

# Geologic Map of the South Garcia SE 7.5-minute Quadrangle, Valencia County, New Mexico

By

Jason W. Ricketts and Karl E. Karlstrom, III

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**New Mexico Bureau of Geology and Mineral Resources**  
*Open-file Geologic Map OF-GM 246*

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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## **Introduction**

The South Garcia SE Quadrangle lies along the western edge of the Albuquerque basin of the Rio Grande rift, central New Mexico. Paleozoic and Mesozoic rocks, partially covered by basalt flows, crop out along the western 1/3 of the map area, while the eastern 2/3 consists of Santa Fe Group rift fill, various basaltic rocks, and unconsolidated Quaternary cover. Deformation in this region is predominantly concentrated along a narrow (1-2 km wide) N-S-trending zone that represents the northernmost continuation of the Lucero Uplift. This uplift separates relatively undeformed rocks of the Colorado Plateau to the west from the Albuquerque basin of the Rio Grande rift to the east. Deformation preserved in this region includes Laramide-age contraction that has been overprinted by extensional deformation related to the development of the Rio Grande rift. More recent landscape denudation is recorded by Pliocene and younger basalt flows and perched travertine deposits throughout the map area.

## **Laramide-Age Structures**

The most prominent Laramide-age structure in the map area is the NS-trending north-plunging Lucero monocline (Callender and Zilinski, 1976). Although the Lucero monocline has been heavily faulted, it largely impacts the distribution of rocks at the surface today. For example, the oldest rock units in the map area are Pennsylvanian, which are only exposed in the southwestern part of the quadrangle. The rocks get progressively younger to the north, and include Permian, Triassic, Jurassic, and Cretaceous sedimentary rocks, reflecting the northward plunge of the monocline. The western limb of the monocline is characterized by relatively gentle westward dips between  $\sim 5\text{-}10^\circ$ , while on the eastern limb sedimentary rocks dip  $\sim 70\text{-}85^\circ$  east. The Lucero monocline is cored by the reverse-sense Comanche fault, a high-angle to vertical structure that dips west (Callender and Zilinski, 1976). In the southernmost part of the map area, the Comanche fault separates Pennsylvanian sedimentary rocks in the hanging wall from Permian sedimentary rocks in the footwall. Total displacement along the fault diminishes to the north, and the Comanche fault dies out within the Permian Yeso Formation.



**Figure 1.** View looking north towards Carrizo Arroyo of the Lucero monocline. Flat-lying Pennsylvanian Atrasado (Pa) and Red Tanks (PrT) Formations are exposed in the valley to the west, and are capped by Permian Abo and Yeso Formations. The Mesa Carrizo basalt flow (Tbmc) caps Yeso Formation (Py) in the background. The steeply-dipping eastern limb of the monocline is made up of Permian Glorieta (Pg) and San Andres Formations (Psa). The Albuquerque basin is to the east.

### **Rio Grande Rift Structures**

Extension on the South Garcia SE Quadrangle is predominantly concentrated along the ~55-60° east-dipping Santa Fe fault, which extends ~N-S along the length of the map area. Seismic reflection data suggests that the Santa Fe fault in this region has accumulated more than 3,050 m of throw (Russell and Snelson, 1994). The Santa Fe fault separates Paleozoic and Mesozoic sedimentary rocks in the footwall from Santa Fe

Group rift fill in the hanging wall, and truncates the eastern limb of the Laramide-age Lucero monocline. In the southern part of the quadrangle, the Laramide-age Comanche fault was reactivated as a normal fault during development of the Rio Grande rift (Callender and Zilinski, 1976) such that extensional deformation is subdivided among several structures.

