

Geologic Map of the Manzano Peak Quadrangle, Valencia and Torrence Counties, New Mexico

By

**Shannon Baer, Karl E. Karlstrom, Paul Bauer, and Sean D.
Connell**

July, 2004

**New Mexico Bureau of Geology and Mineral Resources
*Open-file Digital Geologic Map OF-GM 61***

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**

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Manzano Peak 7.5' Quadrangle
OF-DM -61

GEOLOGY OF THE MANZANO PEAK 7.5-MINUTE QUADRANGLE, TORRANCE AND VALENCIA COUNTIES, NEW MEXICO

by

Shannon Baer, Karl E. Karlstrom, Paul Bauer, Sean D. Connell,

Geologic mapping by

Shannon Baer, Karl E. Karlstrom, Fletcher Schneeflock (Proterozoic), Sean D. Connell (Cenozoic), with
previous mapping by Paul Bauer, Andrew Smith, Donald A. Meyers, and E.J. McKay

New Mexico Bureau of Mines and Mineral Resources

Open-File Report OFDM-XX

May, 2003

Printed ---

New Mexico Bureau of Geology and Mineral Resources
A division of New Mexico Institute of Mining and Technology
801 Leroy Place
Socorro, NM 87801-4796

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Statemap Report

INTRODUCTION

The Manzano Peak 7.5-minute quadrangle comprises an area of about 160 km² (60 mi²) in Torrence and Valencia Counties, New Mexico (Fig. 1). The Quadrangle contains the boundary between the Rio Grande rift on the west and the mountainous rift-flank on the east. The rift-flank consists of the central Manzano Mountains. Earlier studies of the Manzano Mountains were done by Bauer (1983), Stark (1956), Stark and Dapples (1946), Reiche (1949), and Myers and McKay (1974). The geologic map (Plate I) is the result of additional detailed field mapping and integration of these previous works.

Geologic mapping was completed in cooperation with the University of New Mexico (UNM) and the New Mexico Bureau of Geology and Mineral Resources (NMBGMR). The topographic base for the geologic map is the Manzano Peak Quadrangle, 7.5-minute topographic series, published by the United States Geological Survey at a scale of 1:24,000 (one inch equals 2000 feet). Proterozoic rocks and structures were mapped at a scale of 1:12,000; Paleozoic rocks and associated structures were mapped in reconnaissance, with some modifications after Myers and McKay (1974; scale 1:24,000). Tertiary and Quaternary features were mapped with the help of air photos from the U.S. Forest Service.

Principal contributions and revisions that have refined the structure and stratigraphy of this quadrangle include: 1) correlation of Proterozoic metasedimentary and metavolcanic units with other areas in the Sandia-Manzano uplift; 2) differentiation of Precambrian rock units; 3) introduction of previously unmapped Precambrian structures and refinement of the timing of these structures; 4) refinement of Paleozoic and younger structures and their relative movement

sense; 5) recognition and refined mapping of range-bounding structures; and 6) differentiation of the piedmont stratigraphy on both the east and west sides of the highlands.

COMMENTS TO MAP USERS

Mapping of this quadrangle was funded by a matching-funds grant from the 2001-2003 STATEMAP program of the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number 00HQAG0078, to the New Mexico Bureau of Geology and Mineral Resources (Dr. Peter Scholle, Director; Dr. Paul W. Bauer, P.I. and Geologic Mapping Program Manager).

This quadrangle map has been Open-Filed in order to make it available as soon as possible. The map has not been reviewed according to NMBGMR standards, and due to the ongoing nature of work in the area, revision of this map is likely. As such, dates of revision are listed in the upper right corner of the map and on the accompanying report. *The contents of the report and map should not be considered final and complete until it is published by the NMBMMR.*

A geologic map graphically displays information on the distribution, nature, orientation, and age relationships of rock and surficial units and the occurrence of structural features such as faults and folds. Geologic contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic map are based on 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. Significant portions of the study area may have been mapped at scales smaller than the final map; therefore, the user should be aware of

potentially significant variations in map detail. 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 everywhere.

The cross-sections in this report are constructed based on surficial geology, and where available, subsurface and geophysical data. The cross sections are interpretive and should be used as an aid to understand the geologic framework and not used as the sole source of data in locating or designing wells, buildings, roads, or other structures.

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 U.S. Government.

