

Geologic Map of the San Pedro Quadrangle, Bernalillo, Sandoval, and Santa Fe Counties, New Mexico

By

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**New Mexico Bureau of Geology and Mineral Resources
*Open-file Digital Geologic Map OF-GM 029***

Scale 1:24,000

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**GEOLOGY OF THE SAN PEDRO 7.5' QUADRANGLE,
BERNALILLO, SANDOVAL, AND SANTA FE COUNTIES,
NEW MEXICO**

by

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Surficial Geology

Surficial deposits in the map area consist of piedmont and upland alluvium and colluvium derived from South Mountain and the southern San Pedro Mountains. Major structures associated with the Tijeras and Gutierrez fault zones disrupt bedrock units in the northwestern part of the map area, but there appears to be little expression of structural displacement within Quaternary deposits.

Drainage from the northwestern corner of the map area is towards the west and the Rio Grande. An extensive, dissected alluvial plain, extending towards the west, is present just off of the map area. Deposits associated with this surface are mapped as unit Qfo on the geologic map for the adjoining Sandia Park Quadrangle (Ferguson and others, 1996), and extend into a small portion of the present map area, where they are included in unit Qpo. The high position in the landscape of this surface suggests that it has been comparatively stable since at least middle Pleistocene time, and perhaps much longer. Dissected remnants of additional, high-level piedmont sediments in the northwestern corner of the map are also designated as Qpo, although the precise relationship of these units with deposits underlying the extensive, dissected surface to the west is unknown.

Drainage and sediment transport east of the mountains is towards the topographically closed Estancia basin. Incision of older piedmont deposits, and an overall basinward shift in deposition has resulted in a stepped sequence of inset, erosional and depositional surfaces on the eastern piedmont slope of the map area. This erosional/depositional continuum is depicted on the map by: 1) older, mountain-front, alluvial fan deposits (unit Qp1), 2) upper piedmont slope, coalescent alluvial fan deposits grading into middle piedmont slope deposits underlying high-level, interfluvial summits (unit Qp2), 3) inset erosional surfaces and associated fills along major drainageways (units Qp3-4), 4) hillslope colluvium associated with side slopes of incised drainages, and 5) alluvium underlying modern drainage channels and floodplains.

Although absolute ages for Quaternary map units east of the mountains are lacking, relative ages may be assigned based on inset relationships. Furthermore, older piedmont units contain well-developed, pedogenic accumulations of carbonate (stage II to stage III carbonate development), suggesting at least middle to late Pleistocene ages for units Qp2 and Qp3. Pedogenic accumulations of clay as well as carbonate in unit Qp1 suggest at least a middle to early Pleistocene age for this deposit.

Little is known regarding age relationships for older, unconsolidated sediments of the Estancia basin, which are buried by the surficial deposits shown on the map. These older deposits may range in age from Pliocene to late Miocene. Events leading to topographic closure of the Estancia basin in late Tertiary/Quaternary time, as well as the timing of basin-closure, are also speculative.

Overall thickness of unconsolidated fill in the Estancia basin is comparatively small, reaching a maximum thickness towards the basin axis (to east of map area) of ~120 m. Maximum thickness of unconsolidated sediments within the map area is on the order of 30 to 40 meters, based on well-driller's logs for the area.

Bedrock Geology

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The geology of the San Pedro quadrangle is dominated by two small mountain ranges that bound the northwest corner of the Estancia basin in central New Mexico; the San Pedro Mountains which form an east-west trending range of hills along the north edge of the quadrangle, and South Mountain, a large laccolith oriented NE-SW in the north-central part of the map area. South Mountain is held up by a single concordant sill of mid-Tertiary monzonite to monzodiorite (map unit Tap). The laccolith shape of the South Mountain body was originally described by Thompson (1963). The San Pedro Mountains are held up by a concordant sill of the same (Tap) monzonite in the west (San Pedro Mountain) and a discordant stock of augite monzonite (Tam) in the east at Oro Quay Peak. The San Pedro mining district is hosted in Pennsylvanian Madera Formation and Abo Formation limestone, shale, and sandstone directly above the sill at San Pedro Mountain. Atkinson (1961) describes the geology of the San Pedro Mountains.

