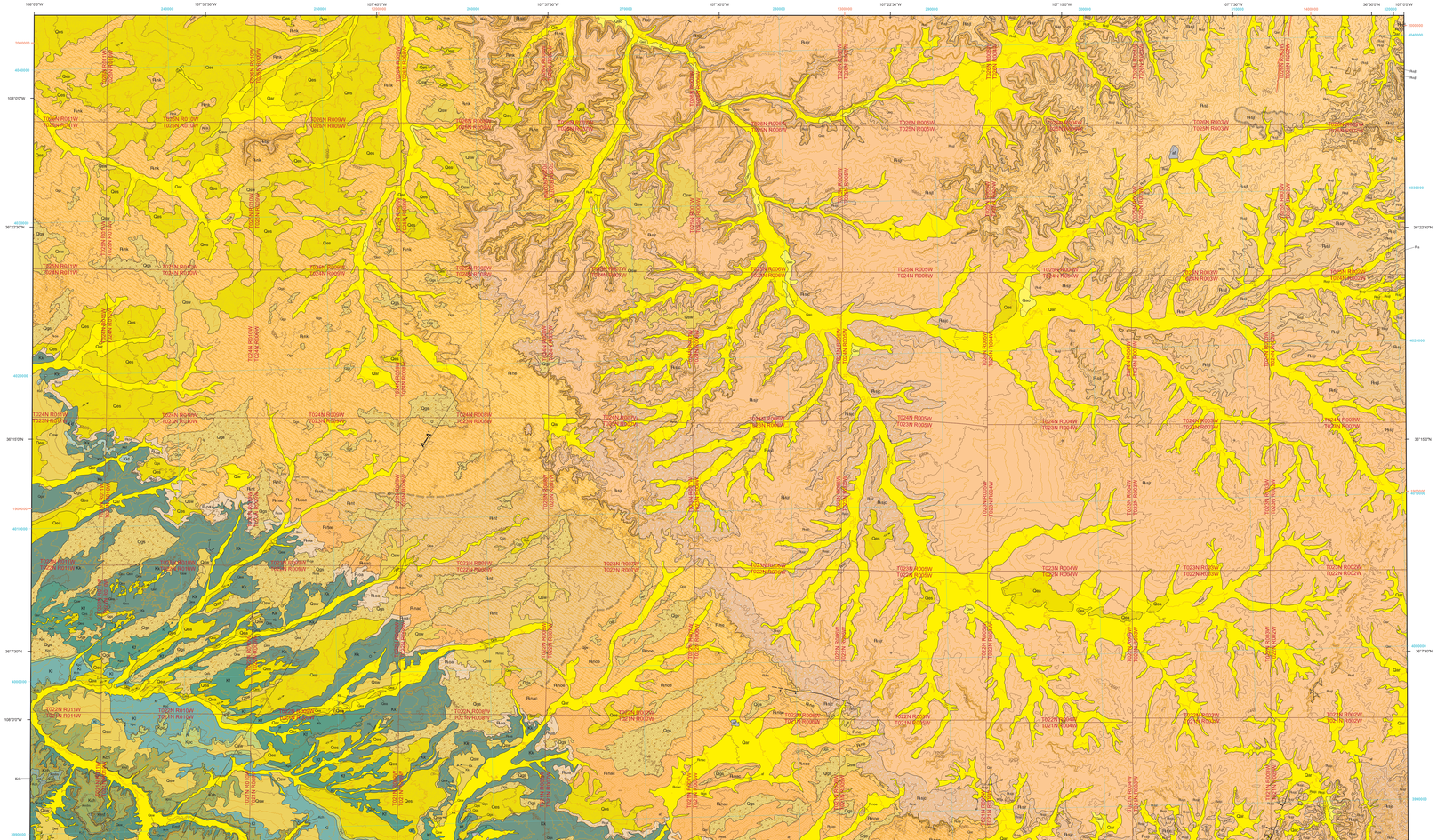
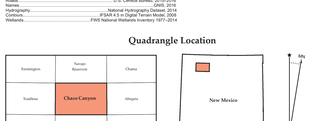


Base map from US Topo U.S. Geological Survey 2021
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 Universal Transverse Mercator, Zone 13S, shown in blue.
100,000-foot ticks: New Mexico Coordinate System of 1983 west zone, shown in red.

