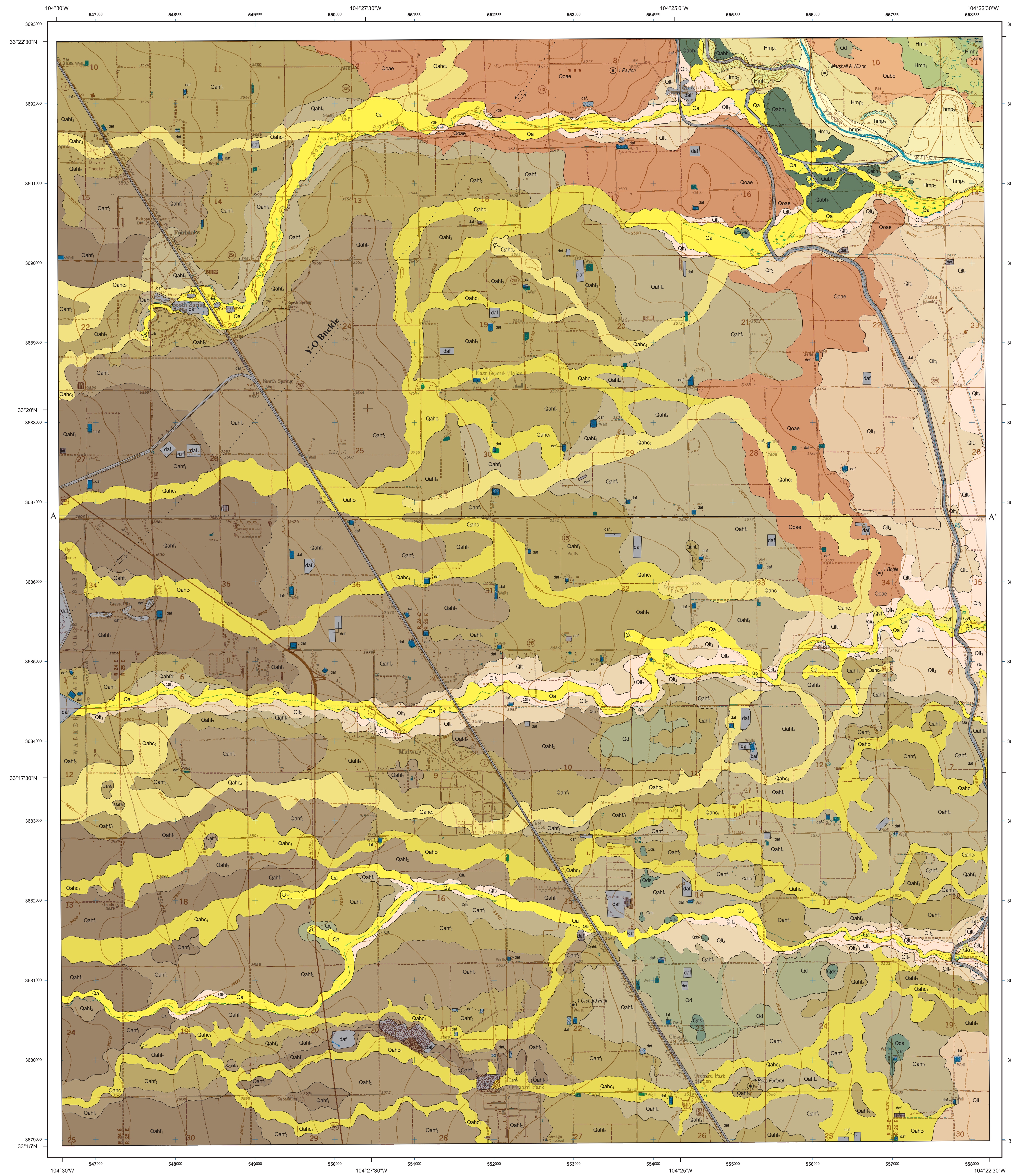
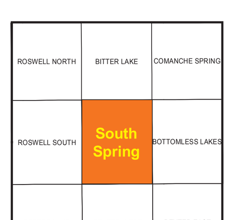
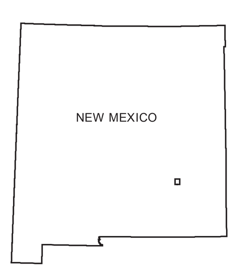
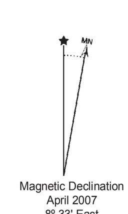


Base map from U.S. Geological Survey in cooperation with U.S. Corps of Engineers 1950, from photographs taken 1961, revised 1962.
1927 North American datum, UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13





QUADRANGLE LOCATION



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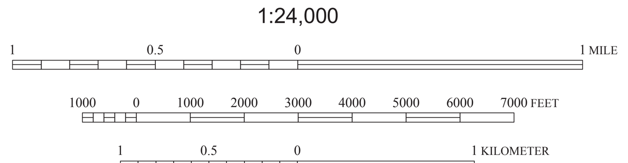

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

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*).