We found the mapping and descriptions of the Phanerozoic stratigraphy and igneous rocks by Thompson (1963) and Atkinson (1961) to be very good. The only significant differences were that the northwestern contact at the base of the South Mountain laccolith is steeply southeast-dipping rather than subhorizontal, and we did not recognize the discordant quartz monzonite stock mapped by Thompson (1963) in the center of the South Mountain laccolith.

The igneous rocks in San Pedro quadrangle were emplaced into a folded sequence of Pennsylvanian through Triassic sedimentary rocks. In some areas it is not clear if the folding was related to Laramide deformation or emplacement of the sills, but Laramide structures are clearly present in the westerly adjacent Sandia Park quadrangle and the large folds in this map area are interpreted as Laramide compressional structures. The concordant intrusive bodies were emplaced roughly parallel to contacts in the sedimentary sequence at three different levels; along the basal Pennsylvanian unconformity, in the upper Madera Formation, and in the upper Yeso Formation along the base of the San Andres and Glorieta formations contact.

A suite of thin, concordant, crystal-poor rhyolite sills (map unit Tr) are also present in the upper Madera Formation of the western San Pedro Mountains, and a similar suite of thicker, concordant, porphyritic rhyolite sills (map unit Trp) are present at the eastern edge of the San Pedro Mountains where they intrude the Triassic Chinle Group. Small discordant stocks of coarse-grained syenite or monzosyenite (map unit TI) are also present in the San Lazarus Gulch area of the central San Pedro Mountains, and a suite of medium to coarse-grained hornblende, augite diorite dikes (map unit Thfd) occur around Oro Quay Peak. The discordant bodies appear to postdate the concordant bodies, but conflicting cross-cutting relationships between some of the igneous rocks are present. Geochronology of similar igneous rocks in the Ortiz Mountains just to the north indicate that the monzonite (Tap) is 34 ± 2.2 Ma and the augite monzonite (Tam) is significantly younger at 29.6 ± 1.5 Ma (Bachman and Mehnert, 1978; Kay, 1986; Maynard, 1995). Ar/Ar geochronology of principle igneous units from this map area is in progress at the New Mexico Geochronological Research Laboratory.

Two major NE-striking fault zones cut through the area, one younger than the mid-Tertiary igneous rocks and one older. The younger structure is the Tijeras fault which is represented by a several meter-wide crushed zone within Early Proterozoic rocks. Blocks of the monzonite (Tap) are present within fault gouge of the Tijeras fault just to the southwest (Abbot and Goodwin, 1995). Directly west of Tijeras fault a high-angle, west-vergent reverse fault juxtaposes Proterozoic quartzite with steeply west-dipping to overturned Pennsylvanian rocks in the eastern limb of the San Pedro synclinorium. The Tijeras fault is interpreted as a mid-Tertiary sinistral strike-slip fault that reactivated and/or cut through a zone of Laramide west-side-down dextral-oblique reverse faults along the eastern limb of the San Pedro synclinorium. Mid-Tertiary sinistral motion is based on the offset of markers in the westerly adjacent Sandia Park quadrangle and the Laramide dextral oblique motion is based on regional map patterns (Ferguson and others, 1996). No evidence of Quaternary motion along Tijeras fault was observed in this map area. The Gutierrez fault is a east-vergent reverse fault in the steep, east-facing limb of an east-vergent fold pair. The sense of motion on the Gutierrez fault is opposite of what is expressed about 10 km to the south on the other side of Frost Arroyo monocline (Ferguson and others, 1996). The South Mountain monzonite sill was emplaced into the syncline just east of the Gutierrez fault zone so that its northwestern contact conforms to the east-facing fold limb and is steeply southeast dipping. Note that even though the axial trace of the syncline in the footwall of the Gutierrez fault is shown within parts of the South Mountain monzonite sill, this does not imply that the igneous rocks were folded. A Laramide age for the Gutierrez fault and the associated fold pair is implied because the fault is intruded by a dike of the early Oligocene monzonite porphyry.

