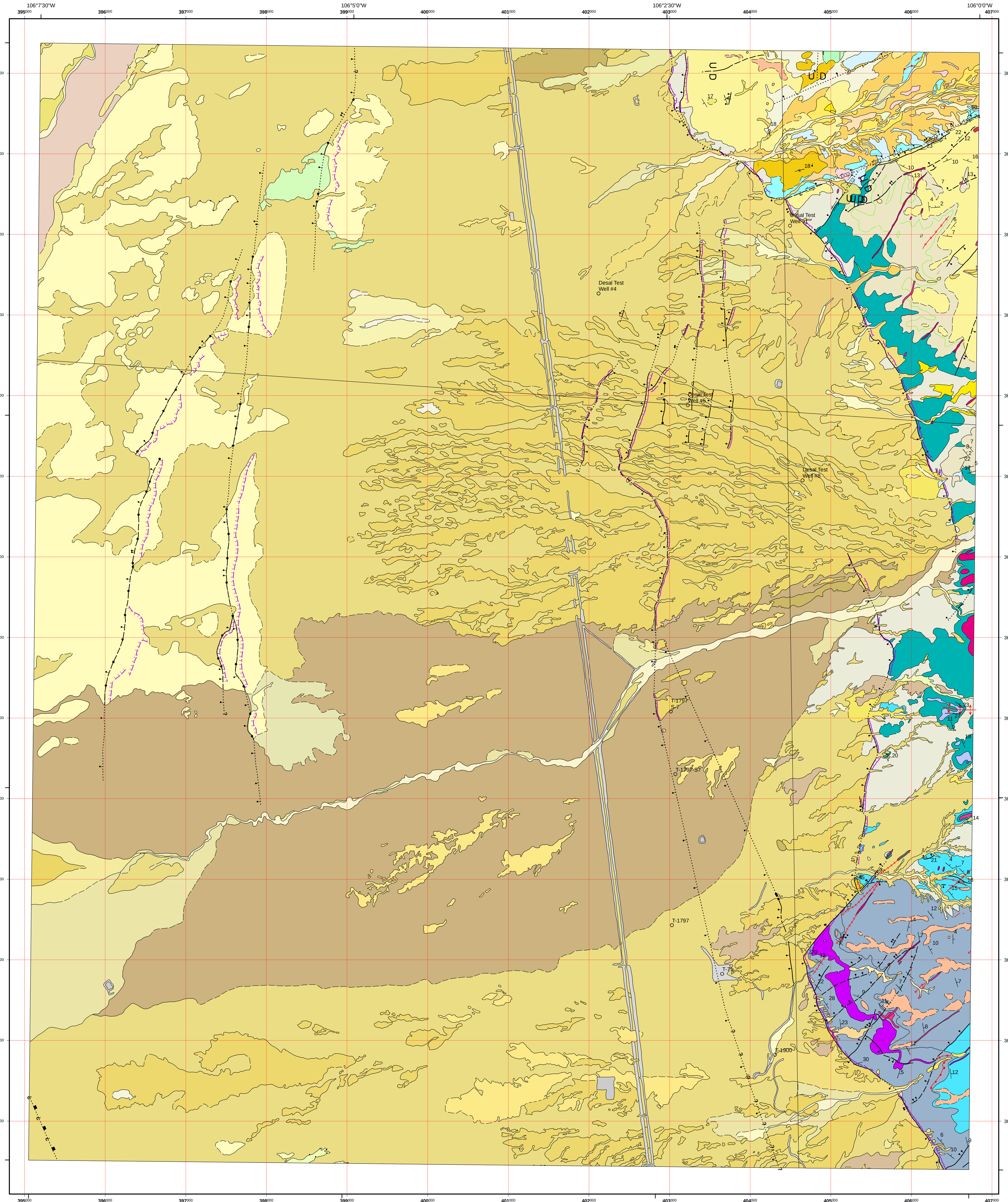
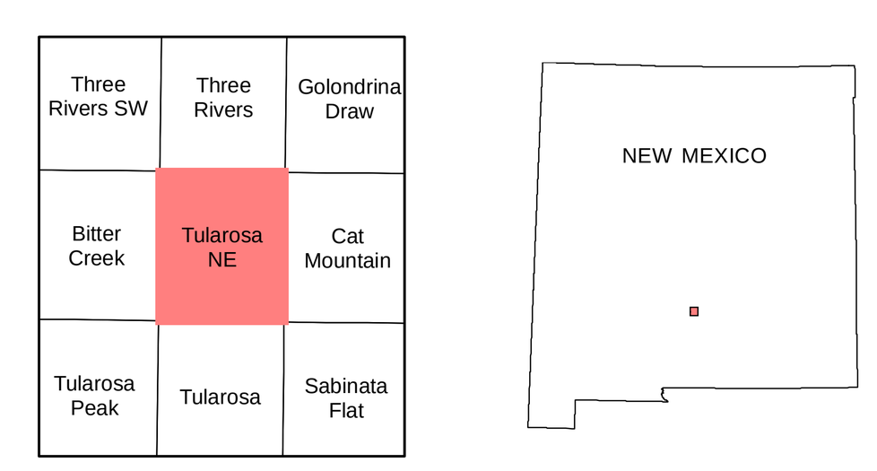
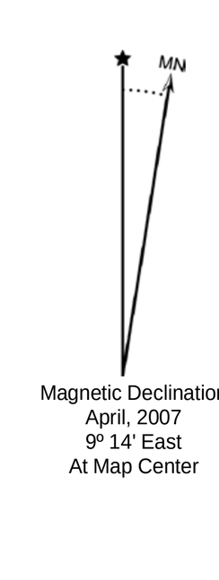


Base map from U.S. Geological Survey 1982, from photographs taken 1972, field checked in 1975, edited in 1982.
1927 North American datum. UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in red



QUADRANGLE LOCATION



1:24,000

0.6 0.3 0 0.6 MILE

980 0 980 1960 2940 3920 4900 5880 6860 FEET

0.95 0.475 0 0.95 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-file Map Series

OFGM 185

Geologic map of the Tularosa NE quadrangle, Otero County, New Mexico

May 2008

by
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This draft geologic map is preliminary and will undergo revision. It was produced from either scans of hand-drafted originals or from digitally drafted original maps and figures using a wide variety of software, and is currently in cartographic production. It is being distributed in this draft form as part of the bureau's Open-file map series (OFGM), due to high demand for current geologic map data in these areas where STATEMAP quadrangles are located, and it is the bureau's policy to disseminate geologic data to the public as soon as possible.

