" Tongue—White to pale-brown coarsening-upwards sequence of sandstones. Sandstones grade upwards from poorly sorted, muddy, and very fine-grained to moderately sorted, clean, and fine- to medium-grained. Grains are angular to rounded, mainly quartz with rare (<5%) tabular feldspars, rare (<2%) black ferromagnesian lithics, and trace biotite and detrital clay. Beds are planar tabular, and grade upwards from medium thickness (10-20 cm) and massive to medium-thick (20-40cm) and planar cross-stratified or massive. Trace shell imprints and burrows become more abundant upsection, and local fossiliferous zones occur throughout. "C" tongue assignment after

Molenaar et al. (1996). Unit thickness is about 10 m.

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Twowells Tongue—Pale-gray to pale-brown, coarsening-upwards sequence of sandstones. Sandstones grade upwards from poorly sorted, muddy, and very fine-grained to well-sorted, clean, and fine-grained. Grains are subangular to subrounded, mainly quartz with rare (<3%) siliceous lithics, rare (<2%) detrital clays, and trace tabular feldspar and black ferromagnesian lithics. Beds grade upwards from medium-thick (10–40 cm), internally wavy-laminated, and planar-tabular to thin to

Paguate Tongue—Pale-brown to yellow, coarsening-upwards sequence of sandstones. Sandstones grade upwards from poorly sorted, muddy, and very fine-grained to moderately well-sorted, clean, and fine-grained with medium-grained lenses. Grains are subrounded to rounded, mainly quartz with rare (<5%) tabular feldspars, rare (<5%) siliceous lithics, rare (<2%) detrital clays, and trace black ferromagnesian lithics. Beds are medium to thick (10-50 cm) and grade upwards from massive and planar tabular to cross-stratified and planar wedge-shaped. Colors of 2.5Y7/4 and 8/6 measured. Unit thickness is about 12–19 m.

black ferromagnesian lithics. Beds grade upwards from massive or internally planar-laminated, medium to thick (10-50 cm), and planar-tabular to cross-stratified, in abundance upsection. Locally fossiliferous. Unit thickness is 10–15 m.

measured. Thickness is <1- to 5 m. **High-level pediment gravels**—Pale-gray to pink cobbly pebble-gravel and pebbly sands. Gravel are poorly sorted, subrounded-rounded, pebbles with lesser (30-40%) cobbles and trace boulders of aphanitic basalt, lesser coarse basalt porphyry, and trace phaneritic mafic and felsic lithologies, with local trace well-rounded siliceous pebbles. Sands are

Largely fine-grained basalt—Light- to medium-gray (weathering brownish-gray to black), fine-grained, slightly porphyritic basalt. Matrix is mainly fine-grained, with minor visible plagioclase and trace pyroxene, and very sparse olivine oriddingsite. Trace phenocrysts of plagioclase up to 1 cm across and lesser pyroxene up to 1 mm across. Irregular basal contact with underlying Tbcp; outcrops of Tbfp are often inset against

development, none to minimal carbonate accumulation, and lack of Bt horizon medium-grained, plagioclase-pyroxene porphyritic basalt. Phenocrysts are relatively common (8-15% of faces), of mainly euhedral-subhedral plagioclase up to 1 cm across and trace anhedral pyroxene up to 1 mm across. Matrix consists of plagioclase, pyroxene, Morrison Formation

> nedium-grained, phenocryst-rich, plagioclase-pyroxene porphyry basalt. Phenocrysts are common (25-40% of faces), of mainly subhedral-anhedral plagioclase lathes and plates as much as 1 cm across, with rare anhedral pyroxene up to 2 mm across and sparse anhedral olivine << 1 mm across. Matrix consists of plagioclase, pyroxene, olivine, and glass. Possibly correlates to unit Tbcp. Thickness is 4–12 m.

Alluvium underlying Ancestral Rio San Jose Qt3 terrace surfaces—Deposits of sandy

Intrusive Rocks pebble to boulder size gravel composed of basalt, quartzite, chert sandstone, andesite, **Picacho Peak basaltic intrusion**—Well-jointed olivine basalt intrusion. Dark-gray, dacite, granite, minor rhyolite, limestone, and obsidian clasts underlying terrace weathering brownish-dark-gray to brown, fine porphyry basalt with phenocrysts all <1 surfaces located approximately 12–20 m above Rio San Jose valley floor/local base level. Deposits include interbedded trough cross-bedded to low angle cross bedded quartz lithic sands. Deposit is 6–12 m thick, with maximum thickness observed in channel filling deposits. Boulder-size fraction of deposit is primarily basalt in composition.

**Young fan alluvium**—Typically fan-shaped deposits of sand, silt, clay, and gravel up to poulder size emanating from tributary drainages. Deposits are characterized by weakly eveloped soils with 10YR-7.5YR color (reflecting varying parent material), none to Stage I carbonate morphology, and lack of Bt horizon development. Deposit thickness is attitude laterally. Generally, Thickness is <1– to 4 m, locally as much as 20 m. <5 m to 10 m or more. Grades into alluvial deposits of major drainages down-slope.

