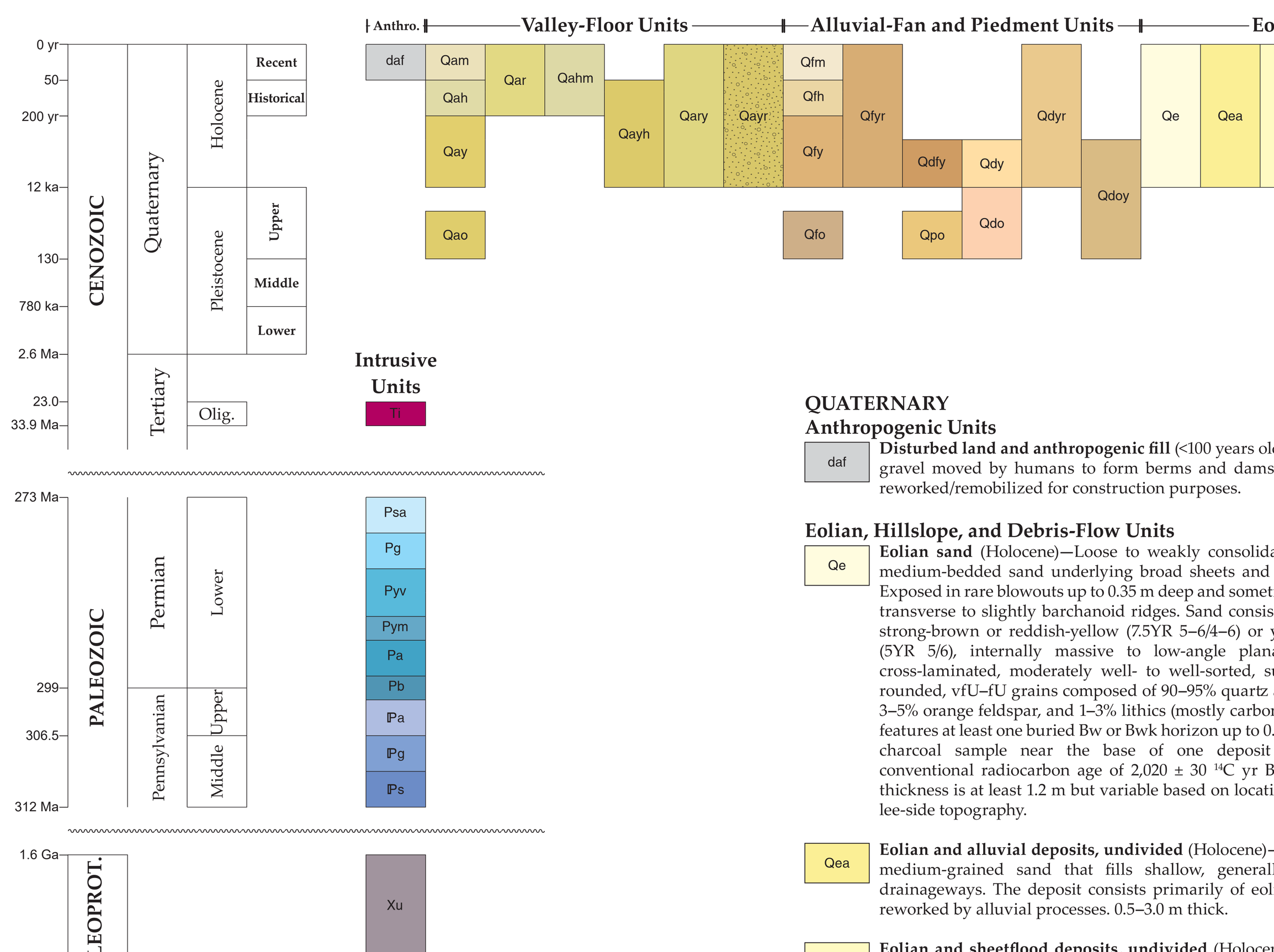
NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A RESEARCH DIVISION OF **NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY**

NMBGMR Open-File Geologic Map 300

Last Modified June 2022

Correlation of Map Units



Description of Map Units

QUATERNARY

Anthropogenic Units

daf — **Disturbed land and anthropogenic fill** (<100 years old)—Sand and gravel moved by humans to form berms and dams or has been reworked/remobilized for construction purposes.

Eolian, Hillslope, and Debris-Flow Units

Qe — **Eolian sand** (Holocene)—Loose to weakly consolidated, thin- to medium-bedded sand underlying broad sheets and dune ridges. Exposed in rare blowouts up to 0.35 m deep and sometimes forming transverse to slightly barchanoid ridges. Sand consists of light- to strong-brown or reddish-yellow (7.5YR 5–6/4–6) or yellowish-red (5YR 5/6), internally massive to low-angle planar or ripple cross-laminated, moderately well- to well-sorted, subangular to rounded, vfU–fU grains composed of 90–95% quartz and gypsum, 3–5% orange feldspar, and 1–3% lithics (mostly carbonate). Deposit features at least one buried Bw or Bwk horizon up to 0.2 cm thick. A charcoal sample near the base of one deposit returned a conventional radiocarbon age of 2,020 ± 30 ^{14}C yr BP. Maximum thickness is at least 1.2 m but variable based on location relative to lee-side topography.

Qea — **Eolian and alluvial deposits, undivided** (Holocene)—Loose silt to medium-grained sand that fills shallow, generally unincised drainageways. The deposit consists primarily of eolian sediment reworked by alluvial processes. 0.5–3.0 m thick.