After this map has undergone scientific peer review, editing, and final cartographic production adhering to bureau map standards, it will be released in our Geologic Map (GM) series. This final version will receive a new GM number and will supercede this preliminary open-file geologic map.

DRAFT

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (Dr. Peter A. Scholle, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

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http://geoinfo.nmt.edu/publications/maps/geologic/ofgm/home.html

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 associated with recent development may not be shown.

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.

MODERN ALLUVIUM

Qam **Sand and gravel, with lesser silt and clay, associated with deposition outside of incised drainages on alluvial fans and in the mountain-front (0-50 yrs old)** – Sand and gravel characterize this unit near the mountain-front, where they comprise relatively small (generally less than 500 m across) depositional lobes at the mouths of incised channels. Sand, clay, and silt form the bulk of this unit in the western part of the quadrangle. Color of non-gravel fraction varies according to source area, but generally ranges from reddish brown in the south to grayish brown, light grayish brown, gray, and pale brown in the middle and north. In gravelly sediment, bar and swale topography is present (up to ~50 cm relief) and gravel consists of pebbles, cobbles, and boulders. Gravel is subrounded and very poorly to poorly sorted. Bedding in gravelly sediment is very thin to medium, planar-horizontal to lenticular. Sand is very fine- to very coarse-grained; mostly medium- to very coarse-grained and moderately to poorly sorted on the proximate-medial alluvial fan, and mostly very fine- to medium-grained and moderately to well sorted on the distal fan. Bed forms are planar-horizontal to cross-stratified, laminated to medium-thick. The surface appears relatively fresh. Deposit is loose and generally less than 2 m-thick.

Qamg **Sand and gravel deposited in incised drainages on alluvial fans and in the mountain-front (0-50 yrs old)** – Sand and gravel deposited within arroyos. Sand is cross-bedded or planar-horizontal, laminated to thin-bedded. Gravelly sediment is in thin to thick, lenticular to concave-up channel-fills. Gravel is subrounded and very poorly to poorly sorted. Color of non-gravel fraction varies according to source area, but generally ranges from reddish brown in the south to grayish brown, light grayish brown, gray, and pale brown in the middle and north. Sand is mostly medium- to very coarse-grained, and moderately to poorly sorted. Surface is fresh and has scour and bar-and-swale topography up to 1-1.5 m. Deposit is loose and generally less than 2 m-thick.

Qah **Historical deposition of sand and silt at the mouths of discontinuous drainages (50-200 yrs)** – Deposits similar to those of Qam but whose surfaces support moderate vegetation and have muted or degraded bar- and swale-topography. There is no evidence on its surface of significant fluvial aggradation in recent time. No observable soil development, desert pavement or clast varnish. In the medial and distal alluvial fans, this unit may include sheetwash deposits of silt and sand that is distinctly planar-laminated, low-angle cross-laminated (<0.5 cm-thick), or wavy laminated. This deposit generally flanks modern drainages, such as Temporal or Coyote arroyos. West of Highway 54, gravelly **Qah** deposits are found alongside, but on top of, the incised arroyo. Here, Qah is a well-stratified sand or pebbly sand to sandy pebbles. Generally less than 2 m-thick.

Qamah **A composite unit consisting of Qam (mostly) and Qah (0-200 years)** – See descriptions of Qam and Qah above.

Qahm **A composite unit consisting of Qah (mostly) and Qam (0-200 years)** – See descriptions of Qah and Qam above.

Qahf3 **A composite unit consisting of Qah (mostly) and Qf3 (0-6000 years)** – See descriptions of Qah and Qf3.

Qamf3 **A composite unit consisting of Qam (mostly) and Qf3 (0-6000 years)** – See descriptions of Qam and Qf3.

ARTIFICIAL FILL AND EXCAVATIONS

ae **Artificial excavation (modern)** – Pit, quarry, or reservoir; the base of these excavations have generally been filled by >10 cm-thick deposits of clay, silt, sand, and gravel carried into the pit by arroyos, mass-wasting, or slopewash 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. Under railroad tracks, very coarse pebbles and cobbles drape compacted fill.

EOLIAN AND SLOPEWASH-SHEETWASH DEPOSITS

Qe **Eolian sand sheets and low coppice dunes (upper Holocene to present)** -- Only mapped in the extreme northwest corner of the quadrangle, which was not accessible for on-site description. Based on eolian deposits in the Three Rivers Quadrangle to the north, this unit likely consists primarily of very fine- to medium-grained sand. Color probably ranges from light brown to pale brown to brown (7.5-10YR 5-6/3), yellowish brown to light yellowish brown (10YR 5-6/4), and brown to light brown (7.5YR 5-6/4). Sand is likely subrounded, well-sorted, well to moderately sorted, and composed of quartz with subordinate feldspar and minor lithic grains. Loose. Probably 1-3 m-thick.

Qec **Large coppice dunes (upper Holocene to present)** -- Mounds of sand around large mesquite shrubs that are greater than ~ 1 m in height. Sand is pale brown to brown (10YR 5-6/3), very fine- to fine-grained, and has 1-10% fines. Surface between the coppice dunes consists of Qf3t that is eroding.

