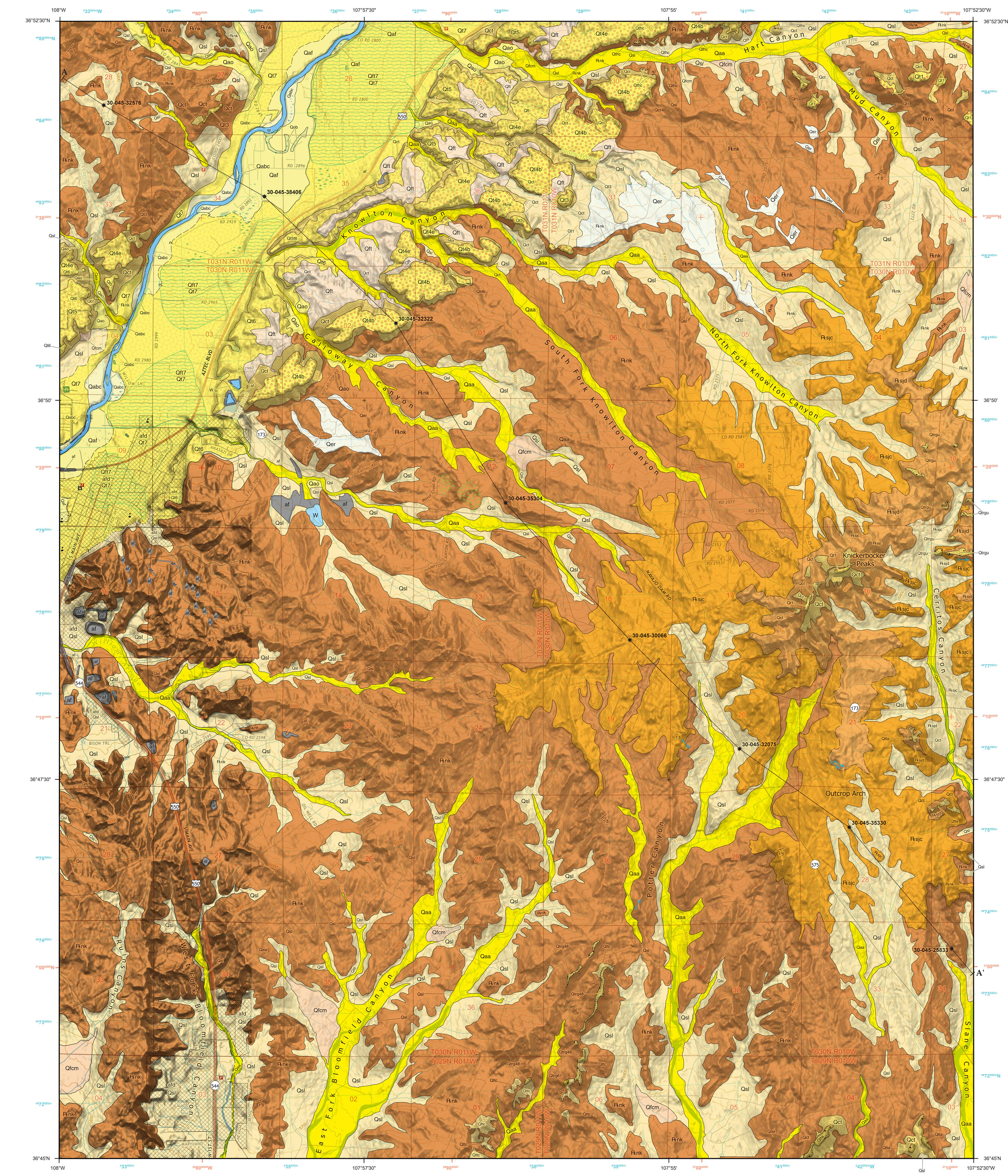
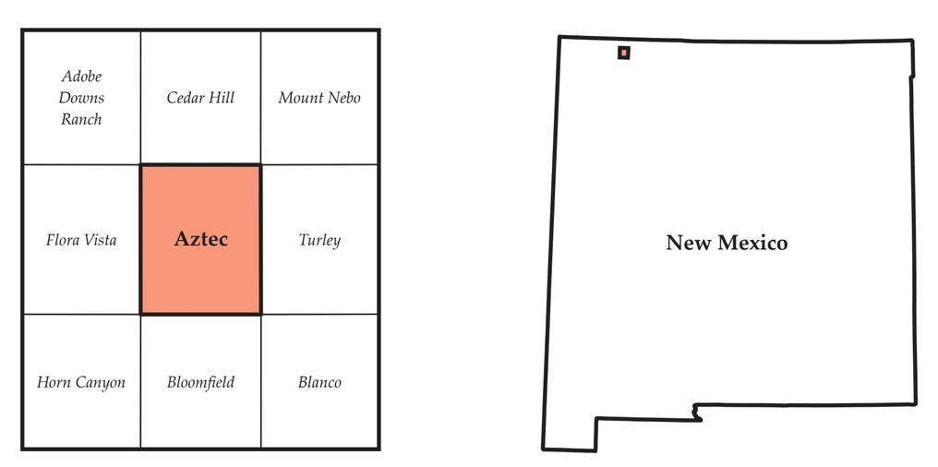


