



Geologic map of the Tularosa quadrangle, Otero County, New Mexico. May 2008 by Daniel J. Koning* and Jed Frechette*.

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DESCRIPTION OF MAP UNITS

QUATERNARY UNIT DESCRIPTIONS

The Quaternary units on this quadrangle are found in two topographic positions: 1) on the gently westward-sloping basin floor in the southwest and western parts of the quadrangle, and 2) on steep alluvial fans emanating from the Sacramento Mountains in the north-central and eastern parts of the quadrangle. The laterally gradational contact between the basin-floor and fan units is drawn based on a variety of factors: increase in clay, lessening of slope from 0-7° to 0.3-0.6°, and farthest eastern extent of gypsum deposits. We categorize the map units according to these topographic positions below.

These units were mapped by field traverses and aerial photography (White Sands Missile Range project, December and November of 1985, BLM, 1975). Initial work consisted of mapping representative parts of the alluvial fan and basin-floor sediment with a hand-held GPS unit and using the 10-ft contours on the published topographic map. This preliminary map was then utilized in identifying and mapping units using aerial photography. Mapping from aerial photographs using the PG-2 plotter at the U.S. Geological Survey in Denver produces relatively precise lines (contacts) separating the map units. Line work from the aerial photographic-based mapping was then field-checked during subsequent field visits to the quadrangle. Not all air photographic-based mapping could be field-checked because of access restrictions for the White Sands Missile Range and private property near Tularosa. In the areas we did field-check, we found that there was an approximate 10% error in map unit identification using the aerial photographs. Consequently, the user should assume that there is a potential 5-10% error in the identification of the Quaternary map units (probably more error in the White Sands Missile Range). Some areas of the alluvial fan have two or more units that cannot be practically differentiated at a scale of 1:24,000. In such cases, we nomenclatured reflecting a combination of units (e.g., Q2am). Otherwise, we interpret 510% of other units present within a single-named unit. For example, in a map unit labeled "Q02" we interpret 410% of other map units, such as Q03 or Q05, within that mapped polygon.

A brief discussion is warranted on the difference between lithostratigraphic and allostratigraphic units. For the alluvial fan depositional environments, we separate units based on unconformable lateral time gaps between depositional and underlying deposits and by contact relations. For example, unit Q02 unconformably overlies unit Q01 and both are met and back-filled by Q03. However, it so happens that these three alluvial fans have lithostratigraphic differences as well, but, one can use sedimentologic criteria to recognize these units. In addition, surface processes dependent on age – such as desert pavement development, clast varnishing, gypsum accumulation, and gradation of original bar-and-swale topography – can be used to differentiate the alluvial fan deposits.

We have subdivided the basin-floor deposits into a younger (Q06y) and older (Q06o) unit, which probably temporally correlate to alluvial fan units Q02 and Q03 (for Q06y) and Q01 (for Q06o). Although there may be an unconformity separating Q06y and Q06o, such a contact is not obvious in the field. Units Q02 and Q01 are differentiated based on lithostratigraphic criteria. Q06o consists largely of clayey sand and clay with minor gravelly channel-fills, and Q06y consists of intercalated sand, pebbly sand, and clay-silt. Another prominent basin-floor deposit, Q05, is readily recognizable because it consists predominantly of gypsum.

Grain sizes follow the Udden Wentworth scale for clastic sediments (Udden, 1914; Wentworth, 1922) and are based on field estimates. Pebbles are subdivided as shown in Compston (1985). The term "clast?" refers to the grain size fraction greater than 2 mm in diameter. Descriptions of bedding thickness follow Ingram (1954). Colors of sediment are based on visual comparison of dry samples to the Munsell Soil Color Charts (Munsell Color, 1994). Soil texture terms follow the Soil Survey Staff (1992). Birkeland et al. (1991) and Birkeland (1999). Stages of pedogenic calcium carbonate morphology follows of Gile et al. (1962) and Birkeland (1999). Because both calcic and gypsum often accumulate together in a given soil horizon on this quadrangle, we use the term "apparent carbonate morphology" to indicate that gypsum accumulation is influencing the determination of the carbonate stage. Discussion of a unit's age content is presented in the accompanying report.