Roads ..... U.S. Census Bureau, 2016–2018
Names ..... GNIS, 2018
Hydrography ..... National Hydrography Dataset, 2014
Contours ..... National Elevation Dataset, 1/3 arc-second, 2013
Wetlands ..... FWS National Wetlands Inventory 1977–2014

Quadrangle Location



Magnetic Declination
July, 2020
8° 42' East
At Map Center

Comments to Map Users

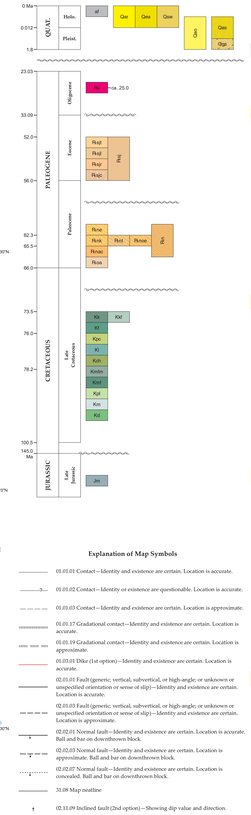
A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation.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 (drillhole) 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 man-made structures.

The New Mexico Bureau of Geology and Mineral Resources created the Open-file Geologic Map Series to expedite dissemination of these geologic maps and map data to the public as rapidly as possible while allowing for maps with as little as geologists continued to work in map areas. Each map sheet carries the original date of publication below the map as well as the latest revision date in the upper right corner. In most cases, the original date of publication coincides with the date of the map product delivered 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 prior to 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.

Digital layout and cartography by the NMBGMR Map Production Group:
Phil L. Miller, Amy L. Dunn, and Andi Knight

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.

01.01.17 Gradational contact—Identity and existence are certain. Location is accurate.

01.01.19 Gradational contact—Identity and existence are certain. Location is approximate.

01.03.01 Dike (1st option)—Identity and existence are certain. Location is accurate.

02.01.01 Fault (generic; vertical, subvertical, or high-angle; or unknown or unspecified orientation or sense of slip)—Identity and existence are certain. Location is accurate.

02.01.03 Fault (generic; vertical, subvertical, or high-angle; or unknown or unspecified orientation or sense of slip)—Identity and existence are certain. Location is approximate.

02.02.01 Normal fault—Identity and existence are certain. Location is accurate. Ball and bar on downthrown block.

02.02.03 Normal fault—Identity and existence are certain. Location is approximate. Ball and bar on downthrown block.

02.02.07 Normal fault—Identity and existence are certain. Location is concealed. Ball and bar on downthrown block.

31.08 Map neatline

02.11.09 Inclined fault (2nd option)—Showing dip value and direction.

09.017 Inclined slickenline, groove, or striation on fault surface (1st option)—Showing bearing and plunge.

16.07 Sediment transport direction determined from dune forms

19.05.010

31.11 Leader line

31.10 Cross section line and label

01-03-02.00.00—unit—Qes—Eolian sheet sands (Pleistocene to early Holocene)—Loose to weakly consolidated sand in broad sheets and stabilized dunes. Younger deposits contain white to pink, well-sorted crossbedded quartz arenite to feldspathic arenite (80-95% quartz in the sand size class) very fine to fine sand in linear or parabolic dunes. Older deposits are more common and consist of light brown, pale brown, and very pale brown loosely consolidated moderately sorted to well-sorted subrounded coarse silt to medium sand in stabilized longitudinal dunes and sand sheets on upland areas. Bedding is disturbed to the point of obscurity in lower portions of the unit. The upper 30 cm of this unit is nonetheless weakly to hydrochloric acid; lower paleosols within the unit are effervescent. At least 4 paleosols are present in older deposits; these comprise pale brown to strong brown poorly sorted to moderately sorted clay to medium sand, very sandy, sandy silt, and clayey silt massive horizons with black ped structures and up to stage II pedogenic carbonate development in the form of coatings, nodules and filamental coatings. In general, lower paleosols are darker (lower Munsell color value), finer grained, and more likely to contain blocky, platy, prismatic, carbonate, and thin clay cutans on ped faces. Distinct contact with underlying units, though this contact sometimes is overprinted by a paleosol where Qes overlies Qgs. Stabilized dunes are typified by big sagebrush (Artemisia tridentata)-dominated plant communities, with subordinate grasses (Achnatherum hymenoides), grama grass (Bouteloua sp.), saltbrush (Atriplex canescens), chamisa (Ericameria nauseosa), brown snakeweed (Gutierrezia sarothrae), and Mormon tea (Ephedra sp.). Pine (Pinus sp.) and juniper (Juniperus sp.) are nearly entirely absent on this deposit. Generally poorly exposed; well-exposed only in active bedcuts and construction trenches for pipelines and roads. Average sediment eolian transport azimuth is 061° as determined by dune morphologies in aerial imagery. Stabilized longitudinal dunes are up to 10 m tall. <12 m thick.

