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Historic Fan Alluvium—Similar to unit **Qah**, but present on alluvial fans. **Recent Fan Alluvium**—Relatively comparable proportions of modern and historic alluvium, similar to units **Qam** and **Qah**, deposited on alluvial fans. **Recent Fan Alluvium with Subordinate Younger Fan Alluvium**—Similar to units **Qar** and **Qay**, but present on alluvial fans. Historic Fan Alluvium with Subordinate Modern Fan Alluvium-Similar to units Qah and Qam, but deposited on alluvial fans. Historic Fan Alluvium with Subordinate Younger Fan Alluvium-Similar to units Qah and Qay, but Qfhy deposited on alluvial fans. Younger Fan Alluvium—Similar to unit **Qay**, but present on alluvial fans. **Younger Fan Alluvium with Subordinate Recent (Historic+Modern) Fan Alluvium**—Similar to units **Qay** and **Qar**, but present on alluvial fans. **Dlder Fan Alluvium**—Weakly consolidated deposits of reddish-brown to brown (5-7.5YR), sandy ebble-cobble gravel. Unit interfingers somewhat with mainstem valley margin deposits. Silt-sand matrix ontains 10–20% clay chips. Calcic horizons appear to be erosionally stripped, but the top of the deposit may feature 10–20-cm-thick A soil horizons overlying cambic (Bw) horizons up to 30 cm thick. 2.0–4.2 m thick. **Deposits Adjoining Fault** Alluvium, Slopewash, and Colluvium–Loose deposits of brown to yellowish-brown (7.5YR 4/3 to 10YR 5/4), Qasc sandy to pebbly silt and silty to pebbly sand. Fills shallow depressions along fault scarps on Cuchillo surface. Typically <3–5 m thick (description modified from Jochems and Koning, 2016). Terrace and High-Level Piedmont Terrace Deposits, undivided—Sandy gravel and gravelly sand deposited under terrace treads in smaller Qt drainages throughout the map area. Composition of sand and gravel reflects the local source area, which is commonly the Palomas Formation. Generally 1–5 m thick and weakly consolidated. errace Deposits Along Willow Springs Draw Lower Terrace Gravel of Willow Springs Draw—Terrace tread lies 9–10 m above modern grade. It correlates Qtw1 to terrace suite Qtc2. Middle Terrace Gravel of Willow Springs Draw-Stage I-I+ carbonate morphology in upper 60 cm. Moderate varnish on 30-45% of clasts at surface. Projects to the Qpc piedmont deposit. Terrace tread lies 15–17 m above modern grade. It correlates to terrace **Qtc3d**. Lower Suite of Terrace Deposits Along Cuchillo Negro Creek Sandy gravel and subordinate pebbly sand in very thin to thick, tabular to lenticular beds; local cross-stratification. Gravel consists of clast-supported pebbles with 10–50% fine to coarse cobbles and 0–7% Lower Stratigraphic boulders. Gravel are mostly subrounded (lesser rounded), poorly sorted, and have a composition of: 20–25% porphyritic intermediate volcanic rocks, 30% fine-grained intermediate volcanic rocks (including basaltic andesite), 30–50% felsic volcanic intermediate volcanic rocks, trace chert+jasper, trace to 1% monzonitic intrusive rocks, trace to 8% Paleozoic sedimentary clasts, and 1–3% Kneeling Nun Tuff (visual percentage estimations and data in Koning et al., 2016). Important differences are noted in the descriptions below. Sand is reddish-brown (5YR), medium- to very coarse-grained (<15% very fine- to fine-grained sand), subrounded, moderately to poorly sorted, and composed of 80–90% lithics (volcanic»chert) and 10–20% feldspar+quartz. Estimate 2–15% clay (in sand fraction) as coatings or sand-size chips. Weakly cemented by clay and weakly to moderately consolidated. Six terraces, labeled 1 through 6 (lowest to highest above the modern grade, respectively) are recognized below a suite of prominent, high-level fill terraces (**Qtch**). Terrace Deposit #1 (Lowest Terrace) Along Cuchillo Negro Creek-Sand and gravel; locally correlating to straths eroded on bare rock outcrop. Tread lies 4–7 m above the Cuchillo Negro Creek valley floor (**Qah**). 1–2 m thick. [Modified slightly from Maxwell and Oakman (1990)]. Terrace Deposit #2 Along Cuchillo Negro Creek—Tread lies 7–10 m above the Cuchillo Negro Creek valley floor. Near Cuchillo, >2 m of coarse gravel (pebbles with 35–50% cobbles) has a 60-cm-thick stage III+ K clasts. N horizon, which in turn is overlain by 3 m of finer sediment. Surface exhibits weak clast varnishing. Includes two sub-deposits distinguished by tread height, although we cannot rule out that the lower of these is a Lower Sub-Terrace of Terrace Deposit #2 Along Cuchillo NegroCreek—Tread is ≈2 m below Qtc2a tread of Qtc2b. Upper Sub-Terrace of Terrace Deposit #2 Along Cuchillo NegroCreek−Tread is ≈2 m above Qtc2b tread of Qtc2a. Terrace Deposit #3 Along Cuchillo Negro Creek-Sandy gravel terrace deposits underlying a series of closely spaced (vertical sense) treads. These treads generally lie 14–26 m above the Cuchillo Negro Creek valley floor and surface clasts are mostly strongly varnished with local areas of well-developed desert pavement. Includes four sub-terrace deposits distinguished by tread height, although some of these may in fill-cut terraces. ≈2 m thick. Lower Sub-Terrace of Terrace Deposit #3 Along Cuchillo Negro Creek—Tread is 2 m below Qtc3a tread of Qtc3b. Areas of well-developed pavement are less common than on the **Qtc3b** tread. Lower Middle Sub-Terrace of Terrace Deposit #3 Along Cuchillo Negro Creek—Tread is 1–2 m Qtc3b below tread of Qtc3c and 2 m above Qtc3a tread. ≈2 m thick. Upper Middle Sub-Terrace of Terrace Deposit #3 Along Cuchillo Negro Creek-Tread is 2 m below tread of **Qtc3d** and 1–2 m above tread of **Qtc3b**. 1–2 m thick. Upper Sub-Terrace of Terrace Deposit #3 Along Cuchillo Negro Creek-Tread is 2 m above tread of **Qtc3c**. 1–2 m thick. Terrace Deposit #4 Along Cuchillo Negro Creek—Sandy gravel underlying a typically broad tread about 7–32 m above the valley floor. Surface clasts are well-varnished. About 3 km west of the eastern quadrangle boundary, this terrace deposit is 2-7 m thick. Near Cuchillo, the deposit is thinner (1-2 m thick) and two treads can be differentiated that are called **Qtc4a** and **Qtc4b**. Lower Sub-Terrace of Terrace Deposit #4 Along Cuchillo Negro Creek—Tread lies about 1 m below the tread of **Qtc4b**. Upper Sub-Terrace of Terrace Deposit #4 Along Cuchillo Negro Creek-Tread lies about 1 m above the tread of **Qtc4a**. **Upper Terrace Deposit Along Cuchillo Creek**—Sand and gravel having a thin soil exhibiting a K horizon. Correlates to **Qt3** of Maxell and Oakman (1990). Tread lies 28–30 m above the Cuchillo Creek valley floor. Cuchillo Negro Creek Terrace Deposit #6-Sandy gravel terrace deposits underlying treads located 34-37 n Qtc6 ove the valley floor. Subdivided into two subunits: Lower Sub-Terrace of Terrace Deposit #6 Along Cuchillo Negro Creek-10-70% strongly arnished clasts are observed at surface. Tread lies 1–2 m below tread of **Qtc6b**. 1–2 m thick. Upper Sub-terrace of Terrace Deposit #6 Along Cuchillo Negro Creek—Sandy gravel (mostly pebbles and boulders) that is typically ≈ 1 m thick. Terrace tread lies 1–2 m above the tread of **Qtc6a**. Higher Suite of Terrace Deposits Along Cuchillo Negro Thick fill terraces preserved alongside along lower Cuchillo Negro Creek and north of Cuchillo. Sediment composed of sandy gravel in very thin to medium (minor thick), tabular to lenticular beds. Gravel are clast-supported, subrounded-rounded, poorly to moderately sorted, moderately imbricated, and comprised of very fine to very coarse pebbles with 10–40% cobbles and 0–1% boulders. Estimated gravel composition of 20-35% porphyritic intermediate volcanic, 50% fine-grained intermediate (including basaltic andesite), 15-35% felsic volcanic rocks, trace to 1% Kneeling Nun Tuff, 0-1% Paleozoic sedimentary rocks, and trace monzonite intrusions. Sand is reddish-brown (5YR 5/3-4/4), fine- to very coarse-grained (mostly medium- to very coarse-grained), subrounded-subangular, poorly to moderately sorted, and mostly composed of volcanic lithic grains. 1–15% clay in the sand matrix as clay chips and clast coatings. Weakly cemented by clays and moderately consolidated. Each terrace subunit appears to be a separate depositional event. Deposits thin (wedge-out) laterally away from Cuchillo Negro Creek. Lower of the Higher Suite of Terrace Deposits Along Cuchillo Negro Creek—Preserved tread stands about -52 m above modern valley floor. Contains local (0-20%) fine-grained beds of clay-silt, very fine- to ne-grained sand, or silty-clayey very fine- to fine-grained sand; fine sand and silt are light-brown to