Qes — **Eolian and sheetflood deposits, undivided** (Holocene)—Loose to weakly consolidated silty sand and subordinate silt-clay in massive to medium (>12 cm), tabular beds underlying sheets and gently incised surfaces of low to moderate slope. Sand consists of strong-brown (7.5YR 4/6), internally massive, well-sorted, vfL–fL grains with 3–5% rounded to well-rounded mL–mU grains composed mostly of quartz (>90%) and trace subangular to rounded granules and fine pebbles of carbonate and sandstone. Silt-clay is yellowish-red (5YR 5/6) to strong-brown (7.5YR 5/6), vaguely laminated (≤0.8 cm), and contains 2–5% floating grains of subangular, fU–mL sand composed of carbonate or dark lithics. The deposit is bioturbated by very fine to coarse roots and medium burrows, including krotovina of sandy material up to 3 cm across. Occasional discontinuous channels incised into the unit typically disappear downstream into low-gradient swales and valley floors. Locally, weak topsoil development is characterized by very fine carbonate coatings indicating Stage I carbonate accumulation. Total thickness is at least 1.0–1.5 m.

Qse — **Sheetflood deposits reworked from eolian sand sheets** (Holocene)—Loose to weakly consolidated sand and sandy silt in massive to medium (15–20 cm), tabular to wedge-shaped beds underlying low to moderate slopes that are commonly rilled or gullied. Sand consists of brown (7.5YR 4/3–4) to strong-brown (7.5YR 4–5/6), crudely horizontal-planar laminated, poorly to moderately well-sorted, subangular to rounded, vfL–fU grains (trace medium grains) composed mostly of quartz. The surface of the deposit features rare to occasional stringers of poorly to moderately sorted, subangular to subrounded (occasionally rounded) pebbles consisting of local lithologies. The base of the deposit may be marked by a thin, pebble gravel where it overlies unit **Qay**. Commonly bioturbated by very fine to very coarse roots and/or burrows. Rare to occasional disseminated gypsum is found near areas of Yeso Group exposure. Topsoil development is characterized by: (A) dark-brown (7.5YR 3/3–4), non-calcareous, sandy to silty A horizons that are 10–40 cm thick; or (B) carbonate filaments indicating Stage I carbonate accumulation in the upper 30–35 cm of the deposit. Deposit is 0.5–1.0 m thick in upland areas to perhaps 2.5 m thick near the margins of shallow valleys.

Qesa — **Eolian and subordinate sheetflood and alluvial deposits** (Holocene)—Loose eolian silt to fine-grained sand that alluvial processes have reworked in places. See unit descriptions for **Qe**, **Qes**, **Qea**, and **Qse**.

Qsea — **Sheetflood and subordinate eolian and alluvial deposits, undivided** (Holocene)—Loose, silty sand on low to moderate slopes that are more commonly incised than those underlain by unit Qesa. Alluvial processes have reworked nearly all eolian sand. See unit descriptions for **Qe**, **Qes**, **Qea**, and **Qse**.

Qsc — **Sheetflood and colluvial deposits, undivided** (Upper? Pleistocene to Holocene)—Loose to weakly consolidated, silty sand and pebble (rare cobble) gravel underlying moderate slopes at the base of bedrock uplands. See unit descriptions for **Qse** and **Qct**.

Qct — **Colluvium and talus, undivided** (Upper? Pleistocene to Holocene)—Loose, poorly sorted, angular to subrounded cobble–boulder gravel forming aprons or mantles at the footslopes of bedrock uplands. <5 m thick.

Qls — **Landslide deposits** (Upper Pleistocene to Holocene)— Weakly consolidated gravel in massive to poorly defined thick or very thick, wedge-shaped beds. The gravel is mostly matrix-supported, internally massive to chaotically bedded and/or slope-parallel, very poorly sorted, angular to subangular clasts, and the clasts consist of 40–70% pebbles, 30–40% cobbles, and 5–20% boulders primarily derived from the Glorieta Sandstone or San Andres Formation. Matrix sand consists of brownish-yellow to yellow (10YR 6/6–8, 7/6), non-calcareous, very poorly to poorly sorted, angular to subrounded, vfU–mU grains (5–10% cL sand to granules) composed of subequal proportions of quartz and lithics (sandstone, siltstone, and carbonate) and up to 5% orange feldspar. Locally features a surface soil with Stage II carbonate accumulation (clast coatings) that is poorly exposed but presumed to occur in the upper 1.0–1.5 m of the deposit. At least 4.0 m thick.

Qdy — **Younger debris-flow deposits** (Holocene)—Loose to weakly consolidated, reverse-graded, silty to pebbly sand and pebble–cobble gravel in massive or thick, tabular to broadly lenticular beds. Sand consists of strong-brown to reddish-yellow (7.5YR 5–6/6–8), weakly calcareous, moderately sorted, subangular to rounded, vfU–mL grains composed of 85–90% quartz, 5–10% lithics (dark mafics or FeOx flakes derived from the Glorieta Sandstone and subordinate sandstone and carbonate), and up to 5% feldspar. Gravel is internally massive to weakly or moderately imbricated, poorly to moderately sorted, angular to rounded, and consists of 60–90% pebbles, 10–30% cobbles, and 0–10% boulders of Glorieta Sandstone, FeOx concretions derived from the Glorieta, and San Andres limestone/dolostone. Gravel matrix is similar to sandy beds. Stage II carbonate accumulation (clast coatings) is observed in the deposit's upper 0.4–0.6 m. Maximum thickness 8.5 m.

