

Geologic Map of the Cañon Agua Buena Quadrangle, Socorro County, New Mexico

By

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Open-file Digital Geologic Map OF-GM 146

Scale 1:24,000

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PRELIMINARY GEOLOGIC MAP OF THE CAÑON AGUA BUENA 7.5' QUADRANGLE, SOCORRO COUNTY, NEW MEXICO

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SUMMARY

The Cañon Agua Buena 7.5-minute quadrangle lies on the east flank of the Rio Grande rift southeast of Socorro, New Mexico. Strata ranging in age from Early Permian to Quaternary crop out in the quadrangle and form a complex, south-plunging anticlinorium.

Stratigraphy

The stratigraphic characteristics of Permian units on the quadrangle are typical for the region, except for aspects of the upper San Andres Formation and the Artesia Group. The upper part of the San Andres in some areas contains thick beds of brownish-gray, well-sorted, quartzose sandstone that in some respects resembles the Glorieta Sandstone that underlies the San Andres Formation. The sandstones in the upper San Andres Formation have not been studied in detail; they were assigned to the Artesia Group (Bernal Formation) by Fagrelus (1982). The uppermost part of the San Andres locally contains bedded gypsum 5-20 m thick. The stratigraphic relationship between the gypsum and the underlying limestone of the San Andres Formation is unclear. It is possible that the gypsum is more closely related to the overlying red beds of the Artesia Group, as they commonly crop out in close geographic proximity to each other and appear to be gradational in the west-central part of section 14, T 3 S, R2E. The thickness of the Artesia Group varies markedly along strike. This suggests the Artesia Group accumulated in shallow paleovalleys, or was locally thinned by later erosion.

The overlying Triassic Moenkopi Formation also varies significantly in thickness, but it is unclear how much of this variation is related to pre-Moenkopi topography versus the effects of erosion prior to deposition of the overlying Santa Rosa Sandstone of the Chinle Group. The Santa Rosa Sandstone appears to have been deposited within shallow paleovalleys by northwest-flowing rivers. The San Pedro Arroyo Formation of the Chinle Group transitionally overlies the Santa Rosa Sandstone.

An Upper Cretaceous succession, Dakota Sandstone through Crevasse Canyon Formation, is present in the quadrangle. S.C. Hook (oral commun., 2007) has recently documented the presence of Mulatto tongue of the Mancos Shale near Carthage. Not depicted on the present map, the Mulatto tongue is about 30 m thick and its base lies stratigraphically about 50 m above the Gallup Sandstone. Coal is locally present in the Carthage Member of the Tres Hermanos Formation and in the lower part of the Crevasse Canyon Formation.

The Baca Formation was deposited in the middle Eocene during the final stage of the Laramide orogeny. It disconformably overlies the Tres Hermanos Formation throughout

most of the quadrangle except near the southern edge where it overlies the Crevasse Canyon Formation. This relationship indicates that the broad, south-plunging anticlinorium that comprises most of the bedrock exposures on the quadrangle is at least in part a Laramide feature. The Baca Formation is composed of coarse-grained detritus shed off of the nearby Sierra uplift to the west (Cather, 1983). The Baca Formation on the quadrangle is unusual because in most places its lower portion consists almost entirely of basement-derived, granite-gneiss clasts, but its upper portion is composed of detritus from Paleozoic units. This is antithetic to the usual unroofing sequence seen in most synorogenic deposits, and may be the result of drainage capture and/or strike-slip juxtaposition within the Laramide Sierra uplift.

Six regional, late Eocene-Oligocene ignimbrites overlie thick middle- to late-Eocene volcanoclastic rocks of the Spears Group on the quadrangle. The 32.3 Ma Hells Mesa Tuff is notably absent, despite proximity to the source caldera in the Socorro-Magdalena Mountains area. Only the basal two ignimbrites (Datil Well Tuff and Rock House Canyon Tuff) are present west of the Bustos fault. Younger ignimbrites were either eroded or not deposited in this area. A ~90 m-thick dacite dome is present in the northern part of the quadrangle where it disconformably overlies the Datil Well Tuff and the Rock House Canyon Tuff. The La Jara Peak Basaltic Andesite commonly fills paleovalleys and forms lenticular map patterns.

The Santa Fe Group, where exposed, is thin (less than a few 10s of m). The Santa Fe Group, however, may thicken in the subsurface of the southeastern part of the quadrangle. Remnants of upland, east-draining paleovalley filled with Santa Fe deposits occur about 2.5 km northwest of Gonzales well. The proximal portions of this paleovalley system were captured by younger, west-flowing drainages, leaving a beheaded paleodrainage along Quebradas road. Modern drainages in the eastern part of the quadrangle are not integrated with the Rio Grande. There, the end of Santa Fe deposition is poorly defined because post-Santa Fe incision has not been pronounced.