QUATERNARY (VARIOUS POST-SANTA FE GROUP CLASTIC DEPOSITS)

excavated areas along Interstate 25 and some stock ponds. 0–10 m thick.

Anthropogenic artificial fill—Thick accumulations of sand with minor gravel and silt from construction

Anthropogenic disturbed ground—Intensely disturbed land surface by human activity, to such an extent that identification of pre-development geologic units is very difficult. Local accumulations of sand with

Sheetwash and Eolian Deposits, undivided-Sheet-like sand that overlies gently sloping geomorphic

Sheetwash Deposits Overlying Axial Sand Lithofacies Assemblage of the Palomas Formation-Sheet-like

Sand predominately derived from reworking of unit Tpam. Unconsolidated and approximately 1–2 m thick.

Modern Alluvium—Grayish-brown to light brownish-gray, sandy gravel forming bars and underlying

active channels. Gravel includes pebbles with subordinate cobbles and boulders that are mostly subrounded,

steep-walled channels characteristic of arroyo bottom. Sparse- to no-vegitation; no topsoil. <3 m thick.

poorly sorted, and composed of lithologic types reflective of source area (mostly volcanic). Bars and

whose treads are 0.3–1.0 m above adjoining active channels. Geomorphic surface is not varnished, does not

have desert pavement, and features bar-and-swale topography (5–50 cm in height, mostly 5–30 cm). Weak A

soil horizons may be present in the upper 5–10 cm of the deposit; no to very weak calcic horizons. <3 m thick.

