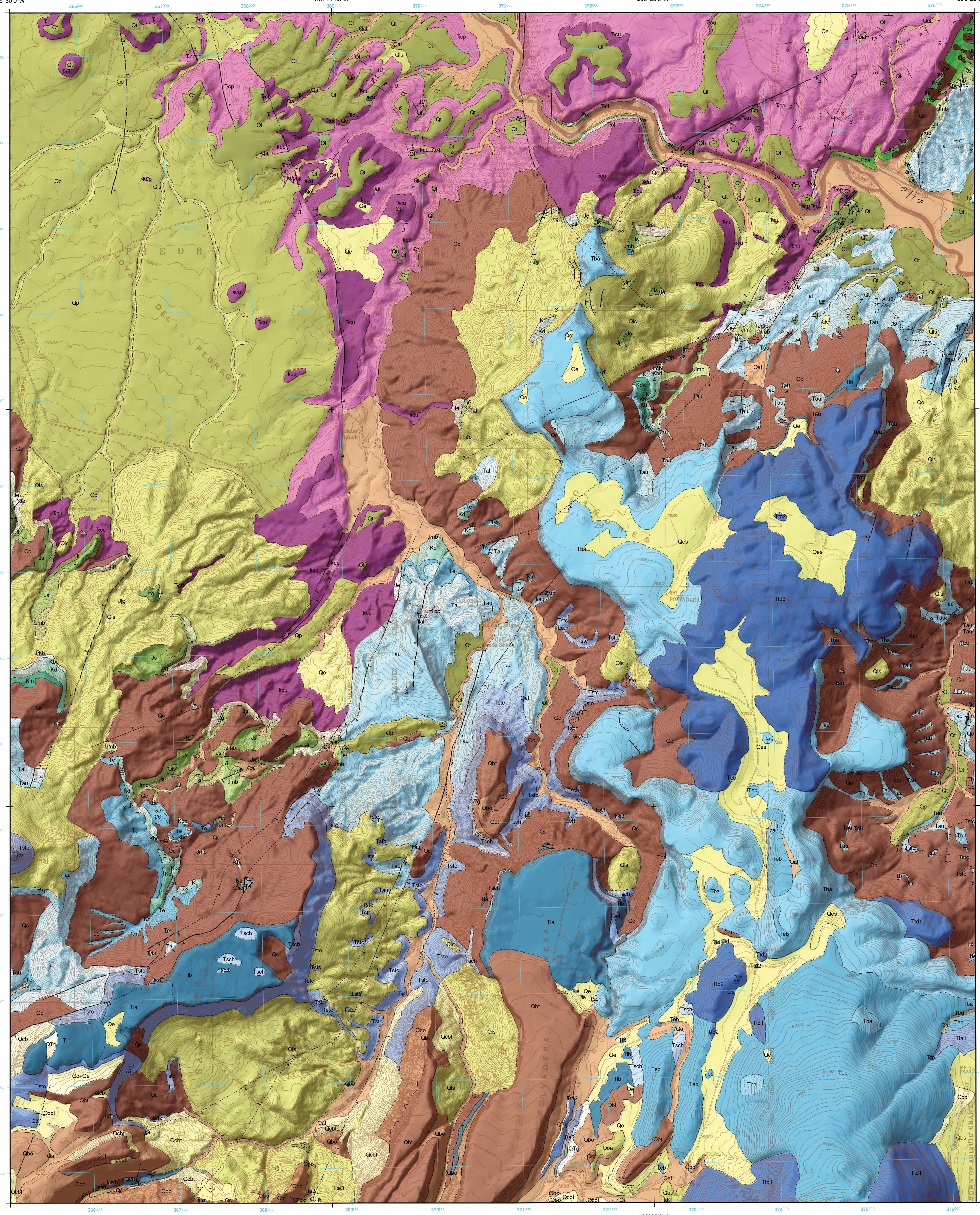
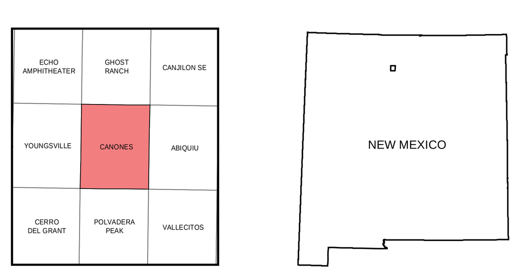