North American Datum of 1983 (NAD83)
Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 13S, shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983 (West Zone), shown in red.

Digital base map data......U.S. Geological Survey, 2019
Contours and hillshade......IFSAR 4.5 m Digital Terrain Model, 2007



Quadrangle Location

Magnetic Declination
September 2024
8° 37' East
At Map Center

1:24,000

Contour Interval 20 Feet

North American Vertical Datum of 1988

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

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

https://geoinfo.nmt.edu

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Digital layout and cartography by the NMBGMR GIS Services Program:
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Tyler Askin, Hannah N. Hunt, Amanda L. M. Doherty

New Mexico Bureau of Geology and Mineral Resources
Geologic Map 81

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Geologic Map of the Aztec 7.5-Minute Quadrangle, San Juan County, New Mexico

April 2026

by
Kevin M. Hobbs[1] and Mary L. Gillam[2]

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Comments to Map Users

A geologic map displays information on the distribution, nature, orientation, and age relationships of rocks and deposits, and the occurrence of structural features. Lithologic and fault contacts are irregular surfaces that form boundaries between different ages or types of units. Data depicted on this geologic map may be based on any of the following: field geologic mapping, a compilation of published and unpublished work, and/or photogeologic interpretation. Locations of contacts are not surveyed but are plotted by relative position on a topographic ororthophotographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the geologist's interpretation.

Resizing this map would cause the details of the map to be misrepresented and result in erroneous interpretations.Using this product at a scale different than originally intended requires verification of site-specific conditions with detailed surface mapping or subsurface exploration. Topographic and cultural changes may not be shown due to recent development.

Cross sections are constructed based on the author's interpretations of geologic mapping and available geophysical and subsurface (drill hole) data. Cross sections should be used to understand the map area's general geologic framework and not be the sole source of information for locating or designing wells, buildings, roads, or other human-made structures.

Point symbols can be set to rotate around a point of observation using their azimuth values. The point of observation can be one of three possibilities: the trailing end—or tail—opposite the arrowhead or other ornamentation of the symbol; the midpoint—or center of the symbol; or the head of the symbol. See the symbol codes described in theGIS data (FGDC_Symbols nonspatial table) for attributes that describe the azimuth measurement convention and the location of the point of observation for each symbol.

