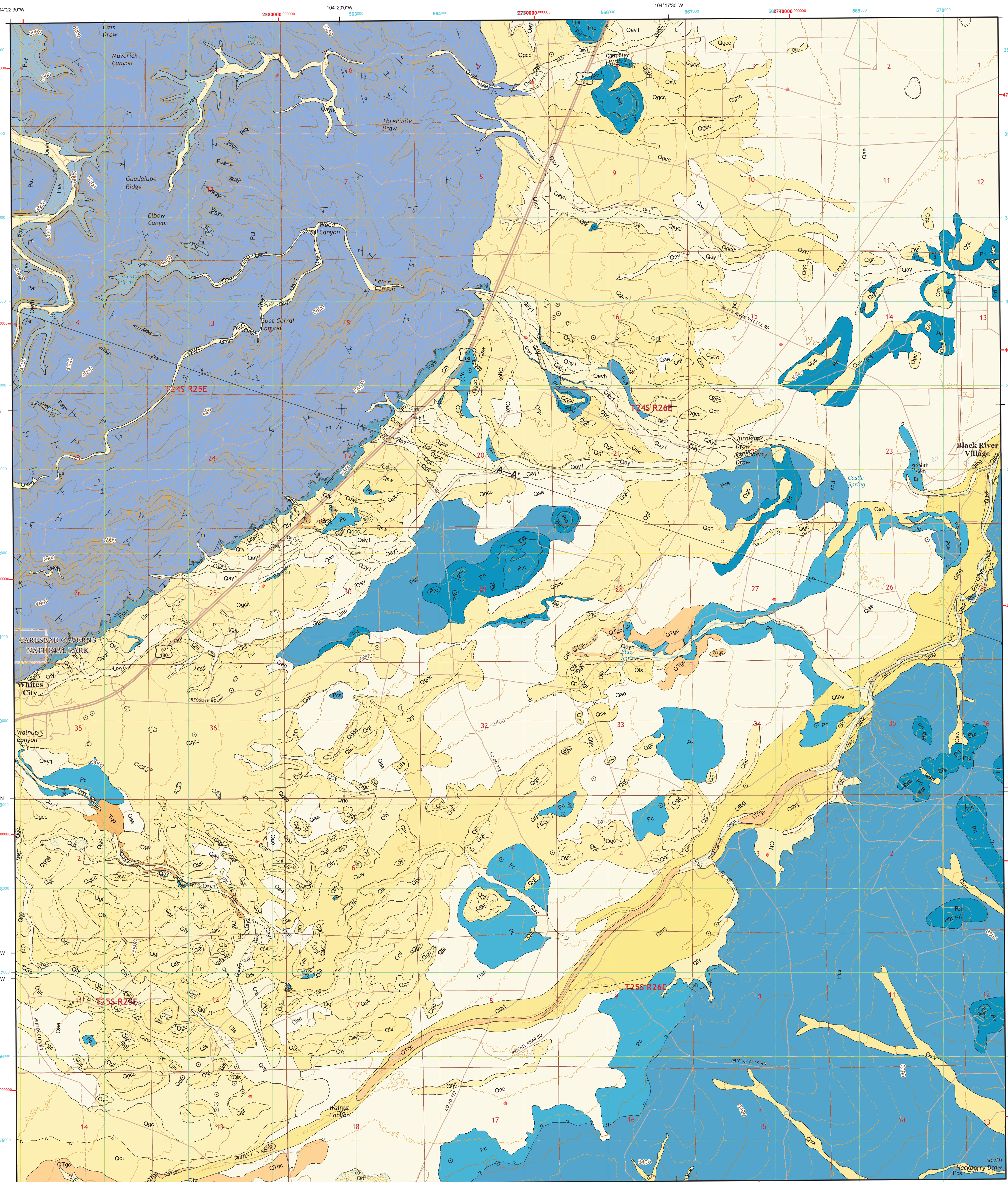
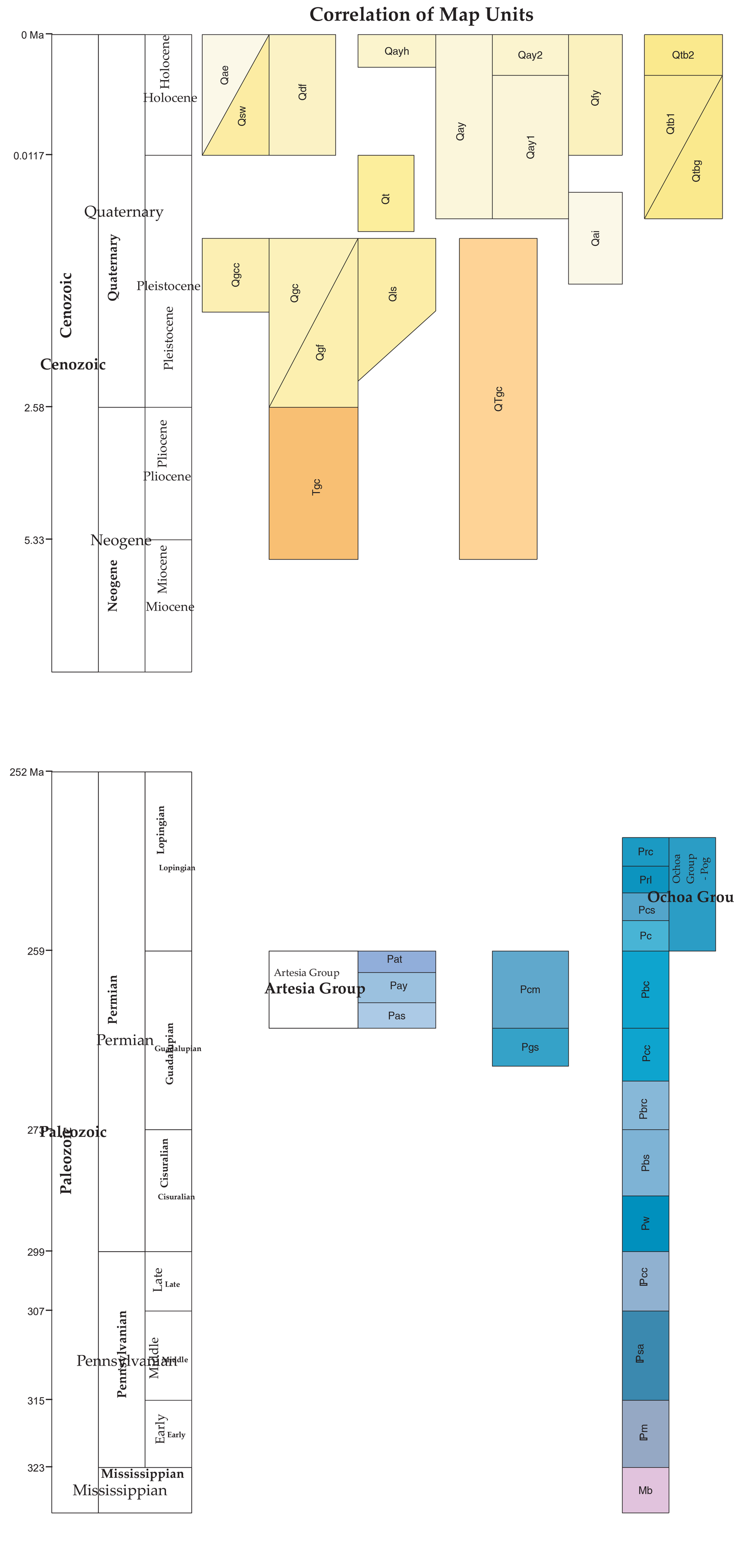


