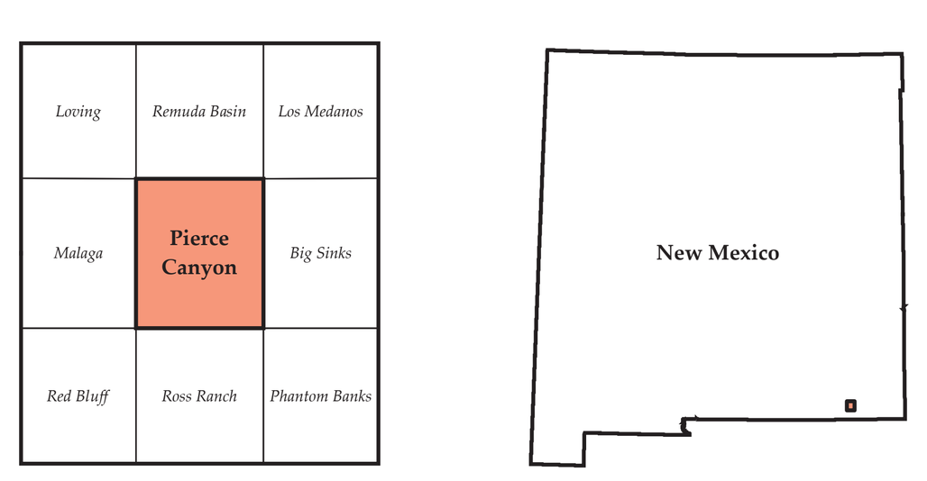
Base map from U.S. Geological Survey 2021.
North American Datum of 1983 (NAD83)
Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 13S, shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983 (East Zone), shown in red.

Roads....U.S. Census Bureau, 2015–2016
Names....GNIS, 2016
Hydrography....National Hydrography Dataset, 2014
Contours....IFSAR 4.5 m Digital Terrain Model, 2008
Wetlands....FWS National Wetlands Inventory 1977–2014
PLSS....Bureau of Land Managment 2019

1:24,000

Contour Interval 10 Feet

North American Vertical Datum of 1988



Quadrangle Location

Magnetic Declination
July 2021
6° 56' East
At Map Center

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico
87801-4796

[575] 835-5490

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

http://geoinfo.nmt.edu

Digital layout and cartography by the NMBGMR Map Production Group:
Phil L. Miller, Amy L. Dunn, Ann D. Knight, and A.R. Baca

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 299

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act (Fund Number: G21AC10770), administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources (Dr. J. Michael Timmons, *Interim Director and State Geologist*; Dr, Matthew Zimmerer, *Interim Program Manager for Mapping Programs*).