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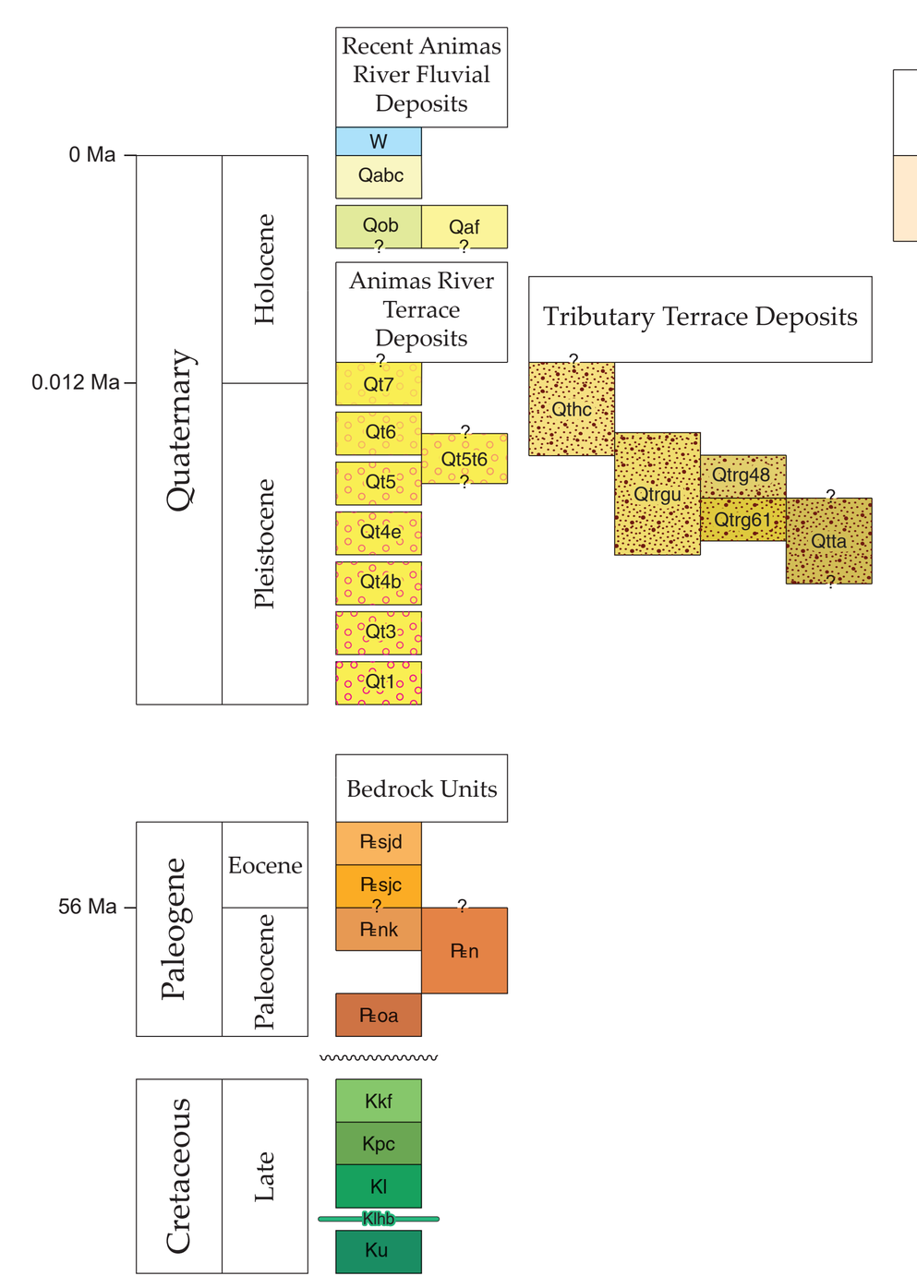
The views and conclusions in these map documents are those of the authors and should not be interpreted as necessarily representing the official policies, expressed or implied, of the State of New Mexico or the U.S.Government.

Correlation of Map Units



Explanation of Map Symbols

Contact—The identity and existence are certain and questionable where queried. The location is accurate where solid, approximate where dashed, and concealed where dotted.

Gradational contact—The identity and existence are certain. The location is accurate.

Key bed—The identity and existence are certain. The location is accurate.

Area of **af** outcrop. See Description of Map Units for unit description.

30-045-25833 Oil and gas well showing API number.

Inclined bedding—Showing strike and dip.

Paleocurrent direction determined from imbrication.

Paleocurrent direction determined from cross-beds.

Spring, type unspecified.

Anthropologically modified topography.

A A' Cross section line and label.

Description of Map Units

ANTHROPOGENIC UNITS

af — **Artificial fill (Quaternary)**—Clay, silt, sand, and pebbles used to construct flood-control dams, berms, and highway grades near the City of Aztec.

afd — **Artificial disturbed ground (Quaternary)**—Used as an overlay in the map area to indicate areas where urban development has so obscured the landscape that the natural geologic materials beneath the ground must be assumed. On the map, the overlay is used most often in the city of Aztecs' urban areas and industrial areas along U.S. Route 550 in the southern map area.

QUATERNARY

Eolian Deposits

Qer — **Remnants of eolian sand sheets (Quaternary)**—Weakly consolidated reddened silty sands on high-landscape positions interpreted to be remnants of previous extensive sand sheets. Colors range from 7.5 YR 6/4–10 YR 6/6 (light brown to brownish yellow). Very weak effervescence with HCl at a depth of 30 cm below ground surface. Maximum observed thickness is 4 m (13.1 ft), but it may be thicker.

Arroyo Alluvium

Qaa — **Active arroyo alluvium (Quaternary)**—Stream-deposited clay, silt, sand, and gravel within active-ephemeral and intermittent-stream channels. Occupies the lowest geomorphic position in any alluvially active valley. Mineral composition and grain rounding are 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, pale-brown, light-brownish-gray, or light-gray unconsolidated sand and silty sand with subordinate pebbly silty sand, sandy silt, pebbles, and silty clay, with trace cobbles. Contains trace pebble- through boulder-sized, rounded to spherical clasts of mud. Contains anthropogenic detritus at the surface and in cross section outcrop at a depth of up to 2 m (6.6 ft), including common litter, asphalt macadam, wire fencing, fenceposts, rubber tires, household appliances, and the bones of domesticated animals. Bedforms include trough cross-bedding, ripple cross-bedding, ripple laminations, graded bedding, scour-and-fill structures, and plane bedding. In cross-section, horizontal plane-bedding is the predominant bedform. Waning-stage mud films often overlie this deposit but are rarely preserved; muds at the surface presumably are removed during early stages of subsequent streamflow events. Includes minor eolian deposits that are too small to map at the 1:24,000-scale; these dunes are up to 1 m (3.3 ft) high and are rare but present in cross-section outcrops. Does not effervesce in 10% HCl. Primarily unvegetated; primary successional grasses, forbs, cocklebur, tamarisk, and annual flowers are present. Observed thickness is 3.1 m (10.2 ft); total thickness unknown.