The Madera Formation of the San Pedro quadrangle is thicker and has a significantly higher proportion of limestone beds (>90%) compared to the Madera Formation in the southerly and westerly adjacent Sedillo and Sandia Park quadrangles where arkose and shale make up over 20% of the formation. The upper Abo Formation

along the north flank of South Mountain contains a pair of 5 to 15 meter-thick skeletal wackstones which contain diverse faunal assemblages and abundant fusulinids. These limestones are unlike the thin (< 30 cm) limestones which occur in the lower Abo Formation of the Sedillo and Sandia Park quadrangles. Triassic strata in the map area are so strongly metamorphosed and injected with igneous sills that careful comparisons of lithology and thicknesses with other nearby areas is essentially impossible

Sedimentary rocks adjacent to the South Mountain monzonite sill are weakly metamorphosed and the contact aureole is narrow and unimpressive. The San Pedro Mountains are characterized by extremely wide zones of contact metamorphism in both Madera Formation limestones and Abo, Yeso, and Moenkopi formations, and Chinle Group argillaceous units. The argillites are altered to black, spotted hornfels, and the limestones are altered to massive garnet, magnetite skarn. The contact metamorphic aureole in siliciclastic units of the San Pedro Mountains is defined by the demarcation of the steep topography, with essentially all high relief areas being underlain by either igneous rocks or contact metamorphosed sedimentary rock.

Proterozoic rocks consist of tectonically interleaved, granite, quartzite, metarhyolite, metabasalt (amphibolite), and rare sillimanite schist.

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**UNIT DESCRIPTIONS
SAN PEDRO 7.5' QUADRANGLE,
SANDOVAL, BERNALILLO, AND SANTA FE COUNTIES, NEW MEXICO**

To accompany NMBM&MR OF-DM 29

QUATERNARY

Qu undifferentiated: Shown only on cross-sections.

Qa Valley-floor alluvium: Holocene. Predominantly silt, sand, and clay underlying modern drainage channels and floodplains. Interfingers with colluvium towards drainage side-slopes. Includes unmapped bedrock exposures in scoured channel reaches. Generally <3 m thick.

Qc Colluvium: Deposits mantling side-slopes of drainages incised in piedmont alluvium of units Qp1-4. Holocene to late Pleistocene (?). May include unmapped, inset alluvial fills in some areas. Interfingers with valley-floor alluvium along drainage foot-slopes <5 m thick.

Qac Upland alluvium and colluvium, undivided: Holocene to early Pleistocene (?). Includes valley-floor alluvium, hillslope colluvium, talus-covered slopes, and unmapped bedrock exposures along mountain-front and in bedrock uplands. Units range from relatively thin, comparatively fine-grained, upland valley fills, to poorly sorted, clast-supported, cobble and boulder gravels mantling steep, mountain-front slopes. Estimated thickness up to 10 m.

Qp Middle and upper piedmont-slope alluvium: Holocene to middle Pleistocene (?). Includes alluvial fan and coalescent alluvial fan complex along mountain fronts, and younger, inset alluvial fills. Ranges from predominantly silt and sand to coarse units dominated by sand and cobble-gravel. Undivided unit (Qp) is mapped in the NW and SW corners of map area where piedmont alluvium in uplands forms a relatively thin mantle (generally less than 5 m) over bedrock. Four map units are differentiated on piedmont slopes of the Estancia basin, as follows:

Qp4 Piedmont alluvium, inset into unit Qp3: Holocene (?) to Late Pleistocene. Predominantly sand, silt, and gravel. Represented by relatively small, inset fills along incised, higher-order drainages. Estimated thickness 3 m.

Qp3 Piedmont alluvium, inset into unit Qp2: Late to middle (?) Pleistocene. Predominantly sand, silt, and gravel. Comparatively extensive inset fills along major drainages, extending to upper piedmont slope. Estimated thickness 3m or more.

Qp2 Piedmont alluvium: Deposits underlie highest, interfluvial summits in map area. Late to middle Pleistocene. Consists of coalescent alluvial fans along upper piedmont slopes, forming an extensive, sheet-like deposit (?) basinward over older, valley-fill/ basin-fill deposits. Unit is inset into unit Qp1 along mountain front. Predominantly sand, gravel, and silt. Tentatively mapped to include deposits inset in older, alluvial fan deposits of Canada de las Narrias.

Qp1 Older, upper piedmont slope and mountain-front alluvium: Early (?) to middle Pleistocene. Predominantly sand and gravel. Deposits generally exhibit fan morphology. Tentatively mapped to include older fan deposits in large, upland canyons (e.g. Canada de las Narrias).