1:22,732

Base map from U.S. Geological Survey 1953, from photographs taken 1951, field checked in 1953. Polyconic projection. 1927 North American datum. Reprojected to UTM projection -- zone 13. 1000-meter Universal Transverse Mercator grid, zone 13, shown in blue

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Magnetic Declination May, 2005 9° 59' East At Map Center



QUADRANGLE LOCATION

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

[575] 835-5490

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

http://geoinfo.nmt.edu

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 107

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

Geologic map of the Cañones quadrangle, Rio Arriba County, New Mexico

May, 2005

by
Shari A. Kelley, G. Robert Osburn, Charles Ferguson, Jessica Moore, and Kirt Kempter

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

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

DRAFT

COMMENTS TO MAP USERS

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

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

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

The Cañones quadrangle lies at the boundary between the Rio Grande rift and the Colorado Plateau, and includes the Cañones fault zone, an important down-to-the-east structure (among many) that marks the transition between these two provinces. This transition zone between provinces extends to the west into the Youngsville and Coyote area (Lawrence, 1979: Kelley et al., 2005). The northern part of the Miocene to Pleistocene Jemez volcanic field covers about 35 percent of the southern and eastern portions of the area. A wonderfully complex history of late Paleozoic to Mesozoic deposition, Laramide-age deformation, erosion, and deposition, Rio Grande rift deposition and faulting, as well as Jemez volcanic field eruptive activity and subsequent deformation is preserved in this special place.

The most significant findings made during this project include (1) the recognition of previously unmapped Pliocene Tschicoma lava domes and flows; (2) establishing that Cañones Mesa is formed by a ~2.8 Ma basaltic andesite that overlies the ~3.0 Ma dacite of Cerro Pelon and underlies El Alto basalt; (3) discovery of a dacitic pumice layer within the Miocene Lobato Formation; (4) observation that the Hernandez member of the Miocene Tesuque Formation is interbedded with Miocene Lobato Formation basalt and andesite on Mesa Escoba; (5) mapping of a low-angle (25 to 30°), north-dipping, possible intraformational unconformity within the Oligocene to Miocene upper Abiquiu Formation; (6) observation of Eocene El Rito Formation cutting through Cretaceous Dakota Sandstone into the underlying Cretaceous Burro Canyon and Jurassic Morrison Formation along the west side of the area; (7) discovery of an outcrop of possible Jackpile member of the Jurassic Morrison Formation, a unit not usually found in the Chama Basin.

Qal Alluvium (Holocene). Unconsolidated clay, silt, sand, and gravel deposits deposited in major drainages and tributaries; up to 5 m thick; locally includes organic-rich sediments.

Qe Eolian silt (Holocene). Unconsolidated windblown tan to brown silt and clay deposited in low-elevation spots and on pediment surfaces. Usually 1 to 3 m thick, but can be 10 m thick.

Qt Terrace deposits (middle Pleistocene to Holocene). Alluvial silt, sand, cobble, and boulder deposits of volcanic, granitic, and Mesozoic sandstone provenance overlying distinct straths and underlying discrete treads related to the large modern drainages of the Rio Chama (Gonzalez and Dethier, 1991; Gonzalez, 1993). Gonzalez (1993) recognizes as many as six terrace levels along Rio Chama between Ghost Ranch and the map area.

Qp Pediment gravels (middle Pleistocene to Holocene). Unconsolidated deposits of angular to subangular pebble to boulder size blocks of Lobato Formation, Pedernal Chert, Mesozoic sandstone, as well as rounded recycled Proterozoic quartzite, granite, and metamorphic pebbles from the Oligocene Lower Abiquiu Formation resting on surfaces graded to the level of the highest terraces. The largest surface, covering several square kilometers, is on La Joya del Pedregal, which is cut on the approximate contact between the Poleo Formation and Petrified Forest Formation of the Chinle Group. Most of the pediment surfaces are covered with eolian silt (**Qe**). Approximately 1to 10 m thick.