Qdyr — **Younger and recent debris- flow deposits, undivided** (Holocene)—Younger (**Qdy**) and subordinate recent (modern + historical) debris-flow deposits. The following description is for recent debris-flow deposits that are not mapped separately in the quadrangle: loose to moderately consolidated gravel in massive or medium to thick (15–35 cm), lobate to snout- or fan-shaped beds. Gravel is open-framework to matrix-supported, internally massive to imbricated, very poorly to poorly sorted, mostly angular to subrounded, and consists of 45–95% pebbles, 5–45% cobbles, and 0–25% boulders of sandstone, siltstone, and carbonate. The open-framework texture is more common in modern deposits. The matrix consists of brown (7.5YR 5/4) to strong-brown or reddish-yellow (7.5YR 5/6–8, 6/8) to yellowish-brown (10YR 5/4), very poorly to poorly sorted, angular to rounded silt to cL sand composed of 60–80% quartz, 10–30% lithics (carbonate, sandstone, siltstone, and minor dark mafics or FeOx flakes derived from the Glorieta Sandstone), and 5–10% orange feldspar. Historical deposits (≈50 to ≈200 years old) may feature an upper sandy gravel comprised of loose pebbles, cobbles, and boulders in massive to medium, lobate to broadly lenticular beds. Gravel in this bed are clast- to matrix-supported and internally massive to moderately imbricated. Clasts consist of 60–80% pebbles, 10–25% cobbles, and 10–15% boulders of sandstone, carbonate, and siltstone. The upper gravel matrix consists of brown to strong-brown (7.5YR 4/4–6), moderately calcareous, very poorly to poorly sorted, subangular to subrounded, fL–vcL sand of similar composition to the lower gravel matrix but with common fine, disseminated charcoal fragments. No topsoil is preserved on recent deposits, which form bar-and-swale topography of 0.4 (historical) to 2.0 m (modern) and are frequently capped by open-framework boulder trains. At least 1.4–2.0 m thick.

Qdo — **Older debris-flow deposits** (Middle? to Upper Pleistocene)—Very weakly consolidated gravel in massive, wedge-shaped beds. Gravel are clast- to matrix-supported, internally massive to vaguely imbricated, very poorly to poorly sorted, angular to subrounded (minor rounded), and consist of 45–60% pebbles, 25–30% cobbles, and 10–30% boulders of San Andres Formation carbonate and Glorieta Sandstone. Bedding is indistinct and clast-supported texture is more common than matrix-supported. The matrix consists of brown to light-brown (7.5YR 5–6/4), very poorly sorted, subangular to rounded, silt to mL sand (<5% mU sand). Where discernible, sand grain lithologies include at least 95% quartz, with the remainder composed of sandstone, carbonate, feldspar, and micas. The deposit surface does not commonly feature notable bar-and-swale topography. At least 2.0–5.0 m thick.

Qdoy — **Older and younger debris-flow deposits, undivided** (Middle? Pleistocene to Holocene)—Older (**Qdo**) and subordinate younger (**Qdy**) debris-flow deposits. See detailed descriptions of each individual unit.

Qdfy — **Younger debris-flow and alluvial-fan deposits, undivided** (Holocene)—Unit mapped where younger debris-flow (**Qdy**) and alluvial-fan (**Qfy**) deposits are highly gradational. See detailed descriptions of each individual unit.

Valley-Floor Units

Qam — **Modern alluvium** (Modern to ≈50 years old)—Loose sand and sandy gravel forming longitudinal bars and underlying channels in modern, ephemeral-stream courses. The gravel are very poorly to moderately sorted, subangular to well-rounded, and consist of 55–90% pebbles, 10–35% cobbles, and 0–10% boulders of local lithologies. Sand consists of light-brown (7.5YR 6/4) to light-yellowish-brown (10YR 6/4), very poorly to poorly sorted, subangular to well-rounded, fL–cL (trace to 3% very coarse) grains composed of 80–85% quartz, 10–15% lithics, and 5–10% feldspar. Surface characterized by bar-and-swale topography exhibiting up to 0.5 m of relief. Maximum thickness 2.0–2.5 m.

Qah — **Historical alluvium** (≈50 to ≈200 years old)—Loose, sandy gravel in thick (0.3–0.9 m) lenticular beds. The gravel are clast-supported, moderately to well-imbricated, very poorly to poorly sorted, subrounded to well-rounded, and consist of 45–65% pebbles, 15–30% cobbles, and 5–25% boulders of local lithologies, primarily carbonates and Glorieta Sandstone. The matrix consists of brown to light-brown (7.5YR 5–6/4), weakly calcareous, angular to subrounded, vfL–mU sand composed of 80–85% quartz, 10–15% lithics (sandstone, siltstone, carbonate, and subordinate dark mafics or FeOx flakes derived from the Glorieta Sandstone), and up to 5% feldspar. Gravel occasionally underlies low-angle to horizontal-planar laminated sand similar to gravel matrix and is often mantled with eolian and/or sheetflood deposits. Deposit is commonly bioturbated by very fine to very coarse roots and may feature a well-developed A horizon in the upper 0.2 m. Surface characterized by bar-and-swale topography exhibiting up to 0.35 m of relief. Tread height is 0.6–1.6 m above modern grade. At least 0.8–1.6 m thick.

Qar — **Recent (historical + modern) alluvium** (Modern to ≈200 years old)—Historical (**Qah**) and modern alluvium (**Qam**) in approximately equal proportions. See detailed descriptions of each individual unit.

Qahm — **Historical and modern alluvium, undivided** (Modern to ≈200 years old)—Historical (**Qah**) and subordinate modern (**Qam**) alluvium. See detailed descriptions of each individual unit.

