

Geologic Map of the Spring Lake Quadrangle, Eddy County, New Mexico

By

David J. McCraw, Lewis A. Land, and Shannon Williams

June 2011

New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 214

Scale 1:24,000

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OVERVIEW

The Spring Lake 7.5-minute quadrangle lies in southeast New Mexico just to the east of the city of Artesia. The area covered by the quadrangle, which extends from 32°45'N to 32°52' 30"N and 104°15'W to 104° 22' 30"W, is approximately 158 km² (61 mi²). Elevations range from approximately 1,002 m (3,288 ft) where the Pecos River flows out of the quadrangle to the south across the former bed of Lake McMillan reservoir to the highest point on the eastern Permian uplands, 1,100 m (3, 642 ft). Physiographically, the Pecos River alluvial valley runs north to south through the center of the quad, averaging 3.6 km in width and roughly 45 m in depth (calculated from data from Lyford, 1973), and is flanked by Pecos River alluvial terraces to the west, distal Eagle Creek piedmont alluvium to the northwest and Permian Artesia Group (Guadalupian) uplands to the east. These uplands are primarily comprised of interbedded dolomites and redbeds, mostly mudstone, in extensive gypsum-dominated evaporites of the Seven Rivers formation (*Psg*, *Psd*), Yates formation (*Py*), Tansill formation (*Pt*), and

the upper Permian (Ochoan/Lopingan) Salado formation (*Ps*), which all dip gently to the east.

The floodplain is dominated by anthropogenic modifications: several channelized reaches are encountered in the southern two thirds of the quadrangle, including the Kaiser Channel, created in the mid 20th Century by the U.S. Bureau of Reclamation. Two major western tributaries draining the southern Sacramento Mountains flow into the Pecos River here, Eagle Creek (including both the abandoned natural channel courses in the quad's west center and the modern channelized course to the north) and Tumbleweed Draw, a former Rio Peñasco course. Three much smaller tributaries drain into the Pecos from the east; from north to south, these are Dog Canyon Draw, Hart Canyon, and Logan Draw. In the southeast corner, Scoggin Draw flows into Chalk Bluff Draw, an eastern tributary on the Lake McMillan North quad to the south. The youngest of the Pecos River terraces grade up most of these drainages.

Given that the bedrock terrain either outcropping or underlying all surficial deposits on the quadrangle is predominantly evaporitic, unsurprisingly, karstic depressions and sinkholes riddle the entire quadrangle. While the majority of these occur in the eastern Permian uplands, a large cluster also occurs in the center of the floodplain. Much of the drainage on the east is subsurface. In many areas on the surface, very little alluvial fill accumulation results in the "channels", and these are mapped as depression fill (*Qd*). Patterns of surficial swales and lows clearly seen on color digital orthophotography reveal an intriguing glimpse of subsurface dendritic drainage networks.

COMMENTS TO MAP USERS

This quadrangle map has been Open-filed in order to make it available to the public. The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources 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 published by the New Mexico Bureau of Geology and Mineral Resources.***

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 section is constructed based on exposed geology, and where available, subsurface and geophysical data. 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. Finally, 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 either the State of New Mexico or the U.S. Government.

STRATIGRAPHY

As alluded to above, surficial depositional units of the western two-thirds of the Lake McMillan North Quadrangle are Quaternary (the oldest of which, *Qbt*, possibly could have formed in the late Pliocene) in age. These deposits are underlain by middle Permian Artesia Group (Guadalupian) evaporites and interbedded dolomites, which outcrop in the eastern Permian uplands. They are in turn overlain by the evaporites of the upper Permian (Ochoan/Lopingan) Salado formation, along the eastern margin of the quad. The Artesia Group consists of series of gypsum beds interfingering with dolomites, and are differentiated into the Tansill (*Pt*), Yates (*Py*), Seven Rivers, and the Queen and Grayburg formations (*Pgq*). The latter two are found only in the subsurface and are undifferentiated here. Two of the dolomites are distinct regional marker beds at the base of the Tansill as well as the top of the Seven Rivers, and are differentiated (*Ptd* and *Psd*, respectively).