Unless otherwise noted below, Quaternary gravel on this quadrangle consists of indurated and possible dolomite with 1-10% sandstone and siliceous clasts, and trace to 5% Tertiary igneous rocks (unit T1). Sand is laminated to subangular. Medium to very coarse sand has a composition consistent with a litharenite, whereas very fine to fine-grained sand is more arkosic (as inferred using a hand lens).

SLOPEWASH

Q25w Cyclic/erosional slopewash (late Holocene) – gypsum and gypsiferous silt and very fine to fine sand reworked from locally adjacent, topographically higher basin-floor deposits (i.e., Q02 and Q06y). Because these deposits lie below the inferred 1-2 km maximum depositional surface (see discussion in report), they are inferred to post-date 2 ka. In the valleys cut into gypsum in the western quadrangle, these slopewash deposits are largely cut into unit Q04w and Q04b. Estimated thickness of 2-5 m.

ARTIFICIAL FILL AND EXCAVATIONS

ae Artificial excavation (modern) – Pit, quarry, or reservoir; the base of these excavations has generally been filled by >10 cm-thick deposits of clay, silt, sand, and gravel carried into the pit by mass-wasting and slippage processes.

af Artificial fill (modern) – Compacted silt, clay, and very fine to medium sand (minor coarse to very coarse sand and pebbles) under highways and railroads, also found in berms surrounding pits, quarries, or reservoirs. In the case of railroads and roads in the White Sands Missile Range, very coarse pebbles and cobbles drag compacted fill.

DEPOSITS SPANNING THE ALLUVIAL FAN AND BASIN FLOOR

Qam Sand, silt, gravel, and clay associated with modern drainages on alluvial fans and the basin floor (0-50 yrs old) – Sand, silt, and clay in various proportions at the mouths of small, discontinuous gullies. Sand and gravel dominate in the channel of Tularosa Creek. The surface of this unit exhibits fresh-appearing bar and swale topography (up to 30 cm relief). Sand is generally pink (5.5 YR 7/3) to light reddish brown (5YR 6/3), very fine to very coarse-grained, and poorly to well-sorted. In the distal alluvium, this unit supports moderate to dense cover of grass and mesquite. Bar and swale topography may be absent on distal alluvial fans. However, topography may still be present because of fine sediments (i.e., clay, silt, and very fine to fine-grained sand) accumulating around dense vegetation, such as grass clumps and creosote bushes. Loose. Generally less than 2 m-thick.

Q0m Historical deposition of sand and silt at the mouths of discontinuous drainages (50-200 yrs) – Light brown (7.5 YR 6/4) silt and very fine to fine-grained sand that is distinctly planar-laminated, low-angle cross-bedded (<0.5 cm-thick), and is wavy laminated. Surface exhibits subtle scouring or possible bar forms. No observable soil development, desert pavement or clast varnish. Unit is generally less than 20 cm-thick and overlies unit Q03. Only mapped where fluvial morphology can be seen on surface using aerial photographs. However, field investigations indicate that unit Q03 may be locally overlain by Q0m at this deposit, even though surface fluvial morphology was not apparent. This unit was deposited by sheet flood processes. 10-30? cm-thick.

Q0h Historical deposition of sand and silt at the mouths of discontinuous drainages (50-200 yrs) – Light brown (7.5 YR 6/4) silt and very fine to fine-grained sand that is distinctly planar-laminated, low-angle cross-bedded (<0.5 cm-thick), and is wavy laminated. Surface exhibits subtle scouring or possible bar forms. No observable soil development, desert pavement or clast varnish. Unit is generally less than 20 cm-thick and overlies unit Q03. Only mapped where fluvial morphology can be seen on surface using aerial photographs. However, field investigations indicate that unit Q03 may be locally overlain by Q0h at this deposit, even though surface fluvial morphology was not apparent. This unit was deposited by sheet flood processes. 10-30? cm-thick.

Q0am A composite unit consisting of Q0m (mostly) and Q0h (0-200 years) – See descriptions of Q0m and Q0h above.

Q0am A composite unit consisting of Q0y (mostly) and Q0m (0-200 years) – See descriptions of Q0m and Q0y above.