**Deposits underlying Qf4 surfaces**—Part of fan complex at the mouth of Water, Timber, Castillo, and Encinal Canyons; Qf4 surfaces form part of the modern piedmont. Deposits **D-Cross Member**—Gray to brownish-gray, gypsiferous, thinly laminated shales, lesser of fine sand to coarse gravel; typically interbedded fine to medium sand and locally siltstones, local sandy shales, and trace sparry gypsum beds overlying Kmj and imbricated cobble- to boulder-size gravel with individual gravel beds 0.25–3 m thick.

Qf4 deposits described on adjacent quadrangles typically include buried soils. Base of deposit is poorly exposed, but locally observe Qf4 gravel overlying Cretaceous bedrock units; total thickness is 2–10 m or more. Qf4 soils are characterized by cambic (Bw) or weakly developed carbonate (Bk) horizons, with maximum Stage I+ carbonate morphology, locally include buried Bw or Bk horizons. Deposits underlying Qf3 surfaces—Part of fan complex at themouth of Water, Timber, astillo, and Encinal Canyons; Qf3 surfaces form part of the modern piedmont. Deposits f sandy pebble to boulder gravel of mixed volcanic lithologies and subordinate

Soils are partially eroded, but exhibit Stage II to III carbonate morphology, Bt horizon Deposits underlying Qf2 surfaces—Deposits of sandy, rounded to subrounded, basalt boulders with subordinate pebbles and cobbles of rounded andesite and subrounded dacite, with rare quartzite and sandstone clasts underlying remnant fan surfaces west of Encinal Creek in the northwest corner of the Quadrangle near Picacho Peak. Deposit is approximately 4 m thick, Qf2 fan surfaces are 12–15 m above local base level. Soils are partially stripped; thin, discontinuous CaCO<sub>3</sub> coatings are observed on some clasts.

**Deposits underlying Qf1 surfaces**—Deposits of rounded to subangular sandy pebble to boulder gravel underlying small remnant fan surfaces west of Encinal Creek. Deposit is extensively eroded; remnants are 1-4 m thick gravel lag overlying Paguate Tongue of Dakota Sandstone mesas. Clast composition is predominantly subangular basalt boulders up to 70 cm in diameter, with common angular quartz and quartzite pebbles and cobbles, plus rounded chert pebbles, minor granite, rare sandstone, limestone, andesite, rhyolite, obsidian, and petrified wood. Deposit may include young colluvium from adjacent tributary drainages. Qf1 fan surfaces are approximately 35 m above local base level. Soils are stripped.

Older fan alluvium, undivided-Deposits of gravels, sands, and muds underlying dissected remnant fan surfaces lying above adjacent Holocene Qfy surfaces. Deposit compositions are reflective of upstream source areas, but deposits are poorly exposed. Fan surfaces are as much as 20 m above nearby channels. Deposit thicknesses are <1 to

Older calcareous alluvium and tufa—Light-brown to gray calcareous alluvium overlain by pinkish-white tufa. Calcareous alluvium consists of light-brown (10YR 6/4 measured), massive, calcite spar-bearing sands; light-gray to yellow (10YR 7/2-7/6), laminated, muddy fine sands; and light-gray (10YR 7/1), undulatory-tabular to irregular-bedded thin beds of sandy clays. Spar-bearing sands are mainly poorly sorted, very fine siliceous grains and fine to coarse, angular carbonate grains (calcite spar) in loose, grain-supported, massive, very thick beds, with local imbrication of spar grains indicating alluvial transport and not in situ growth. Laminated muddy sands are mainly poorly sorted very fine grains of quartz with trace feldspars, siliceous lithics, and carbonate nodules in planar laminated thin to medium, undulatory tabular beds. Red oximorphic textures (irregular bands of pale brown to orange Fe-oxides) are locally abundant in sandy beds. Tufa consists of very fine-sand-sized grains coated and bridged **Crevasse Canyon Formation** by carbonate mud that locally forms cemented aggregates. Beds are massive, very thick, and low-density, with common narrow subvertical wavy-laminated carbonate fracture-fills particularly apparent at bed surfaces. Colors 10YR 8.5/2-9.5/2 measured. Base of tufa marked by very thin bands of Mn-oxides. Unit thins southward to a pinch-out south of the quadrangle boundary. Base unexposed on the quadrangle, unit thickness is at least 8 m.

Age<sup>1</sup> (Ma)  $\pm 2\sigma^2$  Type Ref.3 Comments

2.114 | 0.012 | Ar/Ar | C1

0.11 0.152 K-Ar L93

0.322 | 0.011 | Ar/Ar | C15

Qwcp

2: Uncertainty as published; converted to  $\pm 2\sigma$  as needed.

4.49 | 0.16 | Ar/Ar | H97 | Volcanic plug in the northwest of the quadrangle

0.38 | 0.25\*\* | K-Ar | LM79 | \*\*Uncertain if published error is 1 or 2 standard deviations

3: C15 - Channer et al., 2015; G15 - Goff et al., 2015; L93 - Laughlin et al., 1993; LM79 - Lipman and Mehnert, Hallet, 1979; H97 - et al., 1997; MS67 - Moench and Schlee, 1967.