Geologic Map of the Pierce Canyon 7.5-Minute Quadrangle, Eddy County, New Mexico

September 2022

by
Snir Attia and Bruce D. Allen

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

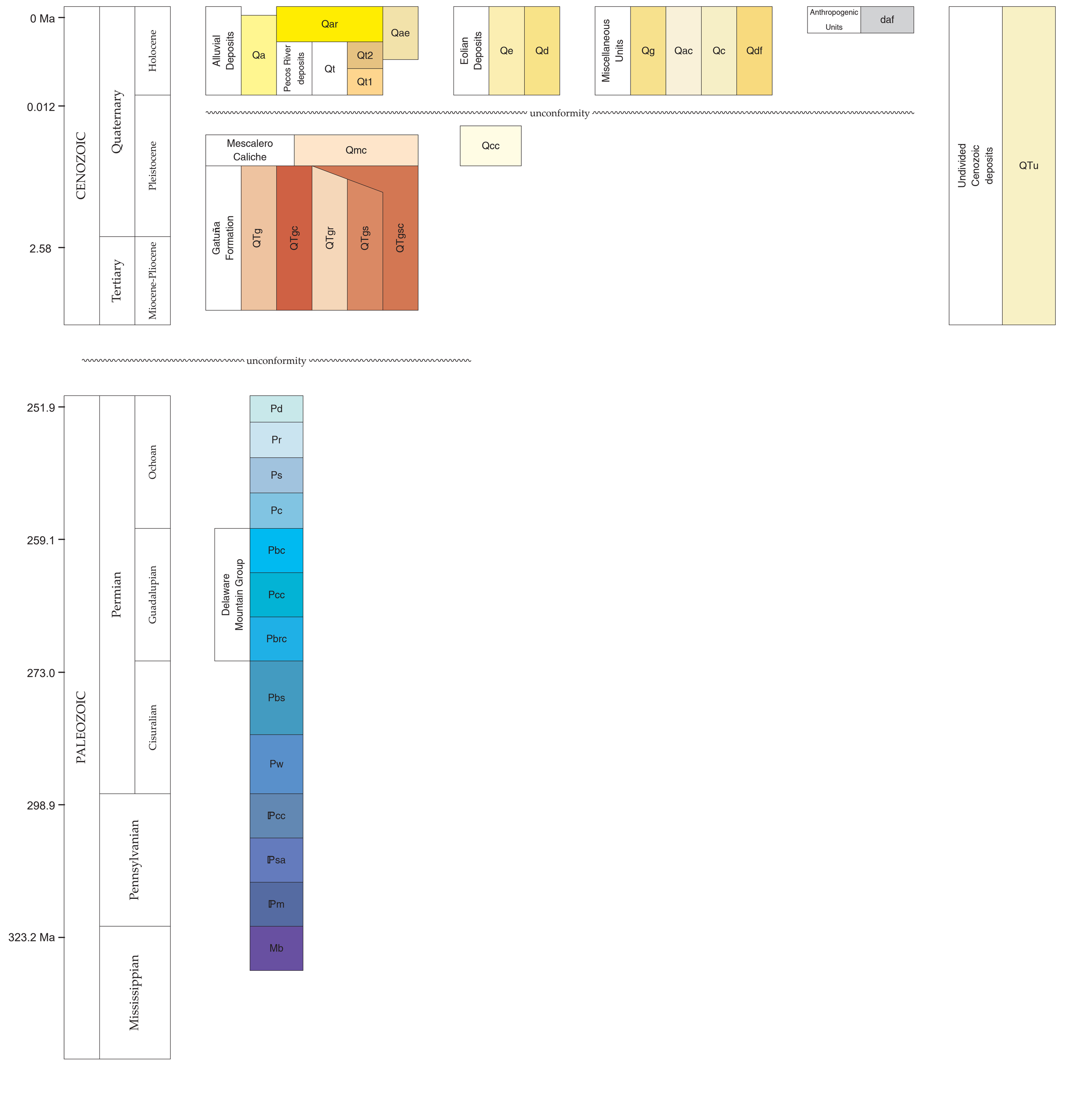
Comments to Map Users

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, a 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(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes may not be shown due to recent development.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping and available geophysical and subsurface (drill hole) data. Cross sections should be used as an aid to understanding the general geologic framework of the map area and not be the sole source of information for use in locating or designing wells, buildings, roads, or other human-made structures.

The New Mexico Bureau of Geology and Mineral Resources created the Open-File Geologic Map Series to expedite the dissemination of these geologic maps and map data to the public as rapidly as possible while allowing for map revision as geologists continued to work in map areas. Each map sheet carries the original date of publication below the map and the latest revision date in the upper right corner. In most cases, the original publication date coincides with the date of delivery of the map product to the National Cooperative Geologic Mapping Program (NCGMP) as part of New Mexico's STATEMAP agreement. While maps are produced, maintained, and updated in an ArcGIS geodatabase, at the time of the STATEMAP deliverable, each map goes through cartographic production and internal review before uploading to the Internet. Even if additional updates are carried out on the ArcGIS map data files, citations to these maps should reflect this original publication date and the original authors listed. The views and conclusions contained in these map documents are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico or the U.S. Government.

Correlation of Map Units



Explanation of Map Symbols

Contact—Identity and existence are certain and questionable where queried. Location is accurate where solid and approximate where dashed.