Accessibility

The eastern portion of the Manzano Peak Quadrangle is within the Manzano Mountain Wilderness area, part of the Cibola National Forest. The area is accessible from N.M. Highway 60 through Bernardo, and onto forest road that gives access to most trailheads leading into the Manzano Peak Quadrangle. Several graded dirt and paved roads allow access to portions of the study area. The western portions of the quadrangle are accessible from dirt roads off of N.M. Highway 47 and is a privately owned land grant.

Geologic and Physiographic Setting

The western part of the quadrangle contains a small amount of eastern Rio Grande rift valley piedmont, the topographic highs of the rift flank contain Precambrian basement which was overlain by Paleozoic strata until uplift of the range in the Tertiary. The Laramide Montosa fault forms the structural boundary between the rift flanking mountain highs and the adjacent Estancia Basin. This is a typical Laramide range-bounding fault or monocline in which Paleozoic strata

are overturned due to west-side-up reverse movement (likely reactivation) on a high angle fault. Within the range, an important structure is the Proterozoic Monte Largo shear zone, which strikes to the northeast along the northwestern edge of the quadrangle and juxtaposes amphibolite grade rocks to the south over greenschist grade rocks to the north. The western part of the quadrangle exposes little of the Tertiary normal faults that form generally straight segments along the mountain front. The mountain-front is embayed by moderate to large size canyons among them rocks in Pipe canyon and Estadio canyon and display spectacular assemblages of the rocks and structures within the Precambrian rocks of the quadrangle. The eastern half of the quadrangle contains mostly Paleozoic limestone, clastic limestone, and sandstone. Topography is generally steep and rugged, especially on the western flank of the range; the eastern side also has steep and difficult topography, but numerous trails make the mountain top accessible. The study area exhibits 4243 feet of maximum topographic relief, with a maximum elevation of 10,098 feet at Manzano Peak.

STRATIGRAPHY

All map units are described in Table 1. The age and stratigraphic relationships of these map units are summarized in the Correlation of Map Units.

Quaternary and Pliocene Deposits

Alluvial Deposits

Quaternary and Pliocene alluvial deposits of the Manzano Peak 7.5-minute quadrangle contain variable proportions of gravel, sand and silt, deposited by intermittent and ephemeral streams; mass-movement deposits typically occur on hill slopes. Map-unit differentiation is based on stratigraphic position (inset or depositional relations), surface morphology, degree of soil-profile development (see Gile et al., 1966; 1981) and sedimentary character. Deposits are a

mixture of poorly sorted, poorly to moderately stratified, clast- and matrix-supported alluvium, having predominantly gravelly to sandy textures; silt-clay textures are locally common. Clast constituents typically reflect bedrock composition of local upland drainage systems associated with the western flank of the Manzano Mountains. Alluvial deposits are 12- to 21-m thick and unconformably overlie older rocks. Detailed soil-profile descriptions were not made during this study, therefore, unit subdivisions may not be correlative across individual drainage basins. Alluvial deposits are divided into three major classes: 1) valley-fill alluvium, 2) piedmont-slope alluvium, and 3) colluvium and spring deposits.

Paleozoic Rocks

The Pennsylvanian strata exposed within the quadrangle include the Sandia Formation and Madera Group (Los Moyos Formation and Wild Cow Formation), and the Permian Bursum and Abo Formations. These rocks are marine and non-marine sedimentary rocks that were deposited within and adjacent shallow seaways that formed in the basins of the Ancestral Rocky Mountains. The closest uplift was the Pedernal Hills to the east. The change from the almost pure limestone of the Los Moyos Formation to the silty and clastic Wild Cow Formation probably represents a change from a shallow marine setting to a tectonically active time during which clasts and other material were shed from the Ancestral Rocky Mountain highs (Kluth and Coney, 1981). For a description of these units see Table 1.

Proterozoic Rocks

Proterozoic rocks in the Manzano Peak Quadrangle consist of ductilely deformed and metamorphosed volcanic, sedimentary and plutonic rocks. Our interpretation is that these rocks formed in volcanic arcs and related arc basins along the growing southern periphery of cratonic North America ca. 1.68-1.65 Ga. The metamorphic sequence is described in Table 1. Due to the

polyphase deformational history, construction of a coherent stratigraphy is difficult. However, there is an emerging regionally coherent stratigraphy that involves a lower metavolcanic suite (mafic and felsic rocks) overlain by a sedimentary succession that gets cleaner and more mature upward, towards massive white, relatively clean quartzites, then overlying shists.