Qao — **Inactive arroyo alluvium (Quaternary)**—Loose to weakly consolidated silty sand, sand, and pebbly sand with trace pebbles and cobbles. The lack of outcrop exposures precludes a detailed description of internal structure and total thickness. The deposit has very weak effervescence in 10% HCl at 10–30 cm (4–12 in) depth. No active avulsion or deposition observed in aerial photographs, and the deposit thickness is likely <10 m. The plant community observed at the surface is dominated by saltbrush (Atriplex canescens), big sagebrush (Artemisia tridentata), nopal (Opuntia sp.), and chamisa (Ericameria nauseosa).

Hillslope Deposits

Qct — **Colluvium derived from Animas River terrace gravels (Quaternary)**—Pebbles through boulders on steep slopes immediately beneath gravel-capped terraces. Material is loose to very poorly consolidated with no noticeable soil development and a thickness of 0.2 to 4 m (0.6 to 13 ft).

Qttc — **Colluvium derived from tributary terrace gravels (Quaternary)**—Pebbles through boulders on steep to moderate slopes beneath gravel-capped terraces. Material is loose to very poorly consolidated, and often includes appreciable silt and fine-grained sand, presumably through eolian input. This deposit has no noticeable soil development and is 0.1–2 m (0.3–6.6 ft) thick.

Qsl — **Slopewash deposits (Quaternary)**—Unconsolidated to very weakly consolidated very pale-brown, pale-brown, light-yellowish-brown, and brownish-yellow silt, sand, and gravel whose composition is dictated by the composition of the terrace deposits or Paleogene sedimentary rocks immediately upslope. Forms alluvial-colluvial aprons around steep outcrops of mesas. Bedding not observed, and erosional rills and gullies throughout this deposit often expose underlying Paleogene siliciclastic units. Differentiated from fan and alluvial deposits by its lack of bedding, geomorphic position at the foot of steep landforms, and steeper slopes (typically 2° or greater, as opposed to <1° for alluvial fans in this map area). The deposit thickness is unknown but assumed to be <5 m (<16.4 ft).

Fan Deposits

Qft7 — **Fan deposits covering the Qt7 terrace deposit (Quaternary)**—Deposit of unknown thickness, similar in composition and setting to **Qft** deposit, but split out as a separate deposit and illustrated as a Map Unit Overlay so as not to obscure details and interpretations of what underlies it. The deposit is easily visible in LiDAR-derived hillshade images and topographic maps.

Qfcm — **Canyon-mouth fan deposits (Quaternary)**—Canyon-mouth fan deposits overlying alluvium with unknown thickness.

Qft — **Alluvial fan deposits capping terraces of the Animas River (Quaternary)**—Sand-dominated fan alluvium covering terrace deposits, up to 18 m (59 ft) thick and generally sloping toward the Animas River.

Tributary Terrace Deposits

Qthc — **Terrace of Hart Canyon (Quaternary)**—Terrace of Hart Canyon. Contains a mixture of rounded cobbles of crystalline rock and quartzite (presumably reworked from higher Animas River terrace deposits upstream in the Hart Canyon drainage) and subangular to rounded cobbles and pebbles of sandstone. Deposit is found at heights of approximately 14 m (46 ft) above the modern bed of Hart Canyon and are 1.5–2.8 m (5–9.2 ft) thick.

Qtrgu — **Reworked terrace gravels, undivided (Quaternary)**—Clast-supported pebbles through cobbles with trace boulders that are subrounded to rounded and moderately to poorly sorted. Gravels have the same composition as the terraces of the Animas River. The deposit is unconsolidated to loosely consolidated and likely represents the deposits of ancient tributaries of the San Juan or Animas Rivers that had their sediment source among the higher terrace deposits of the Animas River, such as **Qt1**. Soil development is variable, from none to Stage II Bk horizon. This deposit is widespread on higher isolated ridges and can be found from 19–81 m (62.3–265.7 ft) above modern adjacent stream grades in the easternmost part of the map area. Deposit thickness ranges from 0.5–3 m (1.6–9.8 ft), and its age is unknown.