Qpo Older piedmont alluvium: Deposits along west side of San Pedro and South Mountains, undivided. Early (?) to middle Pleistocene. Predominantly sand, gravel, and silt. West of map area unit underlies broad, high-level surface mapped as Qfo on the westerly adjoining quadrangle (Ferguson and others, 1996). Undivided unit also includes dissected remnants of older fan deposits and pediment gravels that are present in NW corner of map.

TERTIARY

Thfd Hornblende, pyroxene diorite: Medium- to coarse-grained pyroxene, and hornblende-rich mafic dikes occurring east of Oro Quay Peak.

Tam Augite Monzonite: Fine- to medium-grained, equigranular to plagioclase porphyritic, augite- and hornblende-bearing monzodiorite to diorite. Texture consists of strongly zoned euhedral plagioclase, euhedral to subhedral augite and hornblende with interstitial K-feldspar and rare quartz. Contains up to 10% mafic minerals including augite, hornblende, and magnetite. The unit forms a discordant stock at Oro Quay Peak in the San Pedro Mountains.

Trp Porphyritic rhyolite: White to light gray or dark gray, plagioclase (0.5 to 2.0 mm), quartz (0.5 to 1.0 mm)-phyric felsic hypabyssal sills, dikes and small stocks that invade the Permian and Triassic strata east of Oro Quay Peak. Minor amounts of hornblende, pyroxene, and opaque minerals are also present, set in a fine-grained granular matrix.

TI Latite: Coarse-grained, K-feldspar porphyritic syenite to monzosyenite. Forms small discordant stocks in San Lazarus Gulch.

Tap Andesite porphyry: Fine- to medium-grained, equigranular to plagioclase porphyritic, hornblende monzodiorite and quartz monzodiorite. Texture consists of strongly zoned euhedral plagioclase and hornblende blades with interstitial K-feldspar and quartz. Contains up to 10 hornblende and minor to trace amounts of magnetite and/or other opaque minerals. The unit occurs primarily as sills, but also as dikes.

Tr Crystal-poor rhyolite: White to light gray, sparsely porphyritic rhyolitic sills, containing a few percent plagioclase and quartz phenocrysts in a fine-grained granular matrix. Trace amounts of opaque minerals (possibly pyrite) are also present. The unit occurs as thin sills throughout the San Pedro Mountains and northwest of South Mountain.

TRIASSIC

Tc Chinle Group: Reddish-colored silty, micaceous mudstone with subordinate thin- to medium-bedded, trough and wedge-planar cross-stratified, feldspathic sandstones. The sandstones are typically argillaceous with abundant mud chip intraclasts. Green reduction spots are common in the mudstones and argillaceous sandstones. Medium-bedded limestone-pebble conglomerates are present in some areas, particularly near the base of the unit.

Tz Agua Zarca Formation: Tan to light grayish pink, resistant, thin- to medium-bedded, cross-stratified quartz arenite and feldspathic arenite. Contact metamorphism changes the mudstones and argillaceous sandstones of this unit into a black or dark gray spotted hornfels.

Tm Moenkopi Formation: Recessive-weathering, dark red micaceous shale, silty shale and thin-bedded feldspathic sandstone. The unit also contains some gray, medium-bedded quartz arenites. Contact metamorphism changes the mudstones and argillaceous sandstones of this unit into a black or dark gray spotted hornfels.

PERMIAN

Psg San Andres-Glorieta undifferentiated: The upper two lithostratigraphic units of the Permian are complexly interleaved. The lithotypes, which may not correlate with formations of the same names, are gray limestone (San Andres) and white quartz arenite (Glorieta) These were differentiated where possible.

Ps San Andres lithotype: Light gray and less commonly tan medium- to thick-bedded limestone. The limestones are mostly micrites or skeletal wackstones, commonly with some component of quartz sand.

Pg Glorieta lithotype: White and pink (along contact with underlying Yeso lithotype) massive, or plane-bedded to low-angle planar cross-stratified quartz arenite. Locally, the sandstones are extensively bioturbated (*Macaronichnus*), and near the contact with Yeso Formation they are feldspathic. The sandstones are typically well-sorted.