2.49 0.06 Ar/Ar G15 Correlates to unit Qpptb of G15

0.12 0.146 K-Ar L93 Re-analysis of above

2.42 | 0.18 | K-Ar | LM79 | Too old, as compared to Ar/Ar ages

Artificial fill—Gravel, sand, and mud deposits associated with anthropogenic activities. **Basalt of Laguna Pueblo**—Dark-gray, mainly fine-grained basalt. Trace, fine phenocrysts of pyroxene, plagioclase, and olivine. Age estimates range from 0.11 (± 0.15) to 0.38 (± Map unit includes compacted fill beneath roads and dams, as well as variably ompacted piles associated with the Jackpile mine. Mapped only where a deposit .25) Ma; most recent and most precise age estimate is  $0.322 \pm 0.011$  Ma (Table 1). obscures the underlying geology or is particularly thick. Deposits are mainly 0-5 m Intercalates with valley-floor alluvium. 4–12 m thick. thick, but up to 65 m thick in the Jackpile mine.

Wheat Mountain Basalts and Alluvium

Cinder and pyroclastics—Dark-reddish-brown to black, abundantly vesicular, basaltic Eolian deposits - Deposits of 3-8 m thick of well-sorted, rounded to subrounded, lapilli, bombs, and lesser solid basalt. Lapilli and bombs bear absent to rare (up to 2% of fine-grained quartz sand with 7.5YR to 10YR color. Upper 3 m includes loose, faces) phenocrysts of plagioclase and lesser pyroxene, generally <0.5 mm across, locally unconsolidated sand with weakly developed soil (A-Bw-C profile). Thicker sand up to 4 mm across. Base unexposed; are <1 to at least 80 m thick.

deposits include buried soil with Stage II CaCO<sub>3</sub> horizon 3 m or more below ground Fine-grained basalt-Medium-dark-gray (weathering medium-dark-brown), fine- to nedium-grained, generally non-porphyritic basalt. Matrix consists dominantly of **Eolian dune sands**—Very fine- to fine-grained sands transported mainly be eolian ubequal plagioclase and pyroxene with trace, fine olivine (variably weathered to processes and accumulated into parabolic and longitudinal duneforms. Sands are iddingsite) and light-brown to greenish-gray clay aggregates, with very sparse well-sorted, rounded to subrounded, and dominantly of quartz. Surface soils are absent phenocrysts of degraded pyroxene up to 4 mm across and lesser plagioclase up to 1 mm to weakly developed. Map unit includes interdunal slopewash deposits. Deposits are across. Trace crystalline xenoliths. Reported K-Ar age of 2.42 ±0.18 Ma (Table 1) is likely too old. Thickness is <1–12 m thick.

Medium plagioclase porphyry basalt—Medium-gray (weathering brownish-gray to dark-brown), fine- to medium-grained, slightly porphyritic basalt bearing medium-size phenocrysts of plagioclase. Matrix consists of abundant plagioclase with lesser pyroxene, Colluvium—Poorly sorted slope wash and mass wasting deposits from local sources with common fine grained eolian sand matrix at surface; mapped only where extensive with the abundant plagioclase crystal faces imparting a glistening appearance to fresh faces in bright sunlight. Trace phenocrysts of plagioclase up to 3 mm across and lesser pyroxene up to 0.5 mm across. Trace crystalline xenoliths. Thickness is <1–6 m.

Coarse plagioclase porphyry basalt—Medium-gray (weathering dark-brownish-gray to mantling slopes beneath bluffs of basalt. Deposits typically consist of gravels with little black), fine- to medium-grained, slightly porphyritic basalt bearing coarse phenocrysts of matrix sands or muds; gravels are angular and principally of basalts with trace plagioclase. Matrix consists of plagioclase and lesser to subequal pyroxene, with trace very fine olivine. Trace phenocrysts of plagioclase as much as 8 mm across and lesser pyroxene up to 1 mm across. Age estimate of 2.114 ± 0.012 Ma (Table 1). Thickness is <1-6 Colluvial fans—Fan- or cone-shaped deposits of poorly sorted bouldery gravels and sands. Gravels are dominantly basalts with lesser sandstones in massive beds. Slope-parallel bar-and-swale topography is commonly apparent in aerial imagery and High-level pediment gravels—Strong brown clayey sands with lesser basalt-rich on the ground that is at least in part constructed of debris flow levees. Deposits are pebble-gravels underlying basalts at the southern tip of Clay Mesa. Sands are poorly

sorted, very fine- to very coarse-grained, subrounded, and consisting dominantly of basaltic lithics with lesser but common plagioclase crystals. Clay occurs as bridges Landslides — Poorly sorted debris that has moved chaotically down steep slopes; slumps between and envelopes around sand grains. Color of 7.5YR 5/6 measured. Gravel beds or block slides (toreva blocks) partially to completely intact, that have moved down are lenticular (<1-80 cm thick), trough cross-stratified channel-fills consisting of slope; slumps and block slides usually display some rotation relative to their failure poorly-sorted, clast-supported, subrounded-rounded pebbles with rare cobbles of plane; thickness varies considerably depending on the size and nature of the landslide. aphanitic basalts, coarse porphyry basalts, lesser fine porphyry basalts, and trace quartz Blocky basalt underlain by and/or jumbled chaotically with Cretaceous sandstone blocks sandstones, with a clayey sand matrix. Thickness is <1–2.5 m. and minor gravel from the unit QTpal form local caprock over more erodible shale or

Mount Taylor Volcanic Field Basalts and Alluivum

High-level ancestral Rio San Jose gravels—Siliceous-lithology-rich sandy gravels underlying basalts at the southern tip of Frog Mesa. Gravels are poorly sorted, subrounded to rounded pebbles with trace cobbles of quartzites, granites, cherts, porphyritic rhyolites, fine-grained mafic-intermediate volcanics, pale brown quartz sandstones, and reddish brown fine-grained sandstones. Sands are pink to reddish-yellow (7.5YR 8/4-8/6 measured), poorly sorted, subrounded to rounded, very fine to fine grains of mainly quartz and siliceous lithics, weakly cemented by calcium carbonate. Poorly exposed; Thickness is <1 to no more than 2 m.