In the Manzano Peak Quadrangle, the basal unit is the Sevilleta metarhyolite (Xsr) that has been dated ~1680 Ma (Bowring et. al., 1983). The Sevilleta metarhyolite is interpreted to be the oldest unit of the area based on its stratigraphic relationship with other units. The Sevilleta metarhyolite of the Manzano Peak Quadrangle is similar to and correlated with metarhyolites of the Los Pinos Mountains (Bauer, 1993; Cavin, 1995) and the Monte Largo Hills (Timmons et al., 1995). In the southern portion of the quadrangle the metarhyolite is not exposed but further north it becomes very thick. In the southern part of the quadrangle the metarhyolite is interfingering with mafic units of the metavolcanic package including amphibolites (metabasalt and metagabbro) and mafic schists; these are interpreted as part of the “greenstone” packages mapped elsewhere in the Manzano and Los Pinos Mountains (Bauer, 1993). The overlying metasedimentary succession is a complex sequence of phyllite and metamorphosed metalithic arenite. Near the base of the sedimentary succession are lenticular outcrops of dacitic breccia that resemble the Lacorocah metadacite of Parchman (1980). The lithic arenite succession is compositionally variable and contains more pelitic layers that contain garnet and staurolite schist. All of these rocks are intensely interlayered with amphibolites. The amphibolites have variable texture: some are coarse grained and resemble gabbroic sills and dikes; some are fine grained and contain vesicles and other evidence that they were eruptive units.

The arenites grade upward into cleaner metasediments of the White Ridge Quartzite and related Sais Quartzite units, which are separated by a staurolite schist unit that we name the

Estadio Schist, for excellent outcrops in Estadio Canyon. The stratigraphic top of the White Ridge Quartzite has a distinctive Al-rich layer with spectacular andalusite and in Estadio Canyon. The Sais Quartzite is overlain by the Blue Springs Quartzite, Blue Spring Schist, Blue Spring Rhyolite, and an upper Blue Spring Schist. The Blue Springs metarhyolite is banded metarhyolite defined by mm-10's cm scale compositional bands. This has been correlated with a unit originally mapped as a metachert (Grambling, 1982) and as a metasiltstone (Stark and Dapples, 1946) in the Capilla Peak Quadrangle. Geochemical analyses by (Duran, 2001) suggests that the unit is a metarhyolite.

The upper succession of metasedimentary rocks is intruded by two different plutons. The Monte Largo quartz monzonite intrudes the Blue Springs package in the NW corner of the quadrangle. This pluton yields a U-Pb zircon date of 1656 \pm 10 Ma (Bauer et al., 1993). The Priest Pluton intrudes the Blue Springs Formation in the south-central part of the quadrangle. This pluton yields a U-Pb zircon date of 1443 \pm 10 Ma (Thompson et al. 1996). An extensive metamorphic contact aureole is mapped at the margin of the Priest Pluton with concentric isograds extending away from the pluton (Thompson et al. 1996).

Between the two plutons is the entire stratigraphic section, the Sevietta metarhyolite, the greenstone belt, a lithic arenite, the White Ridge and Sais Quartzites and finally the Blue Springs Formation. The prominent structure, the Monte Largo shear zone, juxtaposed the rocks near the base of the section with rocks near the top of the section. Folding has caused numerous complexities to this succession, as discussed below.

STRUCTURAL GEOLOGY

Folds, faults and shear zones in the Manzano Peak Quadrangle exhibit several styles of deformation related to different periods of tectonic activity since the Proterozoic. This section discusses some of the recent refinements to the structure of the study area.

The previously mentioned Monte Largo shear zone (Bauer, 1983; Thompson et al., 1996) is the most prominent structure in the field area and is an example of a reactivated structure that has a long history of movement during the Proterozoic. Monazite from within the shear zone suggest that it was active at 1.65 Ga during emplacement of the Monte Largo pluton generally referred to as D1/D2 and then again at 1.43 Ga during and after emplacement of the Priest pluton (D3; Baer et al., 2003).