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 171

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This and other STATEMAP quadrangles are (or soon will be) available for free download in both PDF and ArcGIS formats at:

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

Geologic map of the South Spring quadrangle, Chaves County, New Mexico.

May 2008

by
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EXPLANATION OF MAP SYMBOLS

A——A'	Location of geologic cross section.
	Geologic contact. Solid where exposed or known, dashed where approximately known, dotted where concealed or inferred.
	Y-O Buckle. Pennsylvanian-age, left-hand lateral strike-slip fault, reactivated with normal movement during the Laramide, according to Kelley (1971).
	Arrows showing mean direction of paleoflow, based upon pebble imbrication, n=20 each arrow.
	Active spring.
	Extinct spring due to a lowered water table resulting from ground-water pumping.
1 Bogle	Oil & gas exploration well.

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.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology and Mineral Resources. The views and conclusions contained in this document 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.

Panorama of the extinct South Spring looking north to northeast. The spring used to issue out of the low-lying, gray, lacustrine sediments in the foreground-right, and flowed to the Pecos River, some 8 km distant to the north and east.

DESCRIPTION OF MAP UNITS

QUATERNARY/NEOGENE

Alluvium and anthropogenic deposits

daf — **Disturbed land and/or artificial fill** — Dumped fill and areas affected by human disturbances, mapped where deposits or extractions are areally extensive. Includes the Hagerman Canal, the channelized Rio Hondo, gravel ("caliche") pits, and numerous settling ponds associated with the widespread dairy industry.

Qa — **Quaternary tributary alluvium and valley-fill alluvium, undifferentiated (Historic to upper Pleistocene)** — Brown (7.5YR4/2) to pinkish gray (7.5YR6/2) (*tributaries*) to light reddish-brown (5YR 6/4) to reddish brown (2.5YR4/6) (*Pecos floodplain valley-fill*), unconsolidated, moderately sorted, pebbly sand, silt, and clay, often gypsiferous in Orchard Park terrace and Pecos floodplain areas. Varies considerably in thickness from <1 to 3 m in tributaries and up to 10-12 m in the floodplain.

Qvf — **Quaternary valley-fill alluvium, undifferentiated (Holocene to upper Pleistocene)** — Brown (7.5YR4/2) to reddish brown (2.5YR4/6), unconsolidated, moderately sorted, pebbly sand, silt, and clay. Often contains *Qa* bottomland within deposits. Primarily alluvium, occasionally reworked by sheetwash and colluvial processes. Varies considerably in thickness from <1 to 5 (?) m.

Pecos River alluvial valley floor

Pecos River meanderbelt alluvial deposits (Historic to lower (?) Holocene) — During the Holocene, the Pecos River built four distinguishable meanderbelts on top of an upper Pleistocene Pecos River braided alluvial valley-fill deposit (*Qabp*), which is the basal unit of the floodplain. Meanderbelts consist of channel, channel bar, point bar, and natural levee deposits, undivided. McCraw, *et al*. (2007) differentiated these meanderbelts on the Bitter Lake quad, immediately north of South Spring, based upon field observation of cross-cutting relationships and aerial photographic work. They mapped two older Holocene units and two Historic units. Only the youngest of the two older Holocene meanderbelts (Hmp_2) is found on the South Spring quad.

The modern meanderbelt (hmp_4) was mapped from both 2005 digital 1-m resolution, color orthophotography and 1981 color aerial photography, and a 1939-1940 meanderbelt (hmp_3) was mapped using vintage U.S.D.A. – Soil Conservation Service black and white aerial photography. All aerial photography was georeferenced and plotted onto the 2005 orthophotography using ArcGIS, to produce a derivative Pecos River channel historical map showing channel migratory change patterns (not included in the open-file report). The historic units are differentiated from the Holocene units by using a lower case "h" on the unit labels.

hmp_4 — **Modern meanderbelt deposits (Historic)** — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately to well-sorted, occasionally pebbly, coarse- to fine-grained sand in the modern channel and adjacent bar crests, grading to silty sand and sandy clay with distance from the channel. Thickness generally <1 m, but reaches ~1.5 m in a few places.

hmp_3 — **1939-1940 meanderbelt deposits (Historic)** — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately to well sorted, coarse- to fine-grained sand in the Historic channel and adjacent bar crests, grading to silty sand and sandy clay with distance from these older channels. Throughout the upper Holocene, extensive point bar development, with some minor channel bar development has taken place. This has resulted in a series of sweeping meanders, with meander amplitudes >1 km in width common, the largest reaching about 1.8 km in width on the Bitter Lake quad. The largest hmp_3 meander on South Spring has an amplitude of 0.9 km. Thickness 2-4 m.

