Geologic Map of the Loma de las Cañas Quadrangle, Socorro County, New Mexico

By

Cather, S. M.; Colpitts, Jr., R. M.

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New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 110

Scale 1:24,000

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

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EXTENDED ABSTRACT

The Loma de las Cañas quadrangle exposes a wide variety of upper Paleozoic and Cenozoic stratigraphic units as well as structures related to the Rio Grande rift, the Laramide orogeny, and possibly the Ancestral Rocky Mountain orogeny. Cenozoic stratigraphic units exposed in the quadrangle include Quaternary alluvial and eolian units, the Sierra Ladrones Formation of the upper Santa Fe Group (Pliocene–middle Pleistocene), the La Jara Peak Basaltic Andesite (Oligocene), the lower Spears Group (middle toupper Eocene), and the Baca Formation (middle? Eocene). The Santa Fe Group contains permeable axial fluvial sandstones (ancestral Rio Grande deposits) that have excellent aquifer potential. Piedmont deposits in the Santa Fe Group intertongue with the ancestral Rio Grande sandstones and were deposited by west-flowing streams. The aggradational top of the Santa Fe Group is locally preserved and is represented by the calcretes of Las Cañas geomorphic surface.

No Mesozoic strata crop out on the quadrangle. Upper Paleozoic marine and non-marine strata consist of the Pennsylvanian Sandia, Gray Mesa, and Atrasado Formations and the Permian Bursum Formation, Abo Formation, Yeso Formation, Glorieta Sandstone, and San Andres Formation. The total thickness of the upper Paleozoic section on the quadrangle is about 1500 m and represents a prolonged episode of relatively continuous sedimentation. Facies relationships within the Pennsylvanian section are complex and will require further study.

Except for in the western half of the quadrangle where weakly deformed Santa Fe Group and younger deposits are exposed, the structure in the remainder of the quadrangle is characterized by numerous faults and folds. Most faults are steep and strike north–northwest to northeast. Both normal and reverse faults are locally present. At least some of the north–northwest-striking faults are normal faults associated with the Rio Grande rift. These include the Coyote and Gonzales faults that form parts of the eastern margin of the Socorro Basin. The Coyote fault offsets deposits of the Sierra Ladrones Formation and the Las Cañas surface; it is thus an active Quaternary structure. Some of the north–northeast- to northeast-striking faults, such as the Cañas fault, are Laramide, as shown by reverse components of separation and their association with tight, fault-propagation folds

that involve strata as young as the Leonardian Yeso Formation. Many faults are of ambiguous tectonic association due to lack of timing constraints. Some of the north–northeast-striking fault systems may be strike-slip, as shown by apparent fault juxtaposition of dissimilar Pennsylvanian facies along the Amado fault system (see discussion of Adobe-Coane interval in Rejas, 1965).

Folds are widely distributed in the quadrangle. Most folds are upright and open, but systems of tight fault-propagation folds occur in three areas near the eastern rift margin. These systems of major folds are probably Laramide. From north to south, they are the Pinos folds, the Presilla folds, and the Tajo folds. Overturned fold limbs (Fig. 1) occur in all three areas. A marked increase in folding adjacent to the eastern rift boundary suggests the Socorro Basin originated by extensional inversion of an earlier Laramide uplift. This is supported by the dominance of Proterozoic detritus in the Eocene Baca Formation that was derived from a Laramide highland nearby to the west (Cather, 1983)

Detachment faulting, localized along gypsum beds in the upper Yeso Formation (Cañas Gypsum Member) and in the lower San Andres Formation, occurs locally in the northern and eastern part of the quadrangle. These detachment faults typically omit section (e.g., Bausch, 1982, fig. 19), and thus may be regarded as low-angle normal faults. Ramp-flat extensional geometries have produced local areas where tilted upper-plate beds are truncated by the underlying, subhorizontal detachment (Fig. 2). The acute angle of intersection between upper-plate bedding and the detachment fault points opposite to the direction of upper-plate transport (see map). The areal extent of detachment faults is depicted conservatively on the quadrangle, being mapped only where angular discordance or missing strata requires their presence. It is possible, however, that most or all of the major gypsum horizons in the Yeso and San Andes Formations hosted significant bedding-plane slip, but without dip discordance or missing strata. The age of the detachment faults is constrained only as post-Permian.