Qtrg48 — **Younger terrace of Hare Canyon (Quaternary)**—Clast-supported pebbles through cobbles with trace boulders that are subrounded to rounded and moderately to poorly sorted. The deposit is unconsolidated to loosely consolidated and likely represents the deposits of an ancient tributary to the San Juan River that had its sediment source among the higher terrace deposits of the Animas River, such as **Qt1**. This deposit is 1.5–2.5 m (4.9–8.2 ft) thick and capped by a soil that contains a Stage II Bk horizon. This deposit is 48 m (157.5 ft) higher than the modern grade of Hare Canyon immediately adjacent, and its age is unknown but inferred to be middle Pleistocene based on relative relationships to terraces capped by **Qt5** and **Qt4**.

Qtrg61 — **Older terrace of Hare Canyon (Quaternary)**—Clast-supported pebbles through cobbles with trace boulders that are subrounded to rounded and moderately to poorly sorted. The deposit is unconsolidated to loosely consolidated and likely represents the deposits of an ancient tributary to the San Juan River that had its sediment source among the higher terrace deposits of the Animas River, such as **Qt1**. The deposit is capped by a soil that contains a Stage II Bk horizon, has a thickness of 1.5–4 m (5–13 ft), and is 61 m (200 ft) higher than the modern grade of Hare Canyon immediately adjacent. Its age is unknown but inferred to be middle Pleistocene based on relative relationships to terraces capped by **Qt5** and **Qt4**.

Qtta — **Terrace of tributaries, unknown origin (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subrounded to rounded and poorly sorted. The deposit contains lenses of moderately sorted, subangular to subrounded medium- through coarse-grained sand. The deposit is unconsolidated to loosely consolidated, except where cemented by pedogenic carbonate. Gravels (those materials coarser than granules) contain approximately 50% quartzite, 35% volcanic and metavolcanic rocks, 8% intrusive igneous rocks, 5% foliated metamorphic rocks, and traces of limestone, sandstone, and locally derived sedimentary rocks. It is unknown whether this deposit is a previously unreported high terrace of the San Juan River or a tributary terrace of reworked older, higher gravels of Animas Terraces, such as those exposed on Knickerbocker Peak. This deposit has an observed thickness of 9 m (29.5 ft) and is capped by a soil that contains up to a Stage III Bk horizon. The deposit is approximately 125 m (410 ft) higher than the modern Animas River, which is 12 km (7.5 mi) northwest of the deposit's outcrops. The deposit is approximately 165 m (550 ft) higher than the San Juan River, which is 5 km (3 mi) south of the deposit outcrops. Age unknown, but inferred to be greater than 631 ka, given relative relationship to the height of **Qt4**, and only exists on a few mesas in the far southeastern map area.

Recent Animas River Fluvial Deposits

w — **Water (Quaternary)**—Surface water in the channel of the Animas River is visible in aerial imagery. This deposit includes water in a few small reservoirs and sewage treatment facilities east of the Animas River.

Qaf — **Floodplain alluvium of the Animas River (Quaternary)**—Clay, silt, sand, pebbles, and cobbles (predominantly silt through pebbles) deposited by the Animas River after the abandonment of the lowest terrace (**Qt7**) in the map area. It was developed mainly for irrigated agriculture and suburban residential purposes, and hosts riparian and shrubland vegetation. Outcrops of this deposit are rare, and the thickness is unknown.

Qabc — **Bar and channel deposits of the Animas River (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subrounded to rounded and poorly sorted. The deposit contains alluvial clay, silt, and sand at the surface. After alluvial deposition, the deposit was partly covered with minor eolian silt and sand at the surface. Exhibits clearly expressed bar-and-swale topography, supports riparian vegetation, and was likely reworked during modern floods on the Animas River.

Qob — **Oxbow lake deposits (Quaternary)**—Alluvial deposits in former oxbow lakes on the lowest terraces and modern floodplain of the Animas River. Deposits were identified in aerial imagery and not sampled due to land access limitations.

Animas River Terrace Deposits

Qt7 — **Terrace deposit 7 (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. The deposit contains lenses of moderately sorted, subangular, medium- through very coarse-grained sands. The deposit is unconsolidated to loosely consolidated, and contains approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Lower contact not observed, and the thickness is unknown. The deposit is found at heights of approximately 3–10 m (10–33 ft) above the modern Animas River. In the map area this deposit is largely covered with deposits of younger alluvial fans and is utilized for extensive irrigated agriculture. This deposit's age is inferred to be Late Pleistocene (ca. 10–20 ka) by Gillam (1998) and might merge with the modern floodplain, but further work would be needed to test that hypothesis.

