volcanic grains, and 3% mafic grains. Sand is loose. Estimated thickness of 1-6 m.

Qed **Eolian sand in a single, large dune form (Holocene) –** Light yellowish brown (10YR 6/4), fine to coarse-grained sand in a single, large dune form. This unit includes a parabolic dune 1 km east of the center of the quadrangle (as seen on air photos; approximate UTM coordinates of: 417030 E, 4018850 N, zone 13, NAD 27). Sand texture and composition approximately similar to that of unit **Qedu**. Estimated thickness of 1-6 m.

Qedl **Eolian dune-field sand characterized by linear, northeast-trending ridges (Holocene to upper Pleistocene) –** Light yellowish brown (10YR 6/4) to brownish yellow to strong brown (10-7.5YR 5/6), fine to medium-grained, wind-blown sand characterized by a surface exhibiting northeast-trending, relatively narrow, positive-relief features (delineated on the map; see map explanation). These linear features may be up to 10 m-tall and include constructional, longitudinal dunes and eolian sand that simply caps elongated, topographic highs cored by unit **Qao**. We infer that most ridges over 3 m-tall and/or ridges with gravel float reflect the latter. Locally, such as on the crest of the Comanche rim, this unit overlies thick deposits of reddish to brownish, Pleistocene(?)-age **Qes** deposits containing buried soils. Loose; eolian deposit is probably up to 6 m-thick.

Qedl
QTae
Eolian sand in linear dunes (Holocene), overlying sandy-gravelly alluvial and sandy eolian deposits (Pleistocene to Pliocene) -- Yellowish brown to light yellowish brown (10YR 5-6/4), internally massive sand that forms low linear dunes orientated to the southwest. These dunes are loose and generally less than 3 m-tall. Sand is fine- to medium-grained, subrounded (minor rounded and subangular), well-sorted, and composed of quartz, 15-20% orange-stained quartz and possible potassium feldspar, 3% mafic grains, and 0.5% volcanic grains; minor silt and very fine sand are locally present. In the low areas between dunes is relatively thin eolian sediment similar to that just described (less than 1 m-thick) overlying slopewash or alluvial sediment of pebbly sand; on top of the latter may be a soil marked by a calcic horizon and the development of illuviated clay films (TJ-pit 4). This underlying sediment is correlated with unit QTae.

Qedl
Tsb
Eolian sand in linear dunes (Holocene), overlying Servilleta Basalt (early Pliocene) – See descriptions for unit **Qedl** above and unit **Tsb** below.

Qedl
QTae-Tatn
Eolian sand in linear dunes (Holocene), overlying undifferentiated Quaternary and Pliocene sediment – See descriptions for unit **Qedl** bove and units **QTae** and **Tatn** below.

LANDSLIDE AND COLLUVIAL DEPOSITS

Qls **Landslide deposits (likely Plesitocene) –** Quaternary landslide deposit near the northern quadrangle boundary. Deposit consists of poorly sorted sand to boulders that are part of a large rotational slide block along the Comanche Rim, which includes large, rotated and detached beds of Servilleta Basalt (**Tbs**). Distinguished from **Qbt** by the presence of Toreva blocks comprised of relatively intact basalt flows.

Qbt **Quaternary basaltic talus (likely Plesitocene) –** Quaternary talus dominated by subangular-to-angular blocks of Servilleta basalt and covering slopes below basalt flows. 1-5(?) m-thick.

QUATERNARY ALLUVIUM

Qayl **Low-lying cut-fills occupying channels (uppermost Holocene) –** Very pale brown to light yellowish brown (10YR 6-7/4), fine to very coarse sand and gravelly sand that fills relatively recent (less than 200 years old) channel forms in modern valley bottoms. Unit includes low terrace deposits inset below units **Qayh** and **Qayhi** that have surfaces with bar and swale topography and no soil development. Sediment is mostly planar-laminated, with subordinate cross-stratification and sandy pebble, very thin to medium beds. Sand and gravel clasts are subrounded, moderately to poorly sorted, and have a composition reflecting the provenance of the arroyo. Loose to weakly consolidated; thickness uncertain but probably about 2 m or less.

Qayi **Intermediate-level valley fills (Holocene) –** Terrace deposits in valley bottoms that are sedimentologically similar to unit **Qayl** and **Qayh,** but which are assumed to be more than 200 years old because they commonly lack bar-and-swale topography. These are inset more than 2 m below the tread of unit **Qayh**. The soil of this unit was not observed. Mapped 2-3 km south of Mesa Vibora. Probably 1-3 m-thick.

Qayh **High-level valley fills (Holocene) –** Pink to very pale brown (10-7.5YR 7/4) to reddish yellow (7.5YR 6/6) to light yellowish brown to light brown (7.5-10YR 6/4), very fine- to very coarse-grained sand terrace deposits that occupies the higher geomorphic positions in valley bottoms. Internally massive or very thin to medium, tabular bedded with internal laminations (planar- and cross-laminations). One or more buried soils up to 40-50 cm-thick may be present. These buried soils are characterized by weak development [A overlain by Btk or Bw horizon. A horizon: 5-10 cm-thick and light brownish gray (10YR 6/2). Btk or Bw horizon: light brown (7.5YR 6/3-4); strong, medium to very coarse, subangular-subrounded blocky peds that are hard with local clay films (5-25%, faint, and on ped faces); stage I calcic morphology]. Sand is very fine- to very coarse-grained (mostly fine- to medium-grained), moderately to well sorted, and subangular to rounded (mostly subrounded), and in most places composed of quartz, 15-20% orange-stained quartz and possible potassium feldspar, 1-3% volcanic grains, and 3-5% mafic grains. 1-5% scattered, very thin to thick lenses and lenticular beds of clast-supported, sandy very fine to very coarse pebbles and fine to coarse cobbles; clasts are angular to subrounded and poorly sorted. Sand may locally have minor silt or clay. The soil developed on top of this unit commonly has a 10-20 cm-thick, brown to pale brown (10YR 5-6/3) A horizon underlain by a thicker Bw or Btk horizon (Btk horizon: 20-50 cm-thick; moderate, medium to coarse, subrounded to subangular blocky peds with less than 5%, faint, clay films on ped faces; stage I calcic horizon). This unit between various drainages may not be time-correlative. Even in the same drainage, tread heights for this unit may differ by ~1 meter and the deposits underlying these different tread heights may represent distinct cut and fills (latter generally mapped as **Qayi** if the two treads are more than 2 m apart). Minor eolian sand is included in this unit, and minor dune forms may be present on top of this unit in the southwest part of the quadrangle. Weakly consolidated and up to ~12 m-thick.

Qao **Older alluvium alluvium (Pleistocene) –** Generally sand with minor sandy gravel or pebbly sand channel-fills. Unit is relatively common in the south-central to southwestern part of the quadrangle. The coarse-grained channel-fills are in thin to medium, lenticular beds and commonly clast-supported. The gravel ranges from pebbles to small boulders and contain quartzite, rhyolite, tuff and welded tuff, dacite, granite, Paleozoic sandstone, and white, porphyritic, hypabyssal intrusive clasts. Of these, welded tuff, rhyolite, dacite, quartzite, and granite are the most common. Clasts are poorly sorted and subrounded to subangular. Cobbles and boulders are generally composed of Ortega quartzite. Outside of the minor coarse channel-fills, sand is horizontally bedded (laminated to very thin- to thin-bedded) or else massive, and locally has 1-5% scattered very fine to fine pebbles and very coarse sand of comparable composition to the aforementioned gravel. Sand is very pale brown (10YR 7/3-4) to light yellowish brown (10YR 6/4), fine- to very coarse-grained (mostly fine- to medium-grained), subangular to rounded (mostly subrounded), moderately to well sorted, and composed of quartz, 10-20% orange-stained quartz and possible potassium feldspar, 3-5% mafic grains, and ~3% felsic to intermediate volcanic grains. Approximately 1-3% of sediment consists of wavy laminations of slightly silty-clayey sand to silt-clay. Weakly consolidated and non-cemented. Base of deposit is generally not exposed, so thickness not known with certainty (probably up to ~20 m).