Correlation of Map Units



Explanation of Map Symbols

- 01.01.01 Contact—Identity and existence are certain. Location is accurate.
- 01.01.02 Contact—Identity or existence are questionable. Location is accurate.
- 01.01.03 Contact—Identity and existence are certain. Location is approximate.
- 01.01.04 Contact—Identity or existence are questionable. Location is approximate.
- 01.01.19 Gradational contact—Identity and existence are certain. Location is approximate.
- 31.08 Map neatline
- 23.10 Collapse structure or sinkhole (drawn to scale)
- 06.02 Inclined bedding—Showing strike and dip.
- 19.05.010 Drilling well for location hydrocarbon exploration or exploitation
- 23.09 Collapse structure or sinkhole (too small to draw to scale)
- 31.10 Cross section line and label
- 01.01.09 Internal contact—Identity and existence are certain. Location is accurate.

Description of Map

01-00-00-00-00-00 — heading01 — Cenozoic — Cenozoic —

01-01-00-00-00-00 — heading02 — Quaternary — Quaternary —

01-01-01-00-00-00 — heading03 — Eolian, alluvial, and colluvial surface deposits — Eolian, alluvial, and colluvial surface deposits — Eolian, alluvial, and colluvial surface deposits

01-01-01-01-00-00 — unit — Qae — Mixed eolian, alluvial, and colluvial surface deposits — Mixed eolian, alluvial, and colluvial surface deposits (Holocene). Pink to pale brown piedmont-blanketing loessal deposits, alluvium, and colluvium. Dominantly silt, with lesser sand and scattered pebbles. Deposits are typically poorly stratified. Sediment colors of 7.5YR 7/2-4 were measured. Surface soils are absent to weakly developed, locally exhibiting carbonate and/or gypsum filaments, and rarely thin clay films. Deposits may be as much as 3 m thick, usually thinner.

01-01-01-02-00-00 — unit — Qsw — Alluvial and eolian deposits in swales — Accumulations of silt, sand, clay, and trace gravel in swales and covering adjacent, low-gradient slopes. Deposits are loose and poorly exposed. Lithologic and textural characteristics are reflective of sediment underlying adjacent interfluvial summits. Accumulations are typically thin to perhaps 4 m thick.

01-01-01-03-00-00 — unit — Qdf — Depression fill — Accumulations of silt, sand, and clay in larger closed or nearly closed depressions in the map area's southwestern quadrant. Dominantly mud to very-fine sand, with scattered coarser sediment. No evidence of significant soil development was observed. Deposits are estimated to be up to a few meters in thickness.

01-01-02-00-00-00 — heading03 — Alluvial deposits along modern drainages — Alluvial deposits along modern drainages — Alluvial deposits along modern drainages

01-01-02-01-00-00 — unit — Qayh — Recent alluvium — Gravel, sand, and mud in active drainage channels, consisting of loose, poorly sorted gravel and sand and, in some reaches, relatively thick accumulations of winnowed cobbles and boulders. This unit Includes unmapped areas of younger alluvium, particularly Qay2 alluvium, together with unmapped Permian bedrock in scoured reaches of drainages in the Guadalupes. Deposits are 0 to perhaps 4 m thick.

01-01-02-02-00-00 — unit — Qfy — Fan alluvium — Sand, mud, and gravel deposited at the mouths of low-order drainages along the western front of the Guadalupe Mountains and along the Black River's eastern bank. Lithologies and textures reflect characteristics of bedrock and regolith in upstream drainage areas. Accumulations of sediment from adjacent drainages coalesce laterally. Deposits are unconsolidated and typically poorly exposed. No evidence of significant surface soil development was observed. The unit can be up to 4 m thick.

01-01-02-03-00-00 — unit — Qay — Younger alluvium, undivided — Alluvial sand, mud, and gravel along active drainages exhibiting relatively weakly developed soils. Deposits are subdivided based on the degree of soil development, inset relations, and sedimentologic characteristics. The undivided map unit is used where map scale, poor exposure, and/or a lack of differentiating features precludes subdivision. Undifferentiated deposits are primarily like those of Qay2, and less commonly like Qay1. Deposits are 0 to perhaps 7 m thick.

01-01-02-03-01-00 — subunit — Qay2 — Younger subunit of the younger alluvium — Brown to yellowish-brown fine sand to silt and lesser clay and gravel along active drainage channels, commonly underlying low terraces, with no appreciable soil development. Deposits are generally non-stratified or thickly laminated, and are mostly poorly sorted, sandy silt to silty sand, with minor coarser material. Rare channel fills of poorly sorted, rounded, clast-supported pebbles and minor cobbles are present along major drainages. Includes unmapped areas of bedrock or historic alluvium (Qayh) where the map scale prevents the depiction of separate units. Sand and silt colors of 10YR 4/3-5/4 were measured. No evidence of significant soil development was observed. Deposits may be as much as 5 m thick.