Qt6 — **Terrace deposit 6 (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. The deposit contains lenses of moderately sorted, subangular, medium- through very coarse-grained sands. Gravels (those materials coarser than granules) make up 50–70% of the deposit. Sands have an average composition of 45% quartz, 30% feldspar, and 25% lithic fragments. Sand color is 7.5 YR 5/3–6/3 (brown to light brown) when dry. The deposit is unconsolidated to loosely consolidated. Gravels contain approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Bedforms are rarely observed but include massive beds and low-angle plane beds, and clast imbrication is common. Deposit hosts a variably developed soil at its surface that contains up to a Stage I+ Bk horizon and appears to rest upon a bedrock strath developed on the Nacimiento Formation. Observed thickness of the deposit is 3–6 m (1.8–3.7 ft) and is found at heights of approximately 25 m (82 ft) above the modern Animas River. Deposit age is inferred to be Late Pleistocene (ca. 100–130 ka, potentially coeval with the termination of Bull Lake glaciation) by Gillam (1998).

Qt5t6 — **Terrace deposit 5 and 6, combined (Quaternary)**—An intermediate deposit representing the junction of deposits **Qt5** and **Qt6**. Gillam (1998) documented these two deposits merging. Due to limited access, the precise thickness and composition of this deposit in the map area is not known but is assumed to be similar to that of deposits **Qt5** and **Qt6**, described above and below.

Qt5 — **Terrace deposit 5 (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. The deposit contains lenses of moderately sorted, subangular, medium- through very coarse-grained sands. The deposit is unconsolidated to loosely consolidated. Gravels (those materials coarser than granules) make up 50–70% of the deposit. Sands have an average composition of 45% quartz, 30% feldspar, and 25% lithic fragments. Sand color is 7.5 YR 5/3–6/3 (brown to light brown) when dry. Gravels contain approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Bedforms are rarely observed but include massive beds and low-angle plane beds, and clast imbrication is common. Deposit hosts a variably developed soil at its surface that contains up to a Stage II Bk horizon. The deposit appears to rest upon a bedrock strath developed on the Nacimiento Formation. Observed thickness of the deposit is 3–8 m (1.8–5 ft) and is found at heights of approximately 50 m (165 ft) above the modern Animas River. Age inferred to be middle Pleistocene (ca. 240 ±20 ka, Chibanian) by Gillam (1998).

Terrace deposit 4 (Quaternary)—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. Contains lenses of moderately sorted subangular medium- through very coarse-grained sands. Gravels (those materials coarser than granules) make up 50–70% of the deposit. Sands have an average composition of 45% quartz, 30% feldspar, and 25% lithic fragments. Sand color is 7.5 YR 5/3–6/3 (brown to light brown) when dry. The deposit is unconsolidated to loosely consolidated. Gravels contain approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Bedforms are rarely observed but include massive beds and low-angle plane beds, and clast imbrication is common. Deposit hosts a variably developed soil at its surface that contains up to a Stage II Bk horizon. Appears to rest upon a bedrock strath developed on the Nacimiento Formation. Observed thickness of the deposit is 4–11 m (13–36 ft), though Gillam (1998) reports a gravel thickness of 45 m (147.6 ft) in this deposit near the map area, which is interpreted as the axis of the paleo-Animas River at the time of deposition. Found at heights of approximately 76–94 m (250–310 ft) above the modern Animas River. Age constrained to be slightly older than 631 ka due to the presence of well-preserved ash-fall geochemically correlated to the Lava Creek B eruption by Gillam (1998). The ash-fall deposit is near the top of the deposit, implying that most deposition of **Qt4** materials occurred prior to the Lava Creek B eruption.

Qt4e — **Terrace deposit 4e (Quaternary)**—A 4–8 m (13–26 ft) thick terrace that formed late in the episode of the fluvial system—interpreted by Gillam (1998) as a strath terrace based on exposures outside of the map area—and produced all Terrace Group 4 deposits (only one other Terrace Group 4 deposit is present on the map (Gillam 1998)).

Qt4b — **Terrace deposit 4b (Quaternary)**—A 4–11 m (13–36 ft) thick cut terrace that formed after maximum aggradation of the fluvial system that produced Terrace Group 4 deposits (the oldest Terrace Group 4 deposit, Qt4a, is not present in this map area but was mapped and defined by Gillam (1998)). The surface of this deposit is typically ≈20 m (≈65 ft) higher than that of the immediately adjacent deposit **Qt4e**.