As the Comanche fault dies out to the north, numerous normal faults emerge in the footwall of the Santa Fe fault. These faults typically have ~1-20 m of offset, are both synthetic and antithetic to the main Santa Fe fault, and can only be traced for several 10's or 100's of meters. Along the northern boundary of the quadrangle, extension is partitioned among multiple normal faults, including the Santa Fe fault, that can be traced for at least several kilometers and continue into the quadrangle to the north. Together these faults mark the southernmost extent of the Rio Puerco fault zone, a region of distributed deformation along the northwestern edge of the Albuquerque basin that includes north-trending folds and normal faults (Slack and Campbell, 1976). Bedding attitudes in the Santa Fe Group adjacent to the Santa Fe fault define a fault-parallel synform, which is interpreted to be due to continued slip along the Santa Fe fault. This synform can be traced almost the entire length of the quadrangle, but it, along with the Santa Fe fault, are both concealed beneath Quaternary gravels within the northern part of the map area.



**Figure 2.** View looking south of the Santa Fe fault, separating Santa Fe Group (Tsf) rift fill on the east (left side of photo) from Triassic Chinle Formation (Tc) on the west. Perched travertine deposits (Qt2) cover both the Chinle Formation and Santa Fe Group at this location.

A 27.5 Ma granitic body intrudes Permian rocks between the Comanche and Santa Fe faults at the southern edge of the South Garcia SE Quadrangle. This intrusion is probably genetically related to multiple ~1-2 m-wide dikes, which indicate ~EW extension in the region by 27 Ma. Sedimentation rates in the Albuquerque basin dramatically increased after ~16 Ma (Chapin and Cather, 1994), indicating that although the Santa Fe fault may have been active since the Oligocene, the main phase of

extension was most likely during the early to middle Miocene. In some areas the Santa Fe fault offsets Pliocene-early Pleistocene Santa Fe Group deposits (Lozinsky and Tedford, 1991). Extensional calcite-filled veins in travertine deposits preserved several km south of the South Garcia SE Quadrangle also suggest that deformation related to continued movement along the Santa Fe fault system has continued until at least ~250 ka (Ricketts et al., 2014).

### **Pliocene and Younger Landscape Evolution**

Recent and ongoing denudation of the Lucero Uplift is preserved by multiple basalt flows and travertine deposits on the South Garcia SE Quadrangle. The highest-elevation Mesa Carrizo basalt flow (Tbmc) crops out along the northwestern and southwestern parts of the quadrangle. In the northwest, the basalt flow overlies Triassic Chinle Formation, a relatively unconsolidated mudstone unit. Landslide deposits dominate the northwestern part of the map area, where detachment scarps in the Mesa Carrizo basalt flow sole into the underlying Chinle Formation. To the southwest the Mesa Carrizo basalt flow caps Permian Yeso Formation and forms the highest topography. To the east of the Lucero Uplift, the younger Suwanee basalt flow (0.32 Ma) caps Santa Fe Group rift fill at low elevations. This basalt flowed south down a paleo-Rio Puerco, and may have resulted in the eastward shift of the Rio Puerco at that time.

In the southwest region of the quadrangle, the Mesa Carrizo basalt flow is cut by Carrizo Arroyo. Kolomaznik et al. (2013) used the height and age of this basalt flow to calculate a long-term incision rate for Carrizo Arroyo of  $\sim 50 \text{ m Ma}^{-1}$  in 3.7 Ma. Younger travertine deposits are found at lower elevations than the Mesa Carrizo basalt flow, and preserve younger Quaternary denudation. These travertine deposits are found along the entire N-S length of the Lucero Uplift straddling the Santa Fe fault, and were precipitated from fluids emanating from N-S-trending faults (Callender and Zilinski, 1976; Ricketts et al., 2014). These deposits occur at different levels above modern arroyos and mantle pre-existing topography. Using the heights and U-series ages of several perched travertine terraces at different elevations, Kolomaznik et al. (2013) suggested that incision rates in Carrizo Arroyo increased dramatically to  $\sim 150 \text{ m/Ma}$  after 1.2 Ma.

Multiple springs are found emanating from the narrow zone of deformation surrounding the Santa Fe fault. Many of these springs are actively precipitating travertine in EW-oriented arroyos that drain the Lucero Uplift. These active travertine deposits are similar to older perched deposits in that they emanate from springs located in arroyo bottoms and flow east towards the Albuquerque basin. Precipitating travertine is currently mantling the modern topography.