Gradational contact—Identity and existence are certain. Location is accurate where solid and approximate where dashed.

Unconformable contact—Identity and existence are certain. Location is accurate.

A A' Cross section line and label.

45 Inclined bedding—Showing strike and dip.

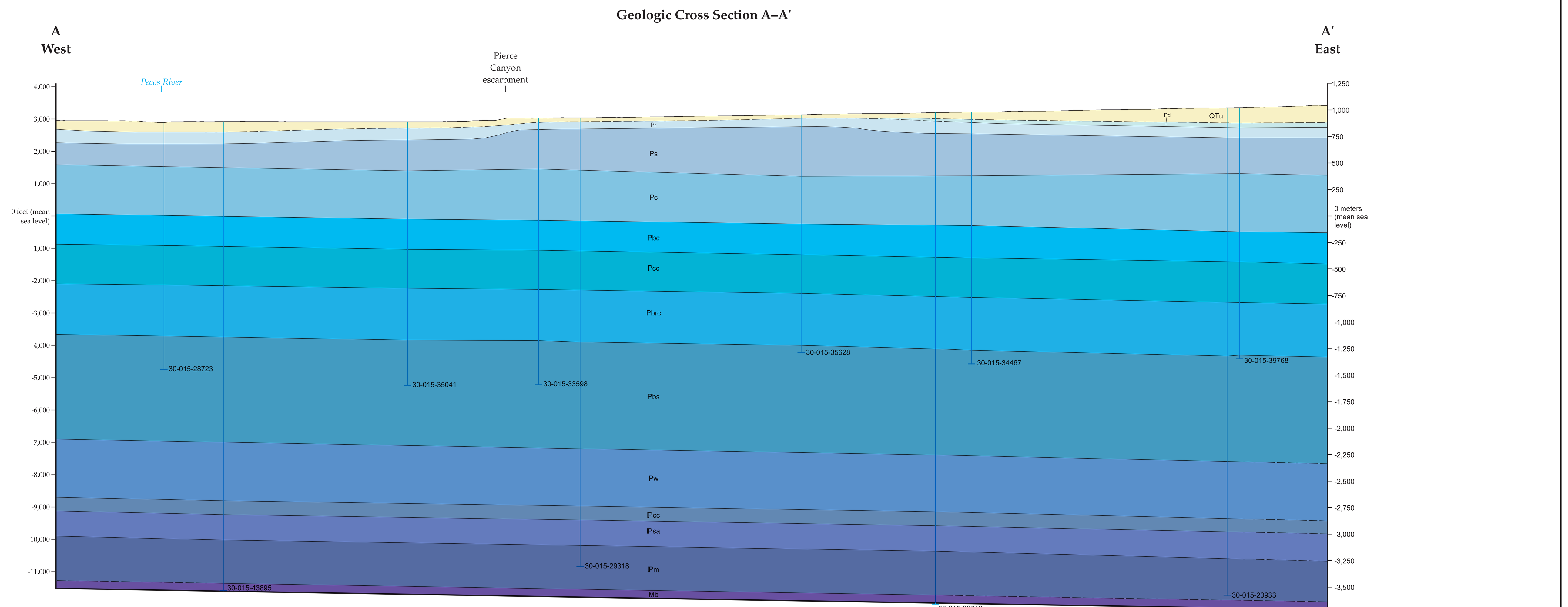
30 Inclined bedding, where top direction of beds is known from local features—Showing strike and dip.

15 Subhorizontal soil horizon—showing strike and dip.

30-015-39768 Drill hole for hydrocarbon exploration or exploitation—Showing name and number.

Well location (in cross section)—The location and depth of a well used to establish stratigraphy and geologic unit depth.

Geologic Cross Section A–A'



Description of Map Units

CENOZOIC ERATHEM
Holocene Series
Anthropogenic Units

daf — **Disturbed ground and artificial fill** (Historic to Modern)—Compacted gravels, sands, and muds underlying dams, roads, areas of intensive agriculture, and other artificial constructions. Only mapped where extensive or concealing underlying geologic relations. Deposit thicknesses are 0 to about 10 m.