There is evidence for multiple generations of deformation including: D1, D2, and D3 (Baer, et al. 2002, Baer et al. 2003). D1 involved west directed thrusting. Field observations include an early foliation, S1, which is generally subparallel to bedding and is seen in thin section, or associated with minor nappe folds (Karlstrom et al. 2001). These F1 folds are subsequently refolded by F2 folds. F2 folds in the Manzano Quadrangle trend to the northeast, and plunge both SW and NE (Baer et al. 2003). D2 involved upright folding and establishment of the main NE-trending cleavage in the rocks. Movement on the Monte Largo shear zone is interpreted to be associated with D2, but movement may have also taken place in D1. Rocks below the shear zone (in the footwall) have undergone very high strain and significant transposition as shown by lenticular outcrops and interfingering of quartzite, rhyolite and schist of the Blue Springs Formation. Rocks in the hangingwall are also tightly folded, but the overall structure is somewhat simpler and is characterized by a km-scale anticline –syncline pair that is interpreted to have initiated as \thrust-style ramp and flat folding. The anticline verges westward like the shear zone beneath it. The large F2 synclinorium in the eastern part of the Proterozoic

exposure is named here the Manzano Peak synclinorium. Preserved cross bedding in the quartzite units and bedding-cleavage relationships both help define it as an upright syncline. It plunges shallowly to the southwest and the S2 cleavage defined by aligned mica is truncated at the northern margin of the pluton indicating the fold developed before the pluton was emplaced. Its axial plan dips steeply to the west, presumably because of D3 in the roof of the Priest pluton

F3 folds fold, kink, or deflect the main S2 schistosity. D3 can be shown to be pluton related shortening because of porphyroblast-matrix studies using contact minerals and intensification of S3 as the pluton is approached. The beautiful and well preserved folds in Estadio Canyon are an example of D3 structures; they consist of a series of tight downward facing folds (antiformal synclines and synformal anticlines) that fold S2. F3 folds are also present in the Sevilleta metarhyolite on the hangingwall side of the Monte Largo shear zone in the northwestern quadrant suggesting 1.4 Ga renewed thrusting on the shear zone. In the northwestern part of the quadrangle below the Monte Largo thrust, syn to post-F3 structures include brittle-ductile thrusts with top-northwest shear sense that drape the Monte Largo pluton (Bauer et al., 1993).

Paleozoic and Younger Structures

Paleozoic and younger structures consist primarily of faults and gentle- to steep- limbed drape or monoclinical folds adjacent to these faults. Most faults trend N-S with minor bends and splays that trend NNE and NNW. Several faults within the Manzano Peak Quadrangle likely had complex movement histories associated with contraction of the Laramide Orogeny in late Cretaceous/early Tertiary time and extension related the development of the Rio Grande rift.

On the east side of the Manzano Mountains the main structure is the Montosa fault system. The fault dips to the west at about 50 degrees, based on the dip of overturned beds adjacent to the fault. It is a west-side-up reverse fault with some strike-slip movement along it as well (Behr, 1997). The Montosa and related faults are interpreted as Laramide age faults. Associated east-facing monoclines in the Paleozoic strata are shown in the NW-SE cross section and are typical of the Laramide faults. Total vertical separation on these structures is shown in the cross section to be about 1500 meters, with the Paleozoic section just above the current level of exposure. This is based on the absence of Paleozoic strata at the highest elevation within the quadrangle (10,098 feet), but their presence at about this elevation just to the north, in the Capilla Peak Quadrangle.

The west side of the Manzano Mountains is controlled by major, down-to-the-west, range-bounding faults that record dip-slip normal displacement associated with extension along the Rio Grande rift in middle to late Cenozoic time. Younger sediments generally conceal the traces of these faults. Similar to the Hubbell bench to the north, the immediate range bounding faults in this part of the rift probably have only moderate displacement (7000-9000'). One Quaternary fault was found in the Manzano Peak Quadrangle and some evidence for others was observed although not confirmed.

PROTEROZOIC METAMORPHISM

The regional metamorphic grade in much of the quadrangle, between the Monte Largo shear zone and the Priest pluton, is amphibolite grade. Northwest of the Monte Largo shear zone, the rocks are greenschist grade. Mafic assemblages include actinolite (not hornblende), chlorite, sodic plagioclase, epidote quartz and white mica, suggesting temperatures of <500°C. Between the shear zone and the contact aureole, rocks contain hornblende and plagioclase suggesting

metamorphic conditions $> 500^{\circ}\text{C}$. The contact aureole of the Priest pluton is defined by two isograds that have been documented by Thompson (1993). These isograds separate the aureole into three zones: the garnet zone, the staurolite zone and the sillimanite zone. The boundary between the garnet zone and the staurolite zone represents the reaction $\text{garnet} + \text{chlorite} \rightarrow \text{biotite} + \text{staurolite}$ (the staurolite-in isograd). The boundary between the staurolite zone and the sillimanite zone is represented by the reaction of andalusite \rightarrow sillimanite and is also the temperature at which potassium feldspar is first seen in pelitic rocks (called the second sillimanite isograd $\sim 650^{\circ}\text{C}$).