**Figure 3.** View looking south of horizontal perched travertine deposits (Qtr2) capping steeply-dipping Santa Fe Group deposits in the immediate hanging wall of the Santa Fe fault.



**Figure 4.** View looking west towards the Lucero Uplift. Active travertine deposition in the arroyo produces waterfalls, dams, and coatings on vegetation.

## Description of Map Units

- Qaf** Artificial fill
- Qa1** Youngest stream alluvium (Historic to Holocene) - Unconsolidated deposits of silt, sand, and gravel in intermittent stream channels draining the Lucero uplift to the east and within the Rio Puerco to the west. Gravels consist of locally-derived clasts of sandstone and limestone derived from the underlying Paleozoic stratigraphy, chert from the Chinle Formation, basalt, and travertine.
- Qa2** Older colluvium, alluvium between active channels, and minor eolian sand. Unconsolidated, well-sorted, fine-grained sand and minor silt. Up to 5 m thick.
- Qoa** Older alluvial deposits, calcic soils, and eolian cover of piedmont areas.
- Qs** Deposits associated with elevated geomorphic surfaces – Unlithified to moderately lithified, poorly sorted sand and gravel with minor silt and clay. Clasts are angular and locally derived, and include travertine, basalt, limestone, and sandstone. Deposits occur at several levels above Qa2. Generally 1-3 m thick.
- Qt** Terraces – Well-cemented, poorly sorted, clast to matrix supported, angular to sub-angular conglomeratic deposits situated above Qa2. Gravels are pebble- to-cobble-sized clasts of sandstone, limestone, and basalt that are sometimes cemented with thin rims of travertine or cemented with thicker (>3 cm to several meters) accumulations of flowstone travertine. Terraces occur at several levels, where Qt1 is the lowest and relatively youngest deposit, and Qt3 is the highest and relatively oldest deposit (Kolomaznik et al., 2013).
- Qtr** Travertine - Terrace deposits consisting of banded travertine and/or sandstone to pebble-cobble conglomerate which is well-cemented with travertine. Banded travertine shows flowstone morphologies with typically well-preserved dam and spillover geometry. Sandstone and pebble-cobble conglomerate is composed of locally derived sandstone and limestone clasts from the Paleozoic section, and minor basalt. Clasts are typically coated with thin (~1-3mm) travertine rinds. East of the Santa Fe fault, travertine deposits are typically flat-lying and elevated above modern drainages. West of the Santa Fe fault the travertine deposits mantle the topography and slope towards the east. Different travertine terrace heights are observed. Qtr1 consists of recently-precipitated to actively-precipitating travertine in drainages with active springs. These deposits are typically associated with salt deposits. Higher order travertine terraces correspond to higher relative elevations in the local drainage.
- Tbs** Suwanee basalt flow - Basalt flow which follows the modern Rio San Jose drainage system. It has a reported K-Ar age of  $0.32 \pm 0.2$  Ma (Bachman and Mehnert, 1978).