Qf3sw **Sheetwash deposits that grade laterally into unit Qf3 (upper Holocene to present)** -- This widespread deposit consists of pale brown to pink (10-7.5YR 7/3) clay, silt, and very fine- to fine-grained sand. Sediment is internally massive, with minor very thin to thin lenses of sandy pebbles or pebbly sand. Minor (1-15%) medium- to very coarse-grained sand and 1-10% pebbles may be scattered through the sediment (probably via bioturbation). Soil development is weak, and marked by ped development but no reddening. Gypsum accumulation is commonly as scattered flecks (1-15%), but is not always present. This fine sediment likely was blown in via wind and then reworked by sheetflooding (or sheetwash) during monsoonal thunderstorms. Unit differs from Qf3 by the lack (or presumed lack) of medium to thick, coarse channel-fills, but mapping the two apart is difficult and a strong case can be made for combining the two units. Moderately consolidated and generally about 1 m-thick or less.

Qsw **Sheetwash deposits , undifferentiated (upper Holocene to present)** -- Similar to Qf3sw, as described above, but commonly localized and overlying an older deposit. Most of Qf1 on the Temporal fan is covered by a thin sheet of this unit, but this unit was only mapped where it obscures the underlying deposit.

Qsw/Qf1 **Sheetwash deposits overlying older alluvial fan sediment** -- See descriptions of unit Qsw and Qf1.

PEDIMENT AND TERRACE DEPOSITS

Qp **Pediment gravel, undifferentiated (upper Pleistocene)** -- Thin sandy gravel, commonly very gypsiferous, that overlies a pediment surface on the immediate footwall of the Alamogordo fault in the southeast corner of the quadrangle. This erosion surface was assumed to be relatively extensive along the base of the mountain-front before latest Pleistocene to Holocene dissection. Surfaces are relatively smooth and exhibit well-varnished desert pavements. Underlying soil marked by gypsum accumulation comparable to a stage III calcic horizon. Less than 1 m-thick.

Qp3 **Lower pediment gravel along Salinas Draw (upper Pleistocene)** -- Thin sandy gravel that overlies the lowest erosion surface south of Salinas Draw. This erosion surface is developed on older alluvium (Qao). Surface supports relatively abundant creosote bushes and has not witnessed the degree of gypsum accumulation as **Qp2** or **Qp1**. Less than 1 m-thick.

Qp2 **Middle pediment gravel along Salinas Draw (upper Pleistocene)** -- Thin sandy gravel that overlies the middle erosion surface south of Salinas Draw. This erosion surface is developed on older alluvium (Qao). Surface has developed a strong gypsic horizon. The surface hosts relatively abundant creosote bushes and has a well-developed desert pavement with varnished surface clasts. Surface may correlate to that developed on most of **Qf1**. Less than 1 m-thick.

Qp1 **Upper pediment gravel along Salinas Draw (middle? Pleistocene)** -- Thin sandy gravel that overlies the upper erosion surface south of Salinas Draw. This erosion surface is developed on older alluvium (Qao). Surface supports sparser creosote bushes and has a stronger gypsic horizon than the lower surfaces. Less than 1 m-thick. Surface may correlate to that developed on Qfo. Less than 1 m-thick.

Qgh **High-level gravel deposits capping ridges in the southeast corner of the quadrangle (lower Pleistocene to upper Pliocene)** -- Sandy pebbles, cobbles, and boulders that cap high ridges within 2 km north of Coyote Canyon. No exposures permitted description of bedding. May correlate to the Qao1 unit in the Three Rivers quadrangle to the north. Up to 20 m-thick.

ALLUVIAL FAN DEPOSITS

Qf3 **Younger alluvial fan deposits (middle to upper Holocene)** –Sediment color is reddish brown to the south (5YR 4-5/3-4) and pale brown to brown (10YR 5-6/3) in the northern parts of the quadrangle. Sediment is mostly a silt-clay and very fine- to fine-grained sand in the distal alluvial fans, but is dominated by sand and gravel in the proximal alluvial fans. In the medial to distal fans, sediment typically consists of a clayey-silty very fine- to medium-grained sand that is moderately sorted. The fine sediment is generally massive or in thick, vague beds that may be bioturbated. Locally, coarse to very coarse-grained sand is present and minor pebbles may be scattered in a sandy matrix. Locally there are minor coarse channel-fills consisting of pebbly sand to sandy pebbles. In the proximal allvuial fans, gravelly beds are very thin to medium and lenticular; gravel includes minor(1-15%) boulders, but is mostly pebbles and lesser cobbles. Sandy beds are laminated to very thin to medium and planar-horizontal to lenticular. Sand is very fine- to very coarse-grained, subangular to subrounded, and poorly to well sorted. Overall, the less gravelly texture helps in differentiating this unit from gravelly Qf2 deposits. 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 by gypsum accumulaton as filaments or disseminated (comparable to a stage I in a calcic soil horizon). Coppice dunes have formed on this surface west of Highway 54 (see **Qec** description). Locally, this unit has been utilized for agriculture. **Qf3** unconformably overlies **Qf1**, and is inset into **Qf2**. 1-6 m-thick.

Qf3t **Younger alluvial fan deposits associated with Temporal Creek (middle to upper Holocene)** – Pale brown (10YR 6/3), with lesser brown (10YR 5/3), clayey-silty very fine- to fine-grained sand deposited by Temporal Creek. Minor (~10%), scattered medium- to very coarse-grained sand and trace-3% scattered pebbles. Very minor, coarse-grained channel-fills. Sediment is internally massive and overprinted by cumulic soil development, the latter marked by ped development, faint clay films (generally as bridges), and gypsum filaments (1-10% of surface area). Sand is well-sorted, subrounded to subangular. Very minor, laminated to very thin to thin beds of clay-silt. Surface is smooth and eroded. Generally lacks signs of gypsum accumulation near the surface. Unit color contrasts with the redder sand deposited by drainages to the south. 1-6 m-thick.

Qf3c **Gravelly sand and gravelly sand (upper Holocene)** – This sediment is similar to unit Qf3 (see above), but is clearly dominated by gravelly sediment. Mapped between Salinas Draw and Temporal Creek. Estimated 1-3 m-thick.