01-03-10.00.00—unit—Qgs—Gravelly sand sheets (Pleistocene)—Weakly to moderately consolidated gravelly sand in broad sheets capping former pediment surfaces in the drainages of Blanco Wash and Chaco Wash. Primarily light brown in color, poorly sorted fine to coarse sand with 2-10% pebbles and trace silt and cobbles. Sand is moderately sorted subrounded to subangular, 50-70% quartz, 25-50% feldspar, and trace to 5% lithics. Gravel is subrounded to very rounded quartzite, chert, dark gray to black petrified wood, yellowish brown to reddish brown petrified wood, crystalline granitic rocks, crystalline gneissic rocks, micrite, and fossiliferous limestone. Pebbles are more abundant from small clitic mudstones with underlying units is often marked by a gravel bed 5-30 cm thick. Where visible, the upper contact is marked by a weakly developed paleosol. Discontinuous gravel lenses, and lens-shaped deposits of fine sands interpreted as coppice dunes. Sands in this soil otherwise are effervescent. At the surface of this unit exhibits subdued topography with little steep-sided incision but a relatively mature soil interconnected swales and small tributary drainages. May include the surficial deposits of recent eolian sands up to 30 cm thick and coppice dunes up to 2 m high. Surface supports plant community including big sagebrush (Artemisia tridentata), grama grass (Bouteloua sp.), saltbrush (Atriplex canescens), chamisa (Ericameria nauseosa), brown snakeweed (Gutierrezia sarothrae), and Mormon tea (Ephedra sp.). Pine (Pinus sp.) and juniper (Juniperus sp.) are nearly entirely absent on this deposit. 3-7 m thick

02.00.00-00.00—heading01—Paleogene—Paleogene (Paleogene)—Paleogene

02-01-00.00.00—heading02—Igneous rocks—Igneous rocks (Tertiary)—Igneous rocks

01-02-01.00.00—unit—PEi—Intrusive dikes of the Dulce Dike Swarm of Lipman & Zimmerer (2019) (ca. 25.0 Ma)—Light gray to gray trachybasalt and basaltic trachyandesite dikes intruding Eocene-aged San Jose Formation mudstones and sandstones. Dike orientation is subvertical. Dikes on this quadrangle are up to 2.4 km long. Dike thickness is 3-8 m. Contains phenocrysts of olivine and clinopyroxene. Mica and amphibole present in groundmass.

02-02.00.00-00.00—heading02—Siliciclastic rocks—Siliciclastic rocks (Paleogene)—Siliciclastic rocks

02-02-01.00.00—unit—PEsj—San Jose Formation (Eocene)—San Jose Formation

Description of Map

01-00-00.00.00—heading01—Quaternary—Quaternary (Quaternary)—Quaternary

01-01-00.00.00—heading02—Anthropogenic Units—Anthropogenic Units (Historic)—Anthropogenic Units

01-01-17-00.00—unit—af—Artificial Fill and Disturbed Ground (Historic)—Accumulations of clay, silt, and sand from construction of dams in southern map area. Deposits of clay, silt, sand, and pebbles on upstream sides of dams. Disturbed ground and spoils piles from surface lignite mine in the Fruitland Formation in the southern map area. 1-8 m thick

01-02-00.00.00—heading02—Valley-floor units—Valley-floor units (Quaternary)—Valley-floor units

01-02-01.00.00—unit—Qar—Modern to historic alluvium (ca. 0.2 ka to present-day)—Stream-deposited clay, silt, sand, and gravel in valley floors. Mineral composition and grain rounding is influenced by and largely inherited from the bedrock composition of the drainage basin in which the deposit is found; deposits typically have the composition of feldspathic arenite or feldspathic wacke. A typical deposit consists of light yellowish brown, light brown, or light gray poorly consolidated to unconsolidated sand and silty sand with subordinate pebbly silty sand, sandy silt, and silty clay. Bedforms include crossbedding, ripple crosslamination, ripple laminations, graded bedding, scour-and-fill structures, and plane bedding. Bed thickness varies from laminated (<1 cm) to thick (>30 cm). Reddish brown to light reddish brown paleosols up to 1 m thick with colluvium pads and root traces are common. Loessly to moderately consolidated, forms vertical faces up to 2 m tall. Distinct contact with underlying units. Gradational contact with surrounding fans and colluvial deposits. Where present in same valley as older alluvium (until Qay on this map), this unit is inset by 1–6 m in a lower geomorphic position. Radiocarbon dates from this unit in Arroyo Chijuilla and Canyon Largo are 2-8 ka. Potsherds from the Pueblo II Period (Pecos Classification; ca. 1 ka) have been found as deep as 3 m below ground level in these deposits. Surface of this unit typically contains grama grass (Bouteloua sp.), galleta grass (Hilaria jamesii), saltbrush (Atriplex canescens), and sahndar (Tamarix ramosissima), with subordinate big sagebrush (Artemisia tridentata). Unit includes debris fans, canyon-mouth fans, colluvium, and minor sheetwash alluvium. Since the 19th Century, this deposit has been incised up to 7 m. <8 m thick.