Foliation- porphyroblasts relationships support the interpretation that amphibolite grade temperatures were probably achieved prior to the emplacement of the Priest pluton. For instance, there are kyanite inclusions within contact metamorphic andalusite porphyroblasts. Some garnet grains have staurolite inclusions. There is field evidence for two generations of staurolite, one that contains the S2 foliation and another that does not. However, most of the minerals are contact minerals that grew at ca. 1430 Ma, during development of the S3 cleavage. Post-emplacement retrograde metamorphism is documented by pseudomorphs of staurolite replaced by sericite, chlorite and some alteration of plagioclase to muscovite. These observations suggest late stage hydration of earlier assemblages, probably during waning stages of pluton emplacement.

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Description of map Units:

Quaternary

- Qaa Active stream alluvium (Holocene)** – Commonly brown to reddish-brown, poorly consolidated sand and gravel. Gravel contains abundant subrounded to angular granite and metamorphic rocks in drainages along western front of the Manzano Mountains; to the east, gravel contains granite, metamorphic, and dominantly reddish-brown sandstone. Deposits occupy active stream valleys. Base is not observed and is at least 2 m thick
- Qa Stream alluvium, undivided (Holocene)** – Commonly brown to reddish-brown, poorly consolidated sand and gravel, locally inset by unit **Qaa**. Base is not observed and is at least 2 m thick.
- Qay Younger stream alluvium (upper Pleistocene-Holocene)** – Brown to reddish-brown, poorly consolidated, subhorizontally bedded, poorly to moderately sorted, matrix- and clast-supported silty sand and sandy gravel. Recognized in larger drainages of the eastern dip-slope of the Manzano Mountains where it underlies broad valley floors about 3-6 m above incised active streams of units **Qa** and **Qaa**; commonly contains undivided deposits of unit **Qa**. Colluvial deposits present near the base of hillslopes near deposit margins. Base not observed, but estimated to be at least 2 m thick.
- Qpa Piedmont deposits, undivided (Pleistocene-Holocene)** – Undivided deposits of units **Qa**, **Qpm**, and **Qpo**. Mostly clast-supported gravel and dominated by granite and metamorphic rocks exposed east of the Manzano Mountains drainage divide. Deposits are locally matrix-supported near mountain front. Locally entrenched near mouths of mountain-front drainages. Base not observed west of the mountain front. Estimated thickness ranges from 1 m to more than 10 m.
- Qpm Middle piedmont deposits (middle Pleistocene)** – Brown to dark yellowish-brown, poorly consolidated, poorly sorted, cobble to boulder gravel and sand. Forms broad, slightly dissected constructional surfaces that are inset against unit **Qpo**. Deposits contain clast- and matrix-supported gravels. Soils are moderately to strongly developed. Base not exposed, but is at least 3 m in thickness.
- Qpo Older Piedmont deposits (lower to middle Pleistocene)** – Poorly consolidated, clast- and matrix-supported gravel and sand with sparse silt and clay. Deposits are dominated by pebbly to locally bouldery gravel containing abundant granite and metamorphic rocks. Forms deeply dissected hills near western front of Manzano Mountains where unit may represent younger aggradational units of the Santa Fe Group. Base not observed west of the Manzano Mountains, but is at least 6 m thick.
- Qp2 Eastern-slope deposits (middle Pleistocene)** – Poorly consolidated, cobble to boulder gravel and sand. Forms moderately dissected, southeast-sloping remnants of a formerly

broad constructional surface that is about 50 m above local base level and is topographically lower than deposits of **Qp2**. Deposits are dominated by pebbly to locally bouldery gravel containing abundant pink granite of the Priest pluton. Base poorly exposed and probably less than 6 m in thickness.

- Qp1 Eastern-slope deposits (lower to middle Pleistocene)** – Poorly to moderately consolidated gravel and sand. Forms moderately dissected, southeast-sloping remnants of a formerly broad piedmont along the northeastern portion of quadrangle. Constructional tops range from about 335-525 m above local base level. Base poorly exposed and probably less than 6 m thick.