Qay — **Younger alluvium** (Holocene)—Loose to weakly consolidated, silty to slightly clayey sand in medium to very thick (0.2–1.4 m), tabular to broadly lenticular beds underlying broad surfaces that are occasionally deeply incised throughout the quadrangle. Sand consists of light- or strong-brown to reddish-yellow (7.5YR 6/4–6) to dark-yellowish-brown (10YR 3/6, 4/4), moderately to strongly calcareous, mostly massive, poorly to moderately well-sorted, subangular to well-rounded, vfL–mL grains (0–5% subangular to rounded mU–cU grains) composed of 75–95% quartz, 5–15% feldspar, and 5–10% lithics (carbonate and sandstone). Sandy beds contain 0–10% matrix-supported (rare clast-supported), poorly to moderately sorted, mostly subangular to subrounded granules to pebbles (rare cobbles) of local lithologies. Less common are beds of weakly consolidated pebble–cobble (rare pebble–cobble–boulder) gravel in thin to very thick (4 cm–1.2 m) lenticular beds. The gravel are moderately well-imbricated, poorly to moderately sorted, subangular to rounded, and consist of 90–95% pebbles and 5–10% cobbles of local lithologies with matrices similar to sandy intervals. Gypsum and carbonate are preserved within the upper part of the unit and brownish carbonate may be present in the lower 3–5 m south of Rayo Hills. Deposit is commonly bioturbated by very fine to very coarse roots and contains rare to common charcoal fragments. Buried Bw or Bt horizons are indicated by rare to occasional clay argillans on larger grains and prismatic ped structures. Diffuse carbonate coatings in the upper part of the deposit indicate Stage I–II carbonate accumulation. Commonly mantled by sheetflood and reworked eolian sediment. Charcoal samples from deposits in the upper Sand Draw and Cañada Montosa watersheds returned conventional radiocarbon ages of 1,600 ± 30 to 3,530 ± 30 ^{14}C yr BP. 3.5–10.0 m thick.

Qayh — **Younger and historical alluvium, undivided** (Holocene)—Younger (**Qay**) and subordinate historical alluvium (**Qah**). See detailed descriptions of each individual unit.

Qary — **Recent (historical + modern) and younger alluvium, undivided** (Holocene)—Recent (**Qah** + **Qam**) and subordinate younger alluvium (**Qay**). See detailed descriptions of each individual unit.

Qayr — **Younger and recent (historical + modern) alluvium, undivided** (Holocene)—Younger (**Qay**) and subordinate recent alluvium (**Qah** + **Qam**). See detailed descriptions of each individual unit.

Qao — **Older alluvium** (Middle to Upper Pleistocene)—A poorly exposed deposit of weakly imbricated pebble–cobble gravel. Clasts comprise 65–95% pebbles and 5–35% cobbles. The matrix consists of strong-brown (7.5YR 4–5/6), strongly calcareous, poorly to moderately sorted, subangular to rounded, silty vfL-mL sand (3–5% mU–cL sand) composed of 85–90% quartz, 10–15% lithics (sandstone and dark mafics and/or FeOx flakes derived from the Glorieta Sandstone), and trace to 3% feldspar. Unconsolidated gravel features Stage IV carbonate accumulation (K horizon with laminations) at least 0.4 m thick at its surface. A conglomerate in massive to medium or thick, lobate to tabular beds is found in upper Sand Draw. The conglomerate is brown to slightly reddish-gray (weathering white to pinkish-white), well-indurated, calcite-cemented, matrix-supported, and internally massive. Clasts consist of poorly sorted, subangular to rounded pebbles (90–97%), cobbles (3–10%), and trace small boulders of Glorieta Sandstone (55–65%), carbonate (35–45%), and a few percent intrusive monzonite clasts. The conglomerate matrix is very poorly sorted, subrounded to rounded, fU–vcU sand (2–5% granules) composed of 85–95% quartz, 5–15% lithics (sandstone and carbonate), and trace to 3% feldspar. Smaller (fine to medium) sand grains in the matrix exhibit a frosted appearance. Total thickness unknown but at least 4.0–5.0 m.

Alluvial-Fan and Piedmont Units

Qfm — **Modern fan alluvium** (Modern to ≈50 years old)—The deposit is loose, sandy gravel forming bars and lobes and underlying braided channels. The gravel are clast-supported to open-framework (rare), weakly to moderately well-imbricated, very poorly to poorly sorted, angular to subrounded, and consist of 40–50% pebbles, 45–55% cobbles, and 5–10% boulders of, primarily carbonates and sandstone with minor siltstone or sandstone derived from the Joyita Member of the Los Vallos Formation. The matrix consists of brown (7.5YR 5/4) to yellowish-brown (10YR 5/4), very poorly to poorly sorted, subangular to rounded, vfU–cL sand (trace to 3% cU sand to granules) composed of 60–80% quartz, 15–30% lithics (carbonate, sandstone, siltstone, and minor dark mafics and/or FeOx flakes derived from the Glorieta Sandstone), and 5–10% orange feldspar. Surface characterized by bar-and-swale topography exhibiting up to 0.4 m of relief. 0.3–2.0 m thick.

Qfh — **Historical fan alluvium** (≈50 to ≈200 years old)—Loose to weakly consolidated gravel in medium to thick (35–65 cm), wedge-shaped beds. The gravel are clast-supported, internally massive or weakly to moderately imbricated, very poorly sorted, angular to subrounded, and consist of 45–55% pebbles, 40–45% cobbles, and 10–15% boulders. The matrix consists of light- brown (7.5YR 6/3–4) to yellowish- or light-yellowish-brown (10YR 5–6/4), moderately calcareous, very poorly to poorly sorted, subangular to subrounded, vfL–cL sand (trace to 12% cU sand to granules) composed of 45–80% quartz, 10–45% lithics (sandstone and dark mafics and/or FeOx flakes derived from the Glorieta Sandstone), and 5–15% orange feldspar with occasional fine, disseminated charcoal. Topsoil features a 0.1–0.2 m thick A horizon where not eroded. Surface characterized by bar-and-swale topography exhibiting up to 0.2 m of relief. A charcoal sample from the upper Cañada Montosa watershed returned a conventional radiocarbon age of 160 ± 30 ^{14}C yr BP. Maximum thickness is 3.2 m.