Medium pyroxene porphyry basalt-Medium-gray (weathering grayish-brown to plack), fine- to medium-grained, porphyritic basalt. Matrix is mainly plagioclase with lesser pyroxene. Phenocrysts are rare (up to 5% of faces) and consist of rounded pyroxene and plagioclase up to 1 cm across. Likely correlates to unit **Qpptb** of Goff et al. (2015), which has an age estimate of  $2.49 \pm 0.06$  Ma (Table 1). Thickness is 3–15 m.

High-level travertine—Pale-yellowish-pink to white, fossiliferous, fine-grained limestones overlying the Tbcp basalt. Coarsens up-section from thickly-laminated arbonate mudstones to medium-thick bedded, very fine-grained packstones; thinner beds are planar-tabular, thicker beds commonly wavy-tabular. Trace fossils consist of conical coiled snail shells and narrow tubular root casts. Colors of 7.5YR 9.5/2 to N

plagioclase, weakly cemented by carbonates. Color of 7.5YR 8/3 measured. Local thin ash beds up to 6 cm thick. Poorly exposed. Thickness is <1 to perhaps 6 m.

those of Tbcp. Thickness is <1–8 m. underlying Qt4 surfaces are weakly developed, with 10YR color, minimal horizon Coarse plagioclase porphyry basalt—Light-gray (weathering brownish-gray and black),

and glass. Likely correlates to unit Tmpxb of Goff etal. (2015), which has a K-Ar age estimate of  $2.93 \pm 0.12$  Ma (Table 1). Thickness is <1– to 16 m. Crystal-rich plagioclase porphyry basalt—Dark-gray (weathering brown to black)

mm across but common, roughly 10-15% of fresh faces, and consisting of olivine, plagioclase, and pyroxene that are often concentrated in aggregates up to 1 cm across that result in pale-gray or very-dark-gray "spots" or "clots"on weathered faces. Olivine is commonly reduced to reddish-brown iddingsite. Ubiuquitous, commonly subhorizontal columnar jointing. <sup>40</sup>Ar/<sup>39</sup>Ar age estimate of 4.49 ±0.16 Ma (Table 1). As much as 60 m Thin basaltic intrusions—Very-dark-gray to brownish-gray (locally greenish, and

weathering to light- or dark-brown), fine- to medium-grained, slightly porphyritic, thin asaltic intrusions. Matrices are dominantly pyroxene and plagioclase. Phenocrysts are absent to trace, most commonly pyroxene but locally plagioclase, generally <2 mm across. Often weather to rounded, granular outcrops. Intrusions of all attitudes (dikes, sills, and inclined) are found, with individual intrusions not uncommonly changing

underlying **Kgc**. Poorly exposed. Unit thickness about 25–30 m.

Juana Lopez Member-Two light-brown to light-yellowish-brown, fossiliferous, calcarenite intervals bracketing an interval of noncalcareous shale. Calcarenites consist of moderately to poorly sorted, subrounded to rounded, very fine- to fine-sand-sized, vitreous light-gray grains that Dane et al. (1966) determined to be principally bioclastic debris, in grain-supported, very thin (1–3 cm) planar-tabular beds with absent to vague internal planar laminations. Calcarenite intervals are each 1-2 m thick. Colors 7.5YR 6/3 and 10YR 6/4 measured. Fossils include Cameleolophalugubris, Inoceramus dimidius, and Scaphites. Intervening shales, which dominate the section, resemble typical Mancos sandstone clasts greater than 3 m thick; base of deposit poorly exposed. Qf3 surfaces are shales. Unit thickness about 10-15 m. generally 1–2 m higher in elevation than adjacent Qf4 surfaces, but may merge with Qf4.

Semilla Sandstone Member—Interval of interbedded light-gray to light-yellowish-brown sandstones and concretionary shales. Sandstones consist of moderately to poorly sorted, variably muddy, subrounded-rounded, very fine to fine Zuni Sandstone grains of dominantly quartz, in very thin to thin, lenticular to planar-tabular, typically cross-stratified (planar, tangential, or trough) beds. Colors 10YR 7/2, 2.5Y 7/1 and 6/3 measured. Bed thickness, lateral continuity, and abundance-as well as grain size of sandstone beds-increase upsection; sandstones are subordinate to shales throughout, however. Shales resemble typical Mancos shales, with the exception of local concretions

up to 1 m across throughout the interval. Unit thickness is about 20 m. Rio Salado Tongue – Gray to brownish-gray, gypsiferous, thinly laminated shales, lesser siltstones, local sandy shales, and trace sparry gypsum beds underlying Kms. As a stratigraphic unit, the Rio Salado includes the Bridge Creek beds and continues down to the top of Kdt; as a map unit, as used here, Kmr only extends down to the top of the Bridge Creek beds. Poorly exposed. Unit thickness is about 90–100 m.