PERMIAN

- Pa Abo Formation:** Red shale, pale-reddish-brown to moderate-reddish-orange fine grained sandstone, and grayish- to dusky-red crossbedded arkosic sandstone and conglomerate. Upper beds of formation absent in quadrangle. Base of formation mapped at top of highest marine limestone bed. Thickness: >300ft. (Myers and Mckay, 1974).
- Pb Bursum Formation:** Reddish-brown, arkosic, hematitic, cross-bedded, locally conglomeratic, but dominantly fine-grained sandstone. Lower part has red shale and siltstone. Base of formation mapped at top of highest limestone bed.

PALEOZOIC

Pm Madera Formation, undivided (Pennsylvanian to Lower Permian?) (Pmu +P ml).

- Pwc Wild Cow Formation:** Interbedded arkosic conglomeratic sandstone, sandstone, siltstone, mudstone, and limestone, mostly slope to ledge forming. Yellowish to reddish brown and light gray arkosic to feldspathic sandstone and conglomeratic sandstone are lenticular and grade into pale yellow-brown, gray and purple-gray mudstones and micaceous siltstones. Clastic units locally contain silicified wood. Tabular, ledge-forming, light to dark gray, fossiliferous limestones are commonly interbedded with mudstones and may locally contain feldspathic detritus. Red muddy soils are common on the upper arkosic member. Generally equivalent to Pine Shadow and La Casa Members of Wild Cow Formation of Myers (1973) or Pmuc and Pmud of Myers and Mckay (1974). Variable thickness of 400-600ft (~120m), with erosional top.
- Plm Los Moyos Formation:** This unit is a cliff-forming, gray fossiliferous limestone with minor interbedded shales and quartzose to feldspathic sandstones and conglomeratic sandstones. Individual massive to nodular limestone beds are commonly ~7-10m thick and may reach ~20m. Irregular masses of black to reddish-orange chert are common in massive limestone beds. Nodular limestone often weathers to mottled gray and brown surfaces. Limestones are interbedded with light to dark gray and yellowish brown to greenish gray siltstones that are often micaceous. Siltstones locally grade up into lenticular to tabular quartz arenites and quartz pebble conglomerates of light gray to yellowish brown color. Clastic units locally contain silicified wood. Includes Los Moyos Limestone and Sol se Mete Member of Wild Cow Formation of Myers (1973). Pml and Pmub units of Myers and McKay (1974). Approximate thickness: 150-250m.
- Ps Sandia Formation:** Mostly slope-forming, yellowish brown, gray, and greenish gray sandstones and micaceous siltstones interbedded with yellowish brown, gray and black shales or carbonaceous shales, grading down to basal quartz pebble conglomerates and up to thin bedded limestone. Limestones occur in uppermost portion of Sandia Formation, near basal contact of Madera Formation. Approximate thickness: 75m.