Qfy — **Younger fan alluvium** (Holocene)—Loose to weakly consolidated, silty to pebbly sand and gravel in massive or medium to thick, wedge-shaped to lobate beds. Sand consists of light-brown to reddish-yellow (7.5YR 6/4–6), strongly calcareous, internally massive, poorly sorted, angular to rounded, vfL–mU grains (trace to 3% cU grains to granules) composed of 80–85% quartz, 10–15% lithics (dark mafics and/or FeOx flakes derived from the Glorieta Sandstone and subordinate sandstone), 5–10% orange feldspar, and 5–10% gypsum. The gravel are internally massive to weakly or moderately imbricated, very poorly to poorly sorted, mostly angular to subrounded, and consist of 55–80% pebbles, 10–30% cobbles, and 10–15% boulders of Glorieta Sandstone, FeOx concretions derived from the Glorieta, and carbonate. Underlying sand may contain stringers of such gravel. Surface soil may contain Bw or Bt horizons up to 0.3 m thick overlying Bk horizons (Stage I–II carbonate accumulation), but the latter are typically eroded. The deposit contains rare to occasional charcoal fragments. Surface characterized by bar-and-swale topography exhibiting up to 0.2 m of relief. 3.9–4.4 m thick.

Qfyr — **Younger and recent (historical + modern) fan alluvium, undivided** (Holocene)—Younger and subordinate recent (historical + modern) fan alluvium. See detailed descriptions of **Qfh** and **Qfy**. Modern fan alluvium consists of loose, clast-supported to open-framework, sandy pebble–cobble–boulder gravel forming bars and lobes and underlying braided channels.

Qfo — **Older fan alluvium** (Middle? to Upper Pleistocene)—Poorly exposed pebble–cobble and pebble–cobble–boulder gravel in wedge-shaped beds underlying high fan remnants in the Chupadera Gap area. Clasts are nearly all Glorieta Sandstone with minor carbonate. A Stage IV calcic soil occurs in the upper 0.75 m of the deposit, which **Qsea** mantles. Thickness unknown but probably <5.0–7.0 m.

Qpo — **Older piedmont alluvium** (Middle? to Upper Pleistocene)—Thin pebble–cobble and pebble–cobble–boulder gravel occurring as small remnants or capping low-gradient ridges emanating from the Rayo Hills. Clasts are 40–60% pebbles, 20–45% cobbles, and 10–20% boulders of Glorieta Sandstone and carbonate. Surface soils are commonly eroded. <2.4–3.0 m thick.

Qxo — **Older pediment gravels** (Middle? to Upper Pleistocene)—Pebble–cobble and pebble–cobble–boulder lag gravels overlying older erosional surfaces formed on the Glorieta Sandstone in the southeast part of the quadrangle. Clasts are angular to subangular and commonly feature strong varnish. Pediment surface is 55–60 m above modern grade. 0.8–2.0 m thick.

TERTIARY

Intrusive Units

Ti — **Intrusive monzonite** (Lower Oligocene)—Whitish to very light- to medium-gray, weathering to medium- or dark-gray, non-vesicular, massive, aphanitic to phaneritic monzonite intruding weakly consolidated strata of the Torres Member of the Los Vallos Formation as dikes or sills. Spheroidal weathering is common. Where phaneritic, phenocrysts include 20–30% hornblende (medium to coarse, subhedral to euhedral prisms), 10–15% plagioclase (fine to medium, anhedral to subhedral), trace to 1% biotite (fine, subhedral), and trace quartz (fine to medium, anhedral). Bates et al. (1947) noted the presence of orthoclase, pyroxene, and magnetite in some samples. Hornblende and biotite are commonly altered to greenish or yellowish, powdery secondary minerals. Aphanitic margins contain trace to 1% very fine, equant phenocrysts inferred to be biotite based on their shape and luster, and feature occasional to common splotches of very pale-green, grainy alteration minerals forming diffuse boundaries with the groundmass. Some dikes contain occasional xenoliths, up to 7 cm in diameter, of mafic material with subequal plagioclase and pyroxene phenocrysts and rare biotite. Whole-rock geochemistry indicates a monzonitic composition (55.2–55.7 wt% SiO_2, 8.3–8.8% $Na_2O + K_2O$). Aldrich et al. (1986) obtained a K-Ar age of 30.2 ± 2.0 Ma from a dike of similar composition in the Chupadera 7.5-minute quadrangle to the east. The size of three small exposures in section 4, T01S, R05E, has been exaggerated to appear at the map's scale. Dikes may be up to 160 m wide but are more commonly 45–75 m wide.

PALEOZOIC

Psa — **San Andres Formation** (Lower Permian)—Light- to medium- or brownish-gray, thin- to thick-bedded, internally massive to horizontal-planar or ripple-laminated, featureless to vuggy, slightly fossiliferous, and/or bioturbated limestone, dolomitic or gypsiferous limestone, and dolostone. Fossils, (very fine crinoids and shell fragments), bioturbation (bedding plane-parallel burrows up to 4 cm in diameter), oncoids up to 22 cm long and 10 cm in diameter, and trace to occasional disseminated chert occur in the upper 10 m of exposure. Limestone may emit a slightly oily odor when struck. The San Andres Formation wackestone, floatstone, and rudstone are recognized (Brose et al., 2013). Limestone and dolostone are interbedded in the lower part with abundant gypsum and minor shale, mudstone, and sandstone. Two distinct gypsum/sandstone sequences are traceable across nearly all exposed outcrops in the southern half of the quadrangle. Gypsum is white to light or medium gray, poorly to moderately indurated, massive to vaguely medium- or thick-bedded, and internally massive to laminated. Abundant blades or nodules of dark-colored secondary gypsum are observed in some intervals. Gypsum is present in beds or as fracture fill. Sandstones are similar to those of the upper Glorieta Sandstone. Mudstone is grayish-purple to reddish-brown, very poorly to moderately indurated, non- to strongly calcareous, internally massive, and silty to gypsiferous. The San Andres Formation caps mesas and plateaus with an upper erosional surface (Brose et al., 2013). 45 m thick near Chupadera Gap; Wilpolt et al. (1946) reported a thickness of 50 m from the southwest side of the Rayo Hills.