Younger Alluvium—Sandy gravel and pebbly sand underlying 1–3 m-tall terraces adjoining active channels. Its geomorphic surface is very weakly varnished, locally has a weak desert pavement, and lacks

bar-and-swale topography. Where not eroded, geomorphic surface is underlain by weak soils sporting calcic

Older Alluvium–Sandy gravel and gravelly sand deposits whose surfaces are typically >2 m above the

modern grade and higher than nearby Qay treads. Where not eroded, its surface may exhibit weak clast

Modern Alluvium with Subordinate Historical Alluvium—See descriptions above for units Qam and Qah.

Historical Alluvium with Subordinate Modern Alluvium—See descriptions above for units **Qam** and **Qah**.

Recent Alluvium Containing Comparable Proportions of Modern and Historical Alluvium-See

Modern Alluvium with Subordinate Younger Alluvium—See descriptions above for units Qam and Qay.

Historical Alluvium with Subordinate Younger Alluvium—See descriptions above for units **Qah** and **Qay**.

Recent Alluvium with Subordinate Younger Alluvium—See descriptions above for units Qar and Qay.

Younger Alluvium with Subordinate Modern Alluvium–See descriptions above for units Qay and Qam.

Younger Alluvium with Subordinate Historical Alluvium—See descriptions above for units Qay and Qah.

Younger Alluvium with Subordinate Recent Alluvium—See descriptions above for units Qay and Qar.

Modern Fan Alluvium–Similar to unit Qam, but present on alluvial fans.

varnishing or desert pavement development. Similar to unit **Qt**, but may be thicker and occupies more of a

horizons (stage I) locally overlain by ≈10 cm-thick A horizons. 1–5(?) m thick.

valley-floor geomorphic position. 1–3 m thick.

descriptions above for units Qam and Qah.

Historical Alluvium-Sandy gravel and subordinate pebbly sand underlying low geomorphic surfaces High-Level Piedmon

minor gravel and silt from nearby excavations or past construction activity. Includes a mix of fill and

surfaces; inferred to have mainly accumulated via sheetwash (or sheet-flooding) and, to a lesser degree, by

Qs/Tpam sand that overlies gently sloping geomorphic surfaces developed on the middle axial-fluvial unit (Tpam) of

the Palomas Formation (unit Tpam); inferred to have mainly accumulated via sheetwash (or sheet-flooding).

activities. Mapped for thick road fill along Interstate 25 as well as levees or dams. 1–10 m thick.

anthropogenic Units

Sheetwash and Windblown

Valley-Floor Units

Valley-Margin Units

eolian processes. 1–3(?) m thick.

slopewash near urban areas.

and fine to coarse cobbles, and composed of subequal felsic- vs intermediate-volcanic rocks and

Lower Axial Unit, Middle Allostratigraphic Subunit-Sand with 30-50% gravelly stratum

illing a 17–20-m-deep paleovalley. Gravel mostly composed of felsic volcanic clasts with minor

aleozoic-Mesozoic sedimentary clasts and 1-3% intermediate volcanic rocks. Sand is fine- to

medium-grained and mostly horizontal-planar laminated to massive. Basal 3–5 m-thick, coarse

Lower Axial Sand Unit, Older Allostratigraphic Subunit–Upward-coarsening unit consisting

white (7.5-10YR 8/1), fine- to very coarse-grained (mostly fine- to medium-grained), and

quartzofeldspathic. Orangish sands in lower 4 m. Disconformable top and base. 14 m thick.

sand and pebbly sand interbedded with 30-40% reddish sandy gravel; reddishc olors due to

5% clay in gravel matrix. Gravel composition similar to that in mid-upper Tpal2. Sand is

10–40% of exotic clasts—mainly quartzite and trace Pedernal chert. 17–19 m thick.

conglomerate composed of Paleozoic to Mesozoic sedimentary clasts. 15-20 m thick.

Sand-Dominated, Undivided Axial-Fluvial Deposits Covered by Slopewash or Disturbed-See

Tpa-swdi descriptions of **Tpam** and **Tpal**. Mapped where strongly disturbed by anthropogenic activity or covered by

Upper of the Higher Suite of Terrace Deposits Along Cuchillo Negro Creek-Terrace deposit typically sks fine-grained interbeds seen in **Qtch2** and **Qtch3**. Tread lies 57–63 m above the modern valley floor. soil has a stage IV calcic horizon. Deposit is 6–20 m thick. Geologic Cross Section A-A'

coarse-grained sand+pebbles. Up to 15 m thick.

a stage III+ calcic horizon. 6–10 m thick.

light-reddish-brown (5-7.5YR 6/3); fine sand may contain minor scattered grains of medium- to very

Middle of the Higher Suite of Terrace Deposits Along Cuchillo Negro Creek-Tread is ≈55 m above

ravel is finer and there are interbeds of brown (7.5YR 5/4) clayey-silty, fine-grained sand. At one locality,

fine-white ash was collected in the fine sand, possibly correlative to the 640 ka Lava Creek B ash. Topsoil has

dern valley floor. Tread and strath are 3–5 m above those of **Qtch1**. The lower 3 m is cobble-rich; above,

Note: terrace and high-level piedmont deposits not shown Mud Springs Mountains Dem, Omsv Oma Omc IPgm pCu Tv-Pz Tv-Pz