Qsp Spring deposits (Quaternary?). White, fine-grained quartz sandstone, well-sorted, angular grains, no reaction to HCl. Associated with a northeast-trending fault and characterized by "popcorn" concretions. Appears to have formed on colluvium. < 1 m thick

Qc Colluvium (Quaternary). Hillslope colluvial deposits composed of pebble to boulder size unconsolidated, unsorted debris derived from local volcanic and sedimentary rocks. **Qcb** designates colluvium composed mainly of Lobato basalt, **Qcbt** is Bandelier Tuff colluvium. **Qc** refers to colluvium made up of a variety of lithologies. Up to 35 m thick.

Qls Landslide deposits (Quatenary). Unconsolidated, unsorted deposits composed of locally derived, cohesive blocks of bedrock. The large landslide on the south side of Mesa Escoba is composed of unconsolidated Ojo Caliente sandstone overlain by blocks of Lobato basalt and andesite. In areas to the south of Cañones Creek, many landslides are made entirely of Bandelier Tuff blocks. Large landslides that cover many square kilometers blanket the shoulders of Cerro Pedernal and the edges of Cañones Mesa. Sometimes the slides are associated with a head scarp in the source area and the top of the deposit is typically hummocky; up to 35 m thick.

Qoa Old Alluvium (Quaternary). Older alluvial deposits of gravel, sand and silt that were deposited after the eruption of the Tshirege Member of the Bandelier Tuff along Polvadera Creek. Dominant clast lithology is Tschicoma dacite, with subordinate amounts of rhyolite lava, obsidian, and rare rounded pieces of Tshirege Member, Bandelier Tuff. These deposits are also located further south along Polvadera Creek on the Polvadera Creek quadrangle (Kempter et al., 2004). Maximum thickness is approximately 10 meters.

Qb Bandelier Tuff (Pleistocene) - pumaceous air-fall tephra, nonwelded to weakly welded rhyolitic ash-flow tuff, and local volcaniclastic sediments; divided into two members, from younger to older:

Qbt Tshirege Member - White to orange to pink non-welded to weakly welded rhyolitic, ash-flow tuff (ignimbrite). The tuff contains abundant phenocrysts of sanidine and quartz, rare microphenocrysts of black clinopyroxene, trace microphenocrysts of hypersthene and fayalite, and pumice fragments in a fine-grained matrix of vitric ash. The sanidine typically displays blue iridescence. The tuff is composed of multiple flow units in a compound cooling unit (Smith and Bailey, 1966; Broxton and Reneau, 1995). Upper flowsare generally more welded than lower flows; includes basal white pumiceous tephra deposits (1-2 m thick) of the Tsankawi Pumice. Qbt forms conspicuous orange to tan cliffs on both sides of Cañones Canyon in the southwest corner of the quadrangle and along the southern .edge of the area. $^{40}Ar/^{39}Ar$ age is 1.22 ± 0.01 Ma (Izett and Obradovich, 1994; Spell et al., 1996). Up to 60 m thick.

Qbo Otowi Member - White to pale pink, generally poorly welded rhyolitic ash-flow tuff containing abundant phenocrysts of sanidine and quartz, and sparse mafic phenocrysts; sanidine may display a blue iridescence. This tuff is welded in the thick section exposed in Canoñes Canyon. Contains abundant accidental lithic fragments; consists of multiple flow units in a compound cooling unit. The stratified pumice fall and surge deposit at base of unit (Guaje Pumice) is generally not found in this area, but 3 cm of Guaje Pumice is preserved at the confluence of Chihuahueños and Canoñes canyons. Qbo discontinuously fills in rugged topography on a pre Toledo caldera age volcanic surface and can form spectacular tent rocks; upper surface quite undulatory due to erosion. Very difficult to distinguish from upper Bandelier Tuff in hand samples; best distinguished by poorer degree of welding, greater tendency to form slopes instead of cliffs, more abundant lithic fragments, less abundant iridescent sanidine, and stratigraphic position beneath the Tsankawi Pumicel. $^{40}Ar/^{39}Ar$ ages 1.61± 0.01 to 1.62±0.04 Ma (Izett and Obradovich, 1994; Spell et al., 1996). Up to 180 m thick where Qbo infilled a paleo-Cañones Canyon.