Pecos River alluvial valley floor

The majority of the alluvium filling the valley floor was deposited by numerous braided channels of the Pecos River during the upper Pleistocene. These *Qabp* deposits form the basal unit of the valley. With the onset of the drier Holocene with smaller

overall discharges, the Pecos River switched to a meandering regime, and built four distinct meanderbelts. McCraw, *et al.* (2007) mapped 4 Pecos River meanderbelts on the Bitter Lake quadrangle near Roswell, two historic and 2 Holocene in age. On the Spring Lake and Lake McMillan North (McCraw and Land, 2008) quads, only the most recent meanderbelt, (*hmp₄*), is thought to be historic.

Pecos Valley alluvial terrace complexes

Alluvial terraces of the Pecos River and its tributaries were first described in the classic study of Fiedler and Nye (1933). They recognized 3 terraces: (from lowest to highest) the Lakewood, the Orchard Park, and the Blackdom. The Lakewood terrace, with an elevation of 6 to 9 m above the floodplain, flanked the inset Pecos floodplain and extended up many of its western tributaries. McCraw, *et al.* (2007) further differentiated two distinct, lower (upper Pleistocene) “Lakewood terraces” for a total of 3 (*Qlt₁₋₃*). The highest and oldest of which (*Qlt₁*) would be Fiedler and Nye’s original. Surface tread elevations above the floodplain for these three are: <1 - 1.2 m, 1.2 - 6 m, and 6 - 9 m, respectively. The Orchard Park terrace (*Qot*) rises 1.5 - 3 m above the Lakewood terrace and 10.5 - 20 m above the Pecos floodplain and the Blackdom terrace (*Qbt*) was mapped above that. On Spring Lake, we map several isolated remnants of *Qbt* on top of *Py*, 25 – 42 m above the Pecos floodplain. All ages are based upon pedogenic carbonate development which increases as follows: *Qlt₃* to *Qlt₁* - stage I to I+ or II; *Qot* - stage III; *Qbt* - stage III to III+.

Permian bedrock

Artesia Group rocks are backreef equivalents of the Capitan Reef formation, which is exposed along the southeast escarpment of the Guadalupe Mountains southwest

of both Carlsbad and the Lake McMillan North quadrangle. The Artesia Group strata are most notable for their dramatic and sometimes abrupt variations in lithofacies north of the Capitan Reef complex (Kelley, 1971). The Group consists primarily of well-bedded dolomite in the near-backreef area of the Guadalupe Mountains. Farther to the north, lithology of the Artesia Group becomes increasingly evaporitic, consisting of interbedded gypsum, reddish-brown mudstone and siltstone, and thin interbeds of dolomite, typical of deposition in a far-backreef intertidal-supratidal-sabkha environment.

Defining formation contacts within evaporitic facies of the Artesia Group is often challenging. Some previous workers (e.g., Motts and Cushman, 1964) have chosen to designate these predominantly gypsum strata as the Artesia *Formation* where the individual units of the Artesia Group are not distinguishable. For consistency with previous geologic mapping in this area (Kelley, 1971; Delher, *et al.*, 2005; McCraw and Land, 2008), we break out individual formations on the Spring Lake quad, with formation contacts dashed where the precise location of the contact is ambiguous.

Seven Rivers formation

The transition to evaporitic facies within the Seven Rivers formation is almost complete in the vicinity of Lake McMillan North. The unit consists of white to brick-red gypsum, reddish-brown mudstone and siltstone, and thin interbeds of gray lithographic dolomite (*Psg*). The formation is capped by dolomites of the Azotea Tongue (*Psd*) described by Kelley (1971), which forms a prominent east-dipping cuesta expressed by the McMillan Escarpment to the south on Lake McMillan North quad. This dolomite serves as a useful marker bed for locating the contact between the Seven Rivers formation and gypsum of the overlying Yates formation.

Yates formation

In the Spring Lake area the Yates formation is composed of white to occasionally reddish-brown gypsum with interbeds of reddish-brown mudstone and siltstone and thin, lithographic dolomite. The contact with the underlying Seven Rivers Formation becomes problematic after Psd plunges under the floodplain just south of U.S. Highway 82. Lithologies of the Yates and Seven Rivers Formations are nearly identical and are very difficult to distinguish on the ground. However, Yates strata appear to contain fewer mudstone-siltstone interbeds, imparting a higher reflectivity to the unit expressed as lighter tones on black and white air photos, in contrast with the slightly darker outcrop of the Seven Rivers Formation. Thick dolomite units such as the Azotea Tongue are not present in the Yates, thus the Yates outcrop is more subdued and rarely forms prominent escarpments.