Hmp_2 — **Younger Holocene meander belt deposits (Historic to upper Holocene)** — Very pale brown (10YR7/4) to reddish brown (2.5YR4/6), unconsolidated, moderately to well sorted, occasionally pebbly, coarse- to fine-grained sand, silty sand, and sandy clay. Meander geometries are similar to hmp_3, and while much of this is obscured by more recent meander belt deposition and/or agriculture, amplitudes are estimated to average about 1 km in width. Thickness 3-10 m.

Qabp — **Pecos River braided alluvial deposits (lower Holocene to upper Pleistocene)** — Light reddish-brown (5YR6/4) to reddish brown (2.5YR4/6), unconsolidated, poorly to moderately sorted, pebbly coarse- to fine-grained sand, silty sand, sandy clay, and clay. Braided channels and bars typify the surface of *Qabp*. Thickness 10 - 20 m.

Rio Hondo alluvial deposits within the Pecos River floodplain: meanderbelts (Historic to lower (?) Holocene) and braided alluvium (upper Pleistocene) — Gravels of limestone, sandstone, and igneous rocks in brown (10YR5/3) to dark yellowish brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt (largely calcareous), and sandy clay. The southernmost (and oldest) deposits of a large, braided, fluviodeltaic fan that the Rio Hondo built out into the Pecos River floodplain during the upper Pleistocene extend into the South Spring quad ($Qabh_1$). At the onset of the Holocene, both the Pecos River and the Rio Hondo began meandering, building meanderbelts. The earliest two Rio Hondo meanderbelts built across the entire Pecos River floodplain (*Qabh* and *Qabp* deposits) during the early to middle Holocene, due to the fact that the Pecos River occupied collapsed karstic depressions along the eastern margin at this time (McCraw, *et al.,* 2007). Responding to an avulsion of the Pecos River in the middle Holocene on the Bitter Lake quad, the Rio Hondo abandoned these meanderbelts and was forced to turn south along the western edge of the floodplain, building a third meanderbelt over $Qabh_1$. While meander geometries are essentially identical among the three Hondo meanderbelts, Hmh_1 certainly exhibited the widest lateral migration (although not necessarily widest meander amplitude).

Hmh_3 — **Modern (pre-channelization) meanderbelt deposits (Historic to upper Holocene)** — Deposition was abandoned in the early to middle 20th Century due to the construction of the Hagerman Canal and the channelized Rio Hondo. Thickness 1-3 m.

Hmh_2 — **Young meanderbelt deposits (middle Holocene)** — This meanderbelt primarily built upon the top of the oldest meanderbelt (Hmh_1). Thickness 1-3 m.

Hmh_1 — **Older Holocene meanderbelt deposits (middle Holocene to lower (?) Holocene)** — Deposition was clearly influenced by the youngest upper Pleistocene channels within $Qabh_5$ on the Bitter Lake quad. Thickness 1-3 m.

$Qabh_1$ — **Oldest braided valley-mouth alluvial-fan deposits (upper to middle (?) Pleistocene)** — Lowest-lying, yet most extensive braided alluvial-fan deposit. Greatly modified by agriculture on its eastern margin adjacent to and within the Pecos floodplain. Only an occasional channel remnant remains. Overriden by Hmp_3. Thickness ~2 to 30 m.

Alluvial terrace deposits

Lakewood terrace alluvial deposits (upper to middle Pleistocene) — Alluvial terraces of the Pecos River and its tributaries were first described in the classic study of Fiedler and Nye (1933). They recognized 3 terraces: (from lowest to highest) the Lakewood, the Orchard Park, and the Blackdom. The Lakewood terrace, with an elevation of 6 to 9 m above the floodplain, flanked the inset Pecos floodplain and extended up many of its western tributaries. Following McCraw, *et al.* (2007), three distinct, low-lying (upper to uppermost middle(?) Pleistocene) "Lakewood terraces" are recognized. The highest and oldest of which (Qlt_1) would be Fiedler and Nye's original. Surface tread elevations above the floodplain for these three are: <1-1.2 m, 1.2-6 m, and 6-9 m, respectively. They are comprised of occasional gravels and pebbles, brown (10YR5/3) to dark yellowish brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt and sandy clay. Pedogenic carbonate increases from stage I to stage II+ (occasionally III) from Qlt_3 to Qlt_1. Mostly non-gypsiferous.