Qaog **Gravelly older alluvium (Pleistocene) –** Gravelly sand and sandy gravel that cap low ridges west of the Comanche rim. Clast types include quartzite, Tertiary volcanic rocks, granite, and minor epidote, amphibolite, vein quartz, Paleozoic sedimentary rocks, and Servilleta Basalt, (Table 2). Sand and gravel derived from erosion of higher Miocene through Pliocene deposits to the east near the Comanche rim. Very poorly exposed and loose. 1 to 3 m thick.

Qgb **Older alluvium with abundant basalt boulders (Pleistocene) –** Basalt-dominated, sandy gravel deposit with abundant boulders; found in the north-central part of the quad. This may represent remnants of a paleo-channel. Away from these presumed paleo-channels, no other basalt clasts are found this far west of the Comanche Rim on the surface. 1 to 5 m-thick.

Qtgh **High-level sandy gravel terrace deposit northwest of Mesa Vibora (lower Pleistocene) –** Sandy gravel comprising an extensive high-level terrace deposit northwest of Mesa Vibora and south of Cañada de los Comanches. No exposures available to described bedding. Gravel is subrounded to rounded (mostly subrounded), poorly sorted, and consists of very fine to very coarse pebbles and fine cobbles, with 3-10% coarse cobbles. Clasts consist of subequal felsic volcanic rocks compared to Proterozoic metamorphic rocks (mostly quartzite and lesser gneissic metarhyolites). Felsic volcanic rocks are composed of rhyolite and rhyolitic tuffs (including assorted welded tuffs and the Amalia tuff). Loose to weakly consolidated. Age of this deposit is 1.6 Ma because a bed of Guaje pumice occurs in the same terrace deposit near Ojo Caliente, located 4-8 m above the strath (Koning et al., 2005; Nelia Dunbar, written commun., 2006; Izett and Obradovich, 1994; Spell et al., 1996). 6-12 m-thick.

Qtsh **High-level sand and pebbly sand, fluvial and slopewash deposit that overlies sandy gravel northwest of Mesa Vibora (lower Pleistocene) –** An internally massive deposit of sand containing 1-5%, volcanic and quartzitic, very fine to very coarse pebbles. Estimate 1% clay and silt in the sand. The sand is mostly very fine- to lower-medium-grained, with an estimated 3-5% upper-medium to upper-very coarse sand. Sand is subrounded to subangular, moderately to poorly sorted, and reddish yellow (7.5YR 6/6). Deposit is interpreted as an intercalated fluvial and slopewash deposit. Approximately 6-12 m-thick.

PLIOCENE-PLEISTOCENE DEPOSITS OF THE SANTA FE GROUP

QTae **Sand and minor sandy pebbles that overlie Servilleta Basalt flows (Pliocene, possibly Pleistocene in part) –** Reddish yellow to light brown (7.5YR 6/4-6) to very pale brown (10YR 7/3-4), massive sand. Sand is fine- to medium-grained, subrounded to well-rounded, well-sorted, and similar to the Ojo Caliente Sandstone Member (Tesuque Formation) in composition. Sandy pebbles are commonly in thin to medium, lenticular beds. Pebbles are subrounded, moderately sorted, and composed of rhyolite and felsic tuffs and welded tuffs. Minor beds of strong brown (7.5YR 5/6) fine- to medium-grained sand with 0.5% clay. Post-basalt alluvium is not exposed in the southeastern map area but float here contains some slate and more quartzite (?) than to the north. Deposit may represent local fluvial reworking of older Pliocene deposits and eolian sediment. May be eolian in part. Thickness is uncertain, but we infer this to be a relatively thin unit (mostly < 10 m) that mantles older strata.

PLIOCENE VOLCANIC ROCKS

Tsb **Servilleta Formation basalt flows (lower Pliocene) –** Dark-gray, diktytaxitic olivine tholeiite that forms thin, fluid, widespread pahoehoe basalt flows of the Taos Plateau volcanic field. These flows commonly form columnar-jointed cliffs on the west-facing

Comanche Rim. Tabular plagioclase and sparse olivine are the only phenocrysts. Two flows are present on this quadrangle that are separated by 7 km. The northern flow on this quadrangle returned a ^{40}Ar/^{39}Ar age of 4.63 ± 0.09 Ma (Appelt, 1998) and overlies unit Tscv. ^{40}Ar/^{39}Ar analyses of the southern flow is pending; this flow appears to overlie units **Tscv** and **Tats**, **Tscp**, and **Tsto** (from north to south). 2-4(?) m-thick on the Comanche rim but flows may thicken to the east.

Tbd **Basalt dike (middle Miocene to lower Pliocene) –** 20 to 400 cm-wide, discontinuous dikes of gray to black basalt that intrude units **Tsto**, **Tstoc**, **Tstc**, and **Tspv**. Dikes are commonly injected along fault zones north of Cañada de los Comanches. Near Mesa Vibora, basalt dikes have 0.5% olivine phenocrytsts up to 0.5 mm and do not appear to be emplaced along fault zones. It is not known whether the dikes south and north of Cañada de los Comanches are of the same age (sample from dike at north quadrangle boundary is undergoing ^{40}Ar/^{39}Ar analyses.).

Tbs **Basalt sill(?) (middle Miocene to lower Pliocene) –** Gray to black, semi-tabular bodies of basalt less than 1-2 m-thick. These form semi-circular-shaped outcrops 15-30 m-wide. Mapped by Mesa Vibora in two areas. 700 m south of this mesa, this unit is a black, dense basalt that bears 1% greenish olivine crystals up to 1 mm in size; this unit overlies phreatomagmatic deposits (unit **Tspv**). 1.4 km northeast of Mesa Vibora, another tabular body of basalt has semi-vertical to slanting (25-65° inclination to SW) columnar jointing and directly overlies the Ojo Caliente Sandstone Member of the Tesuque Formation; no phreatomagmatic deposits are present here and the basalt is vesicular. Both units are connected to feeder dikes. These units are interpreted as very shallow sills, fed by adjoining vertical dikes, that were injected either into phreatomagmatic deposits or the Ojo Caliente Sandstone Member. Alternatively, they may have filled shallow craters in these units. Probably 4.0-4.5 Ma based on ^{40}Ar/^{39}Ar ages of Appelt (1998) (Table 3).

Tsbv **Basaltic vent facies of Servilleta Formation at or near Mesa Vibora (lower Pliocene)** – Very dark gray to black, dense basalt in thick to very thick, discontinuous to continuous beds that appear to fill a former crater based on its circular outcrop pattern and position above inward-dipping phreatomagmatic deposits. In lower part of unit, basalt beds are intercalated with basaltic tephra and agglutinate. Dated using ^{40}Ar/^{39}Ar methods at 4.0-4.5 Ma by Appelt (1998) (Table 3). 40-45 m-thick.

Tspv **Phreatomagmatic deposits of Servilleta Basalt, consisting primarily of basaltic detritus (lower Pliocene) –** Pale yellow (2.5Y 7/3-8/2) sand and gravel in beds that dip inward toward Mesa Vibora or, in exposures south of Mesa Vibora, are generally massive. Beds are laminated to medium, and wedge-shaped to planar to wavy. Composed of clast- to matrix-supported sandy pebbles to fine cobbles, with minor coarse cobbles and boulders. Matrix consists of tuffaceous, subrounded, mostly fine- to medium-grained sand similar in composition and texture to the Ojo Caliente Sandstone of the Tesuque Formation (composition of quartz, 15% orange-stained quartz and possible Kspar, 3% mafic grains, and 3% volcanic grains). The cobbles and boulders are of basalt and angular to subangular and very poorly sorted. Pebbles and coarse to very coarse sand are subangular to subrounded and generally consist of relatively soft pumice, basaltic scoria, or altered basaltic lapilli cinders. Gravel and very coarse sand has subordinate basalt clasts and 3-10% pebbles consisting of Santa Fe Group clasts that include porphyritic dacite and rhyolite (most common), red granite, granodiorite, rhyolitic tuffs and flows (including Amalia Tuff), white, porphyritic hypabyssal intrusive clasts, and quartzite. Where present, boulders are up to 1 m-long and have deformed underlying beds into a sag structure. Unit probably shortly pre-dates unit Tsbv (4.0-4.5 Ma; Table 3). As much as 60-120 m-thick.