FIGURE CAPTIONS

Figure 1. View to northeast of north side of Arroyo de las Cañas showing beds of the Permian Abo and Yeso Formations folded by major overturned syncline. Gray beds on the left are Pennsylvanian Atrasado Formation that has overridden the Abo Formation along a moderately dipping reverse fault. Location of photo is UTM 13S 0334265E, 3765709N (NAD 1927).

Figure 2. View to north-northwest of steeply dipping (75°) beds of San Andres Formation overlying a detachment surface that is subparallel to the underlying, gently dipping (20°) Glorieta Sandstone and the basal bed of the San Andres. These discordant beds resulted from a ramp-flat geometry in a decollement that was localized by gypsum beds in the lower San Andres Formation. Upper-plate movement was toward the left (west).This outcrop is located near the center of NE/4, sec. 17, T3S, R2E.

DESCRIPTION OF UNITS

CENOZOIC ERATHEM

Middle Pleistocene-Holocene

Qsg Sand and gravel (Holocene)-- Sand, gravel, and minor mud in modern active arroyo channels and in the channel of the Rio Grande. 0-30 m thick

Qal Alluvium (Holocene)-- Sand, gravel, and mud adjacent to modern arroyo and river channels. Alluvium is typically at or near grade of modern channels, except in local areas where cutting of toes of piedmont slopes by the Rio Grande has caused arroyos to incise deeply (1-3 m). 0-30 m thick.

Qf Mud and sand (Holocene)-- Deposits on the modern floodplain of the Rio Grande.

Qae Eolian deposits (upper Pleistocene-Holocene)-- Eolian sands and loessic silts; deposits are stabilized by vegetation in most areas, but active dunes are present on lee sides of hills in some areas. Includes thin, discontinuous eolian veneers on stable upland surfaces that are intimately intertongued with alluvium. 0-10 m thick.

Qpy Younger piedmont alluvium (upper Pleistocene)-- Gravel, sand, and mud typically deposited at low elevations (less than about 30 m) above modern stream grade, east of the Rio Grande. Alluvium is representative of deposition in a variety of piedmont environments, including alluvial fans, paleovalley and arroyo fills, strath terraces, fill terraces, and pediments. At least two aggradational episodes are represented by Qpy. 0-25 m thick.

Qpo Older piedmont alluvium (middle to lower(?) Pleistocene)--Gravel, sand, and mud typically deposited at higher elevations (more than about 30 m) above modern stream grade east of the Rio Grande. Range of depositional environments is similar to Qpy. At least two aggradational episodes are represented by Qpo. 0-40 m thick.

Qls Landslide deposits (Pleistocene?)--Mass-wasting deposits consisting mostly boulders of San Andres Limestone. Crops out locally north of Arroyo de las Cañas.

Pliocene to middle Pleistocene

Sierra Ladrones Formation of Santa Fe Group
(thickness unknown; lithofacies subdivisions after Cather, 1997)

QTspc Conglomeratic piedmont facies-- Characterized by conglomerate/sandstone ratio greater than 2/1. 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 common. Mudstone is rare. QTspc includes gravelly veneers on pediment surfaces. In addition to the subdivision of piedmont deposits based on textural criteria, these deposits were further subdivided on the basis of provenance. Siliciclastic piedmont deposits containing a dominance (>50%) of Mesozoic, Paleozoic, and Precambrian detritus are denoted by subscript (**s**) (includes all Santa Fe Group piedmont deposits on this quadrangle); dominantly volcaniclastic rocks are indicated by (**v**) (the volcanic petrofacies occur only on adjacent quadrangles).