Qf3f1 **Combination unit of Qf3 and Qf1 (upper Pleistocene and Holocene)** – See descriptions of Qf3 and Qf1.

Qf3m **Combination unit of Qf3 and Qam (middle Holocene to modern)** – See descriptions of Qf3 and Qam above.

Qf3h **Combination unit of Qf3 and Qah (middle Holocene to historic)** – See descriptions of Qf3 and Qah above.

Qf3cf1 **Combination unit of Qf3c and Qf1 (upper Pleistocene to Holocene)** – See descriptions of Qf3c and Qf1.

Qf3gh **Gravel-capped, slightly high-standing ridges of Qf3 (middle to upper Holocene)** – This is a subunit of Qf3, mapped on the medial portions of the alluvial fans, which is differentiated because of its somewhat gravelly texture, slightly older surface, and its topographically high nature. Unit consists of a reddish brown to pale brown to very pale brown pebbly sand. Sand is very fine- to very coarse-grained. Surface pebbles are very fine- to very coarse. Locally, the surface gravel has 1-5% fine cobbles. Pebbles are subrounded to subangular and form a weak to moderate pavement (generally greater than 10% clast surface cover). Surface clasts are weakly to moderately varnished and lack coats of calcium carbonate. Surface lacks original bar- and swale relief and generally has <5% patches of strong gypsum accumulation. The clast armor of the desert pavement allows preservation of elongated surfaces, probably following paleo-channels, that stand 20-100 cm above surrounding, eroded low areas. In short, this unit represents **Qf3** that has been less eroded than surrounding areas because of a protective, upper layer of gravelly sediment. These highs are generally not as dissected as those underlain by **Qf1**. Base of unit not observed in field, but presumably it overlies **Qf3**, or locally, **Qf1**.

Qf2 **Older unit of younger alluvial fan deposits (lower to middle Holocene)** – This unit is only mapped on the proximal alluvial fans, where it is distinguished by its gravelly surface that is both less varnished than the **Qf1** surface and higher topographically than the **Qf3** surface. Sediment is slightly redder than adjoining Qf3 sediment. Sediment is mostly fine-grained sand with minor (10-15%), narrow, very thin- to thick-bedded, coarse channel-fills. Color ranges from reddish brown to pinkish white (5YR 5/4 and 7.5YR 8/2). Sediment is internally massive and has experienced cumulic soil development marked by gypsum accumulation (7-10% gypsum filaments). Sand has 1-30% clay-silt and is very fine- to fine-grained, subangular, well-sorted, and gypsiferous. Sand in channel-fills is reddish gray to reddish brown (5YR 5/2-3), subrounded to subangular, and poorly sorted. Surface mantled (>50% clast density) by very fine to very coarse pebbles and minor fine to coarse cobbles. These clasts are non- to moderately varnished. Surface clasts generally lack calcium carbonate coats, are poorly sorted, subangular to subrounded, and composed mostly of limestone. Surface is marked by gypsum accumulation comparable to a stage II to II+ carbonate morphology. Desert pavement is moderately to well-developed. Less than 10% strong gypsum accumulation is apparent on the surface. Surface lacks bar and swale topography and is undissected. The surface of Qf3 is lower (by ~ 1 m) or level with this surface. **Qf3** deposits are inset into the **Qf2** deposit. Moderately to well consolidated and 1.5-2.5 m-thick.

Qf1 **Older alluvial fan deposits of sandy gravel, gravelly sand, and silty-clayey fine sand (upper Pleistocene)** – Interbedded sandy gravel, gravelly sand, sand, and clayey very fine- to fine-grained sand. Gravel are clast-supported and consist of pebbles, with minor cobbles and boulders; clasts are poorly to moderately sorted and subrounded. Clast imbrication indicates a westward flow diection. Bedding is planar (minor lenticular) and up to ~40 cm-thick. ~10-15% of beds have abundant cobbles and boulders (i.e., well-graded pebbles through boulders) in a light brown (7.5YR 6/3-4) to reddish yellow (7.5YR 6/6) clayey, fine sand matrix -- these are debris flows. Clayey-silty, very fine- to fine-grained sand is light brown to reddish brown (7.5YR 6/4-6) and consists of thick, tabular beds; sediment has 10-20% medium- to very coarse-grained sand and 1-10%, scattered pebbles; 1-2% very thin to thin, pebble to cobble lenses locally at the base of beds. Fine sediment is very well consolidated and has 10-30% gypsum. Sandy beds are reddish brown to light brown; sand is very fine- to very coarse-grained, subangular to subrounded, and moderately to poorly sorted; up to 50% of sand grains may be composed of gypsum. Beds are internally massive, and gypsum-cemented rhizoliths are present. Unit underlies topographically high, smooth surface dissected by gullies (0.5-1.0 m-deep) that have been partly back-filled by **Qf3** deposits. This surface is smooth and lacks original bar and swale topography. This surface has a weak to moderate pavement of well-varnished clasts (up to 65% clast coverage), and has much indications of high gypsum accumulation (equivalent to a stage III morphology in a clacic soil). Surface gravel include very fine to very coarse pebbles and 8-10% fine cobbles. A stage II+ to III calcic horizon has locally developed on this unit on the Temporal Creek alluvial fan, but generally a strong gypsic horizon characterizes the tops soil. Correlates to the Jornada II alluvium in the Desert Project, which is inferred to be upper middle to upper Pleistocene in age (Gile et al., 1981, table 9). Base of unit not defined, but alluvial fan sediment filling the basin here is several hundred meters thick. Greater than 8 m-thick.

Qfo **Older alluvial fan deposits of silty-clayey fine sand and subordinate gravel (upper middle(?) to upper Pleistocene)** – Pink to light brown (7.5YR 6-7/4), gypsiferous, very fine to fine-grained sand with minor (10-20%) clay-silt and minor, scattered, medium- to very coarse-grained sand. Medium to very coarse sand are subrounded to angular (mostly subangular) and consist of lithic fragments. Internally massive. Minor very thin to medium, lenticular beds of sandy gravel; gravel consists of pebbles and minor cobbles. Gypsum is disseminated or in filaments. Well-developed desert pavement on the surface, with strongly varnished clasts. Interpreted to correlate with Qao in this quadrangle and **Qao2** in the Three Rivers quadrangle to the north. Greater than 9 m-thick.