Qt3 — **Terrace deposit 3 (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. Contains lenses of moderately sorted subangular medium- through very coarse-grained sands. Gravels (those materials coarser than granules) make up 50–70% of the deposit. Sands have an average composition of 45% quartz, 30% feldspar, and 25% lithic fragments. Sand shows color gradation from 7.5 YR 5/3–6/3 (brown to light brown) when dry. The deposit is unconsolidated to loosely consolidated. Gravels contain approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Bedforms are rarely observed, but when present, include massive beds and low-angle plane beds, and clast imbrication is common. Deposit hosts a variably developed soil at its surface that contains up to a Stage II Bk horizon. Appears to rest upon a bedrock strath developed on the Nacimiento and/or San Jose Formation. Observed thickness is 3–7 m (9.8–23 ft). Found at heights of approximately 107–113 m (350–370 ft) above the modern Animas River. Age inferred to be middle Pleistocene (ca. 700–920 ka, Chibanian to Calabrian) by Gillam (1998). This deposit is older than deposit **Qt4b**, whose age is constrained by the presence of the Lava Creek B ash at approximately 631 ka (Matthews et al., 2015).

Qt1 — **Terrace deposit 1 (Quaternary)**—Clast-supported pebbles through boulders (predominantly cobbles) that are subangular to rounded and poorly sorted. Contains lenses of moderately sorted subangular medium- through very coarse-grained sands. Gravels (those materials coarser than granules) make up 50–70% of the deposit. Sands have an average composition of 45% quartz, 30% feldspar, and 25% lithic fragments. Sand color is 7.5 YR 5/3–6/3 (brown to light-brown) when dry. The deposit is unconsolidated to loosely consolidated. Gravels contain approximately 40% quartzite, 39% volcanic and metavolcanic rocks, 15% intrusive igneous rocks, 5% foliated metamorphic rocks, 1% limestone, and traces of locally derived sedimentary rocks. Bedforms are rarely observed but include massive beds and low-angle plane beds, and clast imbrication is common. Deposit **Qt1** hosts a variably developed soil at its surface that contains up to a Stage III Bk horizon and appears to rest upon a bedrock strath developed on the San Jose Formation. It has an observed thickness of 2–6 m (6.5–19.6 ft) and is found at heights of approximately 340 m (1,114 ft) above the modern Animas River. This deposit is only found on Knickerbocker Peak in the east-central map area. The deposit's age is inferred to be early Pleistocene by Gillam (1998).

BEDROCK UNITS

Paleogene

Pesjd — **Ditch Canyon Member of the San Jose Formation (Paleogene)**—Interbedded terrestrial sandstones and mudstones with minor conglomerate. Sandstones contain medium- through very coarse-grained, moderately to well-sorted, angular to subangular sand with stringers of subrounded granules and pebbles, and rare beds of granule-dominated arenites. Sandstone composition varies between 40–80% quartz, 15–65% feldspar, and trace- 8% lithic grains. Most feldspars are white or gray; approximately 5% are pinkish or reddish. Pebbles are dominated by quartzite, with far smaller proportions of arenite, milky quartz, granite, felsic volcanic rocks, chert, mudstones, and black petrified wood clasts. Sandstone outcrop colors when dry include 2.5 Y 5/4, 10 YR 5/3, and 10 YR 6/3 (light olive brown, yellowish brown, and pale brown). Sandstones form cliffs and steep slopes. Sandstone bedding includes very thin to thin cross-beds, low-angle plane beds, horizontal plane beds, graded beds, and massive beds. Contorted beds are rare. Individual sandstone packages in the Ditch Canyon Member are up to 27 m thick. Mudstones in the Ditch Canyon Member contain silty claystones, silty sandy claystones, and clayey siltstones ranging in color from 7.5 YR 4/3–10 YR 3/2–2.5 Y 4/2 and 2.5 Y 7/1 (brown to very dark grayish brown to dark grayish brown and light gray). Individual mudstone packages in the Ditch Canyon Member are up to 12 m (39 ft) thick. Sandstones are approximately 67% of the Ditch Canyon Member, with mudstone making up 33% (Smith, 1992). The upper contact is not observed in the map area. Smith (1992) interprets the Ditch Canyon Member to interfinger with the coeval Regina Member of the San Jose Formation to the east and south. The thickness reported by Smith (1992) is 220 m (722 ft) just north of the map area at the member's type section.