Tansill formation

The Tansill formation in the mapped area consists of interbedded gypsum and dolomite. The base of the unit is marked by a thick, persistent dolomite bed with a tan-to-brown, hackley appearance in outcrop that forms prominent buttes and cuestas (*Ptd*). Gypsum units are poorly exposed, and thin dolomite beds within the Tansill cap isolated buttes west of the main outcrop belt.

Salado formation

The Salado outcrop belt occurs along the eastern edge of the Spring Lake quad. In the subsurface of the Delaware Basin, the Salado Formation consists of almost 2,000 ft of massive halite and argillaceous halite, with lesser amounts of anhydrite and polyhalite. Rare amounts of potassium salts (sylvite and langbeinite) occur in the McNutt potash

zone in the central part of the formation (Cheeseman, 1978). Clastic material makes up less than 4% of the Salado. Because of the soluble nature of Salado rocks, the unit is very poorly exposed in outcrop, consisting of an insoluble residue of reddish-brown siltstone, occasional orange-red gypsum, and greenish and reddish clay in chaotic outcrops (Kelley, 1971). In most areas the Salado outcrop is covered by a thin veneer of pediment gravels and windblown sand. Contact with the underlying Tansill Formation is obscure and very rarely exposed.

STRUCTURE

Structural geology of the Lake McMillan North quad is not complex. Regionally, Artesia Group strata dip gently to the east at approximately 1° (~100 ft/mile). However, the dip of these strata is enhanced on the Spring Lake quad to approximately 12° east, due to the proximity of the Artesia-Vacuum Arch, discussed below. Localized folding occurs in many areas, often as very small-scale folds and undulations in dolomite beds of the Yates and Seven Rivers Formations. These features are almost certainly non-tectonic folds, the result of localized subsidence associated with subsurface dissolution of gypsum.

In the subsurface, the Artesia-Vacuum Arch extends east-northeast beneath the Pecos Valley. The arch is almost completely covered by post-Permian beds, although Kelley (1971) reports that the plunging south limb is expressed by Yates and Tansill strata near Chalk Bluff Draw, just to the south of the Spring Lake quad. The effects of the arch are clearly seen in the cross section accompanying this map. The Artesia-Vacuum Arch controls production from Permian and Pennsylvanian reservoirs in the Empire Abo field and other oil and gas reservoirs over a distance of almost 75 miles into Lea County.

Measureable surface manifestations of the arch are practically non-existent, apart from Kelley's (1971) observations of dipping strata in Chalk Bluff Draw.

DESCRIPTION OF MAP UNITS

QUATERNARY and NEOGENE

Alluvium, lacustrine, and anthropogenic deposits

- daf Disturbed land and/or artificial fill** — Dumped fill and areas affected by human disturbances, mapped where deposits or extractions are areally extensive. Especially notable are the numerous constructed oil and gas well pads. Also includes the U.S. Bureau of Reclamation's Kaiser Channel of the Pecos River, as well as other straightened reaches.
- Qa Quaternary tributary alluvium and valley-fill alluvium, undifferentiated (Historic to uppermost Pleistocene)** — Brown (7.5YR4/2) to pinkish gray (7.5YR6/2) (*tributaries*) to light reddish-brown (5YR 6/4) to reddish brown (2.5YR4/6) (*Pecos floodplain valley-fill*), unconsolidated, moderately sorted, pebbly sand, silt, and clay. Varies considerably in thickness from <1 to 3 m in tributaries and up to 10-12 m in the floodplain.
- Qpec2 Quaternary alluvial channel swale and/or depression fill deposits of the Eagle Creek piedmont alluvial complex (upper Pleistocene to Holocene)** — Light brown (7.5YR6/4) to pinkish gray (7.5YR6/2), unconsolidated, poorly sorted, fine-grained sand, silt, and clay with mostly carbonate gravels and pebbles occupying thin (<1-1.5 m) channels, swales, and coalescing depressions draining the Eagle Creek piedmont complex (*QTpe*).
- Qac Quaternary alluvial channel swale and/or depression fill deposits originating from either Eagle Creek or Rio Peñasco piedmont complexes extending across Pecos Valley terraces (upper Pleistocene to Holocene)** — Light brown (7.5YR6/4) to pinkish gray (7.5YR6/2), unconsolidated, poorly sorted, fine-grained sand, silt, and clay, occasional carbonate pebbles, occupying thin (<1-1.5 m) channels, swales, and coalescing depressions.
- Qaf Alluvial-fan deposits, undivided (Historic to uppermost Pleistocene)** — Predominantly carbonate gravels to pebbles, often in stringers, in a brown (7.5YR4/2) to pinkish gray (7.5YR6/2), unconsolidated, poorly sorted, and coarse- to fine-grained sand to silty sand. Two large fans built by both historic former channels of Eagle Creek (*Qafe*), and by Tumbleweed Draw (*Qaft*),