Qlt_3 — **Youngest Lakewood terrace alluvial deposits (upper Pleistocene)** — Thickness <1 to 1 m.

Qlt_2 — **Young Lakewood terrace alluvial deposits (upper Pleistocene)** —Thickness 1.5 to 5 m.

Qlt_1 — **Older Lakewood terrace alluvial deposits (upper to middle Pleistocene)** —Thickness ~2 to 9 m.

Orchard Park terrace alluvial deposits (upper to middle Pleistocene) — According to Fiedler and Nye (1933), the Orchard Park terrace rises 1.5-3 m above the Lakewood terrace and 6-10.5 m above the Pecos floodplain. It consists of interbedded alluvial and eolian deposits and is mapped as an alluvial-eolian complex (*Qoae*). On the South Spring quad, the Orchard Park terrace is largely buried by the Rio Hondo alluvial fan complex, and is only exposed in the northeast corner. Unlike the majority of *Qoae* deposits on the Bitter Lake quad, these deposits lie primarily west of gypsiferous soils and saline ground-waters, and thus support extensive agriculture. Only along the bluffs, where *Qoae* is so choked with gypsum it forms gypsite, an indurated hyper-concentration of gypsum in the soil (Watson, 1983), is agriculture limited.

Qoae is comprised of very pale brown (10YR7/4) to reddish brown (5YR4/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt, and sandy clay. Stage III to III+ pedogenic carbonate. Where gypsiferous, it is white (2.5Y8/1) to light gray (2.5Y7/1) to very pale brown (10YR7/4), unconsolidated, well sorted, fine-grained, gypsiferous sand, silty sand, and sandy clay.

Qoae — **Orchard Park terrace alluvial and eolian deposits, undivided (upper to middle Pleistocene)** — Thickness 15 to 45 m.

Rio Hondo alluvial fan complex deposits

Rio Hondo alluvial fan lobe deposits (Historic to lower Pleistocene) — During most of the Pleistocene, the Rio Hondo debouched from the western uplands into the Pecos valley south of its current location. It flowed from approximately latitude 33° 17' 30" N, roughly due east through what is now known as Rocky Arroyo onto the valley floor, two quads west of the South Spring quad. From here, it built a very large alluvial fan complex out over Pleistocene Pecos River terraces. It prograded east until a stream capture occurred within the western uplands, sometime in the upper Pleistocene. This capture, loocated at the current site of the dry Twin Rivers reservoir, on the Hondo Reservoir 7.5-minute quadrangle, turned the Rio Hondo northeast into its present channel and cut off fluvial and sediment input to the distal reaches of its fan complex in the South Spring quad.

On the South Spring quad, four distinct fan lobes are mapped, prograding east to northeast ($Qahf_{1-4}$). These are comprised of gravels with a distinct petrographic Rio Hondo signature. While limestone, sandstone, and chert, could've originated anywhere within the Sacramento Mountains and along its eastern flanks, the porphyritic igneous, mafic igneous, and rhyolitic gravels common throughout these deposits could only have originated from Sierra Blanca, the headwaters of the Rio Hondo. These gravels are supported by a matrix of brown (10YR5/3) to dark yellowish brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, silty sand, silt (largely calcareous), and sandy clay. Pedogenic carbonate varies from stage III+ to II, west to east and northeast.

$Qahf_4$ — **Youngest Quaternary alluvial fan lobe (upper Pleistocene)** — Thickness 1 to 3 m.

$Qahf_3$ — **Younger Quaternary alluvial fan lobe (upper Pleistocene)** — Thickness 2 to 4 m.

$Qahf_2$ — **Older Quaternary alluvial fan lobe (upper to middle Pleistocene)** — Thickness 2 to 4 m.

$Qahf_1$ — **Oldest Quaternary alluvial fan lobe (lower to middle Pleistocene)** — Thickness 2 to 4 m.

Rio Hondo alluvial fan channel deposits (Historic to lower Pleistocene) — The Rio Hondo alluvial fan complex contains numerous alluvial channel deposits, ranging from old, abandoned channels to historic ephemeral streams (formerly perennial – artesian spring-fed). The oldest ($Qahc_1$–which flowed eastward off of the oldest *Qahf* lobes) were often mapped primarily by soil moisture increases noted on photography, relative to adjacent lobe deposits, as eolian input from these adjacent lobes often mantles the "v-shaped" contours associated with stream channels. Many of both $Qahc_1$ and $Qahc_2$ channels are also mapped in this matter due to the fact that their deposits have been "blurred" by plowing and dairy farm agriculture. Channel sediments are usually comprised of gravels of limestone, sandstone, and igneous rocks in brown (10YR5/3) to dark yellowish brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine- grained sand, often containing clay drapes

$Qahc_2$ — **Younger Quaternary alluvial fan channels (Holocene to upper Pleistocene)** — Thickness <1 to 3 m.