Alluvial Deposits

Qar — **Modern, historic, and younger alluvial deposits** (Holocene to Modern)—Unvegetated or poorly vegetated sands, muds, and gravels along active drainage channels or underlying low terraces, including some of the youngest and lowest terraces along the Pecos River. Mapped deposits may include areas submerged beneath water on aerial imagery. Deposits are unconsolidated, and no evidence of significant soil development was observed. Deposit thicknesses are 0 to 4 m.

Qae — **Alluvially reworked eolian deposits** (Holocene to Modern)—Alluvially reworked red eolian sand (Qe), reworked by eolian processes in channel floors. Channel walls include exposures of cemented gravel and variably indurated sands with variable proportions of pebbles. Subangular to rounded pebbles dominantly consist of caliche (Qmc), except a single locality containing red-brown mudstone clasts immediately adjacent to Pipeline Road in the northern central portion of the quadrangle.

Qa — **Alluvium** (Holocene)—Alluvial sands, muds, and gravels exposed in canyon floors, minor alluvial fans, and drainages. Deposit characteristics vary with the nature of the materials exposed up-gradient and underlying the deposit. Deposits are unconsolidated with no evidence of significant soil development observed. Includes active channels and Qar where these deposits are too small to map at this scale. Deposit thicknesses are 0 to 7 m.

Qt2 — **Younger terrace deposits** (Holocene)—Brown, thinly laminated silts and very fine sands exhibiting very weak surface soil development. Sands are dominantly siliceous. Deposits are up to 4 m thick.

Qt1 — **Older terrace deposits** (Holocene)—Brown, thinly bedded silts and lesser silty very fine-grained sands overlying light-brown silty sands with trace pebbly channel fills, and bearing a surface soil characterized by a Stage I morphology carbonate horizon. Deposits overall are as much as 8 m thick.

Eolian Deposits

Qe — **Eolian sheet sand** (Holocene)—Windblown fine, distinctive red-brown sands underlying dune fields and wind-sculpted hummocky terrain. Locally color varies to pale-yellow and grey-white. They are principally exposed in a large eolian sand sheet, covered by coppice dunes and other dune-forms, occupying most of the western half of the quadrangle. Deposits are loose with no evidence of notable soil development observed. Up to 10 m thick.

Qd — **Eolian dune deposits** (Holocene)—Windblown, orange- to tan-yellow silts and sands. Generally expressed as areas of significant coppice dunes forming on top of, and likely derived from alluvial deposits. Rarely form more complex dune forms. More isolated deposits than, and distinct in color from Qe. No evidence of notable soil development was observed. Qd deposits are generally less than 2 m thick, with local variations as thick as 8 m.

Miscellaneous Deposits

Qdf — **Depression fill** (Holocene)—Silts, sands, and clays accumulating in closed or nearly closed depressions. Dominantly slope-wash- and eolian-transported muds and very fine sands, with trace coarser material, up to 2 m thick.

Qc — **Colluvium** (Holocene)—Colluvial deposits covering slopes below rims of Qmc in canyon walls. Composed of silt to medium sand with pebbles to boulders of Qmc caliche.

Qg — **Alluvial-colluvial** gravel (Holocene)—Alluvial and colluvial gravel consist of sub- to well-rounded quartzite, chert, volcanics, and limestone pebbles. Generally forms low, hummocky mounds thought to represent weathering and reworking of QTg conglomerates. Differentiated from Qac by a conspicuous lack of caliche clasts derived from Qmc.

Qac — **Alluvial-colluvial deposits** (Holocene)—Alluvial and colluvial gravel consisting of sub- to well-rounded pebbles to cobbles of caliche, quartzite, chert, volcanics, and limestone. Generally covers slopes in canyon walls or forms gentle, hummocky mounds thought to represent reworking of QTg conglomerates and Qmc. Differentiated from Qg by the presence of abundant Qmc caliche clasts.