- Tp** Popotosa Formation of the Santa Fe Group - Poorly to well-indurated, poorly sorted, brown to reddish-brown, fine- to very coarse grained sand, conglomeratic sand, silty sand, clayey sand, and conglomerate. Locally crossbedded. Clasts are angular to subrounded and include ash-flow tuff, calcareous shale, basalt, limestone, quartz, granite, and quartzite (Lozinsky and Tedford, 1991).
- Tbmc** Mesa Carrizo basalt flow - Dark gray basalt with euhedral plagioclase and olivine and minor clinopyroxene and opaque minerals (Zilinski, 1976). K-Ar age of  $3.7 \pm 0.4$  Ma (Bachman and Mehnert, 1978).
- Tbmm** Basalt of Mohinas Mountain - Black to dark-gray, dense basalt and olivine diabase. Occurs as cone sheet within mountain and as sills and dikes around mountain (Lozinsky and Tedford, 1991). To the north of Mohinas Mountain at Hidden Mountain, Baldrige et al. (1987) report a basalt K-ar age of  $8.2 \pm 0.2$  Ma.
- Ti** Intrusive complex - An intrusive suite of rocks, located mainly in the southern region of the map area, intrudes into the Comanche monocline, generally following the NS-trending fabric. In the south, the intrusive rocks form a stock, while to the north these rocks are exposed as NS- to NE-SW-trending dikes that cross-cut the Paleozoic rocks. Petrologically, the southern stock ranges from a biotite-rich olivine gabbro, to a microdiorite, to a biotite-rich diorite. These rocks are intruded by younger quartz monzonite (Callender and Zilinski, 1976). A sample of biotite-rich diorite gives a biotite  $^{39}\text{Ar}/^{40}\text{Ar}$  age of  $27.51 \pm 0.04$  Ma, which was analyzed at the New Mexico Geochronology Research Laboratory at New Mexico Tech in Socorro, New Mexico. Sample location: 13S 308729 m E, 3846054 m N. Elevation 5809 ft.
- Km** Mancos Formation – Dusky yellow to moderate olive brown mudstone, siltstone, and sandstone.
- Kd** Dakota Formation – Very pale orange to grayish orange well-sorted, rounded to subrounded, medium to coarse-grained quartz arenite with some ~5-10 cm thick beds of granule conglomerate. Clasts in conglomerate are subrounded to angular quartz and feldspar ~1-2 mm in diameter. Quartz arenite displays trough cross-bedding. At the base of this unit is a distinctive 0.5-1 m thick matrix supported pebble conglomerate. Clasts are rounded to sub-angular quartzite and chert ~3-20 mm in diameter.
- Jm** Morrison Formation – Brushy Basin Member of the Morrison Formation which consists of grayish yellow green mudstone and siltstone with minor sandstone lenses. Sandstone is well-sorted, rounded to subrounded, medium grained quartz arenite with ~5-10 cm high cross-beds.

- Jb** Bluff Sandstone – Well-sorted, rounded to subrounded, medium to coarse-grained, grayish orange to dark yellowish orange quartz arenite. Contains ~1-2 m high cross-beds.
- Jt** Todilto Formation – Dark gray, thinly bedded, fetid shale and limestone with intraformational folds, faults, and breccia.
- Je** Pale yellow to grayish yellow, medium-grained, well-sorted and well-cemented sandstone.
- Ƨc** Chinle Formation - At the base of the Chinle Formation, ~1-5 m of pebble conglomerate containing sub-rounded to sub-angular clasts of quartzite, chert, quartz, and limestone of the Shinarump Member are exposed. Above the Shinarump Member the Chinle Formation consists of moderate reddish brown to pale purple or whitish-gray bentonitic mudstone and siltstone with minor medium to coarse-grained sandstone beds. This unit contains the Ojo Huelos limestone, a ridge-forming limestone unit ~2-4 m thick.
- Ƨm** Moenkopi Formation – Well-sorted, fine-grained, moderate reddish brown to dark reddish brown sandstone and siltstone. Composed mostly of thin (1-2 cm) beds that commonly display ripples.
- Psa** San Andreas Formation - Contains multiple lithologies, including medium to light-gray nonfossiliferous limestone, grayish-white gypsum and argillaceous gypsum with gypsiferous shale and secondary selenite, and minor light-brown shale (Zilinski, 1976). The San Andres is commonly interbedded with the underlying Glorieta Formation, and the contact between the two is placed at the lowermost limestone bed.
- Pg** Glorieta Formation - Buff, medium-grained sandstone with hematite staining and cross-bedding (Zilinski, 1976).
- Py** Yeso Formation - The upper Yeso formation consists of interbedded reddish-brown to orangeish-brown shale, siltstone and sandstone with gray to white gypsum and limestone. The lower Yeso Formation is a reddish-brown, well indurated, massively-bedded, fine-grained, well-sorted sandstone with spotty reduction zones (Zilinski, 1976).
- Pa** Abo Formation - Deep brown to reddish-brown siltstone and shale interbedded with ridge forming sandstone. The upper part is brown to light-reddish-brown, medium to thick bedded, arkosic sandstone and siltstone with minor shale.
- Ƨrt** Red Tanks Formation - Grayish-white to reddish-brown shale and sandstone interbedded with gray limestone and limestone-pebble conglomerate. The lower part of the Red Tanks consists of dark red shale, siltstone, and sandstone, with minor buff sandstone and limestone conglomerate. The upper part consists of

whitish-gray, thin-bedded nodular limestone and gray shale (Kelley and Wood, 1946). Fossil assemblages in the Red Tanks Formation include fresh water plant-eurypterid-insect, brackish water bivalve, and marginal marine *Myalina* gastropod (Kues and Kietzke, 1976). Approximately 450 feet thick.