01-01-02-03-02-00 — subunit — Qay1 — Older subunit of the younger alluvium — Light brown to pink alluvial sand with lesser gravel, underlying terraces with treads up to a few meters above modern drainage channels, and bearing surface soils characterized by weak A/Bk soil horizons. Sand is mostly poorly sorted, silty to clayey, fine- to medium-grained, and is typically poorly stratified. Locally, scattered pebbles are present. Pebbly channel-fill deposits are present in poorly defined lenticular beds. Gravel clasts in channel fills are predominantly poorly sorted pebbles and rare cobbles consisting of limestone/dolomite and minor sandstone lithic fragments, with varying amounts of locally derived material. Surface soils most commonly consist of a darkened A horizon overlying a weak Bk horizon exhibiting carbonate as thin, fine filaments and fine nodules. Sand colors of 7.5YR 6/2 to 7/4 were measured. Deposits are thin to perhaps 7 m thick.

01-01-02-04-00-00 — unit — Qai — Intermediate alluvium, undivided — Gravel and lesser light brown sand, bearing a stage III to IV calcic soil horizon. Gravel is mainly poorly sorted rounded pebbles consisting largely of carbonate rock. The calcic horizon consists of a 4 to 20 cm-thick interval of laminated carbonate with scattered pebbles, overlying a 30 to 40 cm-thick carbonate-cemented zone that grades downward to uncemented gravel or sand. Overlying soil horizons have been stripped. The exposed thickness is approximately 2 m. Unit is mapped at a single locality, where it appears to be inset against adjacent Gatuña Formation deposits, approximately 7 m above the main drainage from Walnut Canyon.

01-01-03-00-00-00 — heading03 — Black River terrace alluvium — Black River terrace alluvium — Black River terrace alluvium

01-01-03-01-00-00 — unit — Qtb2 — Younger Black River terrace alluvium — Light brown to pink sand, silt, and lesser gravel underlying low terraces along the Black River, exhibiting little evidence of surface soil development. Deposits consist of well-sorted very-fine sand to silt in poorly stratified tabular beds up to 1.5 m thick. Sandy beds locally contain white nodules of gypsum and/or carbonate and scattered small pebbles. Sand and silt colors of 7.5YR 6-8/4 were observed. Minor gravel deposits are in thin, clast-supported, vaguely cross-stratified lenticular beds with a silt and sand matrix and consist of poorly sorted, rounded pebbles and rare cobbles of carbonate with lesser sandstone and reworked Gatuña Formation clasts. No appreciable soil development was observed. Deposits underlying terrace treads are 0 to perhaps 4 m thick.

01-01-03-02-00-00 — unit — Qtb1 — Older Black River terrace alluvium — Light brown to pink sand, sandy mud, and lenticular beds of gravel underlying terrace treads approximately 7-9 m above the Black River channel, bearing relatively weak surface soils. Deposits are dominantly sand and sandy mud in non-stratified planar tabular beds up to 1.5 m thick. Gypsum and carbonate nodules are common throughout. Gravel is present in clast-supported, broad, lenticular, cross-stratified to massive beds and consists of poorly sorted, rounded pebbles with minor cobbles and trace boulders of carbonate and rare sandstone lithic fragments. Carbonate cementation is variable, but common in gravel beds. Sand, silt, and gravel-matrix colors of 7.5YR 7/4 to 8/2 were measured, with common white (carbonate/gypsum nodules) and yellowish (7.5YR 6/6) color mottling. A/Bwt/Bk horizons characterize surface soils, with a thin (up to 20 cm thick) darkened A horizon, trace thin clay films defining a weak argillic horizon, and common carbonate nodules and partial gravel coatings in the calcic horizon. Exposures of the deposits range in thickness up to about 6 m.

01-01-03-03-00-00 — unit — Qtbg — Older gypsiferous Black River terrace alluvium — Gypsiferous muddy sand, sandy silt, and clay with minor stringers of tufa underlying terraces along the Black River. Outcrops exhibit a lower, darker gray, and distinctly mottled interval and an overlying pale-colored interval. The lower interval consists of gray to light gray, stiff, calcareous, non-stratified to thinly bedded clayey to silty fine sand, containing gypsum as detrital grains and finely crystalline nodules, intercalated with minor thin, wavy-bedded sandy silt. The upper interval consists of pinkish-gray (7.5YR 6/2) silty to clayey fine sand containing less gypsum and more clay than the lower interval. Yellowish to rusty Fe-oxide mottling is minor but apparent throughout the unit. Tufa is irregularly distributed as thin, pale yellow, lenticular to ribbon-shaped masses that commonly contain root casts. Tread height is comparable to that of unit Qtb1. No significant soil development was observed. Deposits are up to about 10 m thick.

01-02-00-00-00-00 — heading02 — Neogene-Quaternary Systems — Neogene-Quaternary Systems — Neogene-Quaternary Systems

01-02-01-00-00-00 — heading03 — Gatuña Formation — Gatuña Formation — The term Gatuña Formation is used to the east of the map area for late Neogene to mid-Pleistocene valley-fill deposits along the lower Pecos River valley. Here, the name Gatuña is extended westward to include older piedmont and valley-fill deposits between the Guadalupe and Black River escarpments. Note that some of the deposits designated Qao in the previous mapping to the north (Cikoski, 2019) are similar to deposits now assigned to the upper part of the Gatuña Formation.

01-02-01-01-00-00 — unit — Qgcc — Upper Gatuña Formation - Conglomeratic facies with calcrete caprock — Sandy conglomeratic alluvium along the Guadalupe Mountain's eastern foot slope, consisting of poorly sorted, rounded pebbles and scattered cobbles and boulders of limestone/dolomite and rare sandstone lithic fragments primarily derived from the Guadalupe Mountains to the west. Matrix generally consists of pale, white to pinkish (5YR 8/1-3; 7.5YR 8/2), poorly sorted, fine- to medium-grained siliciclastic and carbonate sand. The deposits are capped by a relict petrocalcic soil horizon, which distinguishes the map unit from other deposits assigned here to the Gatuña Formation (e.g., Qgc). The petrocalcic horizon typically consists of a 20 to 50 cm-thick upper zone of laminated carbonate, underlain by a carbonate-cemented zone 30 to 75 cm thick, followed by an interval engulfed by somewhat looser carbonate to a depth of 2 m or more. Overlying soil horizons have been stripped. The Qgcc surface is pockmarked by small depressions that may be related to the dissolution of underlying Permian evaporites. The unit is recognizable eastward up to about 4 km downslope from the Guadalupe escarpment. The unit thins abruptly at the base of the escarpment and consists of cemented conglomerate containing angular to subrounded gravel clasts floating in white to pale pink carbonate cement. Deposits are discontinuously covered in the map area by eolian or slope wash silt and sand. The stage V morphology of the petrocalcic soil horizon suggests a correlation with the upper part of the Gatuña Formation (Pleistocene) of the lower Pecos River valley to the east.