Tsps **Phreatomagmatic deposits of Servilleta Basalt, consisting primarily of sediment detritus (lower Pliocene) –** Very pale brown to light yellowish brown (10YR 6-7/4) sand with scattered very fine to very coarse pebbles of green Paleozoic sandstones (most common), rhyolite, dacite, granite and granodiorite, and trace gabbro. Beds are planar and very thin to thick. Deposit surrounds Mesa Vibora on its east and south side (possibly on the north and west side as well) and beds dips steeply inward similar to overlying deposits of Tspv. Weakly consolidated. Gravel is similar in composition to that in units **Tatn and Tats**. Unit probably shortly pre-dates unit Tsbv (4.0-4.5 Ma; Table 3). Approximately 90-100 m-thick.

PLIOCENE SEDIMENTARY DEPOSITS OF THE SANTA FE GROUP

Tatu **Undivided sand and gravel alluvium derived from the Taos Range and exposed along the western slope of the Comanche Rim (Pliocene) —** Units **Tatn** and **Tats** that were not differentiated due to thinness of the respective deposits. Complete descriptions of these sedimentary units are provided below.

Tatn **Sand and gravel alluvium derived from Taos Range north of the town of Taos and exposed along the western slope of the Comanche Rim (Pliocene) —** Brown to pale brown (10YR 5-6/3), light yellowish brown (10YR 6/4), or light brown to reddish yellow (7.5YR 6/4-6) sandy gravel and gravelly sand. Differentiated from unit **Tats** mainly by its lack of Paleozoic sandstone clasts. Sandy gravel generally occupies channel-fills, where it is generally in very thin to thin, planar to lenticular beds or planar- to tangential cross-stratified. Sandy gravel beds are commonly clast-supported. Pebbly sand beds may be somewhat silty and are typically planar-laminated to cross-stratified (very thin to thin beds or laminations) within medium- to thick-beds; the pebbly sand may also be massive. Gravel consists of subrounded to subangular, poorly sorted pebbles with 3-20% (mostly 3-5%) fine to coarse cobbles. Clast types include rhyolite flow rocks and felsic tuffs and welded tuffs (including 1-5% Amalia Tuff) with minor granite, granodiorite, quartzite, dacite, and basalt together with very minor vein quartz, Paleozoic sandstone, amphibolite, trace gabbro-diorite, and 3-5% greenish white, quartz-bearing, porphyritic hypabyssal intrusive clasts (Table 1). Clast imbrication direction is variable, indicating paleoflow directions ranging from northwest to southeast. Combining channel trends with imbrication data indicates a general flow direction to the northwest-southwest. The clast composition, in particular the presence of gabbro-diorite, mylonitized quartz diorite-granodiorite, and Amalia Tuff, indicates a source area in crystalline and volcanic rocks north of Taos. In the northern quadrangle, Paleozoic clasts are generally less than 0.5% of gravel fraction, except very locally in cobble beds at the base (lower 1-1.5 m) of the deposit. The percentage of coarse cobbles and boulders increase laterally towards adjacent Servilleta Basalt flows, and generally found only in the lower part of the deposit. Sand is very fine- to very coarse-grained (mostly medium- to very coarse-grained, subrounded to subangular (mostly subrounded), moderately to poorly sorted (mostly poorly sorted), and volcanic-rich litharenite to lithic arkose in composition. Unit is inset below the top of the southern Servilleta Basalt flow, and overlies the northern Servilleta Basalt flow. Thus, it post-dates both of these flows. Unit locally underlies the basalt that caps Black Mesa to the south (Koning, 2004), which has an age of approximately 3.5 Ma (Koning and Manley, 2003; Koning and Aby, 2003; Koning, 2004; Maldonaldo and Miggins, in press). This unit also grades southward into sandy gravel of **Ttas**. Thus, we assign an age of 3.5-4.6 Ma to this unit. Weakly to moderately consolidated, with locally minor moderate to strong cementation by calcium carbonate. This unit has not been formally assigned a formation or member-rank designation. 1-25 m-thick

Tats **Sand and gravel alluvium derived from Taos Range south of the town of Taos and exposed along the western slope of the Comanche Rim (Pliocene) —** Sand and gravel in very thin to thick, lenticular to planar to low-angle, cross-stratified beds. Differentiated from unit **Tatn** mainly by the appearance of relatively abundant Paleozoic sedimentary clasts. Gravel consists of pebbles with subordinate fine to coarse cobbles. Local quartzite boulders are present near Cerro Azul. Clasts are subrounded, poorly sorted, and commonly clast-supported. Lithologic types are dominated by felsic volcanic rocks, Paleozoic sandstone and siltstone, quartzite, and granite with minor intermediate volcanic rocks, basalt, vein quartz, and amphibolite (see Table 1). Sand is light gray (10YR 7/1-2), fine- to very coarse-grained, subrounded to subangular, poorly sorted, and composed of quartz and plagioclase with 10% orange-stained quartz and possible potassium feldspar, and ~15% felsic to intermediate volcanic grains along with minor mafic minerals. This deposit sharply overlies the underlying unit (**Tscv**) over a scoured contact and is found beneath the southern Servilleta Basalt flow (Figure 4). On the southeast corner of Cerro Azul, the lower few meters of a sandy gravel inset below the southern basalt flow consists of this unit, which is overlain by much thicker **Tatn** sediment; here, boulders of the adjacent basalt are cemented within this unit immediately adjacent to the southern basalt flow. Thus, this unit both pre-dates and immediately post-dates this southern basalt flow. This unit pre-dates the phreatomagmatic deposits found in Mesa Vibora (4-4.5 Ma) because of the appearance of Paleozoic sandstone clasts and red granite clasts in these phreatomagmatic deposits (both of which are very sparse in **Tatn**). Unit grades laterally northward into unit **Tatn**. Thus, we believe the most probable age of this unit is 4-5 Ma. Loose, but locally moderately to strongly cemented by calcium carbonate. This unit has not been formally assigned a formation or member-rank designation. 1-8 m-thick.

Tap **Sand and gravel alluvium derived mostly from Picuris Moutnains and exposed along the western slope of the Comanche Rim (Pliocene) —** Poorly exposed sandy gravel (with much cobbles and boulders) consisting of quartzite, Pilar slate, and Tertiary felsic clasts with very minor granite, intermediate volcanic clasts, and Paleozoic sedimentary clasts. Age pre-dates the southern basalt flow and is probably similar to that of unit Tats (4-5 Ma). Thickness not known.