Bridge Creek beds and underlying shales of the Rio SaladoTongue-Interbedded light- to dark-gray shales, gray limey shales, and white limestones. Shales (colors N 5/1-4/1 measured) are similar to typical Mancos shales. Limey shales (color 2.5Y 5/1 measured) are fine-grained, very-thin to thin (2–5 cm) planar tabular bedded, with common cross-laminae. Limestones (colors 10YR-2.5Y 8/1 measured) are fine-grained with trace very fine-sand-sized grains, massive, locally fossiliferous, and thinly (7-10 cm thick) planar or undulatory tabular bedded. Limy shales and limestones weather to Map unit, as used here, includes all Rio Salado shales below the Bridge Creek beds down to the top of Kdt. Unit thickness is about 12–17 m.

Whitewater Arroyo Tongue-Gray to brownish-gray, gypsiferous, thinly laminated shales, lesser siltstones, local sandy shales, and trace sparry gypsum beds overlying Kdp and underlying Kdt. Poorly exposed. Unit thickness is about 26-40 m, thickening

Clay Mesa Tongue—Gray to brownish-gray, gypsiferous, thinly laminated shales, lesser

siltstones, local sandy shales, and trace sparry gypsum beds overlying Kdc and

Rio San Jose Valley

Dilco Member-Interbedded siltstones, sandstones, shales, and local thin coal seams.

underlying Kdp. Poorly exposed. Unit thickness is about 20–26 m.

incompletely preserved on this quadrangle. Here consists mainly of light-gray to plive-brown, gypsiferous, fissile shales and pale-brown sandstones. Sandstones consist of moderately sorted, subrounded to rounded, fine grains of mainly quartz and siliceous lithics with minor (<15%) tabular feldspars, and rare (<5%) black ferromagnesian lithics, with clays occurring as partial grain coats. Beds are medium thickness (10-30 cm), planar tabular, commonly massive but locally cross-stratified. Preserved thickness is no more than 32 m.

medium (5–15 cm), internally cross-stratified or massive, and planar- or undulatory-tabular. Colors of 10YR 8/1-8/2 and 2.5Y 7/2 measured. Bedding-parallel burrows are common near the top, with rare bedding-perpendicular burrows. Unit

medium thickness, and planar-wedge-shaped. Colors 2.5Y 8/2-9/2 and 7.5YR 4/6 measured. Bedding-parallel and bedding-perpendicular burrows throughout, increasing Discontinuous upper Cubero Tongue - Local pale-brown to very pale-brown coarsening-upwards sequence of sandstones overlying the main Kdc tongue. Sandstones grade upwards from moderately sorted, muddy, and very fine-grained to well sorted, clean, and fine-grained. Grains are subrounded to rounded, mainly quartz with trace

Cubero Tongue—Pale-gray to very pale-brown coarsening-upwards sequence of

sandstones. Sandstones grade upwards from poorly sorted, muddy, and very

fine-grained to well-sorted, clean, and fine-grained. Grains are subrounded to rounded,

mainly quartz with rare (<5%) tabular feldspars, rare (<2%) siliceous lithics, and trace

tabular feldspars and siliceous lithics. Beds grade upwards from massive, thick, and

planar-tabular to planar cross-stratified, medium, and planar- or undulatory-tabular.

Colors of 10YR 7/4 and 7.5YR 7/2 measured. Thickness is <1–4 m. Upper Oak Canyon Member—Gray to locally pale-yellowish-brown, thinly laminated, fissile shales. Colors of 10YR 6/1-5/1 and 7/6 measured. Poorly exposed. Unit thickness

Lower Oak Canyon Member—Interbedded, pale-gray sandstones and gray shales. Sandstones consist of moderately well-sorted, subangular to rounded, very fine to medium grains of dominantly quartz, rare (<3%) tabular feldspars, and trace gray siliceous lithics and black ferromagnesian lithics, in 0.5–5-m-thick intervals of medium to thick (10-60 cm), planar-tabular, planar-wedge-shaped, and lenticular beds with common planar or trough cross-stratification. Sandstone occurrence varies throughout the quadrangle, from 4 thin intervals to 2 thick intervals, each separated by shales. Colors of 2.5Y 8/1, 10YR 8/3, and locally 5YR 8/3 measured. Intervening shale intervals

resemble those of Kdou. Unit thickness is about 10–22 m.

Variable unit thickness ranges from <1 to about 10 m.

Encinal Canyon Member—White to pink, variably pebbly, variably kaolinitic, fine- to coarse-grained sandstones and trace pebble conglomerate. Sandstones consist of poorly sorted, angular to subrounded, fine to very coarse grains of mainly quartz with minor (<25%) siliceous lithics (chalky white chert, gray quartzite or chert, and lesser brown to black chert) and trace tabular feldspars in thin to thick (up to 0.7 m), lenticular, trough cross-stratified, commonly fining-upsection beds. Pebbles are up to 1 cm across, concentrated at the bases of fining-upwards sequences, and consist of angular to rounded siliceous lithics of gray quartzite, chalky white chert, and lesser brown to black chert. Chalky, white, disseminated clays are common between grains, but grain-enveloping aggregates (as seen in Jmj) are rare. Base of unit is wavy to irregular, generally scoured, and locally marked by abundant clayey mudstones and discoloration.