01-02-01-02-00-00 — unit — Qgc — Upper Gatuña Formation - conglomeratic facies — Pinkish white to white pebble conglomerate, with interbedded, poorly exposed sand and mud. The conglomerate is clast supported, poorly sorted, and contains subrounded to rounded pebbles, minor cobbles, and rare boulders. Clasts are dominantly limestone/dolomite, with minor sandstone and trace siliceous (e.g., chert) lithologies. Vague, thin lenticular bedding is apparent in some exposures. The matrix is sandy and is commonly engulfed by carbonate cement, which imparts an overall pale color (5YR 7/3-8/1). Individual conglomeratic intervals are typically 0.5 to 1.5 m thick, and are intercalated with finer-grained beds similar to unit Qgf deposits. Overall, the sediments contain more gravel near the Guadalupe Mountains and grade eastward into finer-grained facies of unit Qgf. The unit appears to be up to 8 m

01-02-01-03-00-00 — unit — Qgf — Upper Gatuña Formation - fine-grained facies — Light brown to pinkish yellow sandy mud and muddy fine-grained sand. Deposits consist mostly of planar-laminated clayey mud and subordinate very-fine sand. Colors range from 7.5YR 7/4-6 and 8/2-3, to 5YR and 7.5YR 5-6/4. Qgf deposits grade into those of Qgc to the west, and the contact between the two is somewhat arbitrarily delineated. The unit is poorly exposed and often blanketed by slump blocks or mixed alluvial, colluvial or eolian surficial deposits. Estimated to be up to 12 m thick.

01-02-01-04-00-00 — unit — QTgc — Gatuña Formation, undivided — Light brown to pinkish-white conglomerate and rare sandstone, exposed mainly along the lower-elevation (Black River) portion of the map area. Conglomerate contains poorly sorted, rounded, clast-supported pebbles with minor to trace cobbles and rare boulders consisting of carbonate and minor sandstone lithic fragments. Deposits are commonly cross-stratified in medium to thick, lenticular to ribbon-shaped beds. The matrix consists of poorly sorted clayey sand, which is moderately to well-indurated by carbonate cement. Bedding in most exposures appears to be subhorizontal, with little tilting attributable to solution subsidence. Assignment to upper or lower portions of the Gatuña Formation is difficult to ascertain. Exposed thickness is up to about 10 m.

01-02-01-05-00-00 — unit — Tgc — Lower Gatuña Formation — Light brown to pinkish-white conglomerate and rare sandstone, commonly weathering to a dark gray surface, exposed mainly along the floor of the drainage from Walnut Canyon east of the Guadalupe Mountains. The conglomerate is clast supported and contains poorly sorted, rounded pebbles with subordinate cobbles and rare boulders, consisting mainly of carbonate lithic fragments with rare sandstone and trace siliceous clasts. Deposits are cemented with carbonate and are commonly present in lenticular and cross-stratified (less commonly tabular and massive) medium to thick beds. The matrix consists of poorly sorted fine to coarse sand consisting of carbonate and siliceous grains. The degree of cementation ranges from discontinuous carbonate fillings between clasts to total engulfment. Heavily cemented beds commonly exhibit sub-mm concentric laminae around gravel clasts, and locally pisolitic textures. In some exposures, the deposits appear to be deformed due to solution subsidence, and the top of the unit is truncated by subsequent erosion. Exposed thickness ranges up to about 10 m.

01-02-01-06-00-00 — unit — QT — Undivided Neogene-Quaternary deposits. — Cross section. Based on examination of available water-well logs, the late-Cenozoic piedmont and valley-fill deposits described above overlie Permian sulfate (anhydrite/gypsum), carbonate, or interbedded sulfate and redbed mud (i.e., Permian Ochoa Group deposits in the basin; Capitan Formation near the Guadalupe escarpment). Well logs suggest that gravel and sand (assigned here to the Gatuña Formation) extend to a depth of about 25 meters in Black River Village's vicinity. Late Cenozoic clastic deposits of 90 meters or more in thickness are reported immediately to the north of the map area (e.g., Cikoski, 2019).

01-02-02-00-00-00 — heading03 — Miscellaneous — Miscellaneous —

01-02-02-01-00-00 — unit — Qt — Tufa deposits — Deposits of tufa are mapped separately at two localities in the map area. Accumulations of tufa are present relatively high on the landscape a short distance to the southwest of Blue Spring. They precipitated in association with relatively fine-grained clastic deposits assigned to unit Qgf. Here, the tufa is porous and light gray to brown, and is present in stacked thin beds reaching a thickness of a meter or more, although erosion has reduced the deposit to scattered loose cobbles on the surface in most areas. Along the drainage from Walnut Canyon in the southwestern part of the map area, tufa accumulations one to two meters in thickness lie above a Permian sulfate exposure (mapped as Castile Formation). At this locality, the tufa is light gray, weathering dark gray, and carbonate precipitation appears to have occurred along with fractures in the gypsum, resulting in a distinctive box-work texture on eroded surfaces.

01-02-02-02-00-00 — unit — Qls — Slump or collapse blocks of Gatuña Formation (Middle Pleistocene) partly covered by Qae/Qsw surface deposits (Holocene) — Slump or collapse blocks of Gatuña Formation (Middle Pleistocene) partly covered by Qae/Qsw surface deposits (Holocene). Generally, coherent blocks of Gatuña Formation that appear to have slumped or collapsed from their original depositional position—identified by the presence of out-of-place, laterally discontinuous, commonly tilted exposures of Gatuña Formation, which are surrounded and partially buried by surficial deposits.