MIOCENE-PLIOCENE(?) SEDIMENTARY DEPOSITS OF THE SANTA FE GROUP

Tscv **Vallito Member of Chamita Formation: sand and pebbly sand derived from fluvial reworking of Ojo Caliente Sandstone and from the Taos Range (upper Miocene, possibly lower Pliocene) –-** Very pale brown (10YR 7/3) to light yellowish brown (10YR 6/4) to brownish yellow (10YR 6/6) to light brown (7.5YR 6/4) to reddish yellow (7.5YR 6/6), fine- to very coarse-grained sand (mostly fine to medium). Distinguished from Pliocene-age units (i.e., **Tatn** and **Tats**) by paucity of gravel, and from the underlying Ojo Caliente Sandstone by the lack of thick cross-stratification and the presence of very coarse sand grains and 1-5% pebbles. Sand generally lacks bedding (i.e., is massive) or else is in medium to thick, tabular to broadly lenticular beds that are internally laminated. Estimate 1-5% very thin to thick, tabular clay beds (brown to strong brown to reddish brown to yellowish red; 7.5YR 5/4-6 and 5YR 4/4-5/6) and 1-3% silt beds (very pale brown to pale yellow; 10YR-2.5Y 7/4). Sand is subangular to rounded (mostly subrounded), moderately to well sorted, and composed of quartz, 15-20% orange-stained quartz and possible potassium feldspar, 5-15% mafic grains, 3-10% felsic to intermediate volcanic grains, and trace to 1% green quartz grains and Paleozoic sedimentary fragments. Locally has minor very fine sand. Sand is similar in composition and texture to the Ojo Caliente Sandstone Member of the Tesuque Formation. Trace to 7% very fine to coarse (mostly very fine to medium) pebbles of rhyolite, felsic tuff, welded felsic tuff, greenish Paleozoic sedimentary clasts, dacite, quartzite, and granite (most to least abundant). Pebbles are mostly scattered or locally in very thin lenses. Trace basalt pebbles seen under the northern Servilleta Basalt flow. Pebbles are subrounded and moderately sorted. No direct age control for this unit on this quadrangle except that it is older than the Servilleta Basalt flows and younger than the Ojo Caliente Sanstone Member of the Tesuque Formation (11-5 Ma). This unit is appreciably different in composition and texture compared to the overlying **Tatn and Tats** deposits and these overlying deposits have scoured into this unit. Thus, the upper contact of this unit is an unconformity. The lower contact with the underlying Ojo Caliente Sandstone Member of the Tesuque Formation was not exposed. Weakly to well consolidated (mostly weakly to moderately consolidated) and non-cemented except for locally very minor cementation by calcium carbonate. 5-21 m-thick.

MIOCENE SEDIMENTARY DEPOSITS OF THE SANTA FE GROUP

Tsto **Ojo Caliente Sandstone of the Tesuque Formation (middle to upper Miocene) –** Very pale brown (10YR 7/3-8/2), cross-laminated to cross-very thinly-bedded sand in foresets as much as 5 m-thick. The cross-stratification, very pale brown color, and generally abundant upper-fine to lower medium grain size serve to differentiate this unit from **Tscv** and **Tstc**. Near its base, the unit may have a pink color (7.5YR 7/3) and is slightly finer-grained. Sand is fine- to medium-grained, subangular to rounded (mostly subrounded), well sorted, and composed of quartz with 15-18% orange-stained quartz and possible potassium feldspar, 1-5% felsic to intermediate volcanic grains and chert, and 3-5% mafic grains. Unit grades downward into **Tstoc**. Weakly to moderately consolidated, with locally minor strong cementation by calcium carbonate south of Highway 285. North of Highway 285, this unit may be pervasively indurated by calcium carbonate and silica cements. Unit grades laterally northward into **Tstoc** near the northern quadrangle boundary. Thickness is not confidently known, but cross-section suggests a maximum thickness of 200-250 m.

Age control for this unit is not available on this quadrangle. To the southwest of the quadrangle, the Pojoaque white ash zone is interpreted to extend into the basal part of this unit (Koning, 2004). The Pojoaque white ash zone has an interpreted age of 14.0-13.2 Ma (Koning et al., 2005b, and Koning, 2002, based on data from Izett and Obradovich, 2001, Barghoorn, 1981, Tedford and Barghoorn, 1993, and the revised geomagnetic polarity time scale of Cande and Kent, 1995). An interpreted 11.3 Ma Trapper Creek ash is present in the upper Ojo Caliente Sandstone Member under southern Black Mesa (Nelia Dunbar, written commun., 2005; Koning, 2004). Thus, the age range of the Ojo Caliente Sandstone is interpreted to be approximately 13.4-11.0 Ma.

Tstoc **Mixed and/or interbedded Ojo Caliente Sandstone and Chama-El Rito Members of the Tesuque Formation (middle Miocene) –** This unit occupies the vertical gradation between the Ojo Caliente Sandstone and Chama-El Rito Members of the Tesuque Formation. It is also applied to sediment laterally contiguous with the Ojo Caliente Sandstone Member of the Tesuque Formation, where the eolian sand of this member is intercalated with redder fluvial sand and clay beds. Outcrops are commonly pink to very pale brown (7.5R 7/3-4; 7.5YR 8/3; 10YR 7/3) and locally reddish yellow (7.5YR 6/6) and in thin to thick, tabular beds (internally planar-laminated, massive, or cross-laminated with local clay rip-ups). Sand is fine- to medium-grained (mostly fine-grained), subrounded to subangular, and well sorted. Locally at the base of meter-scale cross-beds are coarse to very coarse volcanic pebbles, indicating that fluvial processes generated some of the thick cross-stratification. Sand is composed of quartz with 15-25% orange-stained quartz and possible potassium feldspar, 3-7% mafic grains, and 1-5% felsic to intermediate volcanic grains. The presence of clay rip-ups, local coarse to very coarse volcanic grains, and local, very thin to medium lenses of very fine pebbles help to distinguish this unit from the overlying Ojo Caliente Sandstone Member (**Tsto**). North of Cañada de los Comanches, this unit is typically strongly cemented by calcium carbonate and silica cement. South of this drainage, unit is generally non-cemented and weakly to moderately consolidated. Unit is slightly older than the Ojo Caliente Sandstone Member where it underlies this member, and equivalent in age to the Ojo Caliente Sandstone Member where the two laterally grade into one another (11-13.5 Ma). 3-30 m-thick.

Tstc **Chama-El Rito Member of the Tesuque Formation (middle Miocene) –** Pink (7.5YR 7/3-4) to reddish yellow (7.5YR 6/6) sand in medium to very thick, tabular beds that are internally massive or planar-laminated, and less commonly cross-laminated. Sand is typically fine-grained (subordinate very fine-grained and medium-grained sand), subangular to subrounded, well sorted, and composed of quartz, 15-25% orange-stained quartz and possible potassium feldspar, 1-5% felsic to intermediate volcanic grains, and 3-10% mafic grains. 1-5% of sediment consists of very thin to thin, planar, reddish brown (5YR 4-5/4) to yellowish red (5YR 4/6) clay and sandy clay beds. Generally weakly to well consolidated and non-cemented, although strong cementation may be expected north of Cañada de los Comanches.

In lower parts of unit are subordinate interbeds of light gray to gray, coarse volcaniclastic channel-fills similar to unit **Tstpc** except that the gravel contains slightly more rhyolite (1-5%) and Proterozoic clasts (trace). These coarse channel-fills are up to 3 m-thick and are internally planar-laminated to medium bedded (planar to lenticular), with minor internal planar, very thin to laminated cross-stratification having foresets less than 1 m-thick. Clast imbrication and channel trends in these coarse channel-fills indicate a southwest to southeast range in paleocurrent directions. The coarse channel-fills are composed of pebbly sand and sandy pebbles with ~5% fine to coarse cobbles; gravel is subrounded, poorly to moderately sorted, and composed mostly of porphyritic dacite having greater than 10% phenocrysts of long (up to 6 mm) feldspar; there is also 10-15% white, weathered, pebbles composed of biotite tuff. The sand of the coarse channel-fills is gray to light gray (10YR 6/1-7/2), fine- to very coarse-grained, subrounded to subangular, poorly sorted, and a litharenite (fine sand appears arkosic, but that may be due to presence of orangish, clayey tuff particles). Unit sharply to gradationally overlies volcaniclastic sediment of **Tstp,** and is gradationally overlain by sediment of unit **Tstoc**. Unit is 30-40 m-thick.

Age control for this unit is not available on this quadrangle. To the south, the Pojoaque white ash zone is present in the upper part of this unit (Koning, 2004). The Pojoaque white ash zone has an interpreted age of 14.0-13.2 Ma (Koning et al., 2005b, and Koning, 2002, based on data from Izett and Obradovich, 2001, Barghoorn, 1981, Tedford and Barghoorn, 1993, and the revised geomagnetic polarity time scale of Cande and Kent, 1995). Fossil data (Tedford and Barghorn, 1993) and a 15.3 ± 0.4 Ma K/Ar date from a basalt bomb in this unit (Ekas et al., 1984) suggest a maximum age of 16-18 Ma. However, we suspect that the age range of the Chama-El Rito Member as mapped on this quadrangle is 13.4-15 Ma (see age discussion of unit **Tsto**), with the underlying volcaniclastic sediment (**Tstp**), being equivalent to the age of the middle and lower Chama-El Rito Member to the south because of interfingering relations of the lower to middle Chama-El Rito Member with this volcaniclastic sediment.