Jackpile Sandstone Member—White, kaolinitic, fine- to coarse-grained sandstones. Sandstones consist of poorly sorted, angular to subrounded, fine to coarse (locally very coarse) grains of mainly quartz and siliceous lithics, rare (<3%) tabular feldspars, and rare black ferromagnesian lithics, with abundant chalky-white kaolinitic clays in grain-enveloping aggregates that impart a white-spotted appearance to outcrops. Beds are mostly medium (locally thick, up to 0.7 m), undulatory-tabular, locally with scoured bases, and bearing common but indistinct trough and planar cross-stratification. Color of 10YR 8.5/1 measured. Trace mudstone interbeds are up to 5 cm thick, internally irregularly or planar laminated, and pale-greenish-gray to pink; similar mudstones occur as rip-up clasts in sandstone beds. Thickens northward, not present south of the Rio San Jose; overall thickness is <1 to 30 m.

Brushy Basin Member-Varicolored clayey mudstones with rare sandstones. Mudstones are poorly exposed and weather to rounded, popcorn-textured hills and slopes; where exposed, mudstones are planar-laminated, with gradational and/or mottled colors ranging from light-reddish-brown to pink to greenish-gray (7.5R5/2, 2.5YR 5/3, 5GY 7/1, and 10GY 7/1 measured). Sparse very fine-sand grains found throughout. Sandstones are like those of Jmbs, <2 m thick, and broadly lenticular or otherwise discontinuous. Unit thickness is (including Jmbs bands) about 40-80 m, erosionally thinned in the south of the quadrangle.

Mappable sandstone bodies in the Brushy Basin Member-Pale-yellow, discontinuous, locally pebbly sandstone bands intercalated into Jmb clayey mudstones. Sandstones consist of poorly sorted, angular to subrounded, fine to very fine grains of mainly quartz with minor (10–15%) tabular feldspars, minor (10–15%) pink to brown to gray siliceous lithics, and trace black ferromagnesian lithics with rare white-chalky clay or carbonate nodules up to 4 mm across, in mainly thin to medium (0-40 cm thick), lenticular, trough-cross-stratified beds. Pebbles up to 2 cm across are trace overall but up to 15% of beds, and consist of subangular to rounded, gray to brown siliceous lithics, rare granites, trace black chert, and trace mafic-intermediate volcanics. Individual bands

are up to 10 m thick, but commonly <2 m.

sand grains. Unit is 8–13 m thick.

Westwater Canyon Member-White, cross-stratified, variably pebbly, coarse-grained sandstones. Sandstones consist dominantly of poorly sorted, angular to rounded, fine to very coarse grains of dominantly quartz and siliceous lithics (mostly brown to gray cherts or quartzites, trace black and chalky-white cherts and white quartzites) with trace granitic and volcanic lithics in thin to medium (up to 20 cm), lenticular or undulatory, commonly trough cross-stratified beds with scoured bases. Colors of 2.5Y 8/1-9.5/1 measured. Gravel are pebbles and granules of siliceous lithologies. Generally about 5 m thick; thins to <1 m over some anticlinal folds.

weak-red to greenish-gray, variably sandy, commonly clayey mudstones; and local lenticular gray limestones. Proportions of components, as well as component colors, are variable across the quadrangle; typically, varicolored sandstones dominate. Sandstones are composed of moderately sorted, subangular to rounded, fine to very fine grains of dominantly quartz, variable (typically rare) siliceous lithics, rare (<2%) tabular feldspars, and trace black ferromagnesian lithics in thin to thick (max 1 m) beds that can be planar-tabular, undulatory-tabular, or lenticular. Thinner beds are typically cross-stratified, thicker beds typically massive. Colors of 2.5Y 7/2, 5Y 7/3, 5YR 6/4, and 5R 5/2 measured; individual beds may be mottled or laterally change color rapidly. Mudstones are clayey, bear variable very fine sand grains, are irregularly laminated, and are mottled, with colors 10Y 8/1, 5R 6/1, 7.5R 5/3 measured. Mudstone intervals are laterally discontinuous, but up to 2 m thick. Lenticular limestones are absent to locally common (concentrated near the upper contact) thin- to medium- beds of white to light-brown (8/N and 7.5YR 6/3 measured), fine-grained limestones with trace very fine

Fluvial facies—Interbedded light-gray to weak-red and red-gray mottled sandstones;

Eolian (principal) facies—Pale-yellow to light-brown, thickly- to very thickly-bedded, prominently cross-stratified fine- to medium-grained sandstones. Sandstones consist of clean, moderately well-sorted, subrounded-rounded, fine to medium grains of dominantly quartz, rare (<3%) siliceous lithics, and rare (<3%) tabular feldspars with trace clays and fine carbonate nodules, in very thick (1-2 m) tabular or undulatory planar beds that are commonly prominently high-angle cross-stratified (locally vaguely cross-stratified or massive). Colors of 2.5Y-5Y 8/2-8/3 and 7.5YR 6/4 measured. Variably calcite-cemented. Thickness is 30 to 40 m.