QTspcs Conglomerate-sandstone piedmont facies-- Characterized by conglomerate/sandstone ratio between 2/1 and 1/2; this is the volumetrically dominant piedmont facies within the Sierra Ladrones Formation. Conglomerate is mostly clast-supported and poorly sorted. Sandstone is typically medium to very coarse-grained, commonly pebbly, and exhibits crossbedding or horizontal stratification. Mudstone is minor. Provenance subdivisions (**v**) and (**s**) are same as for QTspc.

QTsps Sandstone-dominated piedmont facies-- Characterized by conglomerate/sandstone ratio of less than 1/2. Conglomerate is clast-supported and occurs in tabular or lenticular units <2 m thick. Sandstone is very fine to very coarse grained and exhibits a dominance of horizontal stratification. Mudstone is common and occurs as tabular units that locally compose as much as 20% of the unit. Calcareous paleosols are locally well-developed. Provenance subdivisions (**v**) and (**s**) are same as for QTspc.

Qtsa Axial-river facies-- Channel and floodplain deposits of ancestral Rio Grande consisting of variable proportions of sandstone, mudstone, and conglomerate. Sandstone is typically crossbedded and poorly indurated. Clasts in conglomerate consist of well-rounded to sub-rounded pebbles of quartzite, chert, granite, gneiss, sandstone, volcanic lithics, siltstone, schist, phyllite, limestone, obsidian, and pumice. Mudstone ranges in color from reddish brown to greenish gray. Paleoflow was to the south.

QTst Transitional axial-piedmont facies-- Intertongued axial river deposits and piedmont deposits. Transitional deposits are defined as the zone of overlap between the basinward extent of piedmont sand and gravel and the mountainward extent of axial river sand and gravel. Mudstone is ambiguous as to its former position within the facies tract (i.e. piedmont vs. axial), and thus is not a factor in delineating the transitional facies.

Oligocene

Tlp La Jara Peak Basaltic Andesite (Oligocene)--Aphanitic to slightly porphyritic mafic flows and associated breccias of mostly basaltic andesite composition. Phenocrysts are mostly plagioclase and clinopyroxene. 36–24 Ma.

Tsu Upper Spears Group (upper Eocene to lower Oligocene)--Dark- to medium-gray volcaniclastic sandstone, conglomerate, and minor mudstone. 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). 0-80 m thick. Age range ~36-32 Ma (Cather et al., 1987). Spears Group terminology used as defined by Cather et al. (1994).

Eocene

Tsl Lower Spears Group (middle to upper Eocene)-- Medium- to light-gray volcaniclastic sandstone, conglomerate, debris-flow breccia, and minor mudstone. Clasts are dominated by plagioclase- and amphibole-bearing andesite and dacite. Minor amounts of non-volcanic clasts are locally present above transition with underlying Baca Formation. Thickness is ~300-500 m. Age range is ~39-36 Ma (Cather et al., 1987). Usage of the term Datil Group is after Cather et al. (1994).

Tbpg Baca Formation (middle? Eocene)--Fluvial red-bed sandstone, conglomerate, and mudstone dominated by granite-gneiss detritus. Sandstone is commonly cross-bedded; conglomerate contains pebbles, cobbles and boulders of Proterozoic and subordinate Paleozoic lithotypes. Paleoflow was toward the east.

PALEOZOIC ERATHEM

Permian

Psa San Andres Formation (Leonardian)--Interbedded limestone, dolostone, breccia and gypsum. Limestone is brownish-black (5YR 2/1), pale yellowish-brown (10YR 6/2) and medium gray (N5) and ranges from wackestone to grainstone. Dolostone is brownish-gray (5YR 4/1) to olive-gray (5Y 4/1), and locally gypsiferous. Breccia consists of brownish-black (5YR 2/1) limestone and dolostone that grade laterally into thin-bedded, dark gray (N3) unbrecciated limestone. Gypsum is white (N9) to light gray (N7), laminated and poorly exposed. Basal contact is placed at the base of the stratigraphically lowest, thick (>0.5 m) limestone. 60-200 m thick.