Tstpc **Coarse volcaniclastic alluvium of the Plaza lithosome, Tesuque Formation (middle Miocene) –** Gray to pale brown (10YR 6/1-6/3 and 10YR 5/1) and minor reddish yellow (7.5YR 6/6), tuffaceous pebbly sandstone to sandy conglomerate that includes both stream-flow and subordinate debris-flow deposits. Gravel are generally pebble-size with 5-15% cobbles and up to 3% boulders (by sediment volume). Debris flow deposits are in thick, tabular to broadly lenticular beds that are internally massive, matrix-supported, very poorly sorted, and may have relatively abundant boulders up to 1 m-long; color of these debris flows is light gray to white (10YR 7-8/1). The bouldery debris flow deposits become more common northwards. Stream-flow deposits are in very thin to medium, lenticular to broadly lenticular to planar beds of sandy pebble conglomerate and pebbly sandstone (pebbly sandstone is also planar-laminated). Pebbles are very fine to very coarse (mostly very fine to medium), clast- and matrix-supported (mostly matrix-supported), subrounded to subangular, poorly to moderately sorted, and are composed of porphyritic dacite with >10% feldspar phenocrysts as long as 8 mm and 1-3% hornblende phenocrysts and 0.5% biotite pheocrysts; there are 10-40% pebbles of weathered, white, quartz-plagioclase-biotite-bearing tephra clasts; rhyolite is generally significantly less than 5% of the gravel fraction. The tuffaceous sand matrix is a very fine to very coarse (mostly medium to very coarse) and poorly sorted. Fine-grained sand is generally angular to subangular and composed of plagioclase and minor orangish clay (probably altered tuff), quartz, and possible potassium feldspar. Medium to very coarse sand mostly consists of subrounded dacite detritus. Estimate 5-8% tuff, much of which is altered to orangish clay (as seen in a hand lens). Upper part of unit includes up to 15% reddish yellow, medium to thick, tabular sandstone and pebbly sandstone beds that are clayey and possibly have more quartz in the fine-grained fraction than the volcaniclastic sand. Overall gravel size increases to the north. Available measurements of clast imbrication and channel trends suggest an overall southwest paleoflow. This unit correlates with the Plaza lithosome of Ingersoll et al. (1990). Unit was assigned to the Los Pinos Formation by May (1980 and 1984), but for now we place it in the Tesuque Formation because the wide lateral gradation of this unit with the Chama-El Rito Member (observed west of this quadrangle) makes it difficult to map there. Well consolidated and weakly cemented by clay. Estimated to be 90-140 m-thick.

K/Ar ages from gravel in the Chama-El Rito Member assigned to the Plaza petrosome (petrologic equivalent of “lithosome”) ranged between 21.7 ± 0.5 and 22.6 ± 0.5 (Ekas et al., 1984; Ingersoll et al., 1990). The clast ages likely serve as a maximum age for the unit. The minimum age is probably ca. 15 Ma (our preferred maximum age of the overlying Chama-El Rito Member).

PROTOROZOIC METASEDIMENTARY ROCKS

Xoq **Ortega Quartzite of the Hondo Group (early Proterozoic) –** Light gray quartzite that is planar laminated, with minor wavy to cross-laminations (5 cm-thick foresets). Laminations are defined by concentrations of non-biotite, mafic minerals. Up to 20% fibrous silliminite is found in foliation planes; these are typically in radiating clusters up to 10 mm-long. Foliation has developed approximately parallel to bedding. Viridine-bearing quartzite is found on the northeast end of Cerro Azul. Exposed thickness is 825 m, total thickness here is unknown.

UNITS USED IN CROSS-SECTION THAT ARE NOT EXPOSED ON THE QUADRANGLE

Td **Dacite and rhyodacite flows that overlie the Hinsdale Basalt (early Miocene) –** Reddish brown to black, porphyritic dacite and rhyodacite flows containing phenocrysts of feldspar and lesser amounts of hornblende and biotite (and quartz in the rhyodacites). Observed and described on the La Madera quadrangle to the northwest (see Koning et al., 2007). We apply this unit to driller’s descriptions of red granite or red volcanic rock in section 11 of Township 24 North, Range 9 East.

Thb **Hinsdale Basalt (late Oligocene to early Miocene) –** Gray to dark gray, olivine-bearing basalt rocks that locally underlie the dacite and rhyodacite flows. These basalts are described fully in May (1980 and 1984) and Koning et al. (2007). Fractured basalt provides a local target aquifer.

Xv **Vadito Group (Paleproterozoic) –** Tan to gray colored, metasedimentary and metavolcanic rocks that are fully described in Koning et al. (2005 and 2007).

Xu **Undivided metamorphic rocks (Paleoproterozoic) –** Probably includes the Vadito Group together with Ortega quartzite (units Xv and Xq).

OVERVIEW OF MIOCENE-AGE STRATIGRAPHY AND STRUCTURE OF THE QUADRANGLE AND IMPLICATIONS FOR HYDROGEOLOGY

Groundwater may potentially be found in the Miocene- to Oliogocene-age strata that overlie Proterozoic crystalline rocks, in addition to fractures within the Proterozoic crystalline rocks. Exposed Proterozoic rocks on this quadrangle belong to the Ortega Quartzite of the Hondo Group. Folding of Proterozoic strata has probably resulted in metasedimentary and metavolcanic rocks of the Vadito Group being laterally adjacent to the Ortega Quartzite (see cross-section of Koning et al., 2007). Measured fractures or joints in the Ortega Quartzite have two main orientations (Figure 5). The most common joint orientation is a set having a 290-350 strike and a steep southwest to vertical dip (at Cerro Azul) and a 40-90 northeast dip (in the northwest part of the quadrangle). In the northwest part of the quadrangle, there was also a north- to east-striking joint set(s) that had variable dips. The joints in the Proterozoic rock may possibly impart a preferential southeast-directed flow direction in those rocks.

Based on well data and observations in the La Madera quadrangle to the northwest (Koning et al., 2007), we interpret that the Hinsdale basalt overlies the Proterozoic crystalline rocks. Over these basalts may possibly lie reddish brown to black, porphyritic dacite and rhyodacite flows (also based on driller's cuttings reports and observations in the La Madera quadrangle to the northwest). Wells in section 11of T.24N., R.9E. are reported to draw groundwater from fractured Hinsdale basalts (Benson, 2004, fig. 2).

The oldest exposed unit that probably overlies the dacite-rhyodacite flows is the Plaza lithosome of the Tesuque Formation. This tuffaceous, volcaniclastic, pebbly sandstone to sandy conglomerate has distinctive dark gray to purplish gray, coarse-porphyritic dacite clasts. Clast size in this unit increases northwards, and bouldery debris flow deposits are observed in the northern 2 km of the quadrangle. The Plaza lithosome is interpreted to have been derived from a high-standing, largely dacitic volcanic edifice north of the town of Servilleta Plaza (Ingersoll et al., 1990; Koning et al., 2007). Although not strongly cemented, the tuffaceous character of this deposit probably results in relatively low hydraulic conductivity values.

The Plaza lithosome is sharply to gradationally overlain by orangish, fine sand of the Chama-El Rito Member (**Tstc**) of the Tesuque Formation. This orange, fine sand is intercalated with minor pebbly channel-fills that are generally similar in composition to the Plaza lithosome. These coarse channel-fills decrease up-section. Gradationally overlying the Chama-El Rito Member is the gradational unit **Tstoc**; the latter is overlain by the Ojo Caliente Sandstone Member (**Tsto**) over much of the quadrangle. South of Cañada de los Comanches, these three units are generally not cemented and would be expected to have somewhat higher hydraulic conductivity values compared to the underlying units. However, in section 11 of T.24N., R.9E., these three units were not saturated and stock wells drilled in the southern part of the quadrangle, presumably into these units, also were dry or had very low yields (personal commun. with Joe Martinez, local rancher, 2003). Overlying the Ojo Caliente Sandstone is the sandy Vallito Member of the Chamita Formation, but it is not saturated on this quadrangle.