QTg Old alluvial gravels – late Pliocene(?). Alluvial to fluvial gravel and sandstone deposits underlying the Bandelier Tuff or at unconstrained positions in the landscape. Gravel at the base of Qbo on the west side of Chihuahueños Canyon and in Cañones Canyon includes rounded cobbles to boulders of Lobato Formation basalt, El Ranchuelos rhyolite, Tschicoma andesite and dacite, and Ojo Caliente sandstone. Gravel on the east side of Chihuahueños Canyon does not have Qbo directly above it and appears to rest on Ojo Caliente sandstone. This gravel is characterized by clasts of rounded Proterozoic granite and quartzite (recycled from lower Abiquiu Formation?), basalt, Pedernal Chert, and sandstone. Old gravel along Polvadera Creek sits on Tschicoma andesite and underlies Qbo. This gravel contains pebble to boulder-sized rounded Tschicoma andesite and dacite, basalt, Pedernal chert (up to 0.5 m across), obsidian, rhyolite, and minor Proterozoic granite and quartzite. In places along Polvadera Creek, a tan sandy matrix is dominant with respect to the conglomerate. **Gravel on top of the west end of Mesa Escoba** contains rounded Lobato Formation and Tschicoma lavas, as well as angular clasts of upper Abiquiu sandstone and Pedernal Chert. 1 to 3 m thick.

QToc Old colluvium (late Pliocene(?)). Angular blocks of Lobato Formation basalt beneath and incorporated into the base of the Otowi member of the Bandelier Tuff south of Mesa Escoba. This unit also includes Tschicoma andesite boulders beneath the Otowi member in Chihuahueños Canyon. 1 -2 m thick.

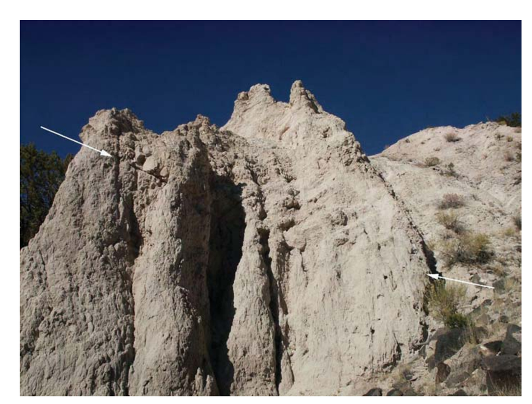


Figure 1. Photograph of north-dipping surface in the Upper Abiquiu Formation at 375380 E 4008960 N, looking toward the west. Arrows highlight the location of the surface

Teb El Alto Basalt (Pliocene). Dark brown to black, vesicular basalt with phenocrysts of plagioclase, pyroxene and olivine. Overlies the basaltic andesite of Cañones Mesa and appears to emit from a vent on the north side of Cerro Pelon. K-Ar age of 3.1 ±0.7 Ma (Manley and Mehnert, 1981). Up to 120 m thick.

Tba Basaltic andesite of Cañones Mesa. (Pliocene). This lava, which caps Cañones Mesa, is generally more crystal poor than a typical Tschicoma lava, containing < 5% phenocrysts of plagioclase, pyroxene, and olivine. The lava is composed of at least two flows, characterized by basal block and ash features, and is platy in outcrop. K-Ar ages are 2.8 ± 0.7 Ma and 2.8 ± 0.5 Ma on Cañones Mesa (Manley and Mehnert, 1981). Overlain by El Alto basalt and underlain by dacite of Cerro Pelon. The base of the basaltic andesite on Cañones Mesa, which is ~380 m above the Chama River, corresponds to the T4 erosion surface of Gonzalez and Dethier (1991) and Gonzalez (1993). Averages about 100 m thick.

Tg Tertiary alluvial gravels (Pliocene). Gravel at the northern tip of Cañones Mesa, apparently under the basaltic andesite of Cañones Mesa and above the Jurassic Summerville Formation, contains a mix of Proterozoic quartzite cobbles, with minor granite, Pedernal Chert, and volcanic pebbles. About 3 m thick.