Pleistocene Series

Qcc — **Cemented conglomerates along the Pecos River** (Upper Pleistocene)—Well-cemented pebble to cobble conglomerates and rare interbedded sandstone lenses. Carbonate cementation is ubiquitous in these units, but does not exhibit pedogenic features. Conglomerates consist of carbonate, siliceous, and volcanic clasts supported by a carbonate-cement matrix.

Mescalero Caliche
Mescalero caliche relict calcic soil horizon.

Qmc — **Mescalero caliche** (Upper Pleistocene)—Relict calcic soil horizon exhibiting Stage IV+ pedogenic carbonate morphology, with a durable, discontinuously preserved upper horizon of laminated carbonate up to a few decimeters thick. Below the laminated caprock is up to 4 m (typically 1 to 3 m) of clastic alluvium engulfed by white to gray carbonate. The carbonate becomes softer and earthier with depth. The relative proportion of parent material also increases with depth. Pedogenic brecciation and recrystallization structures are rare. Unit is relatively resistant to erosion and forms vertical cliffs along bluff lines. Commonly, the paleosol formed in sand and rounded gravelly deposits (Gatuña Formation), which include clasts of limestone, quartzite, chert, sandstone, and porphyritic igneous rock; in other areas it formed in finer-grained deposits, and locally appears to be present immediately above Rustler Formation strata. Over much of the map area the Mescalero caliche is overlain by windblown sand and/or surface alluvium.

Gatuña Formation

QTg — **Undivided Gatuña Formation** (Miocene–Pliocene? to Pleistocene)—The Gatuña Formation generally consists of pale-red sand and mud, with stringers and locally thick lenticular beds of reddish-gray pebbly sand to conglomerate. The unit is capped by a well-developed calcic paleosol (**Qmc**) in the map area. The base of the Gatuña Formation is poorly exposed in the map area. Near the mouth of Wood Draw surface exposures of the Rustler Formation are overlain by Mescalero caliche presumably developed in thin Gatuña deposits. A few meters of Gatuña Formation deposits were observed to overlie the Permian Rustler Formation at the surface. Given the single tephrochronology datum and observed field relationships, we prefer a Pleistocene age for the entire Gatuña Formation but cannot rule out that the formation is partly upper Neogene. According to some reports thickness generally varies from a few meters to 10 m or more, reaching up to 100 m in the Pierce Canyon/Cedar Canyon area.

QTgc — **Conglomerate-dominated facies of the Gatuña Formation** (Miocene–Pliocene? to Pleistocene)—Well-cemented pebble conglomerates and rare sandstones underlying, grading up-section into, or in proximity to the Mescalero caliche. Conglomerates consist of poorly sorted, clast-supported, rounded to well-rounded pebbles with trace cobbles, of lithologies including common limestone, sandstone, quartzite, chert, felsic to intermediate volcanics, and absent-to-trace granite.

QTgr — **Mud and sand-dominated facies of the Gatuña Formation** (Miocene–Pliocene? to Pleistocene)—Dominantly light reddish brown mudstones and sandstones with lesser conglomerates of the Gatuña Formation that underlie caliche in the western portion of the map area. Compared to other Gatuña mudstones and sandstones, these deposits tend to be darker colored, better cemented, and generally thicker.

QTgs — **Sand-dominated facies of the Gatuña Formation** (Miocene–Pliocene? to Pleistocene)—Pink to tan to grey, thin- to thick-bedded, fine-grained sandstones of the Gatuña Formation, locally interbedded with minor, thin mud-silt and pebble conglomerate layers. Uncommonly include yellow, thin-bedded sandstone layers in the western portion of Cedar Canyon. Occasionally overlain across a variably angular intraformational unconformity by 0.1 to 3 m of subhorizontal, medium-bedded to massive, grey to white sandstones and sandy conglomerates (e.g., QTgsc).

QTgsc — **Sandy conglomerate facies of the Gatuña Formation** (Miocene–Pliocene? to Pleistocene)—Medium-bedded to massive sandy pebble conglomerate, interbedded with thin- to thick-bedded, white to grey to tan sandstones, of the Gatuña Formation underlying, grading up-section into, or in proximity to the Mescalero caliche. Conglomerates consist of poorly sorted, rounded to well-rounded, matrix-supported pebbles, with rare cobbles, of limestone, chert, quartzite, and mafic to felsic volcanics.