Strata in the quadrangle generally dip to the east at relatively low angles (generally 3 to 6 degrees for middle Miocene strata and approximately 2 degrees for Pliocene-age strata). There is a relatively tight synclinal, north-plunging(?) fold in a graben immediately north of the Cañada de los Comanches near the western border of the quadrangle. However, such folds are not common elsewhere. We did not find evidence in our interpretations of the well logs in section 11 of T.26N., R9E. of a west dip direction in the Servilleta Basalts, and the nearest surficial attitudes (1 km to the northwest) indicate an eastward dip.

The most important structural features on this quadrangle are normal and oblique-slip faults and grabens associated with these faults. North of Cañada de los Comanches, these faults are associated with prevalent cementation by silica and calcium carbonate. The most important fault is the Vibora fault zone, which is a west-down fault zone that strikes northward from Mesa Vibora past the northern quadrangle boundary. This zone is characterized by much stepping between faults and bending of faults. Measurement of slickenside data along this fault suggest a component of right-lateral slip along this fault. A 2-3 km-long, east-down fault zone strikes north along the western quadrangle boundary north of Cañada de los Comanches. Like the Vibora fault zone, it is also a right-oblique normal fault. The area between these two fault zones, coinciding with the aforementioned syncline, is a full-graben structure. Throw along the western fault zone is about 20 m, whereas the Vibora fault zone has experienced 60-150 m of throw. Along the Vibora fault zone is a north-south alignment of basaltic dikes (4-5 Ma?) and basaltic eruptive centers (4.0-4.5 Ma) that include Mesa Vibora.

The faults in the northwest corner of the quadrangle are associated with prevalent cementation of strata by silica and calcium carbonate.

An unnamed east-down fault strikes NNE from Mesa Vibora 0.5-1.0 km east of the Vibora fault zone. It may possibly link up with the east-down Black Mesa fault zone south of the quadrangle (see Koning and Aby, 2003) via the short, northeast-trending, relatively low-throw faults found near the southwest corner of the quadrangle. Throw along this structure is comparable to that of the Vibora fault zone.

Movement along these faults may create barriers to groundwater flow in two ways. One is the production of clay cores and cemented damage zones along the fault zones themselves, which is commonly seen in the area. Another way is the juxtaposition of a relatively less permeable unit against a more permeable unit. In regards to the latter, we infer that the horst between the Vibora fault zone and the east-down fault to the east probably acts as a groundwater barrier because it is cored by the tuffaceous Plaza lithosome of the Tesuque Formation, which probably has relatively low hydraulic conductivity. Groundwater flowing southwest along upper Cañada de los Comanches may be diverted southward along this structure, and this may possibly create the.southwest-sloping gradient observed in the potentiometric surface for wells in section 11 of T26N., R.9E. (Benson, 2004, fig. 1).

PLIOCENE-AGE SEDIMENTATION AND VOLCANISM

Most of the weakly to moderately consolidated, gravelly sediment underlying the Comanche Rim south of U.S. Highway 285 can be subdivided into two units (**Tatn** and **Tats**) , which may correlate with the QTg(rg) and QTg units of the Carson quadrangle to the east (Kelson and Bauer, 1998). These two units interfinger with one another in section 9 of T.24N., R.10E. The compositions of the gravel, discussed below, indicate derivation from the Taos Range, which is consistent with the general southwest-west paleoflow direction determined from channel trends and clast imbrication data at five sites along the rim. These five sites indicated a range of paleoflow data from the northwest to the south, with one site having a southeast paleoflow direction, but the general direction is to the southwest-west.

The two units (**Tatn** and **Tats**) exhibit distinctive gravel compositions reflecting different provenances within the Taos Range. **Tatn** contains Amalia tuff, trace gabbro-diorite, <5% Paleozoic sandstone and siltstone, >35% felsic volcanic clasts, and <20% quartzite (Table 1). The presence of gabbro-diorite and Paleozoic sedimentary clasts indicates that drainages associated with unit **Tatn** are probably not sourced in the Tusas Mtns, but rather from the crystalline-cored Taos Range north of Taos. The lead author has not encountered comparable gabbro-diorite or Paleozoic sandstone in his mapping of the southeastern Tusas Mountains (e.g., Koning et al., 2007, and unpublished reconnaissance mapping). Unit **Tats** has noticeably more green Paleozoic clasts than **Tatn** (>5% Paleozoic) and less felsic volcanic clasts (<35%), and generally more quartzite (>10% quartzite), but the latter is variable (Table 1). Unit **Tats** has a clast composition and paleoflow direction somewhat comparable with that of the Rio Pueblo de Taos (see table 1, Koning and Aby, 2003, for clast count data of the Rio Pueblo de Taos).

Immediately southeast of Cerro Azul, it is evident that the river associated with **Tatn** had incised a small valley into the southern Servilleta Basalt flow and then back-filled. The basal 1-2 m of **Tatn** there has abundant Pz clasts and looks like unit **Tats**, but we suspect that this basal gravel may represent reworking of unit **Tats** rather than being deposited by the **Tats** drainage. Immediately south of this paleovalley, unit **Tats** appears to underlie the basalt (Figure 3), but prevelant basalt talus precludes adequate thickness estimates. The southernmost exposure beneath the southern basalt flow (**Tap**) contains much Picuris Mountains detritus (i.e., quarzite, Pilar phyllite, felsic volcanics probably derived from Picuris Fm) and appears to represent a Pliocene-age alluvial fan flanking the northwest part of these mountains.

The relation of **Tatn** with the northern Servilleta Basalt flow is more enigmatic than its relation with the southern Servilleta Basalt flow southeast of Cerro Azul. However, we feel that available evidence suggests that **Tatn** also post-dates the northern basalt flow. First, there are large basalt boulders at the base of **Tatn** within 1 km south of the northern basalt flow. These basalt boulders are not in place, but we have not seen them in the middle or upper slopes of unit **Tatn**, so it is likely they are eroding from the lower part of the unit. Second, basalt cobbles also seem to become more abundant in unit **Tatn** as one approaches the northern basalt from the south. Third, the base of unit **Tatn** seems to be about the same stratigraphic level as the base of the northern basalt. Fourth, **Tatn** overlies the basalt (where good exposures in the railroad cut do not reveal basalt cobbles or pebbles). The simple presence of basalt gravel in this deposit does not necessarily indicate that this unit post-dates the northern basalt because the basalt clasts could be coming from other sources. However, the presence of basalt boulders near the base of **Tatn**, up to 1.5 m-long, is strongly suggestive of derivation from the nearby northern basalt flow.

Under units **Tatn** and the northern Servilleta Basalt is sandy sediment of the Vallito Member of the Chamita Formation (**Tscv**). Pebbles are present but very sparse (and only very fine to coarse pebble-size) and the sand is massive, suggesting slow aggradation and much bioturbation. Minor clay beds are also present. Clast composition of the minor pebbles found in **Tscv** include rhyolite, tuff and welded tuff, green Paleozoic sandstone, quartzite, and granite. The sand is similar to the sand found in the Ojo Caliente Sandstone of the Tesuque Formation. There is no paleocurrent data in this unit, but since the clast compositions are similar to that found in the overlying **Tatn** and **Tats** units, we infer that it also came from the Taos Range. This deposit is considerably finer-grained and more massive than the well-bedded, locally cross-stratified, gravelly sediment of **Tatn** or **Tats**. This sedimentological contrast is consistent with an unconformity between **Tscv** and the overlying **Tatn** and **Tats** units. Also, the base of the gravelly **Tatn** and **Tats** units seems to be scoured into the sandy **Tscv** unit.