01-02-02.00.00—unit—Qea—Modern to historic eolian deposits derived from sand-bed arroyos and within valley floors (0.2 ka to present-day)—Well-sorted coarse silt to medium sand, light yellowish brown in white, unconsolidated. Laminated to thin crossbeds with subordinate horizontal plane beds. Ripples and sand avalanches seen on active deposits. Grains are subrounded to subangular and comprise quartz, feldspars, and lithic fragments. Little to no footing observed. Deposits have the composition of feldspathic arenite. Includes coppice dunes up to 3 m tall. Frequently reworked by lateral migration of active stream channels in Bekonie Tassie Wash, Kinibeto Wash, and Escavada Wash. Includes minor amounts of alluvium and sheetwash around active and stabilized dunes. In Kinibeto Wash, Bekonie Tassie Wash, and Escavada Wash, these deposits are substantial enough to disrupt surface drainage and cause the formation of yazoo channels parallel to the main active channel in those valleys. Includes deflation blowouts up to 300 m in length. Where dunes block surface drainages and in deflation blowouts, includes subordinate palustrine deposits consisting of horizontal plane bedded clay and silt. Dune forms are parabolic and longitudinal, with an average sediment transport azimuth of 060° as determined by dune morphologies in aerial imagery. Active dunes are 1.5 – 7 m tall. Stabilized dunes typically contain saltcedar grass (Sporobolus sp.), grama grass (Bouteloua sp.), and saltbrush (Atriplex canescens). Differentiated from map unit Qes (Eolian sand sheets) by its lower geomorphic position, active dunes, less mature lithic composition, lighter color, and less developed soil. <8 m thick.

01-02-03.00.00—unit—Qao—Older alluvium (Pleistocene?) to early Holocene)—Clay, silt, sand, and gravel underlying terraces >3 m above active and historic alluvial deposits. Sediment is in laminated to thick tabular to lenticular beds with crossbeds, ripple crossbeds, graded bedding, scour-and-fill structures, and horizontal plane beds. Mineral composition and grain rounding is influenced by and largely inherited from the bedrock composition of the drainage basin in which the deposit is found; deposits typically have the composition of feldspathic wacke with subordinate feldspathic arenite. A typical deposit consists of brown, light brown, or yellowish brown, loosely to moderately consolidated silty sand with subordinate silty clay, pebbly silty sand, and sandy silt, with trace sandy gravel. Reddish brown to light reddish brown paleosols with columnar peds and root traces are common; stage I calcic horizons are present in some of these paleosols. Forms vertical faces up to 4 m tall. Distinct contact with underlying units. Gradational contact with surrounding fans and colluvial deposits. Surface of this unit typically contains the same plant species as map unit Qsr, with additional juniper (Juniperus sp.), pifion (Pinus edulis), big sagebrush (Artemisia tridentata), cane cholla (Cylindropuntia imbricata), and prickly pear (Opuntia sp.). Unit includes debris fans, canyon-mouth fans, colluvium, and minor sheetwash alluvium. Since the 19th Century, this deposit has been incised up to 13 m. Differentiated from map unit Qar (modern to historic alluvium) by higher geomorphic position, slightly finer-grained texture, slightly darker color in outcrop, and different plant community. <14 m thick.

01-03-00.00.00—heading02—Surficial—Surficial units not confined to valley floors (Quaternary)—Surficial units not confined to valley floors

01-03-01.00.00—unit—Qsw—Sheetwash alluvium (Pleistocene to Holocene)—Loose to weakly consolidated clay, silt, sand, and gravel. Includes colluvium on slopes. At foot of slopes, may include mudflows, poorly sorted debris flow deposits, and associated debris flow levees. At the base of slopes, this unit includes locally derived clay, silt, sand, and mud whose composition and texture is controlled by composition of upslope bedrock outcrops. In these settings, the unit often includes coalesced alluvial sediment aprons that grade upslope into colluvial aprons. Locally contains lag gravel; where this unit is found immediately downslope of outcrops of the Fruitland Formation, Kirtland Formation, Ojo Alamo Sandstone, Nacimiento Formation, or San Jose Formation, the lag gravel frequently contains rounded clasts of crystalline rock and/or petrified wood that are inherited from those Cretaceous and Paleogene units. Where this unit is found on broad upland flats, it consists of alluvial reworked eolian sands. In these settings, it comprises weakly consolidated light brown to light yellowish brown poorly to moderately sorted clay, silt, and sand in poorly expressed very thin to medium horizontal plane beds with trace crossbeds. Grades laterally into adjacent eolian sheet sands (map unit Qes). On surface, dune forms are absent but intermittent drainages often flow parallel to the prominent trend alignment of longitudinal dunes (azimuth of 060° ± 10° or 240° ± 10°). Areas of recent deposition host grasses at the surface. Less recently active areas host roughly equal proportions of saltbrush (Atriplex canescens) and big sagebrush (Artemisia tridentata), with subordinate grasses, Mormon tea (Ephedra sp.), brown snakeweed (Gutierrezia sarothrae), prickly pear (Opuntia sp.), and cane cholla (Cylindropuntia imbricata). In upland areas, the contact with underlying unit often is gradational and may be obscured by pedogenic or paleopedogenic alteration. Where found at the base of slope, the lower contact often is distinct and marked by a scour surface. Contacts with adjacent units are gradational. Interfingers with alluvium. Rarely sharply incised; subdued topography is prevalent. 3 m thick.

