Geologic Map of the Loving Quadrangle, Eddy County, New Mexico

By

Pederson, Joel L.; Dehler, Carol M.

June, 2004

New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 077

Scale 1:24,000

This work was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP) under USGS Cooperative Agreement 06HQPA0003 and the New Mexico Bureau of Geology and Mineral Resources.

New Mexico Bureau of Geology and Mineral Resources
801 Leroy Place, Socorro, New Mexico, 87801-4796

Description of map units—Loving Quadrangle

Sediment color was estimated by comparing dry sediment to Munsell Color Chart (Munsell Color, 1994).

Hd - Human disturbed areas (Holocene) — Disturbance areas are mostly quarries and/or dump areas that obscure the local geology.

Qal - Alluvium (Holocene) — Brown (7.5 YR 6/4), silt to sand, well sorted, subangular to subrounded, dominantly quartz with rare lithics, occupies draws and river channels and associated active floodplains. Little to no vegetation. Overlies or inset into all older units. Thickness 0-2m.

Qp - Playa lake deposits (Holocene) — Fine-grained deposits in playa lake along eastern central edge of map.

Qes - Eolian sand (Holocene) — Yellowish red (5 YR 5/8), very fine lower-fine upper, well sorted, subangular to subrounded, quartz sand derived from reworked QTg in NE part of map area. Forms coppice dunes, climbing dunes, and sand sheets. Typically east of the Pecos River channel and extends ~ 1 mile eastward from the river. Also abundant in northeast part of quadrangle where it overlies QTg. Thickness <10 m.

Qaes - Alluvial and eolian deposits (Pleistocene (?) to Holocene) — Brown (7.5 YR 6/4), silty clay to silt to sand, well sorted, subangular to subrounded grains composed of 70% quartz and 30% carbonate and chert. Weak soil development in upper 1.25 m: upper 15 cm of soil is massive silty clay to clayey silt, brown (7.5 YR 5/4), slightly plastic, bioturbated, effervesces strongly, local organic film with granular soil structure; gypsiferous and calcareous concretions decrease in abundance downward to 40 cm; prismatic structure extends down to 1.25 m. Unit locally weathers into badlands and exhibits piping. Commonly veneers nearly all Quaternary deposits in the map area, especially units Qagp2, Qasp2, Prv, and Prlu. Thickness ≤10 m.

Qasm1 - Alluvial sand mainstem (Pleistocene (?) to Holocene) — Light brown (7.5 YR 6/4), silt to fine sand, subrounded to subangular, well sorted, massive, quartzose and lithic grains, scattered pebbles and rare cobbles dispersed within matrix, rare calcic nodules and laminated drapes of dark red mud. Surface is nearly always reworked into coppice dunes. Top of unit forms a terrace (T1), 5 m above modern the Pecos River. Deposit is equivalent to the flume sand in Carlsbad. May overlie or be inset into Qagm2. Thickness ≤10 m.

Qasp1 - Alluvial sand piedmont (Pleistocene (?) to Holocene) — White to pink (5 Y 8/1-5 YR 7/4), tuffaceous sand and silt with mainstem pebbles, poorly exposed, not capped by calcrete, includes a <20 cm-thick lens of reworked white (5 Y 8/1) tephra. Inset into or capping Qa2 deposits and caps the fill-cut terrace (T2). Laterally equivalent to Qasm1. Thickness 0-2 m.

Qaspm1 - Alluvial sand piedmont (Pleistocene (?) to Holocene) — Transitional deposit between units Qasm1 and Qasp1.

Qagm2 - Alluvial gravel mainstem (Pleiostocene) — Pink (5 YR 7/4) to red to tan, medium sand to pebbles and small cobbles (<12 cm diameter) in sand and gravel lenses, subangular to well rounded, poorly to well sorted. Pebbles consist of chert, gray and maroon quartzite, and metamorphic clasts (?); smaller cobbles include chert, quartzite, dolomite, limestone, metamorphic schist, bull quartz, and basalt; and large pebbles and small cobbles are carbonate lithics. Gravel becomes sandy conglomerate where well cemented by calcite. Local potholes. Associated with a medium-light gray (2.5 Y) tephra (?) that is finely crystalline. Fine-grained facies locally laminated. Sands and gravels are commonly crossbedded, with some imbrication. Paleocurrent data indicate south-southeasterly flow. Capped by calcrete layer (0 - <2 m thick)**.** Cemented mainstem gravels make riffles/restrictions along the river channel in the southeast corner of the quadrangle. The top of Qagm2 with potholes could be a fill-cut equivalent to T2. A low-angle unconformity exists between Qagm2 and underlying TQg. Large irregular chunks of gypsum (from the underlying clastic Rustler Formation) are common where Qagm2 overlies Permian units. Thickness 0-75 m.