02-00-00-00-00-00 — heading01 — Paleozoic — Paleozoic — Carboniferous and Permian rock units underlying the map area accumulated in a subsiding basin (Delaware Basin) at equatorial latitudes along the western margin of Pangea and consist of marine and marginal-marine carbonate, siliciclastic, and evaporite deposits. Note that the gentle eastward dip of subsurface units beneath the map area is interrupted by a flexure in Carboniferous strata, which was apparently buried for the most part during deposition of the overlying Wolfcamp Formation (see cross section).

02-01-00-00-00-00 — heading02 — Permian — Permian —

02-01-01-00-00-00 — heading03 — Lopingian Series — Lopingian Series — Lopingian

02-01-01-01-00-00 — heading04 — Ochoa Group — Ochoa Group (Rustler, Salado, and Castile formations) — Ochoa Group (Rustler, Salado, and Castile formations)

02-01-01-01-01-00 — unit — Ochoa Group — Ochoa Group (Rustler, Salado, and Castile formations) — Cross Section. Ochoa Group (Rustler, Salado, and Castile formations)

02-01-01-01-01-01 — unit — Prc — Culebra Dolomite Member of the Rustler Formation — Cream-colored to white, ledge-forming, dolomitic mud in thin tabular beds. Small (mm-scale) voids are abundant in some intervals, and are characteristic of the unit. Unit is extensively fractured or brecciated in some exposures. The preserved thickness is about 6 to 9 m.

02-01-01-01-01-02 — unit — Prl — Lower part (Virginia Draw or Los Medaños member) of the Rustler Formation — Pale red, reddish brown, and reddish yellow siliciclastic mudstone and siltstone with minor amounts of yellow to reddish-brown sand. Unit locally contains gypsum and carbonate mud. Siliciclastic mudstones vary from fissile to massive (bioturbated?), and are generally poorly exposed. Sandy intervals are typically thin lenticular beds of very fine- to fine-grained, cross-laminated, siliciclastic sand, commonly intercalated with light brown to red siltstone. Gypsum is finely crystalline, white to light gray in color, and is commonly present as thin interbeds or nodules in mudstone. A 2-m thick bed of carbonate mud is present a few meters below the top of the unit in a gravel quarry at the northern edge of the map area, which weathers pale yellowish-brown and contains scattered grains of siliciclastic silt to fine sand. At one locality, large eroded blocks of yellowish-brown, coarse-grained quartzose sandstone containing granules and small pebbles of chert are present in typical, poorly exposed red Rustler siltstone and mud. This coarse-grained sediment may represent infillings by post-Rustler (Mesozoic?) clastic sediment in paleo-karst openings in the unit. Mudstone colors of 5YR 5-6/4, 6-7/6, and 2.5YR 4-5/4, and sandstone colors of 2.5Y 7/4-6, 10YR 6/4, and 2.5 YR 5/4 were measured. Preserved thicknesses up to about 14 m are present in the north-central part of the map area.

02-01-01-01-01-04 — unit — Pcs — Salado and Castile Formations, undivided — Dominantly gypsum breccia with a red to yellow matrix of crystalline gypsum and clay, and lesser stratified deposits consisting of intercalated light gray to white gypsum, pink clayey gypsum, and red mud. Breccia contains mottled white to light gray, finely- to coarsely-crystalline, nodular, color-banded, or structureless gypsum blocks, with lesser amounts of red, coarsely-crystalline, clayey gypsum, and minor fragments of light gray carbonate mud. The matrix is generally porous and consists of crystalline gypsum and reddish-brown clay. Stratified intervals consist of intercalated thin beds and laminae of gypsum and clay. Bedding planes are commonly contorted or folded in stratified intervals. Overall the unit is poorly exposed and typically differentiated based on sparse float blocks and subtle surface color changes. The unit appears to be approximately 30 to 40 m thick, but deformation and poor exposure preclude an accurate estimate.

02-01-01-01-01-05 — unit — Pc — Castile Formation — White to light gray, variously deformed and/or karst-impacted, relatively pure gypsum (at depth in the Delaware basin, Permian sulfate is present as anhydrite, but has hydrated to gypsum near the surface). The gypsum in surface exposures and excavations is generally finely crystalline and may exhibit cm-scale color banding, nodular texture, or have a homogeneous appearance. Veins of gray carbonate filling thin (mm-scale) fractures are present in some exposures. Karst features include subvertical, open, and sediment-filled fractures, larger openings, and irregular contacts with adjoining units. Areas mapped as Castile are assigned based on the presence of relatively clean beds of calcium sulfate. Map units Pc and Pcs are both poorly exposed, however, and the contact between the two where they are juxtaposed is approximate. The base of the Castile Formation overlies the Bell Canyon formation in the subsurface, and the contact between the two is generally readily apparent on wireline logs. Thus, the Castile formation at the surface in the map area implies a thickness for the unit of 570 m, significantly greater than the maximum thickness of about 500 m generally reported for this part of the Delaware basin.

02-01-02-00-00-00 — heading03 — Guadalupian Series — Guadalupian Series — Guadalupian

02-01-02-01-00-00 — heading04 — Marine-Shelf Deposits — Marine-Shelf Deposits — Marine-Shelf

02-01-02-01-01-00 — heading05 — Artesia Group — Artesia Group — Artesia

02-01-02-01-01-01 — unit — Pat — Tansill Formation — Pale-weathering, light gray to tan, bedded dolomitic grainstone, packstone, wackestone, and mudstone. In general, carbonate sediments deposited near the shelf margin are fossiliferous grainstones and packstones forming centimeter- to meter-scale beds that are variously planar-laminated, cross-laminated, nodular, wavy bedded, or structureless. Common fossils include macroscopic fragments of crinoids, brachiopods, and gastropods; fusulinids, calcareous algae (e.g., Mizzia), and other microfossils are apparent under magnification in some samples. Shelfward (west) from the Guadalupe escarpment, tabular to wavy beds containing abundant pisoliths are common. Farther shelfward, along the western side of the map area, thinly bedded carbonate mudstone exhibiting fenestral fabric is commonly exposed at the surface. Lateral changes in carbonate lithofacies are also expressed as vertical changes through the Tansill succession, with carbonate lithofacies alternating vertically in meter-scale, shoaling-upward sets of beds. This stratigraphic cyclicity in Tansill and underlying Artesia Group carbonates has received detailed study in the Guadalupe Mountains, leading to reconstructions of relative fluctuations in sea level during Guadalupian time. Tepee structures in the Tansill have been extensively discussed in the literature and exposed in sub-vertical exposures. Laminae and lenses of translucent silica and red siliciclastic silt are present in some intervals. Rare siliciclastic intercalations in the upper part of the Tansill are pale yellowish-brown laminae and thin beds, consisting dominantly of siltstone with scattered sand-sized grains of quartz and feldspar. The Ocotillo siltstone, a regionally recognized siliciclastic marker interval in the upper part of the Tansill Formation, is generally poorly exposed in the map area but is present in rare exposures within a few hundred meters of the Guadalupe escarpment. Approximately 90 m of Tansill deposits are preserved in the map area.