	NMBGMR Open-File Geologic Map 271
Description of Map Units Terrace Deposits Along Cañada Honda and Mud Springs Mountains	Last Modified June 2018 Rincon Valley Formation
Qthm1 Cover Terrace Gravel of Cañada Honda and Mud Springs Canyon—Terrace tread lies 4–7 m above the valley floors of both drainages. Qthm2 Middle Terrace Gravel of Cañada Honda and Mud Springs Canyon—Terrace tread lies 8–11 m and 11–13 m above the valley floors of Cañada Honda and Mud Springs Canyon, respectively.	TrbutUpper Rincon Valley Formation, Basin Floor Lithofacies Assemblage Near Truth or Consequences – Very thin to medium, tabular beds of reddish (5-7.5YR hues) very fine- to medium-grained sand, clayey-silty fine sand, and silty clays. Minor 5–50-cm-thick beds of silty to clayey very fine- to very coarse-grained sand with variable amounts of pebbles; pebbles are moderately to poorly sorted and composed of angular to subangular sedimentary clasts plus minor granite, chert, and gneiss. >10 m thick.
Othm3Upper Terrace Gravel of Cañada Honda and Mud Springs Canyon—Terrace tread lies 12–15 m above the valley floor of Cañada Honda.Terrace Deposits Near Cantrell Tank in Mud Springs Canyon	Upper Rincon Valley Formation, Basin Floor Lithofacies Assemblage Near Williamsburg— Light-reddish-brown to yellowish-red (5YR 6/4-5/6), very fine- to medium-grained sand, clay-silt, and clayey-silty fine sand in thin to thick, tabular beds (common horizontal-planar to ripple-laminated). There are minor ≈5% beds composed of very fine- to very coarse-grained sand with 5% pebbles. >6 m of exposed thickness.
Qtct1 Lower Terrace Gravel Near Cantrell Tank—Lithologically similar to unit Qtct2, but its tread and strath lies approximately 3 m below those associated with unit Qtct2. 1–2 m thick. Qtct2 Upper Terrace Gravel Near Cantrell Tank—Loose deposits of brown to pinkish-white (7.5YR), calcareous pebble-cobble gravel. Gravel is massive to well-imbricated. Silt-sand matrix consists of >75% carbonate and <15% quartz+feldspar grains. K horizon observed in the upper 0.8–1.0 m of the deposit. Surface features	Trbuc Upper Rincon Valley Formation, Basin Floor Lithofacies Assemblage Near Cuchillo–Weakly to moderately indurated, reddish-brown to yellowish-red (5YR 5/4-6) sand that is internally massive and contains up to 2% floating pebbles of up to 45% Paleozoic lithologies. Subordinate lenses of light-brown (7.5YR 6/3-4), calcite-cemented, internally massive to vaguely trough cross-stratified, medium to very coarse sand. Thickness unknown.
moderate desert pavement and 10–20% weakly varnished clasts. Terrace tread lies 21–29 m above valley floors. 1.5–2.0 m thick. High-Level Piedmont Deposits	TrpluUpper Rincon Valley Formation, Playa Lithofacies Near Elephant Butte [cross-section only]— Reddish-brown to reddish clay. Described using cuttings logs and down-hole geophysical logs from the No. 2 Getty West Elephant Butte Federal 3 well. Apparent thickness of 236 m where penetrated by this well.
Qp High-Level Piedmont Deposit, undifferentiated—Sandy gravel and pebbly sand in thin to medium, tabular to lenticular beds; locally cross-stratified. Where flanking Mud Springs Mountains, gravel is composed of mainly Paleozoic carbonate clasts. In the northeastern quadrangle, unit is composed primarily of volcanic clasts. Subdivided into three geomorphic levels on the east-northeast side of the Mud Springs Mountains. High-Level Piedmont Deposits on East and Southern Flanks of Mud Springs Mountains	Trpl Lower Rincon Valley Formation, Piedmont Lithofacies Assemblage—Interbedded pebble-cobble conglomerate, silt-sand, and fine to coarse sand that are pale brown to very pale brown (10YR 6-7/3). Clasts are mostly Paleozoic sedimentary rocks, felsic volcanics, and tuffs with 10–15% green sandstone and siltstone (Mesozoic?). Conglomerates are imbricated and normally graded; silt-sand and sand are internally massive with minor floating pebbles. Thickness unknown.
Qpl High-Level Piedmont Deposit, Lower Geomorphic Level—Thin piedmont deposit whose associated tread lies a few meters below that of Qpm. 1–3 m thick. Qpm High-Level Piedmont Deposit, Middle Geomorphic Level—Piedmont deposit whose associated geomorphic surface is relatively extensive and serves as a proxy geomorphic datum. Surface stands 6–27 m above adjacent arroyo floors, the large range is due to differential incision of these arroyos. 1–6 m thick.	Trbl Lower Rincon Valley Formation, Basin Floor Lithofacies Assemblage Near Elephant Butte [cross-section only]—Clay, silt, and very fine- to medium-grained sand. Sand is white to light-gray to reddish-brown; contains subrounded to rounded quartz, chert, and limestone grains. Described using cuttings logs and down-hole geophysical logs from the No. 2 Getty West Elephant Butte Federal 3 well. 113 m apparent thickness where penetrated by this well.
Grades to the Qtc5 terrace levels along Cuchillo Negro Creek. High-Level Piedmont Deposit, Higher Geomorphic Level—Piedmont deposit whose associated tread stands 2–7 m above that of Qpm . 1–3 m thick. High-level, Volcanic Gravel-Bearing Piedmont Deposit Graded to the Qtc4–Qtc5 Terrace Levels Along	TERTIARY IGNEOUS ROCKS Basalt—Olivine basalt flow and scoria found ≈1.5 km southeast of Mud Mountain. Similar in composition to tholeiitic basalt flows elsewhere in region (Bachman and Mehnert, 1978). Dated by McLemore and others (2012) at 5.55±0.21 Ma (⁴⁰ AR/ ⁹⁰ AR isochron age) and described as containing numerous xenoliths of limestone, shale, jasperoid, and Proterozoic granite. 11–12 m thick [description modified from Maxwell and Oakman, 1990].