**Bluff Sandstone**—Mainly light-brown to pink, medium-thick bedded, variably structured fine sandstones with minor muddy sandstones and reddish-brown sandstones. Most sandstones are clean and consist of moderately sorted, subrounded to rounded, fine to very fine grains of dominantly quartz, rare brown siliceous lithics, and trace tabular feldspars with trace fine carbonate nodules in medium to thick (0.1-1 m thick) planar tabular beds. Beds are variably low-angle cross-stratified, massive, internally planar-laminated, or high-angle cross-stratified. Colors commonly 7.5YR 6/3-7/4 to 5YR 5/4-6/4, and less commonly 5YR 8/3 and 2.5YR 8/3; redder hues are more common in the southeastern corner of the quadrangle. Muddy sandstones are very fineto fine-grained and occur in medium to thick (0.3–0.5 m) intervals that are internally very thinly planar bedded (1-4 cm thick), and are otherwise like the clean sandstones. Thickness is 60 to 70 m.

ummerville Formation - Interbedded muddy very fine sandstones, sandy mudstones, and rare clean fine sandstones. Muddy sandstones and sandy mudstones are dominantly reddish-brown colors (2.5YR 5/4-6/4, 5YR 5/4 measured), with moderately-poorly sorted, subangular to rounded, very fine to fine sand grains of mainly quartz with rare (<4%) tabular feldspars, rare (<2%) medium-gray and black lithics, and rare fine carbonate nodules. These occur in 1–3 m thick intervals that are massive to thinly bedded, with commonly vague internal planar- or cross-laminations. Clean sandstones are pink (7.5YR 7/4 and 5YR 7/2 measured) and occur in massive to cross-stratified, 0.5-1 m thick planar beds. Sands are moderately sorted, mainly fine-grained, and dominantly of quartz, with rare (<2%) tabular feldspars, and trace black lithics. Base unexposed. Thickness is 40–55 m on the South Butte quadrangle to the south (Moench, 1964).

Entrada and Todilto Formations—Cross-section only. Gypsum, limestones, sandstones, and siltstones underlying the Summerville Formation and exposed on the South Butte quadrangle to the south.

Casa Blanca Mesa

3.72 | 0.02 | Ar/Ar | G15 | Not exposed on quadrangle; mapping by G15 and MS67 indicate Tbae underlies flows on Silver Dollar Mesa

0.12 K-Ar L93 Assignment of age to Tbcp based on description inreference ("high mesa surface...1 km north of Wheat Moutain")

### Geologic Cross-Section A-A'

## Wheat Mountain Silver Dollar Mesa

1: Age as published.

FIGURE 1—The town of Laguna, with Clay Mesa (left) and several higher, unnamed mesas (right and center) in the background. Pale-yellowish-brown outcrops flanking and beneath the town belong to the

Bluff and Zuni Sandstones; gray to pale-brown slopes at the bases of mesas are underlain by Morrison Formation strata; light-brown ledges in the upper halves of mesa slopes belong to Dakota sandstone

units; and mesas are capped by Plio-Pleistocene basalt flows.

Normal fault—Identity and existence are certain, location is accurate. Bar and ball on Anticline—Identity and existence are certain; questionable where queried. Location is accurate where line is solid, approximate where dashed, and concealed where dotted. Monocline—Identity and existence are certain, location is accurate. Monocline, anticlinal bend-Identity and existence are certain; questionable where queried. Location is approximate where dashed and concealed where dotted. Monocline, synclinal bend-Identity and existence are certain; questionable where queried. Location is approximate where dashed and concealed where dotted. Dike—Identity and existence certain, location accurate.

**Explanation of Map Symbols** 

Inclined contact, dike, key bed, clay bed, coal bed, or bed of economically important commodity—Showing dip value and direction Sediment transport direction determined from imbrication

Contact—Identity and existence are certain; questionable where queried. Location is

accurate where line is solid, approximate where dashed, and concealed where dotted.

**Anthropogenic Units** 

**Mass-wasting Units** 

sandstone units.

Recent Alluvium of the Rio San Jose

<1 to likely over 2 m.

Terrace Alluvium

blocks, forming distinctive benches.

surface. Coppice dunes are common surface feature.

poorly exposed; thicknesses are <1 to at least 10 m.

sandstone. Deposit thicknesses are <1 to perhaps 10 m.

poorly exposed; thicknesses are <1 to perhaps 10 m.

or where covering critical relations; thickness can locally exceed 15 m.

Younger colluvium—Unsorted, unvegetated or poorly vegetated bouldery gravels

Recent alluvium of the Rio San Jose-Loose sands, muds, and gravels along the

modern Rio San Jose channel. Alluvium is mainly sand and silt, with rare gravel lenses.