02-01-02-01-01-02 — unit — Pay — Yates Formation — Beds of light gray to tan dolomitic carbonate, interbedded with yellowish-brown siltstone to fine-grained sandstone. The Yates Formation is distinguished from the overlying and underlying Tansill and Seven Rivers formations by a relative abundance of siliciclastic beds, which generally facilitates subsurface identification of the formation on gamma-ray logs. Carbonate beds in the Yates exhibit various bedding types, sedimentary structures, and fabrics, similar to the Tansill and other formations of the Artesia Group. Exposures of siliciclastic intervals in cutbanks reveal decimeter-to-meter-scale beds of yellow, greenish-gray, and brown siltstone and fine-grained sandstone that are commonly planar- or cross-laminated. In many exposures, siliciclastic intervals weather to pale gray colluviated slopes and outcrops low on the landscape and in drainages are common sites of springs or ephemeral seeps that support a relative abundance of vegetation. Only the upper part of the Yates Formation is exposed in the map area; total unit thickness is approximately 145 m based on borehole gamma logs.

02-01-02-01-01-03 — unit — Pas — Seven Rivers Formation — Cross section. Bedded dolomitic carbonate is the dominant lithology; siliciclastic intervals appear to be minor based on gamma-ray log response. Carbonate facies of the Seven Rivers Formation accumulated in the map area immediately shelfward of the Delaware basin's western margin and, based on published descriptions, are similar to carbonate facies in the overlying Yates and Tansill formations. The Seven Rivers Formation overlies the Queen Formation of the Artesia Group to the west, but it is uncertain if a substantial thickness of Queen Formation strata extends beneath the map area (none is depicted on the cross section). It is also unclear, based on available wireline logs, where to draw the contact between the base of the Seven Rivers Formation and the top of the Capitan Formation. Thus, the Seven Rivers is shown on the cross section as approximately 240 m thick, but it could be thicker or thinner. As with the Yates and Tansill formations, the Seven Rivers grades basinward into shelf-margin facies of the Capitan Formation, and to the west of the map area merges into strata containing redbed and evaporite lithofacies.

02-01-02-02-00-00 — heading04 — Shelf-Margin Deposits — Shelf-Margin Deposits — Shelf-Margin

02-01-02-02-01-00 — unit — Pcm — Capitan Limestone/Formation — The Capitan Formation's limited exposures along the base of the Guadalupe escarpment consist of light gray fossiliferous limestone, which commonly weathers to a rough, dark gray surface. The exposed Capitan is distinguished by an apparent paucity of bedding, weathering to rounded surfaces superficially similar in appearance to granitic rocks that have undergone exfoliation. The contact between packstone and grainstone beds of the Tansill Formation and Capitan-massive carbonate is obscured by a thin cover of colluvium along the base of the escarpment, and the transition from shelf to slope facies is subtle, with Capitan-massive facies appearing, disappearing, and reappearing again at different elevations in the walls of drainages cutting the mountain front. Local exposures in scoured reaches of drainages reveal a diverse assemblage of macrofossils in the Capitan Formation, including sponges, corals, brachiopods, bryozoans, gastropods, and crinoids. This rich biogenic framework was engulfed quickly by marine carbonate cement as the Guadalupian carbonate shelf aggraded and prograded toward the floor of the Delaware Basin. Exposed surfaces of the Capitan are commonly pitted or vuggy, and in places, exhibit cm- to dm-scale elongate voids, variously filled with calcite spar. The rocks locally appear brecciated, with dark gray angular carbonate clasts floating in a lighter gray matrix. Conspicuous fractures, several centimeters in width and meters in length, filled with Archaeolithoporella and other microbial remains, are common in the Capitan (but are also present in the Tansill Formation). Sandstone dikes of two types, relatively thin wispy ones with fine-grained siliciclastic fill, and thick (meter-scale), shelf-parallel dikes with coarse-grained fill (similar to the karstic fills observed in the Rustler Formation mentioned earlier) have been documented; both are present in the map area. As reported in the extensive literature concerning the Capitan Formation, the unit transitions downslope (in the subsurface in the map area) into crudely bedded carbonate deposits containing talus blocks and assorted debris, with comparatively steep, basinward dips, which then flatten out eastward toward the floor of the Delaware Basin. These slope deposits comprise the bulk of the formation's thickness. The carbonate deposits of the Capitan Formation interfinger with siliciclastic basin-fill sediment of the Delaware Mountain Group (Bell Canyon Formation). The gradational contact between the two is symbolized with a saw-toothed line on the cross section. Similarly, the gradational upper contact of the Capitan with overlying Artesia Group carbonate is depicted using a dashed line on the cross section. The lithologic contrast between Capitan Formation carbonate and Bell Canyon siliciclastics is readily discernable on most gamma-ray logs. In contrast, the upper contact of the Capitan Formation with Artesia Group carbonate is not. The unit is estimated to be up to 475 m thick in the map area, thinning somewhat to the west.

02-01-02-02-02-00 — unit — Pgs — Goat Seep Dolomite/Formation — Cross section. Light gray, thickly bedded to structureless dolomitic carbonate. Unit is reportedly porous in some intervals, and may contain minor siliciclastic sediment, as suggested by gamma- and neutron-log responses. The Goat Seep underlies the Capitan Formation in the map area and represents the initial development of a carbonate bank along the western margin of the Delaware basin during middle Guadalupian time. The Goat Seep Formation grades into and is underlain by siliciclastic sediment of the Delaware Mountain Group (Cherry Canyon Formation); thus, its lower contact is more confidently placed than its upper contact based on gamma logs. The unit appears to be up to 390 m thick beneath the map area.