From the above observations, we reconstruct the following paleoenvironmental scenario for the late Miocene through Pliocene transition. At times in the late Miocene, sluggish, sandy drainages associated with the Vallito Member of the Chamita Formation flowed west-southwest away from the Taos Range and then flowed more southerly under what is now Black Mesa (the Vallito Member underlies the basalt that caps Black Mesa, as documented in Koning and Aby, 2003). Not only was stream competency low for Vallito Member streams, but aggradation rates were low as well (only 6-21 m between 11-5 Ma) and bioturbation eradicated most of the original bedding. . The northern Servilleta Basalt was emplaced at 4.6 Ma (Appelt, 1998; Table 3) over the Vallito Member. This basalt may have flowed southeast parallel to a gravity gradient and inferred fault by Tien Grauch (shown on the map). A dramatic increase in stream competency occurred after the northern Servilleta Basalt was emplaced, probably due to climatic changes at the start of the Pliocene. Between 4.6 and 4.0-4.5 Ma, the streams depositing units **Tats** and **Tatn** flowed to what is now Mesa Vibora because the gravel of these units is observed in the lower phreatomagmatic deposits associated with the Mesa Vibora eruptions (unit **Tsps**).

These drainages probably turned south near Mesa Vibora and then flowed towards Black Mesa. In the badlands south of Mesa Vibora is much reworked (Quaternary) sediment (unit **Qao**) having a clast composition comparable to units **Tats** and **Tatn**. One does not see this type of sediment near the Rio Ojo Caliente, even though the **Qao** drainages likely flowed to the southwest, so we infer that the older **Tats** and **Tatn** drainages probably did not make it as far west as the Rio Ojo Caliente. Possible faulting along the Vibora fault zone and east-down faults near the southern part of the quadrangle (which likely represent the north end of the Black Mesa fault zone to the south; Koning and Aby, 2003) may have exerted a control on the **Tats** and **Tatn** drainages near Mesa Vibora. In fact, sediment similar to **Tatn** is found in the immediate hanging wall of the Black Mesa fault on the north slope of Black Mesa (Koning and Aby, 2003).

Tatn generally overlies **Tats** south of the private property in-holding in section 9 of T.24N., R10E., so it appears that the northern and southern streams shifted progressively southward shortly after 4.6 Ma. We speculate that the southern basalt flow post-dates the northern basalt flow because the southern basalt flowed over **Tats** gravel that is probably 4-4.6 Ma in age (since it predates the Mesa Vibora volcano and likely post-dates the northern basalt flow). Also, shortly after the southern flow was emplaced the river depositing **Tatn** was already nearby (due to the aforementioned southward shift) and it incised into this southern basalt. We do not see a significant **Tats** deposit above the southern flow, so we suspect that the southern Servilleta Basalt flow or else stream piracy diverted the ancestral Rio Pueblo de Taos to what is now the Rio Grande gorge at about the time of emplacement of this southern flow. The northern river depositing **Tatn** continued flowing southwest across the quadrangle after the diversion of the southern river. Volcaniclastic pebbly deposits similar to **Tatn** have been found overlying a 3.6 Ma basalt on northern Black Mesa (Koning and Aby, 2003). If these were deposited by the river associated with unit **Tatn** (rather than reworking of primary **Tatn** deposits by later streams), it follows that the northern river continued flowing across the southeastern quadrangle until shortly after 3.6 Ma, when it too may have been diverted into what is now the Rio Grande Gorge.

TECTONIC INFERENCES

A few basic inferences relating to tectonics may be made from observations on this quadrangle. First, there is no conclusive evidence of a northwest-trending, antiformal structure like that speculated by Koning et al. (2004). Basin-fill strata and the underlying late Oligocene-early Miocene volcanic rocks seem to generally dip east on this quadrangle, in the La Madera quadrangle to the northwest (Koning et al., 2007), and the Ojo Caliente quadrangle to the west (Koning et al., 2005). The northwest-striking gravity high that passes through Cerro Azul (illustrated in Plate 3 of Brister et al., 2004) is probably related to the northwest-trending Proterozoic folds documented in the aforementioned quadrangles to the northwest and west. This particular gravity high appears to be aligned along scattered outcrops of Ortega quartzite. We speculate that during the general uplift accompanying the Laramide orogeny, erosion left a northwest-alignment of Ortega quartzite-cored hills, exposed remnants which include Cerro Azul and the La Madera Mountains to the west of the northwest corner of the quadrangle. These hills were later buried by Rio Grande rift-related deposition but still leave an imprint on gravity data.

It is noteworthy that streams derived from the Taos Range flowed southwest-west across the eastern quadrangle during the late Miocene in spite of the general eastward tilt of strata, as indicated by deposition of the Vallito Member of the Chamita Formation on the Comanche Rim and similar deposits on the north flanks of Black Mesa. There were probably periods in the late Miocene during which eastward tilting rates were relatively low, which enabled the streams to go so far west. Most of the time, it is likely that the streams associated with the Vallito Member probably were flowing southwest east of Cerro Azul. This inference is based on observations in Cañada Comanche in the north-central Velarde quadrangle to the south. Here, the Vallito Member is significantly more pebbly than exposed along the Comanche Rim, has much more defined bedding (locally, cross-stratification is as much as 45 cm-thick), paleocurrent data are south- to southwest, and the Vallito Member is thicker than on this quadrangle (as much as 100 m-thick compared to 5-21 m thick on the Comanche Rim). Interpreted normal faulting during late Miocene-time in the lower Cañada Comache (on the Velarde quadrangle) may have created more accommodation space for Vallito Member deposition and induced streams of the Vallito Member to flow there much of the time.

In the time period of 4.0-4.6 Ma, discussed above, coarse-grained, Taos Range-derived rivers flowed across much of the quadrangle. This implies that discharge and sediment flux associated with these rivers exerted more of a control than eastward tilting at this time. There was also probably an appreciably low northwest-down throw component along the Embudo fault zone near Pilar (so that the rivers did not flow immediately alongside the fault). It is thus possible that initial Servilleta Basalt volcanism occurred during a time of relatively low tectonic activity. Subsequent to 4 Ma, strata along the Comanche rim were tilted eastward by about 2 degrees, so tilting continued after the initial basaltic volcanism.

ACKNOWLEDGMENTS

Anthony Benson provided data and important driller information for the wells along the cross-section line. He also informed us that the Hinsdale basalt constitutes an important aquifer in that area. The U.S. Geological Survey allowed us to use their photogrammetric laboratory, which greatly improved the accuracy of the mapping. As usual, Jim Messerich of the U.S. Geological Survey proved his adeptness in setting photogrammetric models on the PG-2 plotter.

REFERENCES

Appelt, R.M., 1998, 40Ar/39Ar geochronology and volcanic evolution of the Taos Plateau volcanic field, northern New Mexico and southern Colorado [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 58 p. plus appendices.

Barghoorn, S., 1981, Magnetic-polarity stratigraphy of the Miocene type Tesuque Formation, Santa Fe Group, in the Española Valley, New Mexico: Geological Society of America Bulletin, v. 92, p. 1027-1041

Birkeland, P.W., 1999, Soils and geomorphology: New York, Oxford University Press, 430 p.

Benson, A.L., 2004, Groundwater geology of Taos County: New Mexico Geological Society Guidebook, 55th Field Conference Guidebook, Geology of the Taos Region, p. 420-432.

Cande, S.C., and Kent, D.V., 1995, Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic: Journal of Geophysical Research, v. 100, n. B4, p. 6093-6095.

Compton, R.R., 1985, Geology in the field: New York, John Wiley & Sons, Inc., 398 p.

Cordell, L., 1979, Gravimetric expression of graben faulting in Santa Fe country and the Española Basin, New Mexico: New Mexico Geological Society, 30th Field Conference, Guidebook, p. 59-64.