Undivided Cenozoic Deposits
Cross section only. Undivided Cenozoic deposits, including Quaternary surficial deposits and the underlying Gatuña Formation.

QTu — **Undivided Neogene–Quaternary deposits** (Neogene to Modern)—Cross section only. Undivided Cenozoic deposits, including Quaternary surficial deposits, the Gatuña Formation, and possible subsurface Neogene alluvial fill. Well logs suggest a maximum thickness of approximately 160 m along the eastern end of the cross section, and 100 m in the vicinity of the Pecos River.

PALEOZOIC ERATHEM
Permian System
Ochoan Series

Pd — **Dewey Lake Redbeds** (Ochoan)—Red, laminated to thinly bedded coarse siltstone and fine-grained subarkosic sandstone. Planar, ripple, and larger-scale cross sets are common, as are greenish-gray reduction spots and zones in some exposures. Unit is exposed to the north of the map area in the vicinity of Nash Draw, where it stratigraphically overlies the Permian Rustler Formation and underlies the Triassic Santa Rosa Formation. Along the eastern end of the cross section the unit is estimated to be ≈50 m thick and overlain by late Cenozoic alluvial-fill deposits. However, intervening remnants of basal Triassic strata may be present. Dewey Lake strata may be exposed in the map area near a small gully cut near the mouth of Dog Town Draw.

Pr — **Rustler Formation** (Ochoan)—Red, yellow and gray mudstone, gypsum, fine-grained sandstone, and carbonate. Two widespread carbonate intervals named the Culebra (lower in the section) and Magenta members are recognized as stratigraphic markers to subdivide this lithologically heterogeneous formation into members. Unit is present in the subsurface throughout the map area. It is overlain by Cenozoic alluvial deposits or by the Permian Dewey Lake Formation in the eastern part of the map area. Underlain by the halite-dominated Salado Formation (Ps), the Rustler Formation has been variably deformed by solution subsidence and collapse. Based on borehole logs up to 110 m of Rustler strata are present along the cross section. Several poorly exposed outcrops near the mouth of Wood Draw expose variously deformed, broken tilted blocks of carbonate, red and yellow mudstone, brown sandstone, and gypsum.

Ps — **Salado Formation** (Ochoan)—Cross section only. Largely halite with economically important potash zones, several named anhydrite beds, and minor amounts of siliciclastic mud and fine sand. Dissolution of Salado halite beneath the map area is readily apparent from examining well logs, and unit thickness (≈200 to 500 m along the cross section) changes abruptly. Exposures of variously deformed deposits, consisting mainly of red mud and gypsum, including secondary selenite, have been referred to as "Salado residue" in some reports (e.g., Gard, 1968). Based on lithology, such deposits may represent collapsed Rustler strata, resulting from the dissolution of underlying Salado halite.

Pc — **Castile Formation** (Ochoan)—Cross section only. Finely crystalline, pale-gray calcium sulfate, interlaminated with brown to dark-gray calcite. The unit contains a thin, basal laminated limestone, and relatively thick halite intervals that provide a basis for dividing the formation into members. The Castile Formation underlies the Salado Formation and, unlike the Salado Formation, is restricted to the Delaware Basin proper (i.e. was not deposited on the surrounding marine shelf). Based on geophysical logs much of the halite in the Castile Formation, particularly in the two lower members (Halite I and II), remains intact in the map area. The thickness ranges from approximately 450 to 550 m along the cross section, and is underlain by the Bell Canyon Formation.