Qasgm2 - Alluvial sand and gravel mainstem (Pleiostocene) — Pink (5 YR 7/4) to red to tan, medium sand with lesser pebble and small cobbles (<12 cm diameter), subangular to well rounded, poorly to well sorted. Pebbles of chert, gray and maroon quartzite, metamorphic clast(?),smaller cobbles are carbonates, chert, quartzite, dolomite, limestone, metamorphic, schist, bull quartz, and basalt, large pebbles and small cobbles are carbonate lithics. Local potholes. Associated with a med-light gray (2.5 Y) tephra (?) that is finely crystalline. Locally laminated to trough-crossbedded, and imbrication. Paleocurrent data indicate south-southeasterly flow. Capped by calcrete layer (0-< 2 m thick)**.** Cemented mainstem sands and gravels make riffles/restrictions along river channel in SE corner of quadrangle. Top of Qasgm2 with potholes could be a fill-cut equivalent to T2. Low-angle unconformity between Qasgm2 and underlying TQg. Deposit associated with big irregular chunks of gypsum (from underlying clastic Rustler Fm) and commonly overlies Permian units. Thickness 0-75 m.

Qasgp2 - Alluvial sand and gravel piedmont (Pleistocene) — Pink to red sand and gray to white gravel, poorly sorted, angular to subrounded. Sand composed of quartz and locally-derived limestone, dolomite, and chert. Gravels are composed of locally-derived limestone, dolomite, and chert. Calcrete (1-2 m thick). Piedmont deposit in northeast area of map. Thickness 0->~75 m.

Qasp2 - alluvial sand piedmont (Pleistocene) — Pink to red sand, poorly sorted, angular to subrounded, composed of quartz, and locally-derived limestone, dolomite, and chert. Calcrete (1-2 m thick). Piedmont deposit in northeast area of map. Thickness 0 - >~75 m.

Qagpm2 - Alluvial gravel piedmont and mainstem (Pleiostocene) — **T**ransitional deposit between units Qasgp2 and Qagm2.

Qasgpm2 - Alluvial sand and gravel piedmont and mainstem (Pleistocene) — Transitional deposit between units Qasgp2 and Qasgm2.

QTg - Gatuna Formation (late Tertiary to early Pleistocene?) — Moderate orange pink (5 YR 8/4) to reddish orange (10 R 6/6) to red (2.5 YR 5/6), well sorted, subrounded to well

rounded siltstone to sandstone (silt to fine upper sand), calcite cemented, bluish hue in places, locally gypsiferous, local well rounded granules and pebbles of chert, interbedded with non-calcareous mudstone (weathers blocky). Sandstone and siltstone beds are medium to thick with horizontal planar laminations, low-angle crossbeds, and cut-and-fill structures. Mudstones are in lenticular to tabular thin beds and also in m-scale-thick intervals. Slope former with badland weathering. Capped by mudstone- and gravel-bearing calcrete: plug is 0.5-1.0 m thick, pillar structures penetrate down into bedrock about 2 m. Varying bedding orientations in area indicate local warping (salt tectonics). Forms prominent redbeds in southeast and east part of quadrangle. Overlies Permian bedrock units. Highly variable thickness 0 - >~130 m (from cross section).

Prm - Rustler Formation, Magenta Dolomite (Ochoan) — Pinkish gray fresh, light pink weathered (2.5 YR 6/4 to 2.5 YR 7/2), gypsiferous, sugary limestone, medium crystals (0.25-0.35 mm dia), poorly to moderately indurated. Very finely laminated to massive in thin beds, laminations are planar to crinkly. Microbial buildups present in equant to elongate heads (cm-scale to decimeter scale, maximum of 30 cm) with synoptic relief of mms to cms. Locally vesicular and chicken wire weathering common. Varying bedding orientations indicate local warping (salt tectonics). Exposed in eastern part of quadrangle and shown in cross section. Contacts with other units were not observed. Thickness ~≤3 m.

Prc - Permian Rustler Formation, Culebra Dolomite Member (Ochoan) — Cream-weathered and fresh (7.5 YR 8/1), sugary, finely crystalline, locally yellow to red to pink(10 YR 8/2), sandy limestone. Low-angle crossbeds, planar horizontal laminations to massive in thin to thick tabular beds (< 0.75 m thick). Vesicles follow bedding, hematite present near vesicles and along laminations, auto-brecciated locally, some recessive interbeds where gypsum and (or) mudstone has locally been removed. Vertical and horizontal joints filled with gypsum and calcite, gypsum crystals in vugs, chicken-wire weathering in cm, decimeter, and meter scales. Capped by 1-2 m of calcrete. Exposed in Culebra bluffs area where it is folded into broad synclines and anticlines. Riffles and channel restrictions associated with bedrock exposures of this unit in the area of Herradura Bend and Culebra Bluffs. Thickness ~≤20 m (from cross section).