Tt Tschicoma Formation (3 Ma to 5 Ma). Includes andesites and local dacites occurring as massive lavas, domes, vents, and shallow intrusives on Cañones Mesa and the northern flanks of Cerro Pelon; informally divided into two members:

Ttd Tschicoma dacites (Pliocene). Includes hornblende- and hornblende-biotite porphyritic rocks of diverse texture and lithology that generally overlie Tschicoma andesites. The dacitic flows on Cerro Pelon are 2.96±0.27 Ma and contain minor augite and orthopyroxene as hydrous phases (Goff et al., 1989). Both coarsely porphyritic and fine-grained, flow-banded, weakly porphyritic dacites are present. The northern exposures of the dacite of Cerro Pelon (**Ttd1**) is gray, crystal-rich (30 to 50%) with phenocrysts of plagioclase 9 to 13 mm across, hornblende up to 6 mm long, and biotite. At least 70 m thick. The dacite of Cañones Mesa (**Ttd2**) is gray, has about 20 to 30 % crystals, with plagioclase, hornblende and biotite.

Tta Tschicoma andesite (Pliocene). Mainly coarsely porphyritic, 2-pyroxene andesites that occur as massive flows;about 100 m thick. One flow on the northeast side of Cerro Pelon (**Tta1**) is pink to gray, 10 to 20% crystals, with plagioclase phenocrysts up to 10 mm across, with pyroxene and minor (<1%) biotite. Pumice (**Ttp**) is associated with this flow. One flow at Polvadera Creek (**Tta2**) is black to dark gray, slightly vesicular, 30% crystals, with apple-green and forest green pyroxene. A small flow in Chihuahueños Canyon (**Tta3**) is crystal-poor (5-10%), fine-grained, gray with plagioclase and pyroxene phenocrysts.

Tl Lobato Formation (7 Ma to 8 Ma). Includes basalt, andesite, and local dacite pumice occurring as lavas exposed on Cerro Pedernal, Mesa Escoba, and Polvadera Mesa. K-Ar ages are 7.8 ± 0.7 Ma on Cerro Pedernal, 7.9 ± 0.5 on Mesa Escoba, and 7.8 ± 0.5 Ma on Polvadera Mesa (Manley and Mehnert, 1981). An age of 8.1 ± 0.5 Ma is reported by Luedke and Smith (1978) on the lowest basalt flow on Polvadera Mesa. The base of the Lobato flows corresponds to the T1 erosion surface of Gonzalez and Dethier (1991) and Gonzalez (1993). The T1 surface is ~ 1110 m above the Rio Chama on Cerro Pedernal, 730 m on Mesa Escoba, and 540 m on Polvadera Mesa (Gonzalez, 1993).

Tla Lobato andesite (Pliocene). One andesite flow is preserved on Mesa Escoba (Singer, 1985). The andesite is dark gray, fine-grained, weakly porphyritic rock with microphenocrysts of plagioclase, clinopyroxene, olivine and quartz xenocrysts (Singer, 1985).An andesite flow is exposed in Cañones Canyon below Chama-El Rito sandstone. This andesite is gray, with about 15-20% plagioclase, mainly in the form of fine-needles, and pyroxene. At least 10 m thick.

Tlp Lobato pumice (Pliocene). A poorly-exposed dacitic pumice with phenocrysts of biotite and hornblende is interbedded with Lobato Formation basalt flows on the northeastern side of Polvadera Mesa. 30 to 40 m thick.

Tlb Lobato basalt (Pliocene). Lobato basalt from Mesa Escoba contains microphenocrysts of olivine, augite, and plagioclase (Singer, 1985). Porphyritic olivine basalt on Cerro Pedernal has phenocrysts of subhedral zoned labradorite ($An_{?}$, 12%, 1.5 mm); subhedral to euhedral olivine (2.5 mm), with strong iddingsite replacement and magnetite rims; subhedral augite (2.5 mm) containing poikilitic plagioclase, partly twinned or with orthopyroxene reaction rims. Basal flow, 17-m thick, in a series of flows and interlayered pyroclastic beds totaling 80 m thick (Lawrence, 1979).