Qf1sc **Silty clayey fine sand with subordinate sandy gravel and gravelly sand; deposited by fluvial, slopewash, and colluvial processes near the mountain front (upper middle(?) to upper Pleistocene)** – Temporally equivalent to **Qfo**, this deposit is located on the footwall of the Alamogordo fault, immediately adjacent to the mountain front, and has received much detritus from slopewash and colluvial processes. Sediment is light brown to pink (7.5YR 6/4-7/3) sand with very minor pebbles. Sand is a silty-clayey, very fine- to fine-grained, subangular, and poorly sorted. The high gypsum content is consistent with high eolian input, probably reworked slightly by slopewash or colluvial processes. Sediment is massive, bioturbated, and has strong gypsum accumulations near the surface (comparable to a stage III morphology in a calcic soil). At least 3 m-thick.

ALLUVIAL SLOPE DEPOSITS (mapped on piedmont northeast of Alamogordo fault along Salinas Draw)

Qay **Younger alluvium (middle to upper Holocene)** -- Interbedded: 1) brown to pale brown (10YR 5-6/3), internally massive, silty-clayey sand (estimate 5-15% fines); sand is very fine- to medium-grained, with 1-5% scattered, coarser sand and pebbles; cumulic soil commonly developed on unit, marked by ped development and gypsum accumulation; sand is moderately sorted and subangular; 2) sandy gravel that is clast-supported, imbricated, and in lenticular to planar-horizontal beds up to 50 cm-thick; clasts are composed of pebbles, cobbles, and minor boulders; gravel are subrounded to subangular, poorly sorted; sand is grayish brown to light brownish gray (10YR 5-6/2), very fine- to very coarse-grained, poorly sorted, subrounded to subangular, and composed mostly lithic grains. Unit correlates with **Qf3**. 1-3 m-thick.

Qao **Older alluvium (middle to upper Pleistocene)** -- Sandy gravel overlying reddish, finer-grained sediment. Sandy gravel is matrix- to clast-supported and in thin to thick, lenticular to tabular beds. Gravel consists mostly of pebbles (minor cobbles and boulders) composed of limestone and Tertiary intrusive clasts; gravel are subangular to angular and moderately sorted. Sand is light brown to reddish yellow (7.5YR 6/4-6), very fine to very coarse-grained, subangular to subrounded, and moderately to poorly sorted. Matrix-supported debris flows are interbedded in the clast-supported, stream-flow sediment. The matrix of these gravelly debris flows consist of pink (7.5YR 7/3-4), very fine- to medium-grained sand with subordinate coarser sand. Underlying reddish sediment consists of yellowish red to reddish yellow (5YR 5-6/6), internally massive, clayey-silty very fine- to fine-grained sand that is gypsiferous and hard; local sandy gravel channel-fills are present in this red sediment that are up to 1 m-thick. Unit correlates with **Qfo** and **Qf1**. Total thickness of 8-12 m.

Qaoh **High-level older, gravelly alluvium (middle to lower Pleistocene)** -- Sandy gravel whose surface is ~5 m above that of **Qao** to the north. Gravel consists largely of pebbles (minor cobbles) that are subrounded, poorly sorted, and composed of limestone. Sand is pink (5-7.5YR 7/3), very fine- to very coarse-grained, subangular to subrounded, and poorly sorted. Very fine- to medium-grained sand is composed mostly subangular to angular gypsum grains. Moderately consolidated and highly gypsiferous. ~12 m-thick.

Qf1gy **Distal alluvial fan deposits of intercalated, gypsiferous clay, sand, silt, and gypsum beds (middle? to upper Pleistocene)** – Not exposed on this quadrangle, but from arroyo cuts to the south (i.e., Tularosa quadrangle) this unit likely consists of intercalated clayey fine sand, clay, silt, very fine- to fine-grained sand, and gypsum. Base of unit not defined. Total basin-floor sediment thickness is probably least several hundred meters thick before bedrock is encountered (see cross-section).

TERTIARY IGNEOUS ROCKS IN SACRAMENTO MOUNTAINS

Various igneous rocks filling sills and dikes within the Permian bedrock of the mountain-front. Mineralization is generally absent along the dikes and sills. Occasionally, hematite, limonite, barite, calcite, and manganese minerals occur in the vicinity of intrusions. Dikes generally fill fractures and are 1 to 2 m wide. More rarely, dikes fill faults, but the dikes are not deformed by reactivation of the faults. Ages of units discussed in the accompanying report.

Tif **Fine-grained trachyte (Eocene?)** -- Black to dark green, fine grained dikes with barely discernable needles of plagioclase and pyroxene. Dikes 1 to 2 m wide.

Tita **Porphyritic trachyandesite (Eocene)** -- dikes and sills of light-gray porphyry with 5 to 15% phenocrysts of plagioclase feldspar, dark green pyroxene, and potassium feldspar that are 1-2 mm across. These intrusive bodies may grade into more equigranular textures (Tig). Syenitic and sedimentary xenoliths are locally present.

Tid **Alkali diorite to gabbro-syenogabbro (Eocene)** -- equigranular, medium- to coarse- grained, salt-and-pepper textured dikes and sills with plagioclase feldspar and pyroxene phenocrysts. These intrusive bodies may grade into more porphyritic textures (Tita). These dikes cut sills of megacrystic trachyte porphyry. Alkali gabbro may contain amphibole and biotite (Moore et al., 1988).

Tim **Megacrystic trachyte porphyry (Eocene)** -- greenish gray porphyritic sills and dikes with megacrysts of embayed tschermakitic hornblende (Moore et al., 1988) or green pyroxene that are up to 2 to 4 cm across. Often contains hornblende ± biotite phenocrysts. These intrusives can contain xenoliths of pink coarse-grained syenite with phenocrysts of orthoclase feldspar and hornblende.