ALLUVIAL FAN DEPOSITS

Q03 Silt-clayey sand, sand, and subordinate gravely sand and clay (upper Holocene) – This unit underlies the majority of alluvial fan surfaces in the study area, and coincides with both agricultural and urban areas. Sediment color generally ranges from light reddish brown (5YR 6/4), reddish brown (5YR 5/4), brown to light brown to pink (7.5 YR 5/4, 6/4, and 7/4), and pinkish gray (5YR 6/2) to light gray (10YR 7/2). Sediment consists of a clay-silt-very fine to medium-grained sand that is moderately sorted. The fine sediment is typically massive or in thick, vague beds that may be horizontally (minor planar) laminations. Locally, coarse to very coarse sand and pebbles are present and minor pebbles may be scattered in a sandy matrix. There are also minor coarse-grained fill consisting of pebbly sand to sandy pebbles. These coarse channel fills are in thin to medium beds that are broadly lenticular to lensular. Pebbles are very fine to very coarse with 1-5% fine cobbles, subrounded, and poorly sorted. Sand is coarse-grained to medium-grained, and is reddish gray to reddish brown (5YR 4.2-5.3), very fine to very coarse-grained, and poorly sorted. The overall less gravely texture helps in differentiating this unit from gravelly Q02 deposits. The surface is generally not as bouldery and cobbly as that associated with Q02, but yet commonly has a pebbly to fine cobbly gravel lag in the medial and proximal fans that indicates erosion of the surface (see Q02 description below). The surface has slight bar and swale relief of 10-30 cm. Its desert pavement has weak to no clast armor and no to slight varnish. Soil development is characterized as filamentos or discontinuous filaments or discontinuous filaments (see Q02 description below). Q03 unconformably overlies Q01 (see Figure 3), and appears to interfinger laterally into unit Q02 (the transitional zone was mapped as Q02y). Unit generally corresponds to Q03m and Q03f of Koning (1999) and Koning et al. (2002), and to Q03 of Koning et al. (2007). Unit correlates to the Organ alluvium in the Desert Project, which was assigned an age of 7 ka (Gile et al., 1981). A Q02 deposit on the Male Canyon alluvial fan south of Tularosa Creek consisting of an in-filled swale returned a C-14 age of 1980 ± 50 yrs (Koning, 1999; and Koning et al., 2002). On the distal alluvial fan south of Tularosa Creek, a C-14 date from charcoal returned an age of 5140 ± 10 (radiocarbon years; Table 2). Generally less than 2 m-thick, but locally as much as 3-4 m (particularly in the medial and proximal parts of the fan).

Q03am Combination unit of Q03 and Q0m (upper Holocene to modern) – See descriptions of Q03 and Q0m above.

Q02c Gravelly sand and gravelly sand (upper Holocene) – Sediment color generally ranges from light reddish brown (5YR 6/3-4), reddish brown (5YR 5/4-4), brown to light brown to pink (7.5 YR 5/4, 6/3-4, and 7/4), and dark reddish gray (5YR 4/2). This unit consists of silt-clayey sand intercalated coarse channel-fill. This sediment is similar to unit Q03 (see above), but has slightly more coarse channel-fill of pebbly sand to sandy pebbles. Beds are thin to medium and broadly lenticular to lensular (locally cross-stratified). Pebbles are very fine to very coarse with 1-5% fine cobbles, subrounded, poorly sorted, and composed of limestone with very minor clasts of Paleozoic sandstone-siltstone and Tertiary intrusives. Sand is very fine to very coarse-grained and poorly sorted. Because of the general lack of exposure, this unit was mapped by aerial photographs for the surface with more than 10% surface gravel cover. Surface has slight bar and swale relief of 10-30 cm. Its desert pavement has weak to no clast armor and no to slight varnish. Surface soils characterized by granular processes, similar in amount to a stage 1 to 1.5 in a calcic soil. Commonly has a pebbly to fine cobbly gravel lag in the medial and proximal fans that indicates erosion of the surface; however, the surface has less coarse gravel compared to the Q02. Unit unconformably overlies Q01 (see Tu-154 stratigraphic section in Figure 3). Like unit Q03, this unit correlates to the Organ alluvium of the Desert Project by Gile et al. (1981) and Koning et al. (1981); most deposits are probably 5-2 ka. Weakly indurated and 1-4 m thick.