debound from these western tributaries onto the western floodplain margin, interfingering with and/or spreading out onto Pecos floodplain deposits. Thicknesses decrease from tributary mouths from ≥ 6 m to < 1 m at their distal margins. Fans debouching onto the floodplain from eastern tributaries vary considerably in thickness from < 1 m for small fans and up to ~ 8 m at the apices of fans built by large tributaries (e.g., Hart Canyon, *Qafh*, and Logan Draw, *Qafl*). Many of these fans have been truncated and their deposits removed by the eastward migrating Pecos River from meander belts Hmp2 to hmp4 (e.g., Dog Canyon, *Qafd*).

Qp Quaternary playa deposits (upper Pleistocene to Holocene) — Pinkish white (7.5YR8/2), unconsolidated, well-sorted, fine-grained sand, silt, and clay. Thickness unknown (≥ 1 m).

Pecos River alluvial valley floor

(Historic map unit labels are given a lower case “h” to differentiate them from Holocene map units.)

Pecos River meanderbelt alluvial deposits (Historic to lower Holocene) — At the onset of the Holocene, the Pecos River switched from a braided regime to a meandering one, and proceeded to build four distinguishable meanderbelts on top of the basal, upper Pleistocene Pecos River braided alluvial valley-fill (*Qabp*). Consisting of channel, channel bar, point bar, and natural levee deposits, undivided, these meanderbelts are differentiated based upon cross-cutting relationships observed in the field, as well as aerial photographic work into an historic unit (*hmp₄*) and three older Holocene units (*Hmp₁₋₃*). These older Holocene units reveal a pattern of progressive meanderbelt shifting from west to east across the floodplain.

hmp₄ Historic meanderbelt deposits (Historic to upper Holocene) — Occasional pebbles of dolomite, limestone, sandstone, chert, and quartzite in a very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately to well-sorted, coarse- to fine-grained sand in the former modern channel and adjacent bar crests, grading to silty sand and sandy clay with distance from this channel. Several reaches of the Pecos River on the quad have been channelized by the U.S. Bureau of Reclamation during the mid 20th Century. The northernmost section of the Kaiser Channel extends into the southernmost part of the quad. Meanderbelt thicknesses commonly range from 1 to 5 m.

Hmp₃ Young meanderbelt deposits (upper Holocene) — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately sorted, occasionally pebbly (dolomite, limestone, sandstone, chert, and quartzite), coarse- to fine-grained sand, silty sand, and sandy clay. Unit primarily lies immediately west of *hmp₄* in the center of the floodplain. Thickness 2-5 m.

Hmp₂ Older Holocene meander belt deposits (upper to middle Holocene) — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated,

moderately sorted, occasionally pebbly (dolomite, limestone, sandstone, chert, and quartzite), coarse- to fine-grained sand, silty sand, and sandy clay. Unit lies immediately west of *Hmp*₃. Thickness 3-5 m.

Hmp₁ Old Holocene meander belt deposits (lower to middle Holocene) — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately sorted, occasionally pebbly (dolomite, limestone, sandstone, chert, and quartzite), coarse- to fine-grained sand, silty sand, and sandy clay. Thickness 3-5 m.