Opc Cuchillo Negro Creek—Sandy gravel similar to unit Opm in geomorphic position. However, it is composed of volcanic sandy gravel derived from the upper Palomas Formation. 1–3 m thick. QUATERNARY-TERTIARY BASIN FILL	Td Basalt Dikes—Basalt dike intruding Lower Permian Abo Formation (Pa) is 0.3–1.2 m wide, vertical, dark-olive-green and brown; nesophitic texture; highly altered with chalcedony and chlorite in veinlets and
Palomas Formation Volcaniclastic Units Derived from Western Uplands, Associated with a Piedmont Lithofacies Assemblage Upper Stratigraphic Level Upper Palomas Formation, Deposits with Volcanic-Dominated Gravels Derived from Uplands to West, Coarse-Grained—Stacked gravel bodies interbedded with subordinate clayey-silty sand. Gravel constitutes	cavities, calcite interstitial to feldspar laths, and augite(?) altered to clay, limonite, and chlorite; feldspar laths generally ≈0.02 by 0.2 mm; truncated by overlying Palomas Formation. Basalt dike intruding Pennsylvanian Nakaye (Pn) and Bar B (Pb) Formations, adjacent to porphyritic quartz trachyandesite dike (Tqt), is 0.2–0.9 m wide, dark-brown; similar to basalt dike intruding Pa but is more altered and has more interstitial calcite [description modified from Maxwell and Oakman, 1990].
 >60% of unit and features matrix with up to 40% clay that imparts dark reddish-brown to yellowish-red colors (5YR). Local clayey sand beds and sparse sand lenses are reddish-brown to strong-brown (5-7.5YR). Unit is commonly capped by stage III-IV calcic horizons. 12–37 m thick. Upper Palomas Formation, Deposits with Volcanic-Dominated Gravels Derived from Uplands to the part of the par	Porphyritic Trachyte—Dike intruding Gray Mesa Formation (Pgm). Light- to medium-gray. Quartz phenocrysts 1–2.5 mm and feldspar phenocrysts 7–15 mm in diameter. Feldspar phenocrysts partly altered to clay and calcite. Groundmass is composed of equant orthoclase, quartz, and plagioclase with random biotite, opaques, and interstitial calcite. 1.2–5.5 m wide [description modified from Maxwell and Oakman, 1990].
 Qpvu West—Fine sand and silty to clayey fine sand interbedded with 15–50% sandy pebble-cobbles. Gravels commonly in laterally extensive intervals 1–10 m thick and contain 0.5–15% clay in their sand matrix. Fine strata are in medium to thick beds and have 50% or greater orangish intervals (commonly due to Bt or Bw horizon development); remainder of fine sediment is tan or light-brown. 20–30 m thick. Middle Stratigraphic Level 	Porphyritic Rhyolite —Light-pinkish to reddish-gray sill intruding Bliss Sandstone (COb). Commonly altered and relatively crystal-rich. Phenocrysts include 7–10% fine to medium biotite (euhedral) and 7–10% whitish, very fine to very coarse feldspar (subhedral, equant; occasionally altered to clay). Very fine grained groundmass of feldspar and quartz. K-Ar age of biotite is 40.8±1.5 Ma (R.F. Marvin, written commun. to C.H. Maxwell, 1987) [description modified from Maxwell and Oakman, 1990].
Fine sediment interbedded with variable proportions of volcanic gravels derived from the western highlands. Fine-grained sediment is typically in medium to thick, tabular beds that are internally massive. Fine strata consists of light-brown to light-reddish-brown (5-7.5YR 6/3) silt, very fine- to fine-grained sand (lesser mL), and clayey to silty very fine- to fine-grained sand; fine beds commonly have 1–20%, scattered, mU-vcU sand grains and trace to 15% pebbles—consistent with hyperconcentrated flows; local very thin to	Tta Trachyandesite Sill—Sill intruding Red House Formation (Pr) in southern Mud Springs Mountains. Greenish-gray to olive-green or brown. Nesophitic. Phenocrysts = 1–2% feldspar, 5–8% hornblende. Interstitial material weathered to clay, limonite, and calcite. Hornblende ⁴⁰ Ar/ ³⁹ Ar age of 43.4±0.2 Ma (L.W. Snee, written commun. to C.H. Maxwell, 1989). <1–27 m thick [description slightly modified from Maxwell and Oakman, 1990].
thin lenses of pebbly sand and sandy pebbles. Gravelly intervals are 0.5–4 m thick (locally as much as 6 m) and exhibit very thin to medium, tabular to lenticular beds with 1–15% cross-stratification. These intervals are less laterally extensive than those found in Qpvu , and concave-up, buttress-bounded paleochannel forms are more abundant in this unit compared to Qpvu . Gravels are subrounded (mostly) to rounded, moderately	LATE CRETACEOUS SEDIMENTARY ROCKS Interpreted and described cuttings logs and down-hole geophysical logs from the No. 2 Getty West Elephant Butte Federal 3 well 1.
to poorly sorted, clast- to sand-supported, and weakly to strongly imbricated. 1–10% matrix-supported, poorly to very poorly sorted beds consistent with debris flows; remainder of sediment is primarily deposited by stream-flow processes. Gravels comprised of pebbles with 5–35% cobbles and near Cuchillo Negro Creek is composed of \approx 50% fine-grained intermediate volcanic rocks (includes basaltic andesites), \approx 25% felsic-volcanic rocks, and 20–25% porphyritic-intermediate-volcanic rocks; minor lithologic types (each <3%) include Kneeling Nun Tuff, Paleozoic limestone, Abo Formation, and monzonitic intrusions (visual	Ktmg Undivided Tres Hermanos Formation, Upper Mancos Shale, and Gallup Sandstone [cross-section only]—Interbedded sandstones and shales. Basal strata consists of 15 m of very fine-grained, quartz-rich sandstone. Overlying strata comprised of interbedded sandstone and mudstones. Apparent thickness of 46 m where penetrated by the well (140 m thick true thickness using 17° dip).