02-01-02-03-00-00 — heading03 — Basin Deposits — Basin Deposits — Basin

02-01-02-03-01-00 — heading04 — Delaware Mountain Group — Delaware Mountain Group — Delaware Mountain Group

02-01-02-03-01-01 — unit — Pbc — Bell Canyon Formation — Cross section. Predominately buff to brown, fine-grained sandstone to siltstone, with five named carbonate intervals (from oldest to youngest the Hegler, Pinery, Rader, McCombs, and Lamar members), which thin and pinch out basinward to the east. Siliciclastics are similar to those in the underlying Cherry Canyon Formation, consisting mainly of fine-grained quartz and lesser feldspar (arkose to subarkose), coarse siltstone (many intervals enriched in organic matter), and minor, thin shaley beds. Siltstone and fine sands are commonly finely laminated. Siliciclastic sediment is commonly present as channel fills, reflecting submarine density-flow processes. Carbonate intervals are dark- to light-gray, fossiliferous, thin- to medium-bedded limestone, which thicken and grade into the Capitan Formation along the Delaware Basin's margin. The uppermost named limestone, the Lamar, extends farther basinward than the underlying carbonate intervals and is apparent on gamma-ray logs extending basinward beyond the map area's eastern margin. The top of the Bell Canyon Formation beneath the Castile in the basin is picked at the top of a siliciclastic interval (Reef Trail Member) that overlies the Lamar limestone beds. The contact between the Capitan and Bell Canyon formations beneath the late Guadalupian shelf is chosen on gamma logs at the change from carbonate (Capitan Formation) to siliciclastic deposits (Bell Canyon Formation). The Bell Canyon ranges in thickness from approximately 200 to 300 m in the map area.

02-01-02-03-01-02 — unit — Pcc — Cherry Canyon Formation — Cross section. Predominantly buff to brown, fine-grained sandstone to siltstone, with three named carbonate intervals (the Getaway and overlying South Wells and ManzQswanita members) that thin and pinch out basinward to the east. Siliciclastic beds are thin to thick bedded, frequently occupying discontinuous, submarine channels, are predominantly composed of quartz and lesser feldspar grains (generally altered), and are typically finely laminated. Carbonates are tan to dark gray, fossiliferous, and dolomitic. The Manzanita carbonate interval near the top of the Cherry Canyon reportedly contains layers of volcanic ash. The upper part of the Cherry Canyon Formation grades westward into shelf-margin carbonate facies of the Goat Seep Formation, and the lower part (Cherry Canyon sandstone tongue) underlies the Goat Seep Formation, extending approximately 15 km to the west of the map area. The contact between the Cherry Canyon and Brushy Canyon formations was historically chosen in outcrop, to the southwest of the map area, at a lithologic change from comparatively coarse-grained channel sands of the Brushy Canyon to finer-grained sands in the Cherry Canyon beneath the Getaway limestone interval. Neutron density-porosity logs from the map area show a distinct, laterally traceable log response that is compatible with such a change. The top of the Cherry Canyon Formation is placed at the base of the lowest carbonate interval (Hegler) in the Bell Canyon Formation. Based on the log picks, the Cherry Canyon Formation is approximately 435 m thick in the map area's basinal (eastern) part.

02-01-02-03-01-03 — unit — Pbrc — Brushy Canyon Formation — Cross section. It is very fine- to coarse-grained, tan and brown siliciclastic sandstone and siltstone, with shale in the lower part; unit may contain rare, thin beds of gray-brown carbonate conglomerate near the base of the unit. The unit is thin to thick bedded; coarser-grained sandstones are commonly present in lenticular channels. Sandstone and siltstone are commonly finely laminated. The contact between siliciclastic deposits at the base of the Brushy Canyon Formation and uppermost Bone Spring carbonate sediment is readily identified on gamma-ray logs. Unlike the overlying formations of the Delaware Mountain group, the Brushy Canyon does not grade shelfward into transitional carbonate shelf-margin or bank deposits; instead, it thins westward and overlaps the Bone Spring/Victorio Peak formations, with a relatively thin, intervening interval of deposits (Cutoff Formation) that are discontinuously present in outcrops to the southwest of the map area. The shelfward pinch out of the Brushy Canyon begins to the west of the map area because the unit appears to be of relatively uniform thickness (approximately 450 m) from east to west across the map area.

02-01-03-00-00-00 — heading03 — Cisuralian Series — Cisuralian Series — Cisuralian

02-01-03-01-00-00 — unit — Pbs — Bone Spring Formation — Cross section. Dark gray to brown, thinly bedded carbonate mudstone, with varying amounts of intercalated dark-gray calcareous shale. Contains three regionally recognized sandy intervals (first, second and third Bone Spring sands) consisting of light gray to tan, fine-grained sand with micaceous, shaley, or calcareous intervals (the stratigraphic position of the sandy intervals are indicated on the cross section). Approximately 930 m thick. Interpretation of gamma-ray logs suggests that the Bone Spring Formation's shelfward transition into carbonate facies of the Victorio Peak Formation is approximately 10 km to the W-NW of the map area.

02-01-03-02-00-00 — unit — Pw — Wolfcamp Shale/Formation — Cross section. Greenish-gray, brown, and black calcareous and carbonaceous shale, containing some carbonate and siliciclastic sand. The top of the Wolfcamp Formation, as depicted on the cross section, lies beneath the third Bone Spring sand; the base of the unit was chosen on wireline-logs at the top of a sequence of alternating shale and carbonate beds assigned to the Upper Pennsylvanian Canyon-Cisco interval. Approximately 430 m thick.

02-02-00-00-00-00 — heading02 — Pennsylvanian Subsystem — Pennsylvanian Subsystem — Pennsylvanian Subsystem

02-02-01-00-00-00 — unit — IPcc — Cisco and Canyon formations — Cross section. Interbedded carbonate and shale, with lesser amounts of coarser siliciclastic sediment likely present. Gamma-ray logs suggest carbonate and shale beds alternate on a scale of meters to several meters in the upper 40 m of the unit and that thicker carbonate intervals are present in the lower part. The unit's base is placed at the top of an ~10 m-thick carbonate interval assigned here to the top of the Strawn Formation. The Cisco-Canyon interval is approximately 135 m thick in the map area.