Tsf Santa Fe Group (late Miocene to Pliocene)

Tsth Hernandez member of the Tesuque Formation (late Miocene). A fluvial unit (Koning et al., 2004) containing well-rounded volcanic pebbles below the Lobato Formation basalt and above the Ojo Caliente member of the Tesuque Formationon the east end of Mesa Escoba. The gravel is dominated by intermediate composition volcanic rocks with a few basalt and tuff clasts, along with rare quartzite and orthoclase. A similar gravel with volcanic pebbles (mainly andesite), quartzite, glass, sandstone and quartz appears to sit on the Lobato Formation east of Polvadera Creek. Up to 30 m thick.

Tsto Ojo Caliente member of the Tesuque Formation (late Miocene). Pink to tan-colored, well-sorted, fine-grained feldspathic and quartzo-feldspathic sandstone of eolian origin; cross-beds clearly indicate a prevailing wind from the west. In Cañones Canyon some exposures of the Ojo Caliente Member are strongly cemented, forming impressive cliffs. Most of the unit, however, is poorly consolidated, forming buff-colored sand and silt on the canyon slope; up to 100 m thick.

Tstc Chama-El Rito member of the Tesuque Formation (middle Miocene). Tan to gray medium to coarse-grained fluvial sandstone and granule to pebble conglomerate interbedded with orange red to red siltstone. Clasts in the conglomerate are dominated by rounded andesitic volcanics, flow-banded rhyolite, ash flow tuff (much of which is lithic-rich Amalia Tuff), rare chert and basalt. Petrified wood locally abundant.

Ti/Tb Black, fine-grained basalt dikes (Ti) intruding and basalt flows interbedded with the Chama-El Rito member in Arroyo de las Frijoles.

Ta Abiquiu Formation (late Oligocene to early Miocene). Informally divided into three subunits including, from younger to older:

Tau Upper sandstone member. White, light gray, and buff-colored fine- to medium-grained, tuffaceous and volcaniclastic sandstone, locally conglomeratic. The upper sandstone is a slope-forming unit comprised of moderately sorted, moderately indurated volcanic detritus representing diverse lithologies including pumice, basalt, intermediate volcanics and 25 Ma Amalia tuff. A K-Ar age of 18.9 Ma from a basalt near the top of the unit and an Ar/Ar age of an Amalia Tuff clast of 25 Ma near the base bracket the age of the unit (Smith et al., 2002, Moore, 2000). Up to 460 m thick

TapPedernal Chert member. Varicolored, white, blue-gray, black, red and yellow cryptocrystalline, massive chert, limey chert, and limestone containing nodular chert, conspicuous ledge former. The chert is locally interlayered with thin beds of arkosic sandstone and conglomerate and is typically more limey at its base. 2 to 10 m thick.

Tal Lower conglomerate member. Pinkish tan to gray, generally coarse arkosic conglomerate and fine- to medium-grained sandstone, slope forming,. The lower conglomerate member is poorly sorted, weakly to moderately indurated, calcareous, and characterized by well rounded pebble to boulder-size (up to 50 cm) clasts composed of Precambrian quartzite, granite, pegmatite, gneiss and schist, as well as fine-grained limestone and mudstone. K-Ar ages on a basalt near the base of the unit northeast of the quadrangle and 40Ar/39Ar ages on Amalia Tuff in the upper Abiquiu bracket the age of the unit between 25.1 and 27 Ma (Smith et al., 2002, Moore 2000). ~125 m thick

Ter E1 Rito Formation (Eocene). Orange-red to brick-red, hematitic, micaceous mudstone and siltstone and lenses of fine- to medium-grained arkosic sandstone with few pebbles to cobbles of Proterozoic granite and quartzite, slope forming. The E1 Rito Formation locally has a 2-to 10-m-thick basal conglomerate section made up of very well rounded hematitic Proterozoic Ortega quartzite, as well as Proterozoic schist and gneiss cobbles and boulders (up to 1 m) in a weakly to well indurated matrix of coarse ferruginous sand. Underlies the Abiquiu Formation and overlies Cretaceous Mancos Shale, Dakota Sandstone Burro Canyon Formation, or Jurassic Morrison Formation with erosional unconformity. Estimated 50 to 140 m thick.

Km Mancos Shale (Late Cretaceous). Dark gray and brown, weakly consolidated, calcareous, carbonaceous shale and interlayered thin beds of fossiliferous limestone, slope forming, 0 to 65 m thick. Lowermost part of the section only is locally present; upper contact is an erosional unconformity of moderate relief.