estimation). Near the southern quadrangle boundary, a clast count indicates 5% porphyritic-intermediate-volcanic rock types, 25% fine-grained intermediate-volcanic rocks (including basaltic andesites), 10% Kneeling Nun Tuff, 1% lithic tuffs, 1% monzonite intrusives, 50% rhyolites, 2% monzonitic intrusives, 4% granite, and <3% Paleozoic sedimentary clasts—felsic-volcanic rocks are less abundant to the north. Gravel matrix consists of brown to reddish-brown (5-7.5YR 5-6/3-4), fU-vcU sand that	Kml Lower Tongue of Mancos Shale [cross-section only]—Gray shale noted in well cuttings. Underlies a coal-bearing, interbedded shale+sandstone unit tentatively correlated to the Tres Hermanos Formation (Seager and Mack, 2003; Hook et al., 2012). Apparent thickness of 116 m where penetrated by the well (111 m true thickness using 17° dip). Dakota Sandstone [cross-section only]—Fine- to coarse-grained, quartz-rich sand grains that are
is subangular to subrounded (most of coarse and very coarse sand is subrounded), moderately to poorly sorted, and predominately composed of volcanic detritus with minor feldspar and <20% quartz; 0–2% clay, with redder (5YR) color are associated with higher clay proportions. We interpret that the gravels were deposited on intra-piedmont gully-mouth fan lobes or within paleochannels—features indicating the latter	Kd multicolored. Apparent thickness of 49 m where penetrated by the well (47 m thick true thickness using 17° dip).
include limited lateral extents, convex-down basal contacts, cross-stratification, and heavily scoured bases. Gravelly intervals typically have sharp (over vertical cm) upper contacts, consistent with avulsion-dominated stream processes. Variable proportions of paleosols characterized by illuviated clay horizons overlying calcic horizons; these soils are less abundant than observed in Qpvu . Illuviated clay (Bt) horizons are typically reddish-brown to yellowish-red (5YR 5/6-5/4) and peds are moderately to strongly developed and angular to subangular blocky; there are faint to distinct clay films on ped faces. Calcic	Psg San Andres Formation and underlying Glorieta Sandstone [cross-section only]—Tan to gray to brown limestone and local dolomite, interbedded with minor shale, underlain by 40 ft of very fine- to fine-grained, quartzose sandstone correlated to the Glorietta Sandstone. Apparent thickness of 190 m in the No. 2 Getty West Elephant Butte Federal 3 well. Yess Yess
 horizons are characterized by lighter (whiter) hues and exhibit stage I to II carbonate morphologies. Subunits differentiated based on the proportion of volcanic clast-dominated, gravelly intervals vs. fine-grained deposits. ≈60 m thick. Transitional Unit at the Top of the Middle-Level Volcaniclastic Piedmont Deposits—Transitional unit 	Yeso Formation [cross-section only]—Orange, very fine- to fine-grained, well-sorted sandstone (Meseta Blanca Member, 70 m thick in Caballo Mtns) overlain by an interval of interbedded dolomite, limestone, reddish siltstone-very fine-grained sandstone, and gypsum (Seager and Mack, 2003). Local igneous sills and 250 m apparent thickness in the No. 2 Getty West Elephant Butte Federal 3 well.Abo Formation—Reddish-brown and grayish-red siltstone/mudstone intercalated with sandstone beds that
QTpvmt locally mapped in the northeastern quadrangle between unit Qpvu and underlying strata, particularly where the transition is thick and underlying strata are fine-grained. Elsewhere, the base of unit is difficult to define. Strata are similar to unit Qpvu in terms of gravel proportions, types and textures, and bedding characteristics. However, lowest gravels tend to be finer than overlying gravels. Also, fine-grained sediment has <50% orangish intervals, and paleosols are not as abundant as in unit Qpvu . Interfingers westward with	 Pa are laminar, ripple laminar, and/or cross-stratified. Siltstone and mudstone beds contain lenses and nodules of pedogenic calcrete. Locally, fossils of plants (conifers and peltasperms) and amphibian footprints are present (DiMichele et al., 2012). 240 m thick (from cross-section). Bursum Formation—Interbedded limestone and siliciclastic red beds. A thin carbonate conglomerate forms
Tpfm. 10–24 m thick. QTpvmc Fine-Grained Deposits with 35–60% Gravelly Intervals—Proportion of gravelly intervals is 35–60%. Grades laterally eastward with unit QTpvm. Conformably overlain by Qpvu and underlain by Tpvl. 35–38 m thick. Fine-Grained Deposits with 15–40% Gravelly Intervals—Proportion of gravelly intervals is 15–40%.	Pbthe base of the Bursum Formation in places. Overlying strata are shale and siltstone intercalated with beds of limestone and carbonate conglomerate. Limestones locally contain abundant fusulinids. Rare cross-stratified coarse sandstone/conglomerate composed of carbonate, chert, and quartz grains. 70–80 m thick.Pennsylvanian Strata, undivided—Mapped for weakly hydrothermally altered strata, composed primarily
QTpvm Grades laterally eastward with unit QTpvmf and laterally westward with QTpmvc. Conformably overlain by Qpuv and underlain by Tpvmt or Tplv. 35–50 m thick. Fine-Grained Deposits with 5–20% Gravelly Intervals—Proportion of gravelly intervals is 5–20%. Grades	Pu of carbonates, located near downtown Truth or Consequences. Strata interpreted to have been overturned (Maxwell and Oakman, 1990). Bar B Formation—Interbedded shale and limestone. A conglomerate with carbonate intraclasts and fossil