No appreciable surface soil development. Deposits are poorly exposed; thicknesses are

Slopewash alluvium—Slopewash deposits on hillslopes and alluvial, colluvial, and

eolian deposits mantling slopes below mesas and deposited behind large landslide

Valley-floor alluvium—Deposits of sand, silt, and gravel in valley bottoms; upper 5–10

m of Qal deposits are Middle to Late Holocene in age; older buried alluvial deposits in Rio San Jose valley are Pleistocene in age. Thickness of various alluvial deposits, based

on well log data (Risser and Lyford, 1983) and outcrop descriptions ranges from 5–20 m

in tributary drainages to approximately 50 m under the Rio San Jose valley floor near the

confluence with Encinal Canyon. Alluvium is typically silt and fine-grained sand with

interbedded pebble-to cobble-gravel lenses, eolian sand and thin lacustrine interbeds

along the Rio San Jose, and colluvial interbeds in tributary drainages. Deposits are

characterized by weakly-developed soils with 10YR-7.5YR color (reflecting varying

parent material), none to Stage I carbonate morphology, and lack of Bt horizon

is interbedded with one or more 3–5 m thick basalt flows (Risser and Lyford, 1983).

development. Rio San Jose alluvium includes coarse-grained sandy gravel sections and

Younger terrace deposits, undivided—Gravels and sands underlying terrace treads up

poorly sorted sands to cobbles and rare boulders of compositions reflecting upstream

Alluvium underlying Qt4 terrace surface—Deposits of sandy pebble to boulder size

gravel underlying terrace surfaces located approximately 3–5 m above local base level.

Alluvium underlying Ancestral Rio San Jose Qt4 terrace surfaces—Deposits of sandy

pebble to cobble size gravel comprising subrounded to rounded quartzite, limestone,

located approximately 6-8 m above local base level in western part of Quadrangle.

flow near Casa Blanca or strath terraces cut on Bluff Sandstone near Bang Bang Hill.

Pebble–cobble-size gravel is rounded-subrounded. Maximum Stage III carbonate.

Deposit thickness ranges from 3-4 m, locally observed as strath terrace cut on Laguna

Maximum Stage I+ carbonate, soils typically eroded. Overlain in places by up to 4 m of

pasalt, sandstone, chert, granite and rare metamorphic clasts underlying terrace surfaces

Deposit thickness ranges from 2 to greater than 6 m. Soils developed in deposits

to 6 m above nearby tributary drainage channels. Deposits consist of uncemented,

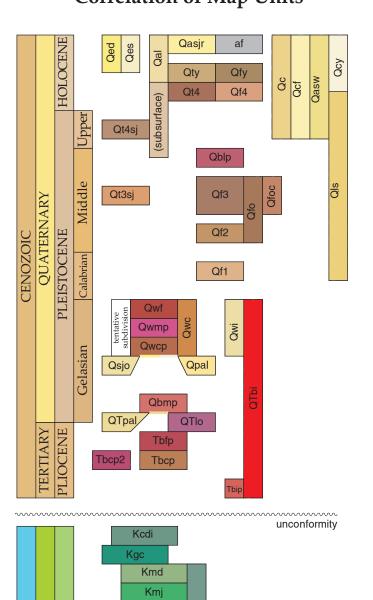
source areas. Deposits are poorly exposed; thicknesses are <1 to at least 6 m thick.

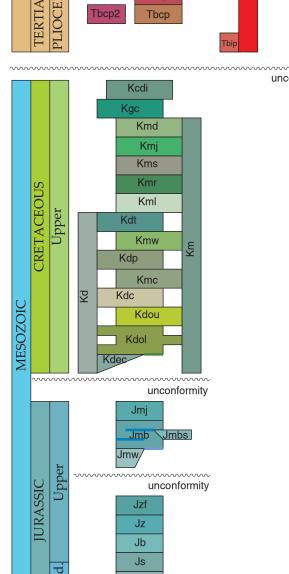
Minor anticline, vertical or near-vertical axial surface. Horizontal bedding

Inclined bedding Inclined flow banding, lamination, layering, or foliation in igneous rock.

Zone of redder Bluff Sandstone

### Correlation of Map Units





### **Comments to Map Users**

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

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

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

Kdc Kdou Jmb Jmj Jzf Kdol Qwi Jmj

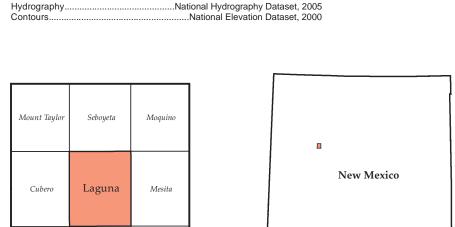
Northward thickening of Jmj inferred from Moench and Schlee (1967) Plate 3; remaining Jurassic unit contacts and trends are projected.

# orth American Datum of 1983 (NAD83) World Geodetic Svstem of 1984 (WGS84)

Magnetic Declination

July, 2017 8º 56' East

At Map Center



Projection and 1000-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.

Quadrangle Location

Socorro, New Mexico 87801-4796

New Mexico Bureau of Geology and Mineral Resources

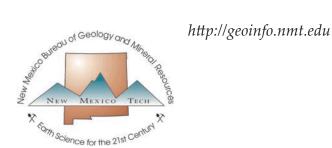
New Mexico Tech

801 Leroy Place

[575] 835-5490 This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

David J. McCraw

Elizabeth H. Roybal



Base map from U.S. Geological Survey 2010.





1:24,000

Contour Interval 20 Feet

North American Vertical Datum of 1988

New Mexico Bureau of Geology and Mineral Resources

Open-File Geologic Map 272

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National

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the New Mexico Bureau of Geology and Mineral Resources, (Dr. Nelia W. Dunbar, Director and State Geologist, Dr. J.

Michael Timmons, Assoc. Director for Mapping Programs).

Geologic Map of the Laguna 7.5-Minute

Quadrangle, Cibola County, New Mexico

## <sup>1</sup> New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM 87801

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