01-03-02.00.00—unit—Qes—Eolian sheet sands (Pleistocene to early Holocene)—Loose to weakly consolidated sand in broad sheets and stabilized dunes. Younger deposits contain white to pink, well-sorted crossbedded quartz arenite to feldspathic arenite (80-95% quartz in the sand size class) very fine to fine sand in linear or parabolic dunes. Older deposits are more common and consist of light brown, pale brown, and very pale brown loosely consolidated moderately sorted to well-sorted subrounded coarse silt to medium sand in stabilized longitudinal dunes and sand sheets on upland areas. Bedding is disturbed to the point of obscurity in lower portions of the unit. The upper 30 cm of this unit is nonetheless weakly to hydrochloric acid; lower paleosols within the unit are effervescent. At least 4 paleosols are present in older deposits; these comprise pale brown to strong brown poorly sorted to moderately sorted clay to medium sand, very sandy, sandy silt, and and clayey silt massive horizons with black ped structures and up to stage II pedogenic carbonate development in the form of coatings, nodules and filamental coatings. In general, lower paleosols are darker (lower Munsell color value), finer grained, and more likely to contain blocky, platy, prismatic, carbonate, and thin clay cutans on ped faces. Distinct contact with underlying units, though this contact sometimes is overprinted by a paleosol where Qes overlies Qgs. Stabilized dunes are typified by big sagebrush (Artemisia tridentata)-dominated plant communities, with subordinate grasses (Achnatherum hymenoides), grama grass (Bouteloua sp.), saltbrush (Atriplex canescens), chamisa (Ericameria nauseosa), brown snakeweed (Gutierrezia sarothrae), and Mormon tea (Ephedra sp.). Pine (Pinus sp.) and juniper (Juniperus sp.) are nearly entirely absent on this deposit. Generally poorly exposed; well-exposed only in active bedcuts and construction trenches for pipelines and roads. Average sediment eolian transport azimuth is 061° as determined by dune morphologies in aerial imagery. Stabilized longitudinal dunes are up to 10 m tall. <12 m thick.

01-03-10.00.00—unit—Qgs—Gravelly sand sheets (Pleistocene)—Weakly to moderately consolidated gravelly sand in broad sheets capping former pediment surfaces in the drainages of Blanco Wash and Chaco Wash. Primarily light brown in color, poorly sorted fine to coarse sand with 2-10% pebbles and trace silt and cobbles. Sand is moderately sorted subrounded to subangular, 50-70% quartz, 25-50% feldspar, and trace to 5% lithics. Gravel is subrounded to very rounded quartzite, chert, dark gray to black petrified wood, yellowish brown to reddish brown petrified wood, crystalline granitic rocks, crystalline gneissic rocks, micrite, and fossiliferous limestone. Pebbles are more abundant from small clitic mudstones with underlying units is often marked by a gravel bed 5-30 cm thick. Where visible, the upper contact is marked by a weakly developed paleosol. Discontinuous gravel lenses, and lens-shaped deposits of fine sands interpreted as coppice dunes. Sands in this soil otherwise are effervescent. At the surface of this unit exhibits subdued topography with little steep-sided incision but a relatively mature soil interconnected swales and small tributary drainages. May include the surficial deposits of recent eolian sands up to 30 cm thick and coppice dunes up to 2 m high. Surface supports plant community including big sagebrush (Artemisia tridentata), grama grass (Bouteloua sp.), saltbrush (Atriplex canescens), chamisa (Ericameria nauseosa), brown snakeweed (Gutierrezia sarothrae), and Mormon tea (Ephedra sp.). Pine (Pinus sp.) and juniper (Juniperus sp.) are nearly entirely absent on this deposit. 3-7 m thick