Q02s Sand and silt sand (middle to upper Holocene) – Pink to reddish brown (7.5 YR 7/4 to 5YR 5/4) silt-very fine to fine-grained sand with minor medium to very coarse-grained sand. Sand is moderately to well sorted and contains minor pebbles. Mapped immediately north of Tularosa Creek for an area that is taller and sandier than sediment found near the northern border of the quadrangle. This unit probably extends south of Tularosa Creek, but in an area that is obscured by agricultural activity. Unit is also differentiated in the southeastern quadrangle near the railroad tracks. Base of unit not observed in field, but presumably it probably overlies Q01. Probably 1-3 m-thick.

Q02sh Sandy distal alluvial fan deposits forming topographic highs near the basin-floor alluvial fan transition. Only mapped in the south-central portion of the quadrangle. Sand is light brown (7.5 YR 6/3-4), very fine to medium-grained, moderately sorted, and contains minor silt. Has 1-15% patches of strong gypsum accumulation exposed on its surface, but generally gypsum accumulation in the soil is probably similar to that of unit Q03. Base of unit not observed in field, but presumably it overlies Q06y, Q03, or Q01. Unit supports moderate creosote and grass vegetation. Probably 1-2 m-thick.

Q02sh Gravel-capped, slightly high-standing ridges of Q03 (middle to upper Holocene) – This is a subunit of Q03 which is differentiated because of its gravelly texture, slightly older surface (and associated higher gypsum content), and its topographically high nature. Unit consists of a reddish brown (5YR 5/4) pebbly sand, very fine to very coarse-grained, pebbles are very fine to very coarse and locally includes 5% fine cobbles. Pebbles are subrounded to subangular, dominated by limestone, and form a weak to moderate pavement generally greater than 10% clast surface cover. Clasts are weakly to moderately varnished. Surface lacks original bar and swale relief and generally has 1-15% patches of strong gypsum accumulation. Surface gravel may overlie pink (7.5 YR 7/4), internally massive, silt-clayey very fine to fine-grained sand, with minor medium to very coarse sand, sediment consists of 5% gypsum fillaments (equivalent to a stage 1 in a calcic soil) in the distal alluvium. The clast armor preservation relatively flat surfaces that are about 20-30 m above surrounding, eroded low areas. Surface supports a moderate cover of creosote (mostly) and other shrubs (about 3 plants per 5 m').

Q02sh Gravel-capped, slightly high-standing ridges of Q03 (middle to upper Holocene) – This is a subunit of Q03 which is differentiated because of its gravelly texture, slightly older surface (and associated higher gypsum content), and its topographically high nature. Unit consists of a reddish brown (5YR 5/4) pebbly sand, very fine to very coarse-grained, pebbles are very fine to very coarse and locally includes 5% fine cobbles. Pebbles are subrounded to subangular, dominated by limestone, and form a weak to moderate pavement generally greater than 10% clast surface cover. Clasts are weakly to moderately varnished. Surface lacks original bar and swale relief and generally has 1-15% patches of strong gypsum accumulation. Surface gravel may overlie pink (7.5 YR 7/4), internally massive, silt-clayey very fine to fine-grained sand, with minor medium to very coarse sand, sediment consists of 5% gypsum fillaments (equivalent to a stage 1 in a calcic soil) in the distal alluvium. The clast armor preservation relatively flat surfaces that are about 20-30 m above surrounding, eroded low areas. Surface supports a moderate cover of creosote (mostly) and other shrubs (about 3 plants per 5 m').

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The Q02sh surface is probably about 12 ka, assuming a regional incision event starting about that time (see accompanying report). The deposit underlying the surface is probably slightly older (2-4 ka). Base of unit not observed in field, but presumably it overlies Q06y, Q03, or Q01. Unit is approximately 1-2 m-thick and includes the lower, gravelly channel-fill immediately under a silt-clayey fine sand mantle.

Q02c Clay in the distal alluvial fan (middle to upper Holocene) – Reddish brown (5YR 5/4) clay and sandy clay. Generally internally massive and hard. Sand is very fine to medium-grained and moderately sorted. Estimate 20% gypsum fillaments throughout exposed profile, with 30-40% gypsum fillaments in the upper 10-20 cm. Unit is approximately 1-2 m-thick and includes the lower, gravelly channel-fill immediately under a silt-clayey fine sand mantle.

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