Hcr Holocene crevasse splay deposits (middle to upper Holocene) — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, graded sand and silty sand closest to the channel bank breached by the crevasse to sandy clay at the distal margins. Thickness <1 to 2 m.

Qbs Floodplain alluvial backswamp deposits (Historic to upper Pleistocene) — Light reddish-brown (5YR6/4) to very dark gray (7.5YR3/1), unconsolidated, well-sorted, silty sand, sandy clay, and clay in low-lying, poorly drained areas. These areas commonly received only fine-grained, slack-water flood deposition, prior to channelization. Thicknesses range from 3-15 (?) m.

Qabp Pecos River braided alluvial deposits (upper Pleistocene to lower Holocene) — Gravels and pebbles of dolomite, limestone, sandstone, chert, and quartzite in a reddish brown (2.5YR4/6) to light reddish-brown (5YR6/4), unconsolidated, poorly to moderately sorted, coarse- to fine-grained sand, silty sand, sandy clay, and clay. Braided channels and bars typify the surface of *Qabp* elsewhere, but on the Spring Lake quad, its largely featureless. Mostly buried by Holocene meanderbelt. Thicknesses vary (based upon Lyford, 1973) from about 5 to 30 m.

Pecos Valley alluvial terrace complex

Alluvial terraces of the Pecos River and its tributaries were first described in the classic study of Fiedler and Nye (1933). They recognized 3 terraces flanking the floodplain: (from lowest to highest) the Lakewood, the Orchard Park, and the Blackdom. All three terraces are present on the Spring Lake quad.

Lakewood terrace alluvial deposits (upper to middle Pleistocene) — The Lakewood terrace, with an elevation of <1 to 9 m above the floodplain, flanks the inset Pecos floodplain and extends up many of its tributaries. Following McCraw, *et al.* (2007) and McCraw and Land (2008), three distinct, low-lying (upper to uppermost middle(?) Pleistocene) “Lakewood terraces” are recognized. The highest and oldest of which (*Qlt₁*) would be Fiedler and Nye’s original. Surface tread elevations above the floodplain for these three are: <1-2 m, 2-6 m, and 6-9 m, respectively. They are comprised of occasional gravels and pebbles, brown (10YR5/3) to dark yellowish brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt and sandy

clay. Pedogenic carbonate increases from stage I to stage II+ (occasionally III) from *Qlt₃* to *Qlt₁*. Mostly non-gypsiferous.

Qlt₃ Youngest Lakewood terrace alluvial deposits (upper Pleistocene) —
Thickness <1 to 2 m.

Qlt₂ Young Lakewood terrace alluvial deposits (upper Pleistocene) —
Thickness 2 to 6 m.

Qlt₁ Older Lakewood terrace alluvial deposits (upper to middle Pleistocene)
—Thickness 6 to 9 m.

Qot Orchard Park terrace alluvial deposits (upper to middle Pleistocene) —
According to Fiedler and Nye (1933), the Orchard Park terrace rises 1.5-3 m above the Lakewood terrace and 10.5-20 m above the Pecos floodplain. It is comprised of gravels and pebbles of dolomite, limestone, sandstone, chert, and quartzite in a very pale brown (10YR7/4) to reddish brown (5YR4/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt, and sandy clay. Pedogenic carbonate is a strong stage III. Thickness ranges from 3 to 15 m.

Qbt Blackdom terrace alluvial deposits (middle to lower Pleistocene) —The Blackdom terrace occurs in isolated remnants primarily atop the Permian Yates formation (*Py*), 25-42 m above and east of the Pecos floodplain. It is comprised of gravels and pebbles of dolomite, limestone, sandstone, chert, and quartzite in a very pale brown (10YR7/4) to reddish brown (5YR4/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt, and sandy clay. Pedogenic carbonate is III-III+. Thickness ~17 m.