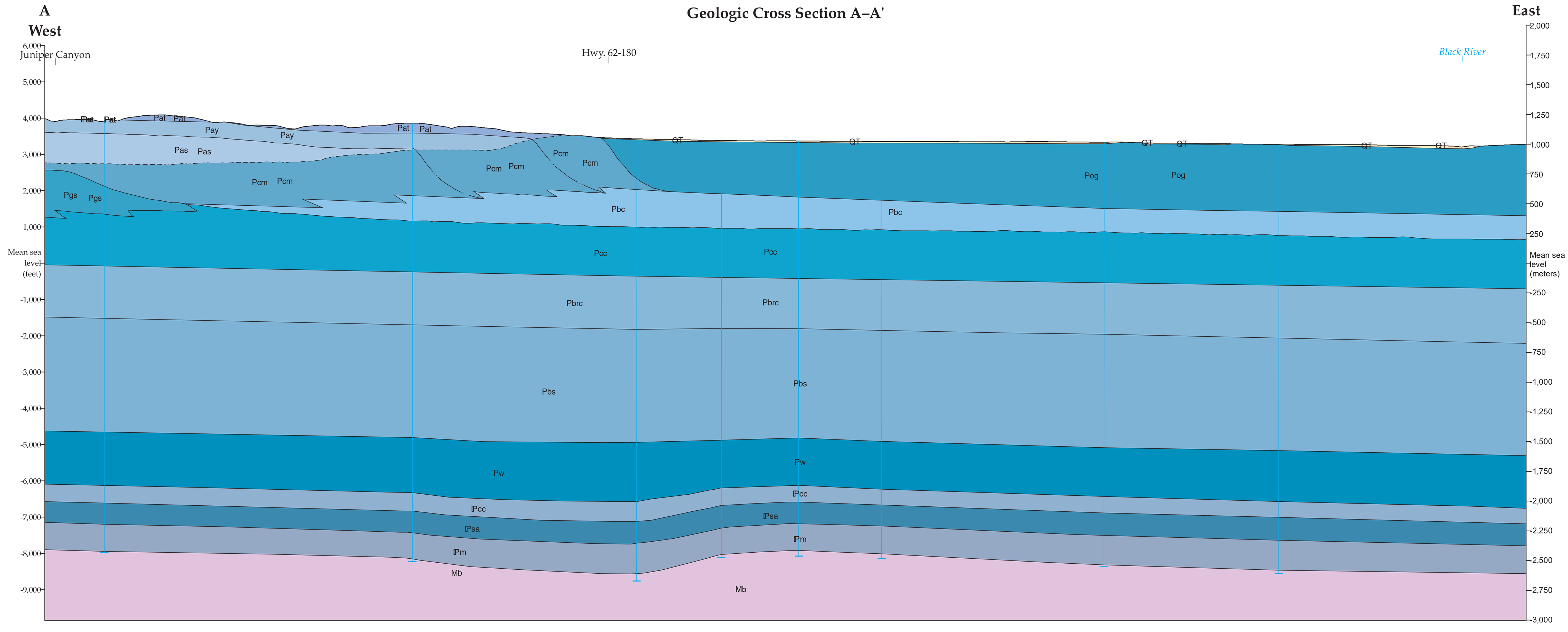
02-02-02-00-00-00 — unit — IPsa — Strawn and Atoka formations — Cross section. Interbedded carbonate, sandstone, and shale. Strawn carbonates are tan to brown and fossiliferous; phylloid algal mounds are reportedly present in the Strawn interval on the Northwest Shelf to the southeast of Carlsbad, NM, where the unit has been targeted for oil and gas production. Sandstones are tan to brown and generally medium-grained, with some pink feldspar grains reported from cuttings. Black shale is also reported. The underlying Atoka Formation in the Delaware basin contains gray to brown carbonate and shaley limestone, some of which is cherty. The base of the Strawn-Atoka interval is chosen at the top of the upper-Morrow carbonate interval, as indicated by gamma-ray logs. Approximately 190 m

02-02-03-00-00-00 — unit — IPm — Morrow Formation — Cross section. The upper ~75 m of the Morrow Formation consists of brown to gray fossiliferous limestone and shaley limestone, some of which is oolitic or cherty, together with brown to gray, fine- to medium-grained sandstone, and shale. The underlying middle and lower Morrow intervals are dominantly fine- to coarse-grained quartz sandstone, with lesser shale. Approximately 250 m thick.

02-03-00-00-00-00 — heading02 — Mississippian Subsystem — Mississippian Subsystem — Mississippian

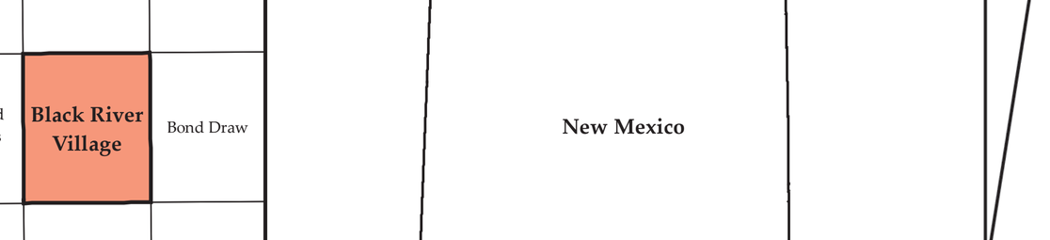
02-03-01-00-00-00 — unit — Mb — Barnett Shale/Formation — Cross section. Brown shale to silty shale with lesser fine-grained sandstone and siltstone. The Barnett Formation is about 135 m thick in the Mule 24 Fed. Com. No 2 well drilled in section 24 T24S R25E, where it is underlain by Mississippian limestone.

Geologic Cross Section A–A'



Base map from U.S. Geological Survey 2010.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 13S, shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in red.

Roads............©2006-2010 Tele Atlas
Names............GNIS, 2008
Hydrography............National Hydrography Dataset, 2005
Contours............National Elevation Dataset, 2000



Quadrangle Location

Magnetic Declination
July, 2018
7º 13' East
At Map Center

1:24,000

Contour Interval 20 Feet

North American Vertical Datum of 1988

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This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

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New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 283

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Geologic Map of the Black River Village 7.5-Minute Quadrangle, Eddy County, New Mexico

June, 2020

by
Colin T.Cikoski and Bruce Allen

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

Comments to Map Users

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