Prv - Rustler Formation Virginia Draw Member (Ochoan) — Deep orange-red weathered and fresh (10R 4/6) and locally green to gray (GLEY 7/10 Y), siltstone to very fine lower to medium lower sandstone, with rare coarse grains, moderately well sorted, subangular to round, interbedded with gypsiferous green-red claystones and mudstones. Medium beds of silty sandstones interbedded with very thin beds of greenish gypsiferous claystone and mudstone, massive, finely laminated to medium bedded, wavy bedding and ripples crossbeds. Highly contorted into micro- and mesoscale folds, highly fractured with gypsum veins, and fractured into intraclastic breccia. Capped by 1-2 m thick calcrete. Weathers into badlands. Exposed in irrigation ditches in southwest part of quadrangle—good area to characterize lower siliciclastic Vdraw member(?) of Rustler Member. Base of unit not exposed. Thickness ~130 m (from cross section).

Prlu - Ruster Formation lower undifferentiated (Ochoan) — Irregular masses of gypsum, dolomite (Prc), and salt in large blocks scattered on surface and outcrops with chaotic bedding orientations. Exposed in eastern and southern part of quadrangle. Associated with yellow ripple-

cross-laminated sandy dolomite blocks and massive gypsum blocks at surface in Gypsum Bend area. May include upper Salado Formation. Thickness unknown.

Pru - Rustler Formation undifferentiated (Ochoan) — Irregular masses of gypsum, dolomite(Prc and Prm), and salt in large blocks scattered on surface and outcrops with chaotic bedding orientations. Exposed in eastern part of quadrangle. Highly contorted with overlying QTg by railroad cut east of factory. May include upper Salado Formation. Thickness unknown.

Ps - Permian Salado Formation (Ochoan) — In cross section only. Halite and anhydrite with subordinate potash salts, dolmite to silty-sandy dolomite, and claystone to siltstone. Thins to southwest. (550-650 m thick).

Pc - Permian Castille Formation (Ochoan) — In cross section only. Anhydrite and interbedded halite. Thickness ~60-100 m.

Pl - Permian Delaware Mountain Group, Bell Canyon Formation, Lamar Limestone Member (Ochoan- Guadalupian) — In cross section only. Limestone, siltstone, and possibly sandstone and shale. Thickness ≤0-15 m.

Pd - Permian Delaware Mountain Group, undifferentiated (Guadalupian) — In cross section only. Sandstone, siltstone, and shale with subordinate limestone. Thickness >350 m.

Map symbols:

Pleistocene bar-and-swale paleocurrent indicators--from air photo interpretation, only

Paleocurrent direction-arrow indicates paleoflow direction from imbrication or crossbedding

Bedding contact-dashed where approximately located or where interpreted from air photo

Basin- arrows on axis denote plunge direction

Hatchures- indicate depression made by salt removal/collapse and (or) wind deflation

Oil/gas well location
(suggested type logs for subsurface stratigraphic picks are logfile numbers 47113 or 24319)

Water well location

Depositional environments of Permian facies

Permian outcrops in the Loving quadrangle are exposed along the Pecos River and in a few places in the southern part of the quadrangle. It is difficult to characterize these units due to the poor exposure and the contorted nature of the strata. Sedimentary structures are rare and macrofossils were not found during this study. The sedimentary characteristics of the Culebra and Magenta dolomites suggest a restricted shallow shelf environment. The lower Rustler Formation (Virginia Draw Member) also likely represents a restricted low-energy environment. The Virginia Draw Member is nicely exposed in irrigation ditches in the southwest part of the

Loving quadrangle. This is a good area to characterize the lower siliciclastic Virginia Draw Member(?) of Rustler Formation.

Structural geology

The structural history of this quadrangle is difficult to interpret based on limited exposure of bedrock units. The cross section and map, although very crude, reflect gentle folding of the Permian units, although bedding orientation is not well established. Laramide reactivation of late Paleozoic structures and (or) deformation from salt tectonics are two viable scenarios (Hiss, 1976c), however salt tectonics is favored because deformation does not appear to propogate downward through the strata (see Culebra Bluffs area of cross section). Additionally, the random orientation of much of the bedding, and the presence of domes and basins in the area, suggest that salt mobility has been, in part, responsible for local deformation of bedrock units. Varying bedding orientations and convolution of all pre-Holocene deposits suggest that salt tectonics has been active as late as mid-Pleistocene(?) time.