Kd Dakota Sandstone (Late Cretaceous). White, gray, and tan, fine-grained quartzose sandstone, well sorted, locally kaolinitic, conspicuous as a cliff former, 60 to 67 m thick. The Dakota Sandstone is well sorted, thick bedded to massive, and locally contains thin interbeds of black, carbonaceous shale. The basal contact with the underlying Morrison Formation was arbitrarily determined as the lowest occurrence of carbonaceous matter observed in the rock, whether sandstone or shale.

Kbc Burro Canyon Sandstone (Cretaceous). White to tan, fine-grained, kaolinitic, quartzose sandstone, moderately to well indurated. Contains abundant thin beds of chert and quartz pebble conglomerate; sandstone clasts also occur. The rounded chert pebbles are usually tan, white, and gray, and rarely black to red and much of the chert is tripolitized (Saucier, 1974; Aubrey, 1986). Locally exhibits medium-scale cross bedding. Thin light green to pink mudstone is interbedded with the conglomeritic sandstone, indicating recycling of the underlying Brushy Basin mudstones (Saucier, 1974). Conspicuous cliff-forming unit, thick bedded to massive, 57 to 67m thick.

We follow the Jurassic stratigraphy for the Chama Basin outlined by Lucas and Anderson (1998).

Jm Morrison Formation (Late Jurassic). Shown on the map as an undivided unit, two members are recognized in the map area from younger to older, the subunits are:

Jmj - Jackpile sandstone in the Brushy Basin Member. Orange red, fine-grained, moderately sorted, carbonate cemented quartz sandstone with abundant clay matrix. Goethite concretions. Quartz angular to subround. Medium to thin bedded. The sandstone just above the underlying green Brushy Basin siltstone is a granule sandstone to pebble conglomerate with clasts of reworked Morrison siltstone, chert, and quartzite. Conglomeritic material in the Jackpile sandstone is usually sparse and is usually limited to the base of the unit (Aubrey, 1986).

Jmb - Brushy Basin Member. Variegated green to reddish orange to dark reddish brown siltstone and grayish-white to gray, very fine-grained subarkosic, cross-bedded sandstone, slope forming, 110 m thick.

Js Summerville Formation (Late Jurassic). The basal 8 to12 m of this unit consists of white to light gray, fine- to very fine grained quartzose sandstone, thin-bedded, containing small-scale ripple marks, gypsum blade casts, and soft-sediment deformation. The basal sandstone is overlain by variegated maroon and gray quartzose to subarkosic siltstone. This unit tends to form slopes. The upper contact is the stratigraphically highest maroon siltstone that contains abundant pedogenic carbonate concretions, located above the Bluff Sandstone interval. The Bluff Sandstone, a tan fine grained, cross-bedded sandstone that is about 10 m thick, is included in the Summerville Formation on this map. Approximately 60 m thick.

Jt Todilto Formation (Late Jurassic). White to gray, dominantly fine-grained, massive gypsum, sloping-forming unit; with a 2- to 3-m-thick basal section of gray, laminated, fissile shale and thin-bedded limestone; total unit thickness 15 to 27 m. A gray, crusty "popcorn" texture typically develops on erosional surfaces of Todilto gypsum.

Je Entrada Sandstone (Late Jurassic). White, pink, and yellowish tan, fine- to very fine-grained quartzose sandstone, well sorted, cross-bedded, exhibits large-scale eolian dunal cross-bedding, cliff former, 60 to 67 m thick.

TRc Chinle Group (Late Triassic). Three units are mapped at the 1:24,000 scale, from youngest to older:

TRcu an upper unit that contains the Rock Point Formation and Petrified Forest Formation. The stratigraphically highest unit in the Chile Group is the Rock Point Formation, reddish brown to gray-red siltstone and fine-grained sandstone that is 0-70 m thick (Lucas et al., 2003). The Petrified Forest Formation is composed of a basal red-brown laminated sandstone-dominated section (Mesa Montosa member) and upper red-brown mudstone-dominated section (Painted Desert member) (Lucas et al. 2003). Both the upper and lower contacts of this formation are gradational. The Petrified Forest Formation is up to 200 m thick.