Guadalupian Series

Pbc — **Bell Canyon Formation** (Guadalupian)—Cross section only. Predominately buff to brown, fine-grained, subarkosic sandstone and siltstone, with some shale intervals. Siltstone and fine sandstone are commonly finely laminated and carbonaceous. The unit contains named carbonate intervals, which thicken and grade into the Capitan Formation along the margin of the Delaware Basin. The uppermost named limestone, the Lamar, is readily apparent on gamma-ray logs. The top of the Bell Canyon Formation is at the top of a siliciclastic interval (Reef Trail Member) that overlies the Lamar limestone beds. The Bell Canyon is approximately 290 m thick in the map area.

Pcc — **Cherry Canyon Formation** (Guadalupian)—Cross section only. Predominately buff to brown, fine-grained, subarkosic sandstone and siltstone, with some shale intervals. Siltstone and fine sandstone are commonly finely laminated and carbonaceous. The unit contains named carbonate intervals, which thicken and grade into the Capitan Formation along the margin of the Delaware Basin. The top of the Cherry Canyon Formation is placed at the base of the lowest carbonate interval (Hegler Member) in the Bell Canyon Formation. The Cherry Canyon Formation is approximately 375 m thick in the map area based on log picks.

Pbrc — **Brushy Canyon Formation** (Guadalupian)—Cross section only. Tan and brown sandstone and siltstone, with shale beds in the lower part. The unit may contain thin beds of gray-brown carbonate and coarse-grained siliciclastic deposits near its base. Sandstone and siltstone are commonly laminated. The contact between the Cherry Canyon and Brushy Canyon Formations was historically chosen in outcrop at a lithologic change between comparatively coarse-grained sandstone beds in the Brushy Canyon and finer-grained deposits beneath the Getaway Limestone member of the Cherry Canyon Formation. Neutron density-porosity logs show a distinct, laterally traceable log response compatible with such a change. The contact between siliciclastic deposits at the base of the Brushy Canyon Formation and uppermost Bone Spring carbonate mud is readily identified on gamma-ray logs. The Brushy Canyon Formation is approximately 485 m thick in the map area.

Cisuralian Series

Pbs — **Bone Spring Formation** (Cisuralian)—Cross section only. 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, shale or calcareous intervals (the stratigraphic position of the lower and upper sandy intervals are indicated on the cross section). The Bone Spring Formation is up to 990m thick in the map area.

Pw — **Wolfcampian Series** (Cisuralian)—Cross section only. Greenish-gray, brown, and black calcareous and carbonaceous shale, with some carbonate and siliciclastic sand. The top of the Wolfcamp 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 540 m thick in the map area.

Pennsylvanian Subsystem

Pcc — **Cisco Formation and Canyon Group undivided** (Upper Pennsylvanian)—Cross section only. Interbedded carbonate and shale, with some sandy siliciclastic intervals likely present. Gamma-ray logs suggest carbonate and shale beds alternate on a scale of one to several meters. The unit's base is placed at the top of a prominent carbonate interval assigned here to the top of the Strawn Formation. The Cisco-Canyon interval is approximately 130 m thick in the map area.

Psa — **Strawn and Atoka Formations undivided** (Middle (Lower-Upper?) Pennsylvanian)—Cross section only. Interbedded carbonate, sandstone, and shale. Phylloid algal mounds are reported in the Strawn interval to the southeast of Carlsbad, NM, where the unit has been targeted for oil and gas production. The underlying Atoka Formation in the Delaware Basin contains carbonate beds, sandstone, shale, and calcareous shale. The base of the Strawn-Atoka interval is chosen on gamma-ray and resistivity logs at the top of the upper Morrow carbonate interval. Approximately 240 m thick in the map area.

Pm — **Morrow Formation** (Lower Pennsylvanian)—Cross section only. The upper third of the Morrow Formation consists of carbonate and calcareous shale, together with fine- to medium-grained sandstone and shale. The underlying middle and lower Morrow intervals are dominantly fine- to coarse-grained sandstone, with lesser shale. Approximately 410 m thick beneath the map area.

Mississippian Subsystem

Mb — **Barnett Formation** (Mississippian)—Cross section only. Shale and silty shale with lesser fine-grained sandstone and siltstone. The Barnett Formation is approximately 75 m thick in the map area, and overlies older Mississippian carbonate strata.