Pesjc — **Cuba Mesa Member of the San Jose Formation (Paleogene)**—Terrestrial sandstones with minor conglomerate and mudstones. Sandstones contain medium- through very coarse-grained, well-sorted, angular to subangular sand with stringers of subrounded granules and pebbles. Sandstone composition averages 45% quartz, 55% feldspar, and trace lithic grains. Most feldspars are white or gray; approximately 5% are pinkish or reddish. Pebbles are dominated by quartzite, with far smaller proportions of arenite, milky quartz, granite, felsic volcanic rocks, chert, mudstones, and black petrified wood clasts. Sandstone outcrop colors when dry include 7.5 YR 8/4, 10 YR 8/2, 10 YR 7/6, and 10 YR 8/6 (pink, very pale brown, and yellow). The member forms cliffs and steep slopes. Bedding includes laminated to thin low-angle plane beds (by far the most common bedform), horizontal plane beds, trough cross-beds, and massive beds, and contorted beds are rare. Contains white to pink, poorly preserved, and often iron-stained petrified wood. The upper contact is placed at the base of the lowest overlying, laterally continuous, recessive siltstone or mudstone and is rarely well-expressed in outcrop. The unit appears to be paraconformable, and its thickness in the map area is 38–55 m (124.6–180.4 ft).

Penk — **Kutz Member of the Nacimiento Formation (Paleogene)**—Terrestrial mudstones, sandstones, and rare conglomerates. Sandstones contain fine- to very coarse-grained sand with 1–4% pebbles. Sandstone composition averages 65% quartz, 30% feldspars, and 5% lithic grains. Sandstones are well-sorted with angular to subangular grains. Pebbles are subrounded and contain reddish and orangish chert, milky quartz, crystalline felsic rocks, and petrified wood. Sandstone colors range from 10 YR 8/2–10 YR 6/6 (very pale brown to brownish yellow) on weathered faces when dry. Sandstones mostly form steep slopes of cliffs. Sandstones contain laminated to thin (predominantly very thin) horizontal plane beds, trough cross-beds up to 160 cm (63 in) in height, cut-and-fill structures, low-angle plane beds, and rare contorted beds. Sandstones have erosional bases with up to 11 m (36 ft) of topography into underlying units. Individual sandstone packages are 1–17 m (3.3–55.7 ft) thick and discontinuous over hundreds of meters. Mudstones contain clay through fine-grained sand (predominantly silt) and are colors ranging from 5 YR 3/3–7.5 YR 6/1 (dark reddish brown to pinkish grey) with rare 10 YR 4/1 (dark gray) on dry weathered surfaces. Mudstones typically form slopes with a crumbly popcorn-like texture at the surface when dry. Contains logs of silicified petrified wood that are typically very pale-brown to pale-brown in color. Upper contact is placed at the base of the lowest laterally-continuous sandstone that can be traced for over 1 km (0.6 mi). The unit's upper contact is uneven but conformable and exhibits about the same amount of relief as the bases of individual sandstone units within the Kutz Member; its lower contact was not observed here. The unit's thickness was reported to be up to 300 m (984 ft) by Cather et al. (2019).

Pen — **Nacimiento Formation, undivided (cross section only) (Paleogene)**—Terrestrial mudstones, sandstones, and rare conglomerates. Only the upper member, the Kutz Member of Cather et al. (2019), is exposed on the map. Approximately 435 m (1,427 ft) thick in the southeastern map area based on logs of the Schumacher 11M well (30-045-30066).

Peoa — **Ojo Alamo Formation (cross section only) (Paleogene)**—Used here in the sense of Baltz (1967) to exclude the Maastrichtian-aged Naashoibito Member, the unit is not exposed on the map. However, well logs in the map area provide a thickness of approximately 15–45 m (49–147.6 ft).

Cretaceous

Kkf — **Kirtland and Fruitland Formations, combined (cross section only) (Cretaceous)**—The unit is composed of terrestrial mudstones and sandstones, approximately 385–440 m (1,263–1443.5 ft) thick in well logs in the map area, and not exposed on the map.

Kpc — **Pictured Cliffs Sandstone (cross section only) (Cretaceous)**—Shoreface sandstones, approximately 23–53 m (75.4–173.8 ft) thick in well logs in the map area and not exposed on the map.

Kl — **Lewis Shale (cross section only) (Cretaceous)**—Marine shale, not exposed on the map, but identified in well logs, the portion of the unit above the Huerfanito bentonite bed is approximately 200 m (656 ft) thick in the map area.

Klhb — **Klhb—Huerfanito bentonite bed of the Lewis Shale (cross section only) (Cretaceous)**—An altered volcanic ash-fall deposit widely used as a stratigraphic marker in the subsurface of the San Juan basin, and not exposed on the map. Unit age reported by Fassett et al. (1997).

Ku — **Cretaceous units, undivided (cross section only) (Cretaceous)**—Includes Cretaceous sedimentary units below the Huerfanito Bentonite Bed and is not exposed on the map.

Geologic Cross Section A–A'

(5x vertical exaggeration)