QTpvmf Intervals properties of gravely intervals is 0.20%. Characteristic of gravely intervals is 0.20%. Character	Pbb fragments locally forms base of unit. Overlying intervals are: a lower limestone, marly limestone, and shale; middle nodular to algal limestone; and an upper red mudstone, limestone, conglomerate, and sandstone. Common marine fossil assemblages. Thickness: 178 m (stratigraphic sections) to 280 m (cross-section).
Tpvmt Grades laterally eastward with unit Tpvmtf. Northwest of the dam on Cuchillo Negro Creek, poor exposure necessitated lumping this unit with Tpvm. 18–28 m thick. Transitional Unit at the Base of the Middle Stratigraphic Level, Fine-Grained—Proportion of gravelly	Pgm Gray Mesa Formation—Ledge- and cliff-forming gray, dark-gray, brown and yellowish-orange limestone beds, intercalated gray shale/covered intervals, and a few brown to dark-brown sandstone and conglomerate beds in the upper part. 160–185 m thick. Pgm Bad Hause Formation — Clause forming gray, and a few brown to dark-brown sandstone and conglomerate beds in the upper part. 160–185 m thick.
Tpvmtf intervals is 5–15%. Grades laterally westward with unit Tpvmt. ≈30 m thick. Lower Stratigraphic Level Coarse Volcaniclastic Deposits Interbedded with 30–60% Fine Sediment—Sandy gravel interbedded with 30–60% fine sediment. Sandy gravel is in very thin to medium, tabular to lenticular beds; <10% cross-bedding. Fine sediment is in medium to thick, tabular, massive beds; composed of light-brown to pink,	Pr Red House Formation—Slope-forming gray shale/covered intervals and interbedded diverse lithotypes of gray to dark gray limestone and a few thin sandstone beds. Intercalated sandstone beds are composed mainly of quartz and rare feldspar grains. Jasperoid bodies in the Red House Formation consist of silicified mudstone with recognizable, but not identifiable, fossils. Underlain by unconformity. 56–59 m thick (stratigraphic sections) to 80 m thick (cross-section).
 Series of the second of the sec	Percha Formation —Greenish- and brownish-yellowish marly shale with intercalated thin, even-bedded limestone beds, nodular limestone beds and limestone nodules dispersed in shale. Small coral colonies and fossiliferous limestone nodules and lenses are found in the lower 16 m. Only mapped in southern Mud Springs Mountains, where it is 35–40 m thick.
siltstone and very fine- to fine-grained sandstone (about 50–70%); and 2) fine- to medium-grained sandstone (\approx 20%), and 3) coarse channel-fills (increasing up-section from 10 to 25%) composed of pebbly sand or sandy pebbles. Extensive calcium carbonate bed at top of unit. \approx 30 m thick.	Montoya Group—The Montoya is treated in the literature as either a group or a formation; we treat it as a group because its subdivisions are mappable at a scale of 1:24,000 in the Mud Springs Mountains. We use Kelley and Silver's (1952) named subdivisions of the Montoya Group—Cable Canyon, Upham, Aleman and Cutter Formations. 110–150 m thick, thinning to NE.
Units Derived from Mud Springs Mountains, Associated with a Piedmont or Alluvial Fan Lithofacies Assemblage Qpxu Deposits with Precambrian-Dominated Gravels Derived from the Mud Springs Mountains—Moderately to strongly cemented conglomerate composed of granite and minor gneiss; only ≈1% Paleozoic carbonate clasts. No bedding observed. Gravel is subangular, very poorly sorted, and comprised of pebbles through	Omc Cutter Dolomite of the Montoya Group—Above a thin, basal bed of carbonate conglomerate, light-gray, mostly medium-bedded, partly laminated, partly bioturbated dolomite with rare chert and rare limestone beds. A massive chert horizon (1.5 m thick) is present in the lower part. Covered intervals are up to 5.7 m thick. 40–45 m thick
Image: Construction of the sedimentation of the sediment is in medium to thick, tabular to lenticular, internally massive beds and composed of tan silt	Oma Aleman Formation of the Montoya Group—Mostly gray to dark-gray, medium- to thick-bedded cherty dolomite containing abundant chert nodules, chert lenses and thin chert layers. A few covered intervals (0.7–0.8 m thick) present in upper part of unit. In the lower and middle part of the formation, some beds contain abundant silicified brachiopods and few gastropods. 39–46 m thick (stratigraphic sections) to 95 m thick (cross-section).
QTpsf Deposits with Sedimentary Clast-Dominated Gravels Derived from the Mud Springs Mountains, Fine-Grained—Mapped near the southeast end of the Mud Springs Mountains, this unit consists of light-brown (7.5YR 6/3-4) to pink (7.5YR 7/3) silt to fine sand with =15% sandy pebble conglomerate beds. Fine	Omsv Second Value Dolomite of the Montoya Group—Gray, sandy dolomite that is generally cherty above brown to dark yellowish brown quartz sandstone and pebbly sandstone. Dolomite may contain limestone debris. Sandstone is massive to cross-stratified and forms a sharp, erosive contact on the underlying McKelligon Limestone. 20–25 m thick.