Tip **Amphibole-rich trachydacite (Eocene)** -- Black to dark green, medium-grained sills composed of ~30% dark green elongate amphibole needles, and subequal amounts of plagioclase and potassium feldspar. Sills 1 to 5 m thick.

Ti **Undifferentiated intrusive rock (Eocene)** -- Greenish gray, light gray, or gray igneous rock filling a dike on the eastern quadrangle border.

SEDIMENTARY ROCKS IN SACRAMENTO MOUNTAINS

Kdu **Upper unit of Dakota Sandstone (upper Cretaceous)** -- Intercalated light gray to dark gray shale, light gray siltstone, and white very fine-grained to medium-grained sandstone. Sand is well-sorted, subrounded, and composed of quartz. Sand is in medium to thick, taublar beds that are internally planar-laminated or gently cross-laminated. Sandstone beds are strongly cemented. Both the lower and upper units of the Dakota Sandstone are better exposed to the north (see descriptions of the Three Rivers quadrangle). Approximately 90 m-thick..

Pag **Grayburg Formation of Artesia Group (lower to upper Permian)** -- Reddish brown to light reddish brown (2.5YR 4/4 and 5/4-6), very fine- to fine-grained sand and clayey very fine- to fine-lower sand. Bedding is mostly very thin to thick and tabular, but very thin to medium, lentiuclar beds are locally present. Minor light gray to light greenish gray reduction spots (0.5-2.0 mm). ~10%, medium to thick, tabular beds of gypsum which are commonly folded or deformed. Although definitively Artesia Group, we assign this to the Grayburg Formation because of lithologic characteristics, thickness, and the fact that higher formations of this group extend progressively shorter distances from the deepest parts of the Delaware Basin to the south (Kelley, 1971 and 1972). We did not recognize the Queen Formation of the Artesia Group because we did not note scattered large, rounded, frosted quartz grains indicative of the upper part of this formation (Tait et al., 1962). 90-110 m based on well-data in the Three Rivers Quadrangle to the north.

Psa **San Andres Limestone (lower to upper Permian)** - Kelley (1971) recognized three members of the San Andres Limestone in south-central New Mexico. The lower part of the deposit, the Rio Bonito Member, is composed of medium- to thick-bedded dark gray, fossiliferous limestone, golden tan dolomite, and thin beds of yellow siltstone and gypsum. The middle part of the unit, the Bonney Canyon Member, is fossiliferous, gray thin-thick bedded dark gray limestone. The intercalated limestone gypsum unit in the upper part of the San Andres Limestone belongs to the Fourmile Draw Member of Kelley (1971). The Bonney Canyon Member was not deposited in this area; only the Rio Bonito Member, with the intercalated Hondo Sandstone Member of Harbour (1971), and the Fourmile Draw Member are present. 240-250 m-thick, based on well data in the Three Rivers quadrangle to the north.

Psr **Rio Bonito Member:** Dark gray, thin to thick bedded, fossiliferous limestone with thin to medium-bedded gypsum near the top of the unit and rare thin beds of gypsum near the base. Fossils include productid brachiopods, crinoids, echinoderm spines, and bryozoa fragments. The contact with the underlying Yeso Group is generally quite sharp; however thin (<0.5 m) discontinuous gypsum beds can persist a few meters above the contact.

Ph **Hondo Sandstone Member:** This unit was described by Harbour (1971). The sandstone is interbedded with the Rio Bonito Member approximately 30 m above the base of the limestone. The Hondo Sandstone is a gold-brown to tan, well-sorted, medium to fine-grained quartz arenite with well-rounded sand grains. The unit consists of a single sandstone bed that is 0.5 to 4 m thick in the hills just north of Temporal Creek. Bedding is commonly tabular, cross-bedding is rare. An outcrop of Hondo Sandstone at 406593 3675665 (NAD27) that is in proximity to a fault contains nodules of barite near the top of the exposure. The sandstone unit thickens to 10 m thick toward the northwest just south of Salinas Draw, where two sandstone beds are separated by a medial dolomite that is 1 m thick. Here, the lower sandstone is massive, and the upper sandstone has tabular bedding

Psf **Fourmile Draw Member:** The Fourmile Draw Member is composed of interbedded light gray dolomite, dark gray limestone, and laminated gypsum. The carbonates contain fossils, but fossils are not as common as they are in the Rio Bonito Member. The relative percentage of gypsum to carbonate increases upsection through the member.