PROTEROZOIC

- Yqv** **Quartz Veins** interpreted to have been associated with the Priest pluton
- Ya** **Aplite dikes:** related to emplacement of the Priest pluton.
- Yp** **Pegmatite dikes and granite dikes:** Intrusions related to the emplacement of the Priest pluton. Most follow the S2 foliation that was developed during emplacement of the Priest pluton and were later boudinaged or folded during a third deformation event (D3).
- Ypp** **Priest Pluton Granite:** Gray to pink, megacrystic to coarse-grained biotite- quartz-feldspar granite with cm- scale microcline phenocrysts. The granite consists of feldspar, quartz, biotite and epidote. Slightly foliated at the pluton margins and in discrete shear zones within the pluton, but overall exhibits little to no tectonic foliation. Variably developed alignment of megacrysts is interpreted as a flow foliation. U-Pb zircon ages on the pluton yield a ca. 1.43 Ga emplacement age (Bauer, et al., 1993). Quartz veins, pegmatite dikes and granite dikes related to the emplacement of the pluton are common in the Manzano Peak Quadrangle.
- Xgb** **Metagabbro:** Amphibolites interpreted to be meta-intrusive mafic igneous rocks, probable protolith gabbroic dikes. The emplacement of the dikes may be related to intrusion of the 1.65 Ga Ojito pluton and other plutons to the north. Although the dikes are common throughout the field area, they are dominant within a package of meta-lithic-arenite and may be responsible for local contact metamorphism of these units. These were mapped as part of the Basic Schist and Mixed Flow units by Myers and McKay (1974) and as non-rhyolitic components of the Sevilleta Formation by Bauer, 1983).
- Xml** **Monte Largo Granite:** Variably deformed granodiorite, quartz monzonite, and granitic rock. The granodiorite is medium-grained and consists of altered feldspar (30-40%, much sericitized), quartz (20-25%), chloritized biotite, rare hornblende (altered to chlorite and biotite), and epidote. Minor phases include calcite, apatite, zircon, tourmaline, and altered sphene. Mafic enclaves are common in the granodiorite; pegmatites are rare. U-Pb zircon date of 1656+/-10Ma (Bauer et al., 1993).
- Xbsu** **Blue Springs Upper Schist:** green to white chlorite muscovite schist. This rock is eroded out of the Manzano Peak synclinorium, but is found north of the Monte Largo thrust in the northwest corner of the quadrangle. Equivalent to the Metaclastics Series pCm of Myers and McKay (1974).
- Xbr** **Blue Springs Rhyolite:** Black and brown to gray with lenticular quartz-feldspar pink colored stripes within the darker unit. This is interpreted as a metaryholite because of the presence of potassium feldspar in the felsic lenses and geochemical composition close to rhyolite. Numerous folds, some of which may be reminiscent of a rhyolitic flow folds, others are clearly F1 folds that are then refolded by later generations of deformation. Equivalent to the part of pCa, the argillite of Myers and McKay (1974), named the Blue Springs Quartzite (bq1) by Bauer (1983).
- Xbq** **Blue Springs Quartzite:** Thin bedded medium grained quartzites interbedded with chlorite-muscovite schist and quartz-muscovite schist. Partly equivalent to Sais Formation and lower part of the Pine Shadow Springs of Myers and McKay (1974); mapped as Blue Springs Formation (bs1) by Bauer (1983).
- Xbqr** **Blue Springs Red Quartzite:** Red to pink in color, massive resistant hematitic quartzite. This single isolated bed of quartzite forms the ridge on the east side of the Manzano Peak synclinorium. Although the bed is well defined because of the color and resistant nature of the unit, it is not a continuous bed. Equivalent to the part of pCa, the argillite of Myers and McKay (1974) and the Sais quartzite (ss3) of Bauer (1983)

- Xbs Blue Springs Schist:** Green to white schist near the Priest pluton this rock contains, garnet, chlorite, quartz muscovite. Just west of the synclinorium, this unit is highly kinked. It appears as a beautifully crenulated schist with well preserved garnet. Near the Priest pluton sericite nodules are common and probably formed during retrograde metamorphism after emplacement of the pluton. Equivalent to the part of pCa, the argillite of Myers and McKay (1974) and the Sais Quartzite (sq3) of Bauer (1983)
- Xsq Sais Quartzite:** Thin bedded reddish schistose quartzite however cleaner than Xqs. Bedding planes commonly show mica concentrations. Grains size ranges from very fine to coarse sand. Primary structures include preserved cross bedding. Originally called the White Ridge and Sais quartzites of Myers and McKay (1974), called the White Ridge Quartzite 2 (wq2) of Bauer (1983).
- Xes Estadio Schist marker unit:** staurolite, garnet biotite schist unit forms the main anticline exposed in Estadio Canyon. It is a coarse grained schistose unit. The schist's shows multiple episodes of deformation and contains local crenulation cleavage and at least three generations of foliation. Probably originally deposited as a mudstone layer within the sandstone. Equivalent to the Lower part of the Pine Shadow Springs of Myers and McKay (1974); called the White Ridge schist (ws1) of Bauer (1983).
- Xwq White Ridge Quartzite:** Course grained impure orange to gray thin-bedded aluminous quartzite. Fairly immature metasedimentary rock with well preserved cross bedding. Cross-bedding indicated that the bedding is overturned. The upper part of the unit has a distinctive andalusite –muscovite (Xwqa) foliated schistose layer. This unit forms the western limb of the Estadio Canyon fold. This may represent the base of a generally fining upward sequence of sediment. Part of the Lower part of the Pine Shadow Springs of Myers and McKay (1974); called the White Ridge Quartzite 2 (wq2) of Bauer (1983).
- Xs Abajo Schist:** Schistose metasedimentary rocks intruded by or interlayered with mafic meta-igneous dikes and flows. The metasedimentary rocks are rich in staurolite, garnet and amphibole porphyroblasts. Possible protoliths could be siltstones. Correlated with the Lower part of the Pine Shadow Springs of Myers and McKay (1974). Equivalent to units A,B,C of Parchman (1976) and Bosque metasediments of Edwards (1976)
- Xla Abajo Lithic Arenite:** This unit consists of a variety of metasedimentary rocks including meta-pelites, meta-arkose and impure quartzite. The chlorite schist, and some quartzites interbedded with metarhyolite are thinly bedded; more massive, quartzite domains are locally dominant. Locally, garnet staurolite schist and may be related to the intrusion of gabbroic dikes (now amphibolite). Compositional layering (S_0) is commonly preserved and is generally at low angle to dominant schistosity (S_1). Correlated with the lower metaclastic series of Reiche (1949), and the Flaggy Schist Zone of Myers and McKay (1974), Equivalent to units A,B,C of Parchman (1976) and Bosque metasediments of Edwards (1976)
- Xd Lacorocah dacitic tuff and breccia:** Gray to black with pink flecks. Matrix is granular and compositionally quartz with some potassium feldspar (pink flecks), and some rare plagioclase. Clasts range from mm to 3 cm and seem to be fairly well sorted with smaller clasts clustered together and gradig into larger clasts. The clasts are dark gray to black, and are mostly composed of biotite and hornblende. Correlated with the Lacorocah metatuff of the Mount Washington Quadrangle originally named by Reich (1949) and described by Parchman (1976). Equivalent to one of the units of the pCb "basic schist" of Myers and McKay (1974).
- Xa Amphibolite:** Black to dark green, fine- to coarse-grained amphibolites with varying amounts of macroscopic white plagioclase that ranges in texture from salt and pepper to smeared-out shear banding. Coarse-grained metadiorites are present locally. Mafic units have apparent widths up to 150+m and may thicken, thin, fork, and pinch out along strike. Equivalent to the pCb "basic schist" of Myers and McKay (1974). May be confused with the intrusive gabbro described above, but some units may be part of the supracrustal sequence. These were mapped as Basic Schist and Mixed Flow units by Myers and McKay (1974) and as non-rhyolitic components of the Sevilleta Formation by Bauer, 1983).