Structure

A great variety of faults and folds are exposed in the quadrangle. Faults exhibit a wide range of strike directions, but northerly strikes are dominant. Fault dips range from subvertical to subhorizontal and bedding-parallel. Faults are more numerous within rheologically stiff, sandstone-dominated stratigraphic intervals, such as the Dakota Sandstone, and commonly did not propagate through rheologically weak intervals (such as the Mancos Shale). These relationships imply some degree of detachment exists within several of the incompetent stratigraphic units. Detachment is best manifested within the Permian section (Craig, 1992), particularly within the Cañas Gypsum Member of the Yeso Formation and within bedded gypsum near the base of the San Andres Formation. These detachment faults are commonly subparallel to bedding. They typically omit section and thus are low-angle normal faults. Timing of slip on exposed detachments within the Permian section may be either Laramide or rift-related, and the slip direction of the upper plate has not been determined.

The Bustos fault in the northern part of the quadrangle, however, may help in the interpretation of low-angle faults within the Permian section. The Bustos fault divides weakly tilted footwall rocks on the west from strongly tilted hanging-wall strata. Cross-section A-A' shows that the Datil Well Tuff has been rotated about 30 degrees with only 1 km of stratigraphic separation on the fault. The Bustos fault is thus strongly listric, and its geometry suggests it may sole in a detachment in the Permian section. If so, this detachment must be rift-age, as it cuts upsection through the Oligocene volcanic succession, and the upper plate must have moved eastward relative to the lower plate. These observations do not rule out additional Laramide movement on the detachment.

The Ranchito fault is a major north-striking, steeply-dipping, east-down fault exposed in the northern and central part of the quadrangle. About 2 km north of Gonzales well the fault steps to the left about 0.6 km. The stepover coincides with an area of crustal extension in which parts of the Oligocene volcanic succession are repeated by several northwest-striking normal faults. This geometry requires sinistral-oblique extension along the Ranchito fault, and suggests the region experienced northeast-southwest extension during rifting.

Most folds in the quadrangle are gentle, open, and do not plunge steeply. They trend northerly, ranging from northwest to north-northeast. It is unclear if these folds are the result of Laramide contraction or formed as drape folds over rift-age normal faults. Probably both types are present.

DESCRIPTION OF UNITS

CENOZOIC ERATHEM

Middle Pleistocene-Holocene

Qal Alluvium (Holocene)-- Sand, gravel, and mud in and adjacent to modern arroyo channels. Alluvium is typically at or near the grade of modern channels. 0-10 m thick.

Qe Eolian deposits (upper Pleistocene-Holocene)-- Eolian sands in active sand sheets and small dunes. 0-10 m thick.

Qae Eolian deposits (upper Pleistocene-Holocene)-- Eolian sands and loessic silts locally reworked by alluvial processes. Deposits are stabilized by vegetation in most areas. Includes thin, discontinuous eolian veneers on stable upland surfaces. 0-5 m thick.

Qvy Younger piedmont alluvium (upper Pleistocene)-- Gravel, sand, and minor mud deposited at low elevations (less than about 10 m) above modern stream grade. Alluvium is representative of deposition in a variety of piedmont environments, including alluvial

fans, paleovalley and arroyo fills, strath terraces, fill terraces, and pediment surfaces. 0-15 m thick.

Qvo Older piedmont alluvium (middle(?) Pleistocene)--Gravel, sand, and mud deposited at higher elevations (more than about 10 m) above modern stream. Range of depositional environments is similar to Qvy. 0-10 m thick.

SANTA FE GROUP

Late Miocene(?) to middle(?) Pleistocene

QTsp Piedmont facies undivided--Weakly consolidated sandstone, conglomerate, and minor mudstone. Conglomerate is typically poorly sorted and clast supported. Sandstone is typically medium to very coarse and crossbedded or horizontally stratified. Matrix-supported debris-flow deposits are rare. QTsp includes gravelly veneers on pediment surfaces. Clasts consist mostly of Permian sandstone and limestone.

Oligocene

Tsc South Canyon Tuff--Light gray to light purple, densely welded, crystal-poor to moderately crystal-rich rhyolite ignimbrite. Crystals are mostly sanidine and quartz; lithic fragments are common. About 230 m thick. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 27.4 Ma (all $^{40}\text{Ar}/^{39}\text{Ar}$ ages are from McIntosh et al., 1991).