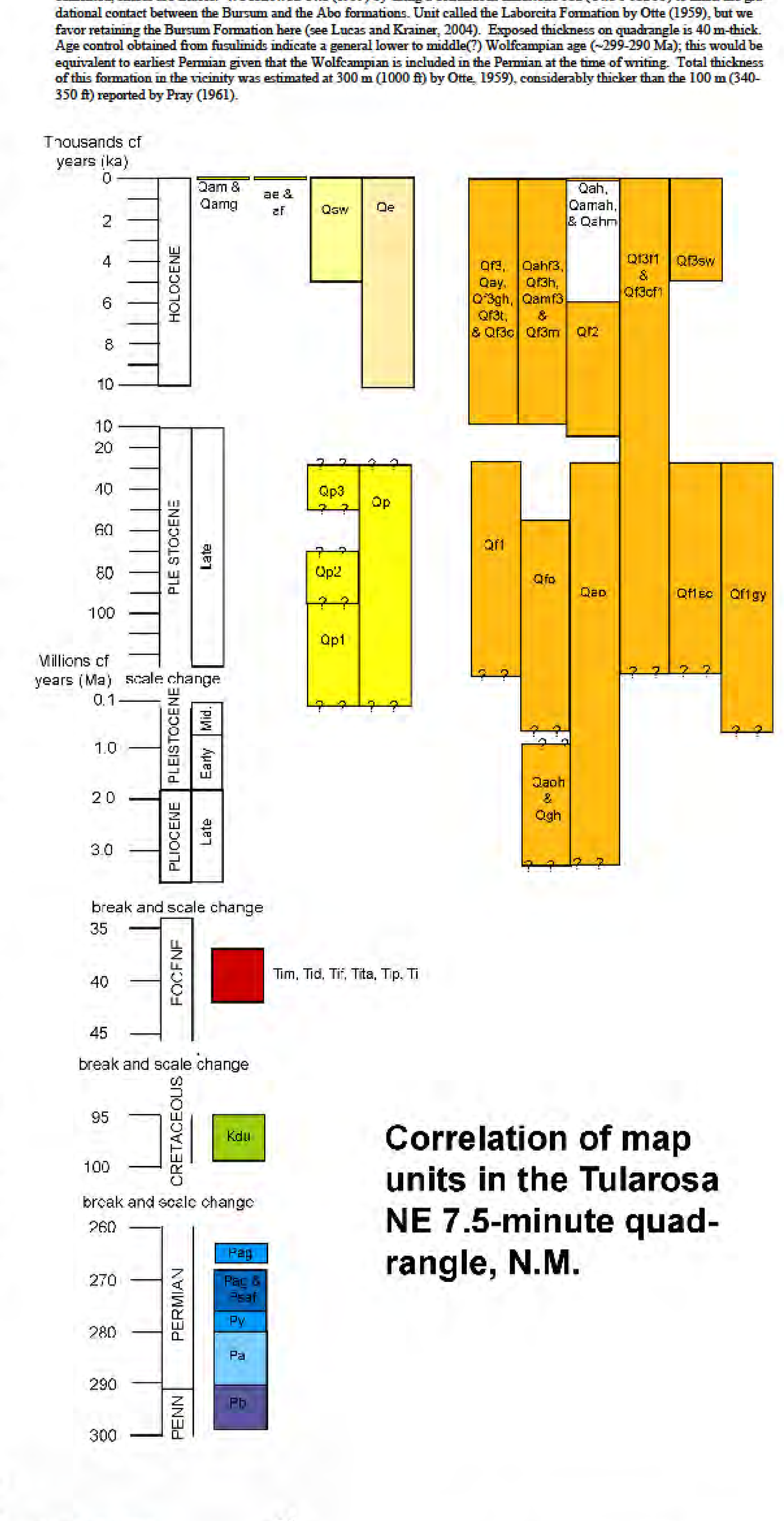
The contact between the Rio Bonito and Fourmile Draw members is very gradational and is here defined to be at the base of a distinctive limestone bed present across the map area. The marker limestone is dark gray, fossiliferous, and has a gypsum bed that is about 6 m thick below it. The carbonates above the marker limestone become progressively more dolomitic up section. The marker limestone is generally the thickest succession of carbonate beds above cliffs of the Rio Bonito Member, but the marker does vary in thickness (6 to 30 m; average is 12 m). The marker limestone forms an easily traceable unit on the gypsum-mantled hills between Temporal Creek and Salinas Draw.

The 6-m thick gypsum bed is continuous across the area, but thin, discontinuous gypsum and intercalated limestone often occurs as much as 25 m in the uppermost Rio Bonito Member below the mappable marker limestone. Similarly, thin sequences of dark gray, fossiliferous limestone that grade up into dolomite and thick beds of gypsum are present above the marker limestone.

Py **Yeso Formation (lower Permian)** – The basal limestone, gypsum, and red to yellow siltstone of the Yeso Formation are exposed in low hills between the Coyote Hills and the west end of Coyote Ridge along the east-central edge of the quadrangle. A 30-m thick medium-bedded limestone succession in the middle portion of the unit forms the prominent cliffs of western Coyote Ridge. The upper part of the Yeso Formation in the hills between Temporal Creek and Salinas Draw is gypsum and thin-bedded dark gray limestone with yellow and red siltstone. The limestones are sparsely fossiliferous, containing brachiopods. The Yeso Formation has a gradational contact with the underlying Abo Formation that is particularly well exposed along the east-central edge of the quadrangle. The red arkosic sandstone and red mudstone of the Abo Formation grade upward into thin beds of black shale, gypsum, and limestone. The upper contact is gradational with the San Andres Formation. Kelley (1971) measured a complete section of Yeso Formation on the Cat Mountain quadrangle to the east in the vicinity of Coyote Peak in T13S, R10E, sec. 21 and 22. Maximum thickness 372 m (1220 ft).

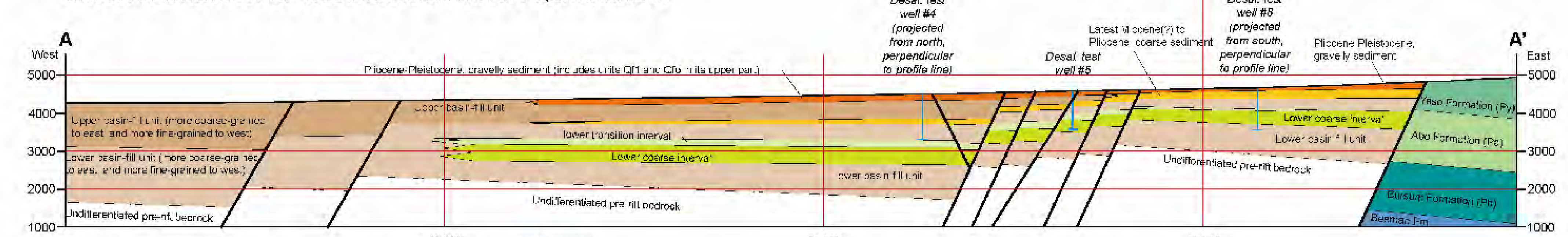
Pa **Abo Formation (lower Permian)**– Brick red sandstone, mudstone, siltstone, and conglomerate. The Abo Fomation is dominated by mudstone (50%) and arkosic sandstone and conglomerate (40%). Fossiliferous limestone and pedogenic carbonate, which are primarily found in the basal 150 m, make up the rest of the unit (Otte, 1959). Sandstones are cross-bedded to tabular, coarse to medium-grained, and poorly to moderately sorted. Angular to subround quartz, orthoclase feldspar, and muscovite are common sand grains. Conglomerates contain well-rounded clasts of Proterozoic quartzite, Proterozoic rhyolite porphyry, chert of uncertain age, and sandstone. Thin fossiliferous limestone beds that are 0.2 to 0.7 m thick locally occur near the transitional base of the unit, particularly in the southeast corner of the quadrangle. 427 m thick (Otte, 1959).