02-02-05.00.00—unit—PEnac—Arroyo Chijuilla Member of the Nacimiento Formation (Paleocene)—White to light gray and pinkish gray sandstone and yellowish gray beds dominated by medium mudstone. Sandstones are very fine- to medium-grained moderately to well-sorted subangular to subrounded clay-cemented feldspathic arenites and feldspathic wackes. Mudstones are 1-5 m thick and contained laminated to medium horizontal plane beds and crossbeds. May contain cannonball concretions up to 1 m diameter. Sandstones are weakly to moderately indurated and form steep slopes and small discontinuous cliffs. Mudstones are slightly calcareous to noncalcareous slope formers. Very dark gray to black discontinuous lignites up to 20 cm thick are common. At the Arroyo Chijuilla Member contains Puercan fossils (64.3 - 63.3 Ma). At Mesa de Cuba in the southeasternmost map area, the upper half of the Arroyo Chijuilla Member contains Torrejonian fossils (63.3 - 60.2 Ma) (Williamson, 1996). Base is conformable with the underlying Ojo Alamo Sandstone. Top is disconformable with the overlying Ojo Encino Member of the Nacimiento Formation. Interfingers to the northwest with the adjacent Tosie Member of the Nacimiento Formation and possible the Kutz Member of the Nacimiento Formation. Thickness 30-130 m

02-02-03.00.00—unit—PEoa—Ojo Alamo Sandstone (Paleocene)—Note: we use the term Ojo Alamo Sandstone sensu Baltz (1967), since this definition includes only one proposed member (the Kimbeto Member sensu Baltz, 1967); we do not name members within the Ojo Alamo Sandstone here. Very pale brown to yellowish brown sandstone and conglomerate with subordinate pale brown to brown and dark gray mudstones. Sandstones are fine- to coarse-grained moderately sorted angular to subrounded micaceous feldspathic arenites. Sandstone composition is 22-46% quartz, 26-43% feldspar, and 8-36% lithics. Pebbles are subangular to well-rounded chert, purplish quartzite, intermediate composition plutonic igneous rocks, petrified wood, and limestone. Intraformational mud clasts up to 40 cm diameter occur at the base of some sand bodies within the Ojo Alamo Sandstone. Sandstone bedforms include horizontal plane beds, tabular and epsilon crossbeds, graded beds, and scour-and-fill structures. Bed thickness ranges from medium to very thick. Moderately to strongly cemented with clay and silica. Typically forms prominent outcrops. Mudstones within the Ojo Alamo Sandstone in the map area are discontinuous lenses up to 100s of m in width. They include sandy clay mudstone, silty claystone, and organic shale lenses with preserved plant material. The unit generally fines upward. Contains petrified logs up to 2 m diameter at 30 m length. In outcrop, the Ojo Alamo Sandstone in the map area often is marked by juniper (Juniperus sp.) and pifion (Pinus edulis) trees, mozgras (Achnatherum hymenoides), grama grass (Bouteloua sp.), and a decrease in abundance of tall grasses and shrubs relative to surrounding units. Disconformably overlies the Kirtland Formation. Conformably overlain by the Nacimiento Formation. Thickness 3 - 120 m.

03-00-00.00.00—heading01—Cretaceous—Cretaceous (Cretaceous)—Cretaceous

03-01-00.00.00—heading02—Siliciclastic rocks—Siliciclastic rocks (Cretaceous)—Siliciclastic rocks

03-01-01.00.00—unit—Kk—Kirtland Formation (Campanian-Maastrichtian? (Late Cretaceous))—White and very pale brown to dark gray and pale olive mudstone and siltstone with minor dark grayish brown to black coal beds and lenses of light gray sandstone. Sandstones are very fine to medium grained moderately to well-sorted subangular to subrounded feldspathic arenites to feldspathic litharenites. Sandstones contain 21-60% quartz, 17-48% feldspar, and 4-53% lithics. Weakly to moderately indurated. Forms slopes, vegetated flats, and steep badlands topography. Abundant Campanian (83.6 - 72.1 Ma) vertebrate fossils constrain the age of the Kirtland Formation, and the base of the Formation is dated at 75.02 ±0.13 Ma (Fowler, 2017). The upper Kirtland Formation northwest of the quadrangle is known to host Maastrichtian (72.1 - 66.0 Ma) vertebrate fossils and palynomorphs; it is unknown whether these Maastrichtian strata continue onto the quadrangle. Conformable lower contact with underlying Fruitland Formation. Disconformable upper contact with the overlying Ojo Alamo Sandstone. Thickness 150-170 m.