Eagle Creek alluvial piedmont complex

Eagle Creek alluvial piedmont deposits (Upper to middle Pleistocene) — Eagle Creek (or Eagle Draw further west) heads on the easternmost flank of the southern Sacramento Mountains in San Andres Formation (*Psa*) rocks and flows east to the Pecos River. Where it leaves the Permian highlands, it has built a large piedmont alluvial complex, which coalesces with the Rio Felix to the north and the Rio Peñasco to the south. This piedmont complex grades to and onto the Pecos Valley alluvial terraces. Oldest, highest remnant surfaces may be as old as Pliocene, which possibly grades to a river system which forms Gatuña formation deposits today. It is comprised of gravels that are almost exclusively limestone derived from *Psa*, supported in a matrix of light brown (7.5YR6/3), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt (largely calcareous), and sandy clay. On the Spring Lake quad, only the two youngest piedmont deposits (*Qpe₃₋₄*) are mapped. Topographic expression between these deposits are often to subtle to practically non-existent. Distinction is often based upon a stronger developed

pedogenic carbonate (Qpe_3 = stage III – II+; Qpe_4 = stage II). Qpe_4 grades to Qlt_3 .

Qpe₄ Youngest Quaternary alluvial piedmont deposit (upper Pleistocene) —
Thickness 1 to 3 m.

Qpe₃ Younger Quaternary alluvial piedmont deposit (upper to uppermost middle Pleistocene) — Thickness 2 to 4 m.

Quaternary depression fill and sinkhole deposits

Qd Quaternary depression fill, undifferentiated (Holocene to middle Pleistocene) — Unconsolidated, well-sorted, fine-grained (fine sands to clay) complexes of alluvial, colluvial, eolian, and occasional lacustrine deposits within closed depressions. Colors variable. Depressions are created by either gradual subsidence or sudden collapse followed by gradual subsidence of underlying gypsiferous carbonate terrane. These complexes are often significantly modified by stream erosion and deposition, playa deposition, deflation, and mass wasting. Depression fills have been active since the middle Pleistocene and are usually 1-3 m thick but can reach thicknesses in excess of 30 m.

Qds Quaternary sinkhole deposits, primarily caused by collapse (Historic to middle Pleistocene) — Complexes of unconsolidated, well- to poorly-sorted, coarse- to fine-grained sands to clay, alluvial, colluvial, eolian, and occasional lacustrine deposits within closed depressions. Colors variable. Thickness <1 to 3 m.

PALEOZOIC

Permian Artesia Group

Ps Salado formation, mixed gypsiferous facies (Guadelupian) — Irregular masses of gypsum, dolomite, and salt in outcrops with chaotic bedding orientations. Exposed in eastern part of quadrangle. Thickness unknown.

Ptd Tansill formation, dolomitic facies (Guadelupian) — Light gray dolomite forming the basal part of the section, grading upward into interbedded mixed facies. Thickness <1 to 3 m.

- Ptm Tansill formation, mixed silty gypsiferous facies (Guadelupian)** — Interbedded mixed gray silty dolomite, siltstone and gypsum, and yellowish sandstone with sublitharenite and orange-red chert grains. Thickness 2 to 50 m.
- Py Yates formation, mixed gypsiferous facies (Guadelupian)** — Very light gray, massive to vesicular gypsum interbedded with pink dolomite, green to white and orange to red siltstone and minor sandstone. Folded into domes and basins on a meter to several decimeter scale. Forms caverns. Outcrop exposures poor. Thickness increases westward from 2 to 50 m.
- Psd Seven Rivers formation, dolomitic facies (Guadelupian)** — Light gray to yellowish to pink, thinly to thickly bedded, vesicular to massive dolomite interbedded with pink dolomitic siltstone, yellowish sandstone and thin beds of milky gypsum. Thickness 1 to 3 m.
- Psg Seven Rivers formation, gypsiferous facies (Guadelupian)** — White to gray, occasionally yellow to red massive gypsum interbedded with thin- to medium-bedded, light gray dolomite and red gypsiferous siltstone, often containing gypsum nodules, and yellowish sandstone, which often exhibit soft sediment deformation. Commonly fractured, occasionally forming caverns, with many low amplitude folds varying in scale from meters to kilometers. Thickness unknown.
- Pgq Queen and Grayburg formations, undifferentiated (Guadelupian)** — Cross section only.

Lower Permian Formations

- Psa San Andres formation** — Cross section only.
- Pg Glorieta sandstone tongue** — Cross section only.
- Pye Yeso formation, undifferentiated** — Cross section only.
- Pa Abo formation, undifferentiated** — Cross section only.

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