**Pa** Atrasado Formation - Ridge forming gray limestone and cherty limestone, with minor light-gray to reddish-brown shale, sandstone and conglomerate (Zilinski, 1976).

## References Cited

- Bachman, G. O., and Mehnert, H. H., 1978, New K-Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico: *Geological Society of America Bulletin*, v. 89, p. 283-292.
- Baldrige, W. S., Perry, F. V., and Shafiqullah, M., 1987, Late Cenozoic volcanism of the southeastern Colorado Plateau: I. Volcanic geology of the Lucero area, New Mexico: *Geological Society of America Bulletin*, v. 99, p. 463-470.
- Callender, J. F., and Zilinski, R. E. Jr., 1976, Kinematics of Tertiary and Quaternary deformation along the eastern edge of the Lucero Uplift, central New Mexico: *New Mexico Geological Society Special Publication 6*, p. 53-61.
- Chapin, C. E., and Cather, S. M., 1994, Tectonic setting of the axial basins of the northern and central Rio Grande rift: *in: Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, Stratigraphy, and Tectonic Setting: Geological Society of America Special Paper 291*, p. 5-26, doi:10.1130/SPE291-p5.
- Kelley, V. C., and Wood, G. H., 1946, Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: *U.S. Geological Survey Oil and Gas Inv. Prelim. Map No. 47*.
- Kolomaznik, M., Ricketts, J. W., Priewisch, A., Crossey, L. J., Karlstrom, K. E., Asmerom, Y., and Polyak, V., 2013, U-series dating and stable isotope analysis of Quaternary travertines with implications for incision rates in western Rio Grande rift, Carrizo Arroyo, New Mexico: *in: Zeigler, K., Timmons, M. J., Timmons, S., and Semken, S., eds., Geology of Route 66 Region- Flagstaff to Grants: New Mexico Geological Society, Guidebook 64*, p. 199-204.
- Kues, B. S., and Kietzke, K. K., 1976, Paleontology and stratigraphy of the Red Tanks Member, Madera Formation (Pennsylvanian) near Lucero Mesa, New Mexico: *New Mexico Geological Society, Special Publication 6*, p. 102-108.
- Lozinski, R. P., and Tedford, R. H., 1991, Geology and paleontology of the Santa Fe Group, southwestern Albuquerque Basin, Valencia County, New Mexico: *New Mexico Bureau of Mines and Mineral Resources, Bulletin 132*.
- Ricketts, J. W., Karlstrom, K. E., Priewisch, A., Crossey, L. J., Polyak, V. J., and Asmerom, Y., 2014, Quaternary extension in the Rio Grande rift at elevated strain

rates recorded in travertine deposits, central New Mexico: *Lithosphere*, v. 6, p. 3-16, doi: 10.1130/L278.1.

Russell, L. R., and Snelson, S., 1994, Structure and tectonics of the Albuquerque Basin segment of the Rio Grande rift: Insights from reflection seismic data: *in*: Keller, G. R., and Cather, S. M., eds., Basins of the Rio Grande Rift: Structure, Stratigraphy, and Tectonic Setting: *Geological Society of America Special Paper 291*.

Slack, P. B., and Campbell, J. A., 1976, Structural geology of the Rio Puerco fault zone and its relationship to central New Mexico tectonics: *New Mexico Geological Society Special Publications 6*, p. 46-52.

Zilinski, R. E., Jr., 1976, *Geology of the central part of the Lucero uplift, Valencia County, New Mexico* [M.S. thesis]: Albuquerque, University of New Mexico, 69 p.