Pg — **Glorieta Sandstone** (Lower Permian)—White to yellowish-white or very pale-pinkish, poorly to moderately indurated, strongly calcareous, massive or thin- to thick-bedded, tabular to lenticular, internally massive to horizontal-planar laminated to low-angle planar or tangential cross-stratified, moderately to well-sorted, subangular to rounded, quartzose, vfL–fU sandstone. Some sandstone bodies may present up to 5–10% feldspar and lithics (dark mafics and/or FeOx flakes). Iron oxide stains and concretions up to 20 cm in diameter are occasionally observed in the upper 37 m of the unit. Rare siltstones are gray to dark-greenish-gray, slightly calcareous, lenticular, and massive. Sandstones are interbedded with thin siltstones and dark-purplish-gray, non-calcareous, massive to ripple-laminated mudstones in the lower 2 m of the unit, suggesting a gradational contact with the underlying Joyita Member of the Los Vallos Formation. Forms prominent cliffs and ledges below slopes of the lower San Andres Formation. 69 m thick near Chupadera Gap; Wilpolt et al. (1946) reported a thickness of 70 m from the southwest side of the Rayo Hills.

Pyv — **Los Vallos Formation of the Yeso Group** (Lower Permian)—Interstratified limestone, dolostone, gypsum, mudstone, siltstone, and sandstone. The Joyita Member forms the upper approximately 12 m of the unit and consists of interstratified siltstone and sandstone with rare mudstone and neither gypsum nor carbonates present. Mudstones and siltstones are light-reddish or reddish-yellow-brown to maroon, poorly indurated, non- to slightly calcareous, massive or thin-bedded, internally massive to low-angle planar laminated (rare), and commonly gypsiferous. Sandstones are yellowish-white to reddish-brown, poorly to moderately well-indurated, non- to strongly calcareous, massive or thin- to thick-bedded, tabular, internally massive to low-angle planar cross-stratified, moderately well- to well-sorted, and subangular to rounded. Sand grains are vfL–fU and composed of 75–90% quartz, trace to 15% orange feldspar, and 3–7% lithics (dark mafics) with occasional reworked gypsum flakes. The Cañas Member forms an interval approximately 30–55 m thick below the Joyita Member and consists of whitish to grayish, poorly to moderately well-indurated, massive or wavy/thin- to medium-bedded, internally massive to nodular or laminated gypsum that is enterolithic in places. Mudstones and siltstones are as described above in the Joyita Member and commonly underlie covered slopes. A dolostone marker bed near the stratigraphic center of the Cañas Member is medium- to dark-gray, moderately indurated, wavy/thin-bedded, internally massive, and gypsiferous. The Torres Member forms the lower 168 m or more of the unit and consists of most of the lithologies described above. Carbonates in the Torres Member are medium- to dark- or brownish-gray, moderately to well-indurated, very thin- to very thick-bedded, tabular to broadly lenticular, internally massive to horizontal-planar or ripple-laminated to brecciated dolomite or, rarely, dolomitic limestone. These are largely non-fossiliferous, slightly to very vuggy, and may emit a fetid or oily scent when struck. Wackestone, grainstone, and rudstone are recognized from the Torres Member, and four to six dolomite intervals may be traced over 100s of meters or more (Lucas et al., 2013). Torres Member gypsum is whitish to dark-gray to mottled (red-yellow-gray), very poorly to well-indurated, massive or thin- to medium-bedded, internally massive or nodular to wavy laminated, and occasionally sandy with up to 5–7% grains of subangular to rounded, vfU–mL sand composed of at least 10% lithics (dark mafics) and feldspar. Mudstone and siltstone are light-red or brownish-red, very poorly to poorly indurated, non- to slightly calcareous, massive or thin-bedded, internally massive to vaguely ripple-laminated, and commonly gypsiferous. Sandstone in the Torres Member is yellowish, weakly calcareous, moderately well-sorted, and dominantly fine-grained with common gypsum flakes. The total thickness of the Los Vallos Formation in the quadrangle is uncertain due to poor exposure of the basal Torres Member and pervasive folding. However, a stratigraphic section and well logs suggest a thickness of approximately 235 m in the east-central part of the quadrangle.

Pym — **Meseta Blanca Formation of the Yeso Group** (Lower Permian)—Whitish-gray to buff or pinkish-tan to occasionally green mottled, variably indurated to friable, thin- to medium-bedded, tabular, internally massive to low-angle planar or trough cross-stratified, moderately well- to well-sorted, subangular to rounded, vfL–mL sandstone composed of 80–95% quartz, 2–20% feldspar (plagioclase and minor potassium feldspar), and trace to 3% lithics (dark mafics and mica). Less common are intervals of reddish-brown, moderately indurated, calcite-cemented, thin- to medium-bedded, tabular to lenticular, ripple cross-stratified (asymmetric), very well-sorted, arkosic vfL–vfU sandstone. Induration and texture impart a metaquartzite-like appearance to some intervals (Lucas et al., 2013). Siltstones containing halite pseudomorphs low in the unit are common elsewhere (Lucas et al., 2013) but not well-exposed in the map area. The lower contact with the Abo Formation is gradational and has not been strictly defined. We have mapped this contact at the approximate level where lighter-red/orangish sandstones of the Meseta Blanca predominate over generally darker-red sandstones and relatively thick, brick-red mudstones of the Abo Formation. In the north-central quadrangle, the unit is commonly mantled by 1–2 m of alluvial material that is not mapped due to its thin and discontinuous nature. Approximately 97 m thick in the west-central part of the quadrangle.