Pay Abo-Yeso undifferentiated (San Pedro Mountains): the lower two lithostratigraphic units of the Permian represent a siliciclastic sequence that was mapped as a single unit in most areas because of the lack of a prominent

boundary marker be, and because it is extensively contact metamorphosed in the San Pedro Mountains which changes the rocks into black or dark gray spotted hornfels.

Py Yeso Formation: Reddish to pink or tan medium- to thin-bedded, feldspathic sandstone, shale and silty shale. The sandstones are typically cross-stratified and/or cross-laminated and virtually identical to those within the underlying Abo lithotype except that, locally, salt hopper casts and molds are present. The base of the unit is marked by a continuous, plane-bedded to low-angle cross-stratified tan sandstone bed less than 10 meters thick along the southern flank of South Mountain. Elsewhere, the contact is gradational, difficult to pick consistently and is shown only cross-sections.

Pac Abo-Yeso limestone: Two massive to medium-bedded micrites or skeletal wackstones that are present in the upper Abo Formation or lower Yeso Formation along the northwest slope of South Mountain. Each bed is less than 10 meters thick. The limestones are locally very fossiliferous, containing abundant fusulinids.

Pa Abo Formation: Red and locally tan (particularly near the base) medium- and thin-bedded arkose or feldspathic sandstone interbedded with red, micaceous siltstone and mudstone, commonly with green reduction spots. The lowermost arkoses are typically lighter colored and coarser grained than the younger feldspathic sandstones. The sandstones are cross-stratified (typically trough and wedge-planar geometries) and the finer grained rocks are commonly ripple cross-laminated. In addition, mud-chip clasts and plant debris are common. Recognized as a map unit only along the south flank of South Mountain, but shown consistently on cross-sections.

PENNSYLVANIAN

IPm Madera Formation (undifferentiated): A mixed sequence dominated by medium- to thick-bedded, light-gray, limestone and two types of siliciclastic rocks which make up <10% of the formation; greenish to tan and rarely red arkose or feldspathic sandstone, and dark-colored mudstone intervals with variable amounts of thin-bedded, black micrite and / or cherty, gray laminated to thin-bedded micrite. Contacts between the limestones and coarse siliciclastics are generally sharp, and those between the limestones and mudstones more gradational. Limestones, which vary in thickness from 20 cm to 20 meters, dominate the formation and are typically matrix-supported; micrites and skeletal wackstones. Clast-supported limestones (skeletal grainstones and packstones) are less common although locally abundant, and these tend to occur towards the top of sequences. Skeletal debris in the Madera limestones consist mostly of crinoid stems and columnals, brachiopods, corals, and bryzoans. Molluscan shell fragments are rare. The arkosic sandstones are typically coarse- to medium grained, but granules and rarely pebbles are also present. In the San Pedro Mountains where the formation is in contact with Tertiary igneous rocks, Madera Formation siliciclastics are strongly altered to black or dark gray spotted hornfels, and some of the limestones are transformed into garnet magnetite skarn with abundant copper mineralization.

IPs Sandia Formation: A sandstone-rich sequence of interbedded arkose or feldspathic sandstone, siltstone, silty mudstone and quartz-sandy limestone. Its contact with the overlying Madera Formation is chosen at the base of the oldest, light gray-colored, either massive-appearing limestone or amalgamated sequence of medium- to thick-bedded limestones. Limestones in the Sandia are typically thinner bedded, clast-supported (packstones and grainstones), greenish colored, and they contain abundant siliciclastic sand.

EARLY PROTEROZOIC

Xu undifferentiated: shown only on cross-sections.

Xq Quartzite: Light-gray, banded quartzite, locally micaceous. Bedding severely transposed. Forms resistant ridges.

Xs Sillimanite schist: A thin band of schist associated with the quartzite unit along one hill in the northwest corner.

Xa Amphibolite: Dark greenish gray and red-weathering medium- to fine-grained foliated amphibolite, locally associated with dark-colored biotite schist. Typically forms recessive, clay-rich intervals.

Xf Felsic gneiss: Light-colored, pink to gray, medium- to fine-grained feldspar, quartz, muscovite and biotite gneiss. Although interpreted as metarhyolite in the westerly adjacent Sandia Park quadrangle, some of these rocks may represent metamorphosed granitic or hypabyssal rhyolitic rocks. Typically crumbly weathering and forms subdued outcrops.