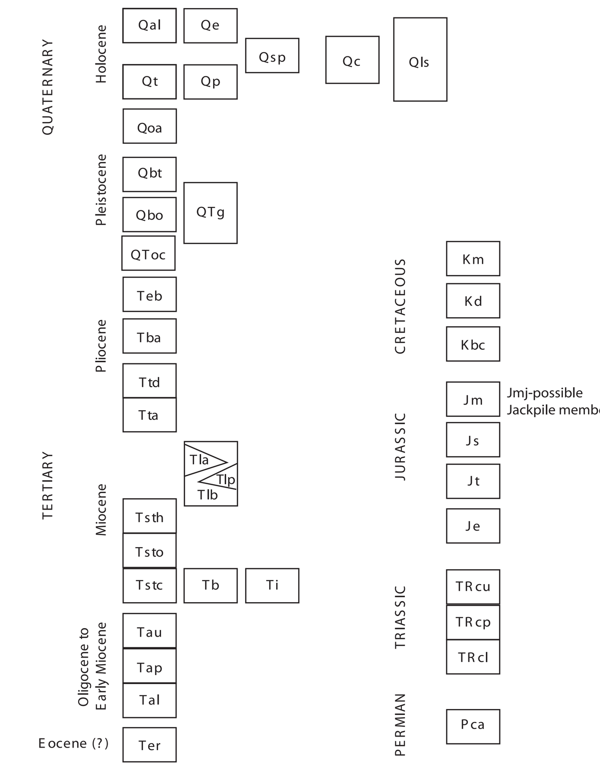
TRcp Poleo Formation – Yellow-brown to yellow- gray, medium to fine-grained, micaceous, quartzose sandstone, conglomeritic sandstone and conglomerate. The conglomerate contains both intrabasinal siltstone clasts and extrabasinal siliceous clasts; locally cross-bedded. This unit forms prominent cliffs. The base of the unit is sharp (corresponds to the Tr-4 unconformity of Lucas (1993)) and the upper contact is gradational into the overlying Petrified Forest Formation, up to 41 m thick at Abiquiu Dam.

TRcl a lower unit that contains the Salitral Formation and the Shinarump Formation –The Salitral Formation is an olive gray to brown sandstone to silty mudstone near the base (Piedra Lumbre member) and a reddish brown mudstone (Youngsville member) near the top. Upper bed of the Piedra Lumbre member, called the El Cerrito Bed, is a yellow to brown intraformational conglomerate (Lucas et al. 2003). The Shinarump Formation, the stratigraphically lowest unit in the Chinle Group, consists of red to orange to brown quartz sandstone, conglomeritic sandstone, and extrabasinal conglomerate that includes clasts of quartz, chert, and quartzite (Lucas et al., 2003). Petrified wood is common. Both the basal and upper contacts are sharp; the basal contact corresponds to the Tr-3 unconformity of Lucas (1993).

Pc Cutler Group (Late Pennsylvanian?- Early Permian) Spencer Lucas (personal communication) recognizes two informal formations in the Chama Basin, the Arroyo del Agua Formation and the El Cobre Formation. Only the upper unit is exposed in the Cañones area.

Pca - Arroyo del Agua Formation- Orange red micaceous siltstone with thin, trough cross-bedded sheet arkosic sandstone. Contains extensive calcrete nodule horizons. Little or no conglomerate is present in this formation. This unit tends to form slopes. About 30 m exposed.

Correlation of Map Units for the Cañones 7.5-Minute Quadrangle



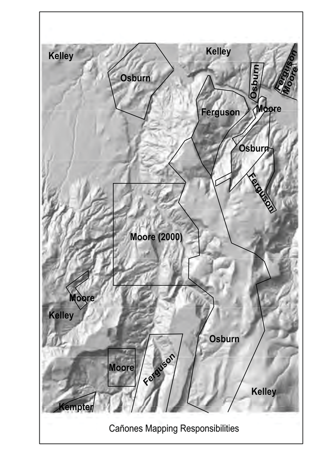


Figure 2. Photograph of north-dipping surface at 376120 4008315, looking toward the west. Arrows highlight the position of the surface.