Geomorphology and landscape evolution of the Pecos River

The Gatuna Formation likely represents the earliest Pecos River deposits and may be older than mid-Pleistocene, but is likely post Ogallala Fm. The Gatuna Formation represents a north- to south-directed river system that underwent a significant valley-filling episode. This unit is not fully within the present landscape position in that it is not confined to the modern Pecos Valley, but parallels it in a broader region between uplands to the west and east.

Two hypotheses address the landscape position of the Quaternary deposits in the Loving quadrangle. The preferred hypothesis is that the deposits underlying the hills in the quadrangle (Qamg2) are the same deposit as that in the topographically lower surrounding landscape (Qaes/Qagp2). Another hypothesis is that these deposits at higher elevations are an older deposit and that the hills represent eroded terraces preserved in the landscape. This hypothesis is not favored due to: insignificant differences in calcrete development; similar composition of clasts (provenance); calcrete surfaces follow land surface; and no terrace risers observed. In keeping with the first hypothesis, Qamg2 and related deposits are the oldest known Quaternary deposits in the field area. They are post-Ogallala Fm (and post Gatuna Fm—TQg) and pre-modern Pecos River, and likely represents the ancestral (Pleistocene) Pecos River in a setting analogous to the modern Pecos River. Although most of the alluvial gravels in the quadrangle may be approximately the same age, they may be polygenetic. There is however a notable thinning of the calcrete layer in the SE part of the Loving quadrangle on Qasm2. This may be due to age (is this T2?) or it may be the effect of finer material on soil development**.**

Aeolian deposits (Qes and Qaes) in the area are dominantly confined to the eastern side of the Pecos River (downwind side), within about a mile of the Pecos River. The main sand source for these dunes is from the paleo- and modern Pecos River deposits.

References

Austin, G.S., 1978. Geology and mineral deposits of Ochoan Rocks in Delaware Basin and adjacent areas. New Mexico Bureau of Mines and Mineral Resources, Circular 159, 88 p.

Bachman, G.O., 1984. Regional geology of Ochoan evapoites, northern part of Delaware Basin. New Mexico. State Bureau of Mines and Mineral Resources, Circular 184, 22 p.

Boyd, D.W., 1958. Permian sedimentary facies, Central Guadalupe Mountains, New Mexico. State Bureau of Mines and Mineral Resources, New Mexico Tech, Bulletin 49, 100 p.

Hawley, J. W., 1993. The Ogallala and Gatuna Formations in the southeastern New Mexico Region, A progress report. *In* Love, D.W., Hawley, J.W., Hues, B.S., Adams, J.W., Austin, G.S., and Barker, J.M., (eds): Carlsbad Region, New Mexico and West Texas, NMGS 44th annual field conference. pp. 261-269.

Hawley, J.W., and Love, D.W., 1993. Supplemental road log 1, from Pierce Canyon to New Mexico Highway 31/128 Junction north of Salt Lake, via Mescalero Plain, Los Medanos (WIPP) and Nash Draw. *In* Love, D.W., Hawley, J.W., Hues, B.S., Adams, J.W., Austin, G.S., and Barker, J.M., (eds): Carlsbad Region, New Mexico and West Texas, NMGS 44th annual field conference. pp. 87-97.

Hendrickson, G.E., and Jones, R.S., 1952. Geology and Ground-water resources of Eddy County, New Mexico. New Mexico Institute of Mining and Technology, Ground-water report 3, 169 p.

Hill, C. A., 1999. Geology of the Delaware Basin Guadalupe, Apache, and Glass Mountains New Mexico and Texas. Permain Basin SEPM, Publication 96-39. 480 p.

Hiss, W. L., 1976a. Thickness of the Permian Guadalupian Capitan Aquifer, Southeast New Mexico and West Texas. U.S.G.S. Resource Map 5.

Hiss, W. L., 1976b. Structure of the Permian Guadalupian Capitan Aquifer, Southeast New Mexico and West Texas. U.S.G.S. Resource Map 6.

Hiss, W. L., 1976c. Structure of the Permian Ochoan Rustler Formation, Southeast New Mexico and West Texas. U.S.G.S. Resource Map 7.

http://iwaters.ose.state.nm.us:7001/iWATERS/. New Mexico Office of the State Engineer [website for water data used in cross sections].

Kelley, V.C., 1971. Geology of Pecos Country, southeastern New Mexico. New Mexico. State Bureau of Mines and Mineral Resources, Memoir 24, 78 p.

Petroleum Library at New Mexico Bureau of Geology and Mineral Resources [recource for all oil and gas well data used in generating cross section].

Powers, D.W., and Holt, R.M., 1993. The upper Cenozoic Gatuna Formation of southeastern New Mexico. *In* Love, D.W., Hawley, J.W., Hues, B.S., Adams, J.W., Austin, G.S., and Barker, J.M., (eds): Carlsbad Region, New Mexico and West Texas, NMGS 44th annual field conference. pp. 271-282.