Tl Lemitar Tuff--Pink, densely welded, moderately crystal-rich rhyolite ignimbrite. Crystals are sanidine, plagioclase, quartz, and biotite; lithics are minor. Thickness is about 40 m. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 28.0 Ma.

Tvp Vicks Peak Tuff--Light gray, moderately welded, crystal-poor rhyolite ignimbrite. Thickness is about 50 m. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 28.6 Ma.

Tlj La Jencia Tuff--Pink to gray, densely to moderately welded, crystal-poor, rhyolitic ignimbrite that exhibits compound cooling. Upper part of unit is prominently flow-banded. Crystals are mostly sanidine and quartz; lithics are typically sparse. Thickness is about 95 m. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 28.9 Ma.

Tsu Upper Spears Group--Dark- to medium-gray volcanoclastic sandstone and conglomerate. Debris-flow breccias are locally present. Clast lithotypes are mostly dark gray basaltic andesite (plagioclase- and clinopyroxene-bearing) but also andesite-dacite (plagioclase- and amphibole-bearing) and ignimbrite clasts. 0-80 m thick. Spears Group terminology used as defined by Cather et al. (1994).

Tlp La Jara Peak Basaltic Andesite--Aphanitic to slightly porphyritic mafic flows and associated breccias of mostly basaltic andesite composition. Phenocrysts are mostly

plagioclase and clinopyroxene. In the quadrangle, the unit occurs as two tongues 0-60 m thick, above the Datil Well Tuff and above the Rock House Canyon Tuff.

Ti Andesite to basaltic andesite dikes--Mafic to intermediate-composition dikes typically less than 3 m in width. Phenocrysts are mostly plagioclase and clinopyroxene. Commonly exhibits greenish alteration. Probably represents intrusive equivalent of the La Jara Peak Basaltic Andesite.

Tdd Dacite extrusive rocks--Medium brownish gray, plagioclase and amphibole-bearing dome rocks. Forms a single flow unit ~90 m thick with an autobrecciated base. Undated, but disconformably overlies Datil Well Tuff and Rock House Canyon Tuff in north-central part of the quadrangle.

Trh Rock House Canyon Tuff--Light gray, crystal-poor rhyolitic ignimbrite. Phenocrysts are mostly sanidine with rare quartz, biotite, and hornblende(?). Poorly to moderately welded. Contains local zones of abundant flattened pumice. About 65 m thick. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 34.4 Ma

Tdw Datil Well Tuff--Medium brownish gray, crystal-rich rhyolitic ignimbrite. Crystals are mostly sanidine with subordinate plagioclase and minor quartz, biotite, and pyroxene(?). Lithic-rich and pumice-poor. About 50 m thick. $^{40}\text{Ar}/^{39}\text{Ar}$ age is 35.5 Ma.

Tsl Lower Spears Group--Medium- to light-gray volcanoclastic sandstone, conglomerate, debris-flow breccia, and minor mudstone. Clasts are dominated by plagioclase- and amphibole-bearing andesite and dacite. Non-volcanic clasts are locally present above transition with underlying Baca Formation. Thickness is ~760 m. Age range is ~39-36 Ma (Cather et al., 1987). Usage of the term Datil Group is after Cather et al. (1994).

Eocene

Tb Baca Formation (middle Eocene)--Fluvial red-bed sandstone, conglomerate, and minor mudstone deposited in piedmont environments. Sandstone is commonly cross-bedded; conglomerate contains pebbles, cobbles and boulders of Paleozoic and Proterozoic lithotypes. Sedimentary-clast dominated facies (**Tbps**) in most places underlies the granite-gneiss dominated facies (**Tbpg**), in opposition to the normal unroofing sequence seen in Baca Formation exposures in surrounding regions. Both facies were derived from the west, from the Sierra uplift of Cather (1983). About 300 m thick.

MESOZOIC ERATHEM

Upper Cretaceous

Kcc Crevasse Canyon Formation (Coniacian-Santonian?)--Drab to gray sandstone, mudstone, and coal deposited in coastal plain and fluvial settings. Thickness is about 300 m. Includes a tongue of marine shale (Mulatto tongue of the Mancos Shale) about 30 m thick, the base of which lies about 50 m stratigraphically above the top of the Gallup sandstone (S.C. Hook, 2007, oral commun.).