Ekas, L.M., Ingersoll, R.V., Baldridge, W.S., and Shafiqullah, M., 1984, The Chama-El Rito Member of the Tesuque Formation, Española Basin, New Mexico: New Mexico Geological Society Guidebook, 35th Field Conference Guidebook, Rio Grande Rift, northern New Mexico, p. 137-143

Grauch, V.J.S., and Keller, G.R., 2004, Plate 3: Isostatic Residual Gravity – Southern San Luis Basin: New Mexico Geological Society, 55th Field Conference Guidebook, Geology of the Taos Region, p. 116.

Gile, L.H., Peterson, F.F., and Grossman, R.B., 1966, Morphological and genetic sequences of carbonate accumulation in desert soils: Soil Science, v. 101, p. 347-360.

Ingersoll, R.V., Cavazza, W., Baldridge, W.S., and Shafiqullah, M., 1990, Cenozoic sedimentation and paleotectonics of north-central New Mexico: Implications for initiation and evolution of the Rio Grande rift: Geological Society of America Bulletin, v. 102, p. 1280-1296.

Ingram, R.L., 1954, Terminology for the thickness of stratification and parting units in sedimentary rocks: Geological Society of America Bulletin, v. 65, p. 937-938, table 2.

Izett, G.A., and Obradovich, J.D., 1994, 40Ar/39Ar age constraints for the Jaramillo Normal Subchron and the Matuyama-Brunhes geomagnetic boundary: Journal of Geophysical research, v. 99, p. 2925-2934.

Izett, G.A., and Obradovich, J.D., 2001, 40Ar/39Ar ages of Miocene tuffs in basin-fill deposits (Santa Fe Group, New Mexico, and Troublesome Formation, Colorado) of the Rio Grande rift system: The Mountain Geologist, v. 38, no. 2, p. 77-86.

Kelson, K. and Bauer, P.W., 1998, Preliminary geologic map of the Carson quadrangle, Taos County, New Mexico. , New Mexico Bureau of Mines and Mineral Resources, Open-file Geologic Map OF-GM 22, scale 1:24,000.

Koning, D.J., 2004, Geologic map of the Lyden 7.5-minute quadrangle, Rio Arriba and Santa Fe counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Geologic Map OF-GM-83, scale 1:24,000.

Koning, D.J., and Aby, S., 2003, revised June-2004, Geologic map of the Velarde 7.5-minute quadrangle, Rio Arriba and Taos counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Geologic Map OF-GM-79, scale 1:24,000

Koning, D.J., and Manley, K., 2003, revised December-2005, Geologic map of the San Juan Pueblo 7.5-minute quadrangle, Rio Arriba and Santa Fe counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Geologic Map OF-GM-70, scale 1:24,000.

Koning, D.J., Ferguson, J.F., Paul, P.J., and Baldridge, W.S., 2004a, Geologic structure of the Velarde graben and southern Embudo fault system, north-central N.M.: New Mexico Geological Society, 55th Field Conference, Guidebook, p. 158-171.

Koning, D., Karlstrom, K. May, J., Skotnicki, S., Horning, R., Newell, D., and Muehlberger, W.R., 2005a, Preliminary geologic map of the Ojo Caliente 7.5-minute quadrangle, Rio Arriba and Taos Counties, New Mexico, New Mexico Bureau of Geology and Mineral Resources, Open-file Geologic Map OF-GM 101, scale 1:12,000.

Koning, Daniel J., Connell, Sean D., Morgan, Gary S., Peters, Lisa, and McIntosh, William C., 2005b, Stratigraphy and depositional trends in the Santa Fe Group near Española, north-central New Mexico: tectonic and climatic implications: New Mexico Geological Society, 56th Field Conference Guidebook, Geology of the Chama Basin, 2005, p. 237-257.

Koning, D., Karlstrom, K., Salem, A., Lombardi, C., 2007, Preliminary geologic map of the La Madera 7.5-minute quadrangle, Rio Arriba County, New Mexico, New Mexico Bureau of Geology and Mineral Resources, Open-file Geologic Map OF-GM XX-XX, scale 1:12,000.

May, J., 1980, Neogene geology of the Ojo Caliente-Rio Chama area, Española Basin, New Mexico [Ph.D. thesis]: Albuquerque, New Mexico, University of New Mexico, 204 p.

May, J., 1984, Miocene stratigraphic relations and problems between the Abiquiu, Los Pinos, and Tesuque formations near Ojo Caliente, northern Española Basin: New Mexico Geological Society, 35th Field Conference, Guidebook, p. 129-135.

Munsell Color, 1994 edition, Munsell soil color charts: New Windsor, N.Y., Kollmorgen Corp., Macbeth Division.

Soil Survey Staff, 1992, Keys to Soil Taxonomy: U.S. Department of Agriculture, SMSS Technical Monograph no. 19, 5th edition, 541 p.

Spell, T. L., McDougall, I., and Doulgeris, A.P., 1996, Cerro Toledo Rhyolite, Jemez volcanic field, New Mexico: 40Ar/39Ar geochronology of eruptions between two caldera-forming events: Geological Society of America Bulletin, v. 108, p. 1549–1566.

Steinpress, M.G., 1980, Neogene stratigraphy and structure of the Dixon area, Española Basin, north-central New Mexico [M.S. thesis]: University of New Mexico, Albuquerque, N.M., 127 p. plus 2 plates.

Steinpress, M.G., 1981, Neogene stratigraphy and structure of the Dixon area, Española basin, north-central New Mexico: Geological Society of America Bulletin, v. 92, p. 1023-1026.

Tedford, R.H., and Barghoorn, S.F., 1993, Neogene stratigraphy and mammalian biochronology of the Española Basin, northern New Mexico: Vertebrate paleontology in New Mexico, New Mexico Museum of Natural History and Science, Bulletin 2, p. 159-168.

Udden, J.A., 1914, The mechanical composition of clastic sediments: Bulletin of the Geological Society of America, v. 25, p. 655-744.

Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: Journal of Geology, v. 30, p. 377-392.

CAPTIONS

FIGURE 1. Index map of the Taos Junction quadrangle that shows areas mapped by the respective authors relative to major physiographic features.

FIGURE 2. Time-stratigraphic correlation of map units.

FIGURE 3. Schematic diagram showing north-south spatial relations of selected lithostratigraphic units. Figure is not to scale.

FIGURE 4. Stratigraphic section of Pliocene deposits on the southeast end of Black Mesa (site GTM-752).

FIGURE 5. Stereonet of joint sets measured in the Ortega Quartzite at Cerro Azul and in the northwest part of the quadrangle.

TABLE 1. Clast count data from Pliocene sedimentary deposits.

TABLE 2. Clast count data from Plio-Pleistocene sedimentary deposits

TABLE 3. Age data relating to Servilleta Basalts in and near Taos Junction (from Appelt, 1998)

PHOTO CAPTION: Photograph of Mesa Vibora, taken from the south. A distinctive landmark on this quadrangle, this mesa is composed of ejecta and basalt flows associated with a volcanic vent. $^{40}Ar/^{39}Ar$ ages of basalt samples at and around this vent are 4.0-4.5 Ma (Appelt, 1998). Three distinctive lithologic units are found here.

Locally at the base are phreatomagmatic deposits (Tsps) composed of sand from older sediment units (Ttan and Ttas) that were involved in an initial explosion created by molten basalt intruding into shallow groundwater. The types of gravel in this basal phreatomagmatic deposit indicate that a river(s) from the Taos Range was flowing here prior to the eruption. A second, overlying phreatomagmatic deposit (Tspv) is composed of sand mixed with gravel. The gravel and coarse to very coarse sand is composed of pumice, basaltic scoria, altered basaltic lapilli, and basalt together with minor assorted gravel from earlier Pliocene-Miocene sedimentary units. Capping the butte are near-vent facies of intercalated basaltic tephra, basaltic agglutinate, and basalt beds (Tsbv).

Comments to map users

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

The map has not been reviewed according to New Mexico Bureau of Mines and Mineral Resources standards. Revision of the map is likely because of the on-going nature of work in the region. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Mines 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. Cross-sections are constructed based upon the interpretations of the authors made from geologic mapping, and available geophysical (regional gravity and aeromagnetic surveys), 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.