sediment is in medium to thick, tabular beds that are internally massive and contain local calcium carbonate nodules. This fine sediment consists primarily of silt and very fine- to fine-grained sand (<15% scattered medium to very coarse sand grains and 0–10% scattered pebbles); up to 20% very thin to thin beds of silty very fine- to very coarse-grained sand; medium and very coarse sand are composed of Paleozoic carbonate and chert detritus. Minor (<15%) sandy pebble conglomerate and pebbly sandstone bodies that are 0.1–1.5 m thick and lenticular; bedding is typically very thin to thin and lenticular. Gravel is composed primarily of	El Paso Group El Paso Group—There have been three different schemes of lithostratigraphic nomenclature applied to the El Paso Group strata in the Mud Springs Mountains (Kelley and Silver, 1952; Hayes and Cone, 1975; Clemons, 1991). We assign the El Paso Group to the Hitt Canyon and McKelligon formations, following Hayes and Cone (1975). 142–180 m thick, thinning to NE.
Paleozoic limestones and dolostones; 5–15% chert + silicified limestone. <5% cobbles in the gravel fraction. Gravel are subangular to angular, poorly to moderately sorted, and generally poorly imbricated. Sand in the conglomerates is very fine- to very coarse-grained, subangular, and poorly sorted; medium to very coarse sand is composed of Paleozoic carbonate detritus. Trace to 5% greenish mudstone beds. Well-consolidated;	Oem McKelligon Limestone—Medium-bedded, subordinately thick-bedded to massive, commonly bioturbated limestone. Thin- to thick-bedded cherty and bioturbated limestone and bedded dolomitic limestone/dolomite are intercalated. A thin stromatolite bed is developed near the base. 30 m thick near Mud Mountain.
gravels are typically cemented. Sparser paleosols compared to unit Qpsu . Unit grades laterally away from the Mud Springs Mountains into unit QTptvf . >40 m thick. Deposits with Sedimentary Clast-Dominated Gravels Derived from the Mud Springs Mountains, QTps Middle-Lower Stratigraphic Level —Strongly cemented conglomerate grading up-section to interbedded	Oeh Hitt Canyon Formation—Partly dolomitized to bedded limestone with columnar stromatolites and rare to occasional chert in upper part. Sparse shale or covered intervals are present. Lower part consists of dolomitic, laminated siltstone-sandstone intercalated with bedded, fossiliferous limestone and rare chert lenses. 102–112 m thick.
QTpsMiddle-Lower Stratigraphic Level—Strongly cemented conglomerate grading up-section to interbedded conglomerate and fine sediment. Conglomeratic intervals are in vague, medium to thick, tabular to lenticular beds. Cobble abundance and size decrease up-section. Fine-grained sediment composed of tan silt and very fine- to fine-grained sand, with 1–20% scattered coarser grains+pebbles and 1–5% thin pebbly beds. 20–25 m thick.Fine-Grained Strata Associated with a Marginal Basin Floor Lithofacies Assemblage	COB Bliss Sandstone —Alternating dark-brown sandstone, siltstone, shale and rare, fossiliferous carbonate beds. Sandstone sedimentary structures include horizontal or ripple lamination and trough or rare herringbone cross-stratification. Greenish glauconitic sandstone and dendroid graptolites are present in the upper part of the formation. Sparse iron ooids are present in sandstone in the lower part. 45–55 m thick.
Fine-Grained Strata Associated with a Marginal Basin Floor Lithofactes Assemblage Fine-Grained Strata with <5% Volcaniclastic Gravel Beds—Siltstone, very fine- to fine-grained sandstone, and mixed clay-siltstone and very fine-grained sandstone; minor claystone. 1–5% thin to thick, tabular beds of pebble conglomerate. Local beds of microcrystalline calcite (>95% by volume, remainder is sand) and very minor (<2%) tongues of Tpam . Pumiceous bed ≈35–50 m below top is 3.1 Ma based on geochemical correlation (Mack et al., 2009). 115 m thick.	PCu Precambrian Rocks, undivided—Meta-sandstone, quartzite, quartz or quartz-biotite schist, amphibolite schist and gneiss, and intercalated granite and granite-gneiss. Locally, pegmatitic to aplitic dikes cut the granite. Forms the core of the Mud Springs Mountains and is only exposed in limited outcrops along the western face of the range.
Axial Lithofacies Assemblage, Lower and Middle Stratigraphic Levels Middle Axial Lithofacies Unit—White to light-gray, cross-laminated (common troughs) to horizontal-planar bedded, medium- to coarse-grained sand with ≤20% pebbly beds. Pebbles typically dominated by volcanic rocks but include minor, variable proportions of granite, sedimentary clasts, and chert. Sparse (<7%) intervals	MISCELLANEOUS CROSS-SECTION UNITS Undivided Santa Fe Group Underlying the Palomas Formation—Sand, gravels, and clayey-silty sands that underlie the middle Palomas Formation. Correlative in part to units Trbuc, Trbuw, Trbut, Trplu, and Trpl.
of thickly bedded clay, silt, very fine sand, and clayey-silty very fine-grained sand. ≈110 m thick to north. Lower Axial Lithofacies Unit—Very pale brown to white (10YR 7/3-8/1) sand interbedded with 10–50% gravelly intervals. Sand is horizontal-planar laminated to low-angle cross-stratified (locally massive), quartzofeldspathic, and mostly medium- to coarse-grained. Three allostratigraphic units are present near	Tv-Pz Undivided Pre-Santa Fe Group Strata—Primarily dolomites and limestone rocks in the lower to middle parts, possibly overlain by a thin interval of sandstone and shales correlative to the Cretaceous, which in turn is overlain by an unknown thickness of Oligocene to Eocene volcanic rocks. Mapped to the west of the Mud Springs Mountains.
Truth or Consequences, the younger and middle ones occupying unambiguous paleovalleys. 25–46 m, thickening to north. Tpal3 Tpal3 Tpal4 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 Tpal5 T	