Kg Gallup Sandstone (Lower Coniacian)--Fine grained, gray to yellowish gray, regressive coastal barrier-island sandstone and mudstone. About 10-15 m thick. Transitional between underlying marine shale and overlying coastal plain deposits.

Kmd D-Cross Tongue of the Mancos Shale (Upper Middle Turonian-Lower Coniacian)--Noncalcareous, medium gray, marine shale. About 90 m thick with a sharp basal contact and a gradational upper contact. Fossils *Prionocyclus wyomingensis* (Meek) and *Scaphites warreni* Meek and Hayden, *Prionocyclus novimexicanus* (Marcou), *Forresteria* sp., *Lopha sannionis* (White), and sparse *Ostrea elegantula* White.

Kth Tres Hermanos Formation (Middle Turonian)--Sandstone and shale unit that forms a regressive-transgressive wedge of nearshore marine and non-marine deposits that is about 80 m thick with a gradational base and a sharp top. Consists of three unmapped members, in descending order: Fite Ranch Sandstone Member (upper Middle Turonian)--highly bioturbated, coastal barrier sandstone that coarsens upward from very fine grained to fine grained. Sandstones are light gray, but weather light to dark brown and constitute a 10-12 m thick ridge-forming unit with sharp top and gradational base. Contains *Lopha bellaplicata novamexicanum* Kauffman. Carthage Member (middle Middle Turonian)--marine, marginal marine, and non-marine sandstone and shale slope-forming unit 58-64 m thick; lower two-thirds contains thin, fine grained sandstone beds of paludal-lacustrine or crevasse splay origin and discontinuous, cross-bedded channel sandstones. Upper third contains marine shale with fossiliferous concretions and *Prionocyclus hyatti* (Stanton). Atarque Sandstone Member (lower Middle Turonian)--regressive coastal barrier sandstones that weather light gray to dark brown or buff. Lower sandstones are transitional with underlying shale and constitute a 5-7 m thick, ridge-forming unit that has very fossiliferous lenses and concretionary sandstone bodies with *Pleuriocardia* (*Dochmocardia*) *pauperulum* (Meek) and *Gyrodes* spp. Uppermost bed is commonly a brackish water coquina of *Crassostrea soleniscus* (Meek).

Kml Lower part of the Mancos Shale (Middle Cenomanian-Lower Turonian)--calcareous and noncalcareous, gray, marine shale with minor, thin sandstone beds near base and top. Sharp basal contact and gradational upper contact. Calcareous shale in upper part of unit contains abundant *Pycnodonte newberryi* (Stanton). Thin sandstones in basal 15 m contain common *Ostrea beloiti* Logan. About 135 m thick.

Kd Dakota Sandstone (Middle Cenomanian)--Gray to yellow, fluvial to marginal marine medium to coarse-grained sandstone and minor mudstone. No body fossils have been found in the Dakota. About 20 m thick.

Triassic

TRcp Chinle Group, San Pedro Arroyo Formation (Upper Triassic)--Red, gray and maroon fluvial mudstone with subordinate sandstone, limestone-pebble conglomerate, and limestone. Forms slopes and valleys. About 165 m thick.

TRcs Chinle Group, Santa Rosa Sandstone (Upper Triassic)--Medium to coarse-grained, locally pebbly, brown to gray sandstone and reddish mudstone. Pebbles are chert, quartz, and clasts of sandstone and siltstone. 0-70 m thick.

TRm Moenkopi Formation (Middle and Lower Triassic)--Red-brown, brown, and locally drab continental mudstone, sandstone and minor conglomerate. 0-30 m thick.

PALEOZOIC ERATHEM

Permian

Pag Artesia Formation (Permian, Guadalupian? to Ochoan?)--Interbedded moderate red (5R 4/6) to pale reddish-brown (10R 5/4) and very pale orange (10YR 8/2), calcareous and locally gypsiferous siltstones, and very fine to fine-grained quartz, calcareous and slightly micaceous sandstones, with are dark reddish-brown (10R 3/4) to light olive-gray (5Y 6/1), slightly micaceous mudstones, which have scattered halite casts and are broadly lenticular. Thickness is 0 - 30 m.

Psa San Andres Formation (Permian, Leonardian)--Interbedded limestone, dolostone, breccia and gypsum. Limestones are brownish-black (5YR 2/1), pale yellowish-brown (10YR 6/2) and medium gray (N5) and range from wackestone to grainstone. Dolostones are brownish-gray (5YR 4/1) to olive-gray (5Y 4/1), and locally gypsiferous. Local bedded gypsum at top of San Andres Formation mapped separately (**Psu**). Breccias consist of brownish-black (5YR 2/1) limestone and dolostone breccias that grade laterally into thin-bedded, dark gray (N3) limestones. The gypsums are white (N9) to light gray (N7), laminated and poorly exposed. Thickness about 120-150 m.