Pa — **Abo Formation** (Lower Permian)—Interbedded dark-reddish-brown to pale-red or dark-purplish-brown to maroon siltstone and very fine- to medium-grained sandstone. Sandstones are moderately indurated, non- to weakly calcareous, thin- to medium-bedded, internally massive or vaguely horizontal-planar to low-angle planar cross-laminated, well- to very well-sorted and arkosic. Contains trace to 2% subangular to subrounded, fL–cL sand grains composed of quartz, feldspar, dark mafics, and/or mica. Moderately well-exposed in the northwestern part of the quadrangle with a maximum thickness of approximately 235 m.

Pb — **Bursum Formation** (Upper Pennsylvanian to Lower Permian)—Interstratified red to maroon and greenish-gray mudstone and shale, reddish- to yellowish-brown sandstone, gray fossiliferous limestone, and minor intraformational (limestone-clast) conglomerate beds. Poorly exposed on this quadrangle. Approximately 76 m thick (Scott et al., 2005; Allen et al., 2014).

ℙa — **Atrasado Formation** (Upper Pennsylvanian)—Cross section only. Gray, thin- to thick-bedded, fossiliferous limestone and intervening intervals dominated by greenish-gray to reddish-brown siliciclastic mudstone, siltstone, and calcareous shale. Cross-stratified to planar-laminated, silty sandstone to pebbly sandstone in thick, lenticular channel fills are common. 180–240 m thick (Allen et al., 2014).

ℙg — **Gray Mesa Formation** (Middle Pennsylvanian)—Cross section only. Medium- to thick-bedded, fossiliferous, cherty limestone and siliciclastic deposits consisting of mudstone, shale, and sandstone. Approximately 120 m thick (Allen et al., 2014).

ℙs — **Sandia Formation** (Middle Pennsylvanian)—Cross section only. Greenish-gray, reddish-brown, and yellowish mudstone to silty or sandy shale and calcareous shale, yellowish- and reddish-brown, gray, and greenish-gray planar-laminated and cross-stratified sandstone to pebble conglomerate, and gray to brownish-gray fossiliferous limestone and sandy limestone. Approximately 70 m to more than 100 m thick (Allen et al., 2014).

PROTEROZOIC

Xu — **Paleoproterozoic rocks, undivided** (Paleoproterozoic)— Cross section only. Chiefly the lower member of the Sevilleta Metarhyolite, described by Allen et al. (2014) as medium-gray to black, dense, finely banded metarhyolite with minor white mica, oxides, epidote, and biotite. Speckled with 1.0-2.5 mm white feldspar crystals that have been sericitized.

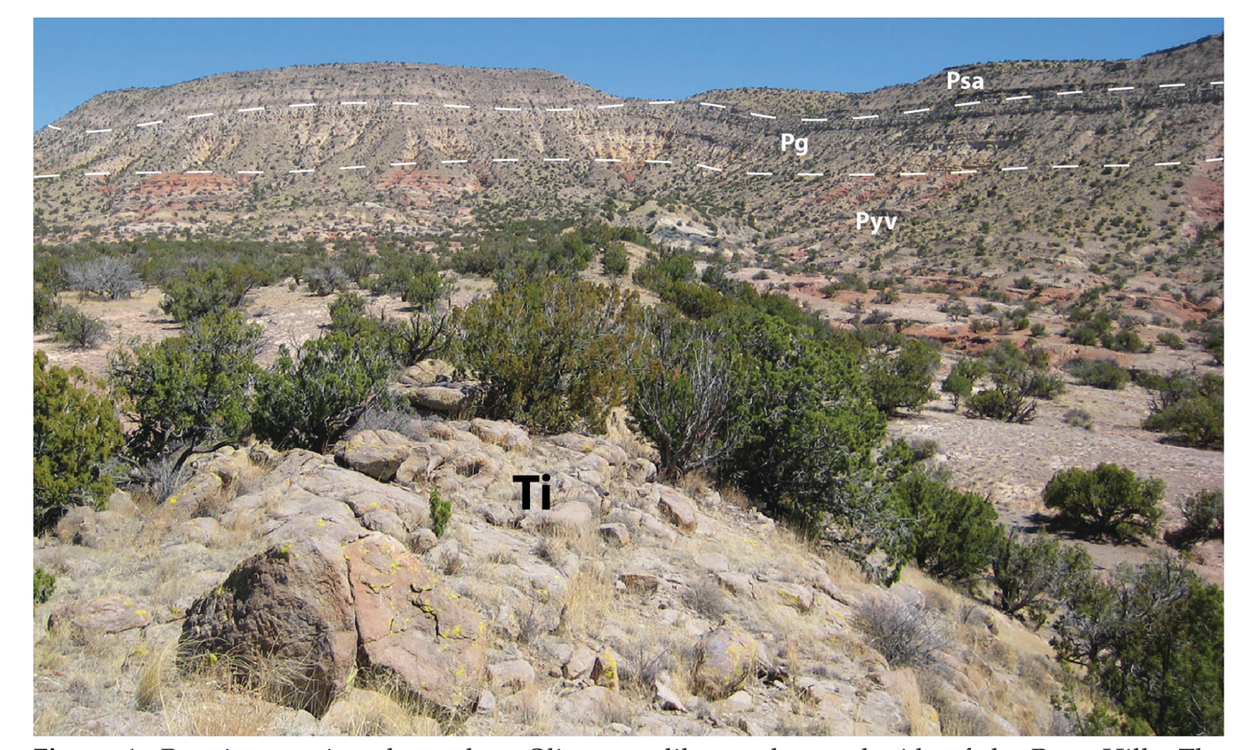


Figure 1—Permian stratigraphy and an Oligocene dike on the south side of the Rayo Hills. The monzonitic dike (**Ti**) intrudes and warps the Los Vallos Formation of the Yeso Group (**Pyv**) but does not breach its upper contact with the Glorieta Sandstone (**Pg**). Instead, a gentle anticline has formed over the dike in the Glorieta and overlying San Andres Formation (**Psa**) that can be traced for at least 4 km to the northeast. View is toward the north. Photo taken from atop the dike at approximately 13S 366975mE 3792700mN NAD83.