Pg Glorieta Sandstone (Leonardian)--White (N9) to very pale orange (10YR 8/2), fine- to medium-grained, friable to well-indurated, Texturally and mineralogically mature, crossbedded quartzarenite (Plate 12). Has scattered coarse-grained, well-rounded, frosted quartz grains, especially in the lower half of the unit. Basal contact is placed at the base of the lowermost thick-bedded (>0.5 m), light-colored sandstone. 55-63 m thick.

Py Yeso Formation (Leonardian)--Interbedded sandstone, siltstone, dolomitic limestone and mudstone. Divided into four members (in ascending order): Meseta Blanca, Torres, Cañas Gypsum, and Joyita Members. The Meseta Blanca Member constitutes the lower Yeso Formation (**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 mudstone. Basal contact is placed at first occurrence up-section of laterally continuous, orange, fine-grained non-fluviatile sandstone above the Abo Formation; this basal sandstone typically forms a prominent ridge. 40–100 m thick. The upper Yeso Formation (**Pyu**) consists of three members. 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) limestone that ranges from carbonate mudstone to peloidal or oolitic packstone and grainstone and are locally fossiliferous, dolomitic, and argillaceous. As many as 12 limestone beds are present within the section. Approximately 170 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. 0-100 m thick. Joyita Member: Thin bedded, 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. 10-35 m thick.

Pa Abo Formation (Wolfcampian)--Interbedded dark reddish brown (10R 3/4) mudstone and shale, and grayish red (10R 4/2) to dark reddish brown (10 R 3/4) siltstone, sandstone and, locally, thin conglomerate and rare limestone. Nodular paleosols are common. Large, lenticular channel sandstones are common in the lower part. Approximately 200 meters thick.

Pb Bursum Formation (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, locally pebbly, notably lenticular and trough cross-bedded sandstones. The upper contact is placed at the top of the uppermost lenticular, gray, coarse sandstone. Approximately 200 m thick.

Pennsylvanian

IPma Atrasado Formation of Madera Group (Desmoinsian, Missourian, and Virgilian)--Marine and paralic interbedded brownish-gray arkosic sandstone, greenish-gray to gray mudstone, and light gray limestone. Includes Bartolo, Amado, Adobe-Coane, Council Spring, Burrego, Story, Del Cuerto, and Moya units of Rejas (1965). Basal contact is placed at base of lowermost major clastic unit in the Madera Group. Approximately 250 m thick.

IPmg Gray Mesa Formation of Madera Group (Desmoinsian)--Medium-gray, fossiliferous, commonly cherty, marine limestone, greenish-gray mudstone, and minor sandstone. Includes Elephant Butte, Whisky Canyon Limestone, and Garcia units of

Rejas (1965). Basal contact is placed at top of uppermost thick sandstone that defines the top of the Sandia Formation. Approximately 150 m thick.

IPs Sandia Formation (Atokan)--Continental and marine, Arkosic to quartzitic light brown sandstone, greenish-gray mudstone, and medium gray limestone. 90–175 m thick.

PROTEROZOIC

Xgg Weakly to moderately foliated granitic gneiss, locally pegmatitic.

EXPLANATION OF MAP SYMBOLS

Contact between geologic units, or between textural lithofacies of Santa Fe Group. 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 moderate- to low-angle fault that repeats section (older over younger).

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

Overturned anticline showing trace of axial surface, dashed where approximately located, dotted where concealed.

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

Overturned syncline showing trace of axial surface, dashed where approximately located, dotted where concealed.

Slip direction of upper plate of detachment fault, as shown by down-dip truncation of bedding in upper plate

Las Cañas geomorphic surface

Strike and dip of bedding.

Vertical bedding.

Horizontal bedding.

Paleocurrent direction based on pebble imbrication or crossbedding.

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