Pb **Bursum Formation (uppermost Pennsylvanian(?) to lowermost Permian)** – The Bursum Formation consists of interbedded marine intervals (dark shale and limestone beds) and fluvial intervals of subequal mudstone relative to sandstone and pebbly sandstone beds. Fluvial mudstone consists of weak red, reddish gray, and dark reddish gray (2.5-5YR 4-5/2) mudstone and sandy claystone, where the minor sand is very fine- to coarse-grained and arkosic. Sandstone and pebbly sandstone occupy medium to thick, lenticular to tabular channel-fills; internal bedding is massive to planar-laminated or in very thin to medium, planar to lenticular beds. Channel-fill sediment is pinkish gray to reddish gray (5YR 5-6/2) to pinkish gray (7.5YR 6/2). Sand is fine- to very coarse-grained (mostly medium- to very coarse-grained), angular to subangular (mostly) to subrounded, moderately sorted, and an arkose to lithic arkose. Pebbles are very fine to very coarse (mostly very fine to medium) and consists of poorly sorted subangular to subrounded granite with various proportions of subrounded to rounded quartzite. Limestone beds occupy medium to thick (mostly thick), tabular beds, are gray to light gray (2.5-5Y 5-7/1), and micritic to bioclastic. Marine shales are gray (2.5Y 5/1) and planar- to slightly wavy-laminated. Strata are typically strongly cemented; shales are friable. We followed Otte (1959) by using a continuous limestone bed (Otte's bed 55) to mark the gradational contact between the Bursum and the Abo formations. Unit called the Laborcita Formation by Otte (1959), but we favor retaining the Bursum Formation here (see Lucas and Krainer, 2004). Exposed thickness on quadrangle is 40 m-thick. Age control obtained from fusulinids indicate a general lower to middle(?) Wolfcampian age (~299-290 Ma); this would be equivalent to earliest Permian given that the Wolfcampian is included in the Permian at the time of writing. Total thickness of this formation in the vicinity was estimated at 300 m (1000 ft) by Otte, 1959), considerably thicker than the 100 m (340-350 ft) reported by Pray (1961).



Correlation of map units in the Tularosa NE 7.5-minute quadrangle, N.M.

CROSS-SECTION A-A' OF TULAROSA NORTHEAST QUADRANGLE



Note: Depths of subsurface units are not constrained except where intersected in wells. Dips are inferred.

SCALE 1:24000

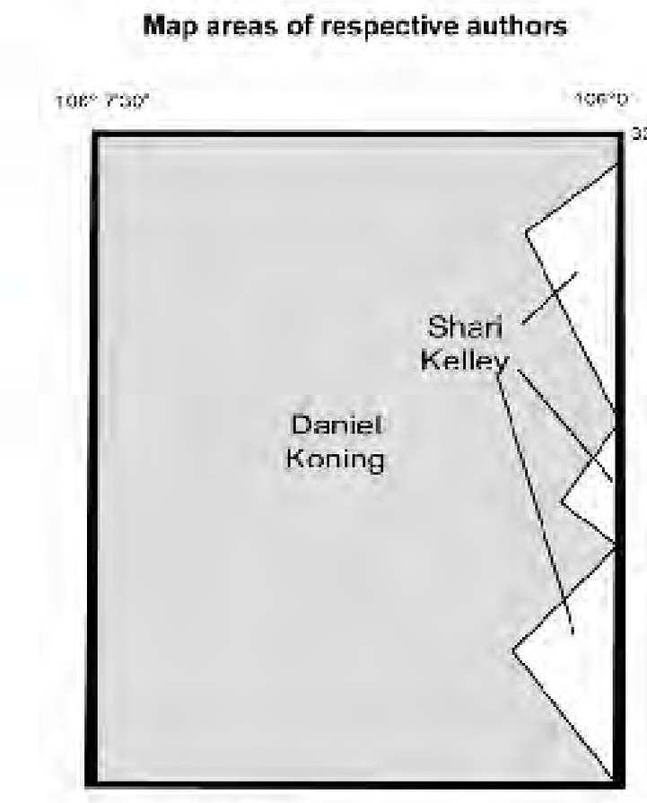
No vertical exaggeration

Daniel Koning and Shari Kelley; May 2009

EXPLANATION

- Uppermost gravelly sediment (Plio Pleistocene) -- Sand, sandy clay, and interbedded gravel to the west, grading eastward into a gravel. Weakly consolidated.
- Relatively coarse sediment in the upper basin-fill unit (upper Miocene(?) to Pliocene) -- Interval characterized by sandy-gravelly channel-fills intercalated with clayey sediment. Channel fills become more gravelly to the east.
- Upper basin-fill unit (upper Miocene(?) to Pleistocene) -- Interbedded clay-silt, silty sandy clay, and gravel beds. Sandy clay dominates to the west.
- Lower basin-fill unit (upper Miocene(?) to upper Oligocene) -- Interbedded clay-silt, silty sandy clay, and coarse channel-fills of sand or sandy gravel. Consolidated and likely cemented to some extent
- Lower transition interval (upper to middle Miocene(?)) -- Interbedded coarse-channel-fills and fine-grained sediment, located at the top of the lower coarse interval.
- Lower coarse interval (upper to middle Miocene(?)) -- Sand and gravel, locally clayey; coarsens-upwards. Consolidated and probably cemented to some extent.

Map areas of respective authors



TULAROSA NE 7.5-MINUTE QUADRANGLE, NM