Pg Glorieta Sandstone (Permian)--White (N9) to very pale orange (10YR 8/2), fine- to medium-grained, friable to well-indurated, crossbedded quartz arenite (Plate 12). Has scattered coarse-grained, well-rounded, frosted quartz grains, especially in the lower half of the unit. About 40 m thick.

Py Yeso Formation (Permian, Leonardian)--Interbedded sandstone, siltstone, dolomitic limestone, mudstone, and gypsum. Consists of four members (in ascending order): Meseta Blanca, Torres, Cañas Gypsum, and Joyita Members. The Meseta Blanca Member constitutes the lower Yeso Formation map unit (**Pyl**) and the Torres, Cañas Gypsum and Joyita Members constitute the upper Yeso Formation (**Pyu**). Meseta Blanca Member: interbedded very pale orange (10YR 8/1), pinkish-gray (5YR 8/1) and moderate reddish-brown (10R 4/6), very fine- to coarse-grained quartz sandstone, are very light gray (N8) to dark reddish-brown (10R 3/4) siltstone and are dark reddish-brown (10R

3/4) to grayish-red (5R 4/2) slope forming mudstones and shales. About 90 m thick. Torres Member: interbedded pale to moderate reddish-brown (10R 5/4 to 10R 4/6), grayish-pink (5R 8/2) or grayish-red (5R 4/2), fine- to medium-grained quartz sandstone, white (N9) to light gray (N7) gypsum thin layers and lenses of dolomitized oolitic limestone, and pale yellowish-brown (10YR 6/2) to olive black (5Y 2/1) limestones that ranges from carbonate mudstone to peloidal or oolitic packstones and grainstones and are locally fossiliferous, dolomitic, and argillaceous. About 140 m thick. Cañas Gypsum Member: interbedded very light gray to white (N8 to N9) laminated to chicken-wire gypsum and minor, thin very fine-grained silty sandstone and a thin, medial, fetid, gypsiferous carbonate mudstone. About 0 - 10 m thick. Joyita Member: pale reddish-brown (10R 5/4) to moderate reddish-orange (10R 6/6), friable and calcareous, fine- to very fine-grained quartz sandstones with scattered displacive halite casts and clay flakes on bedding surfaces. The upper beds display low-angle cross beds and ripple cross-laminations. About 50 m thick.

Pa Abo Formation (Permian, Leonardian)--Interbedded dark reddish brown (10R 3/4) mudstone, and grayish red (10R 4/2) to dark reddish brown (10 R 3/4) siltstone, sandstone and, locally, thin conglomerate and rare limestone. About 115 m thick.

Pb Bursum Formation (Permian, Wolfcampian)--Interbedded medium dark gray (N4) to brownish gray (5YR 4/1) with some grayish red (5R 4/2) shale, medium gray (N5) to brownish black (5YR 2/1), peloidal and fossiliferous locally dolomitic limestone, and grayish orange pink (10R 8/2) to grayish orange (10YR 7/4), fine to very coarse-grained, very lenticular and trough cross-bedded sandstones. About 60 m thick.

Pennsylvanian

IPma Madera Group, Atrasado Formation (subsurface only; Pennsylvanian, Desmoinsian to Virgilian)--Interbedded medium to dark gray (N3 to N5) marine limestones, dark gray (N3) to moderate reddish brown (10R 4/6) shale and siltstone, and marginal marine sandstone and conglomerate. About 250 m thick.

EXPLANATION OF MAP SYMBOLS

Contact between geologic units. Dashed where approximately located.

Fault showing direction and dip of fault plane. Dashed where approximately located; dotted where concealed. Bar and ball on downthrown block of steep faults. Square teeth on upper plate of moderate- to low-angle fault that parallels bedding or cuts out section (younger over older); triangular teeth on upper plate of low-angle fault that repeats section (older over younger). Arrows show sense of strike slip. Relative strike-slip separation in cross-section shown by T (toward) and A (away).

Anticline showing trace of hinge plane and plunge direction. Dashed where approximately located, dotted where concealed.

Syncline showing trace of hinge plane and plunge direction. Dashed where approximately located, dotted where concealed.

Strike and dip of bedding.

Horizontal bedding.

Paleocurrent direction based on pebble imbrication or crossbedding.

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