03-01-01.00.00—subunit—Kkf—Farmington Sandstone Member of the Kirtland Formation (Campanian (Late Cretaceous))—Light yellowish brown to yellowish brown sandstone with interbedded light gray to very pale brown mudstones. Sandstone is fine- to medium-grained poorly to well sorted, subangular to subrounded clay-cemented feldspathic wacke. Well indurated and forms resistant but discontinuous cliffs. Mudstone is silty claystone and sandy claystone, less resistant, and forms rounded low-relief outcrops between sand bodies. Constrained by dated ashes to between 74.11 ± 0.62 Ma and 73.37 ±1.28 Ma (Sullivan and Lucas, 2003). Member pinches out to the southeast near Tsan-ja-shin approximately 7 km east of the western map boundary. Thickness in the quadrangle is 9-30 m.

03-01-02.00.00—unit—Kcf—Fruitland Formation (Campanian (Late Cretaceous))—Variegated gray, yellowish gray, and yellowish brown sandstone, siltstone, and mudstone, with dark brown to black carbonaceous shale and coal. Coal beds are often marked by reddish yellow oxidized zones in the overlying and underlying strata. Sandstones are less-shaped and 0.5-1.0 m thick, very fine- to medium-grained moderately to well-sorted subangular to subrounded quartz arenites, subfeldspathic arenites, quartz wackes, and subfeldspathic wackes. Sandstone composition is 86-97% quartz, 1-10% feldspar, and 1-5% lithics. Bedforms include horizontal plane beds, crossbeds, and ripple laminations. Ironstone concretions are common in Fruitland Formation sandstones. Multistoried sand bodies are better indurated and form benches. Isolated sandstones are weakly indurated and form slopes. Mudstones include silty claystone, sandy claystone, and clayey siltstone. Mudstones are carbonaceous and have carbonized plant material and roots. Mudstones are generally poorly indurated and form slopes. Indurated reddish yellow mudstones associated with coals form steeper outcrops. Palynomorphs suggest a late Campanian age (Lucas et al., 2006). Conformable and interfingering upper and lower contacts. Thickness within the quadrangle varies from 20-80 m.

03-01-03-00.00—unit—Kpc—Pictured Cliffs Formation (Campanian (Late Cretaceous))—Very pale brown, pale brown, and yellow sandstone with thin interbeds of light gray to light yellowish brown siltstone and subordinate gray shale. Sandstones are discontinuous over 100s to 1000s of m in bodies that are 4-12 m thick. Sandstones are very fine- to fine-grained well-sorted subrounded quartz arenites, subfeldspathic arenites, quartz wackes, and subfeldspathic wackes; arenites predominate. Sandstones are often organic-rich, interbedded with siltstones, and heavily burrowed by Ophiomorpha. Bedforms include wavy beds, flaser beds, ripple crossbeds, herringbone crossbeds, and horizontal plane beds. In most of the map area, the Pictured Cliffs Formation contains the stratigraphically highest occurrence of Ophiomorpha. Sandstones are moderately to well-indurated and form 3-10 m tall cliffs in the eastern outcrop area, and steep slopes and broad outcrops in the area between Escavada Wash and Chaco Wash and west of Kimbeto Wash. Represents the final regression of the Cretaceous Interior Seaway from northwestern New Mexico. Conformable and interfingering upper and lower contacts. Thickness 12-24 m.

03-01-04-00.00—unit—Kl—Lewis Shale (Campanian (Late Cretaceous))—Upper part light olive gray, olive gray, and dark gray calcareous sandy shale and silty shale with pale brown to light brown sandstone interbeds up to 1.5 m thick. Becomes sandier upsection and grades into the overlying Pictured Cliffs Formation. Middle part light gray to dark olive gray claystone, shale, and silty claystone with thin to medium light brown sandstone beds and trace concretionary limestone and marls. Lower part very pale brown to light yellowish brown sandstone, silty sandstone, and clayey sandstone with abundant light gray to gray mudstone and shale interbeds; becomes clayier upsection. Forms slopes. Generally outcrops poorly, best exposed beneath cliffs of overlying Pictured Cliffs Formation and in steep arroyo walls. In most of its outcrop area, the Lewis Shale forms broad flats and low-relief hills supporting grasses and small shrubs. Contains Campanian marine invertebrate fossils, particularly in thin limestone interbeds of the middle part. May contain Ophiomorpha burrows in sandy intervals, particularly near the base and upper contact. Conformable upper and lower contacts. Outcrop thickness 30-35 m. Thickens northeastward in subsurface to >850 m.