Explanation of Map

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

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

Generic fault—Identity and existence are certain. Location is approximate where dashed and concealed where dotted.

Normal fault—Identity and existence are certain and questionable where queried. Location is accurate where solid, approximate where dashed, and concealed where dotted. Ball and bar on downthrown block.

Low-angle normal fault—Identity and existence are certain and questionable where queried. Location is accurate where solid and approximate where dashed. Half-circles on downthrown block.

Anticline—Identity and existence are certain. Location is accurate where solid, approximate where dashed, and concealed where dotted.

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

Monocline, anticlinal bend—Identity and existence are certain. Location is accurate where solid, approximate where dashed, and conclealed where dotted. Arrows show direction of dip; shorter arrow on steeper limb.

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

Inclined fault—Showing dip value and direction.

Horizontal bedding

Inclined bedding—Showing strike and dip.

Vertical bedding—Showing strike.

3,140 ± 30 BP — Radiometric sample locality—Showing age (if available at the time of publication).

A — A′ — Cross section line and label

Fault in cross section showing local up/down offset—The arrows show the relative motion along the fault plane.

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

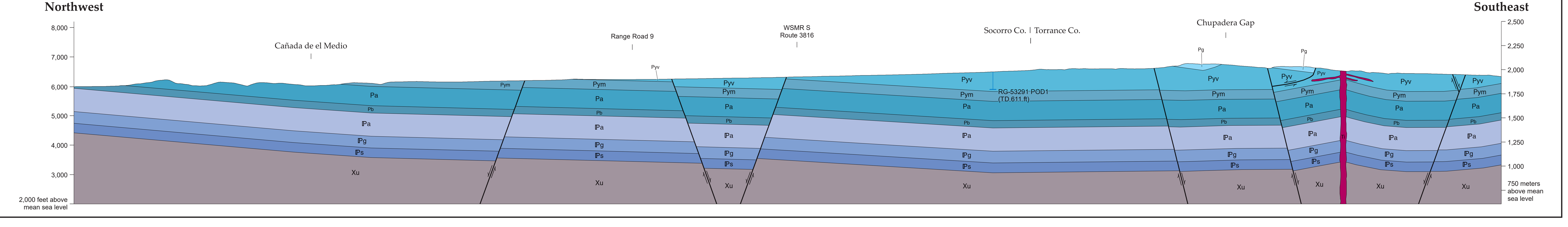
Comments to Map Users

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, a compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes may not be shown due to recent development. Cross sections are constructed based upon the interpretations of the author made from geologic mapping and available geophysical and subsurface (drill hole) data.

Cross sections should be used as an aid to understanding the general geologic framework of the map area and not be the sole source of information for use in locating or designing wells, buildings, roads, or other human-made structures.

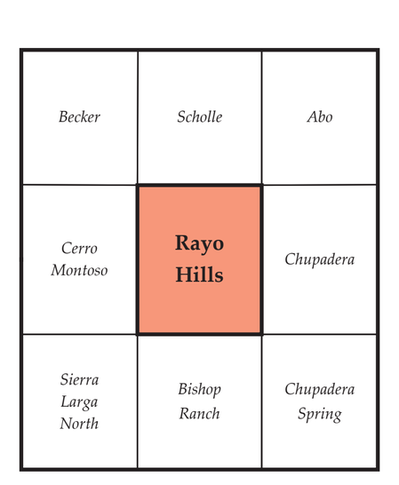
The New Mexico Bureau of Geology and Mineral Resources created the Open-File Geologic Map Series to expedite the dissemination of these geologic maps and map data to the public as rapidly as possible while allowing for map revision as geologists continued to work in map areas. Each map sheet carries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

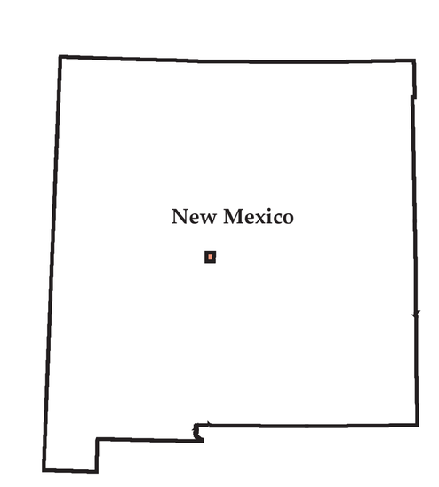
Geologic Cross Section A–A'



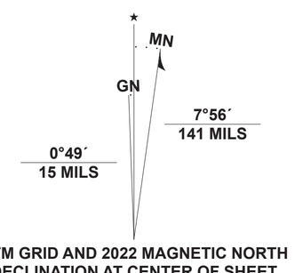
Base map from U.S. Geological Survey 2021.
North American Datum of 1983 (NAD83)
Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 13S, shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983 (Central zone), shown in red.

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





Quadrangle Location



1:24,000

1 0.5 0 1 Mile

1000 0 1000 2000 3000 4000 5000 6000 7000 Feet

1 0.5 0 1 Kilometer

Contour Interval 20 Feet

North American Vertical Datum of 1988

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 300

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Geologic Map of the Rayo Hills 7.5-Minute Quadrangle, Socorro and Torrance Counties, New Mexico

September 2022

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

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