Xsr **Sevietta Metarhyolite:** Felsic meta-igneous rocks with quartz and feldspar phenocrysts interpreted as metarhyolite. The metarhyolite is generally pink to gray, blocky-fracturing porphyritic aphanites with quartz and feldspar clasts ~1mm in diameter. Texture ranges from thin, well developed compositional banding to massive. Planar features, such as flow bands or shear bands, are common and range considerably in thickness, ~1mm-~5cm. Quartz veins, pegmatite and massive schistose units are present locally and generally parallel foliation. Equivalent to the Sevietta metarhyolite of Reiche (1949) and Myers and McKay (1974).

Correlation of Map Units

Quaternary

Qaa- active stream base

Qa- Stream Alluvium

Qay- younger stream alluvium

Qpa- Piedmont deposits

Qpm- middle piedmont deposits

Qpo- Older piedmont deposits

Qp2- eastern slope younger piedmont

Qp1- eastern slope older piedmont deposits

Permian

Abo Formation

Bursum Formation

Pennsylvanian

Madera Group

Wild Cow Formation

Los Moyos Formation

La Casa Member

Pine Shadow Member

Sol se Mete Member

Sandia Formation

Proterozoic Rocks:

Priest pluton – 1430 ± 10 Ma

Monte Largo Granite- 1656- 10 Ma

Blue Springs Upper Schist

Blue Springs Metarhyolite

Blue Springs Quartzite

Blue Springs Red Quartzite

Blue Springs Schist

Sais Quartzite

Estadio Schist

White Ridge Quartzite

Abajo Schist

Abajo Lithic Arenite

Lacoracah Dacite

Amphibolite

Sevilletta Metarhyolite

Quartz veins

Gabbroic Dikes

Pegmatite dikes

Geologic Map of the Manzano Peak 7.5 minute Quadrangle Explanation of Map Symbols

Contact, dashed where approximately located or gradational, dotted where concealed by younger deposits.

Fault trace, dashed where approximately located, dotted where concealed, queried where uncertain or continuity uncertain. Barb on upthrown side of Laramide reverse fault; bar and ball on downthrown side of Miocene normal fault.

Strike and dip of bedding and overturned bedding.

Cross bedding, truncated foresets represent top

Trace of axial plane of anticline, syncline showing plunge direction, dashed where approximately located.

Trace of axial plane of overturned antiform and synform

S1 compositional layering in metasediments arrow represents F1 minor fold axis

S2 schistosity and crenulation cleavage, arrow represents F2 minor fold axis

S3 crenulation cleavage, and shear bands