03-01-05-00.00—unit—Kch—Cliff House Sandstone (Campanian (Late Cretaceous))—Upper part white to brownish yellow sandstone with shark teeth, gastropods, bivalves, and rare ammonites. Upper unit often includes a capping brown to dark brown well-cemented sandstone with death assemblage of broken marine invertebrates. Middle part sandstones similar to upper part but with abundant light gray to grayish brown shale interbeds. The fossil bivalve Inoceramus is more common in the middle part. Ophiomorpha, shark teeth, and ammonites also are present. Lower part very pale brown to brownish yellow sandstone with crossbeds, ripple laminations, abundant Ophiomorpha nodosa burrows and rare shark teeth, bivalve, and ammonite fossils. Sandstones are fine- to coarse-grained moderately to well-sorted subrounded with lenticular beds, horizontal plane beds, crossbeds, and massive beds. Upper and lower parts are well indurated and form vertical cliffs. Lower and upper sandstone is highly fractured by joints parallel to cliff faces. Middle part forms slopes. Conformable and interfingering contacts. Thickness in outcrop 100-112 m. Thins northeastward in subsurface to 30 m.

03-01-06-00.00—unit—Kmn—Menefee Formation, undivided (Campanian (Late Cretaceous))—Pale brown to light yellowish brown sandstone with intervals of light olive gray to gray sandstone and brown carbonaceous mudstone and siltstone. Sandstones are moderately indurated, 0.5-3 m thick, fine- to coarse-grained moderately sorted subrounded to subangular with crossbeds, laminations, and wavy and flaser bedding. Mudstones and siltstones are rich in coalified plant material and contain abundant lignite layers. Silicified trees present. Rare turtle, fish, crocodile, dinosaur, palm, and conifer fossils. Sandstones form small cliffs; mudstones with underlying units is often marked by a gravel bed 5-30 cm thick. Where visible, the upper contact is marked by a weakly developed paleosol. Discontinuous gravel lenses, and lens-shaped deposits of fine sands interpreted as coppice dunes. Sands in this soil otherwise are effervescent. At the surface of this unit exhibits subdued topography with little steep-sided incision but a relatively mature soil interconnected swales and small tributary drainages. May include the surficial deposits of recent eolian sands up to 30 cm thick and coppice dunes up to 2 m high. Surface supports plant community including big sagebrush (Artemisia tridentata), grama grass (Bouteloua sp.), saltbrush (Atriplex canescens), chamisa (Ericameria nauseosa), brown snakeweed (Gutierrezia sarothrae), and Mormon tea (Ephedra sp.). Pine (Pinus sp.) and juniper (Juniperus sp.) are nearly entirely absent on this deposit. 3-7 m thick

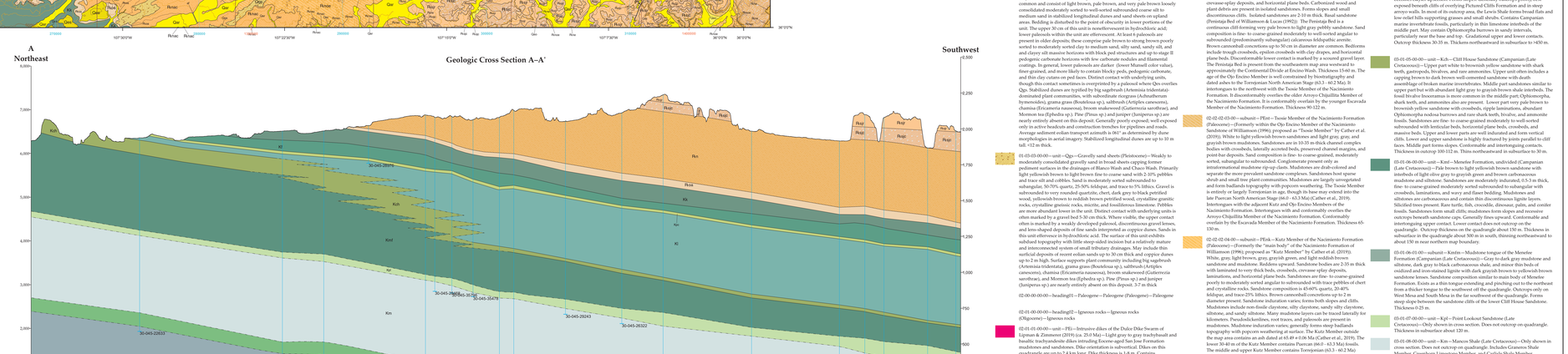
03-01-07-00.00—unit—Kd—Dakota Sandstone (Early Cretaceous to Late Cretaceous)—Only shown in cross section. Does not outcrop on quadrangle. Thickness in subsurface about 130 m.

04-00-00.00.00—heading01—Jurassic—Jurassic (Jurassic)—Jurassic

04-01-00.00.00—heading02—Siliciclastic rocks—Siliciclastic rocks (Jurassic)—Siliciclastic rocks

04-01-01-00.00—unit—Jm—Morrison Formation (Late Jurassic)—Only shown in cross section. Does not outcrop on quadrangle.

Geologic Cross Section A–A'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