$Qahc_1$ — **Older Quaternary alluvial fan channels (upper to middle Pleistocene)** — Thickness 1 to 3 m.

View of western gravel pit wall developed in an old Rio Hondo fan channel ($Qahc_1$) developed in the oldest fan unit ($Qahf_1$). Paleoflow directions, based upon clast imbrication varys from 118° to 128° (roughly represented by the observer's face).

Qd — **Quaternary depression fill, primarily caused by subsidence (Historic to middle Pleistocene)** — Unconsolidated, well-sorted, fine-grained (fine sands to clay) complexes of alluvial, colluvial, eolian, and occasional lacustrine deposits within closed depressions created by either gradual subsidence or sudden collapse followed by gradual subsidence of underlying gypsiferous carbonate terrane. These complexes are often significantly modified by stream erosion and deposition, playa deposition, deflation, and mass wasting. Depression fills have been active since the middle Pleistocene and are usually 1-3 m thick.

Qds — **Quaternary sinkhole deposits, primarily caused by collapse (Historic to middle Pleistocene)** — occasional pebbles in a fine-grained sandy clay matrix. Thickness <1 to 3 m.

PALEOZOIC

Pemian Artesia Group

Psr — **Seven Rivers Formation (Guadelupian - upper Permian)** – White to pale gray gypsum, brick red, pale red, to orange very fine sandstone, siltstone, and mudstone, and minor limestone. Near surface in eastern part of quadrangle. Top not exposed; at least 75 m based on cross-section.

Pqg — **Queen and Grayburg Formations, undivided (Guadelupian - upper Permian)** – cross section only.

Psa — **San Andres Formation (middle to upper Permian)** – cross section only.

Pya — **Yeso and Abo Formations (lower to middle Permian) –** cross section only.

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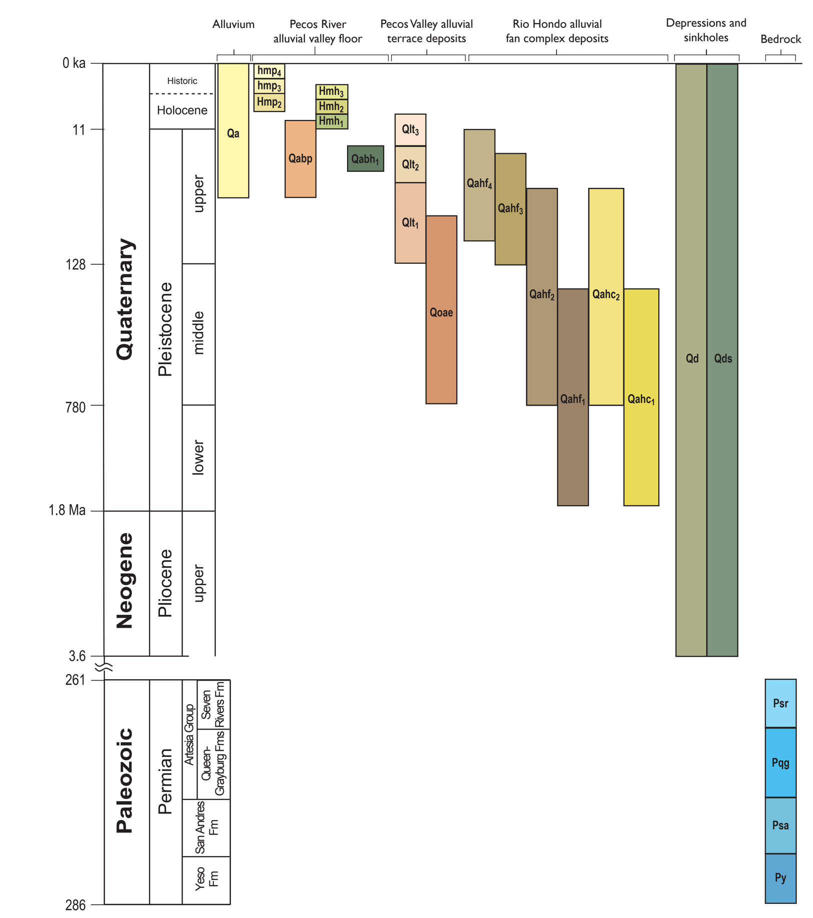
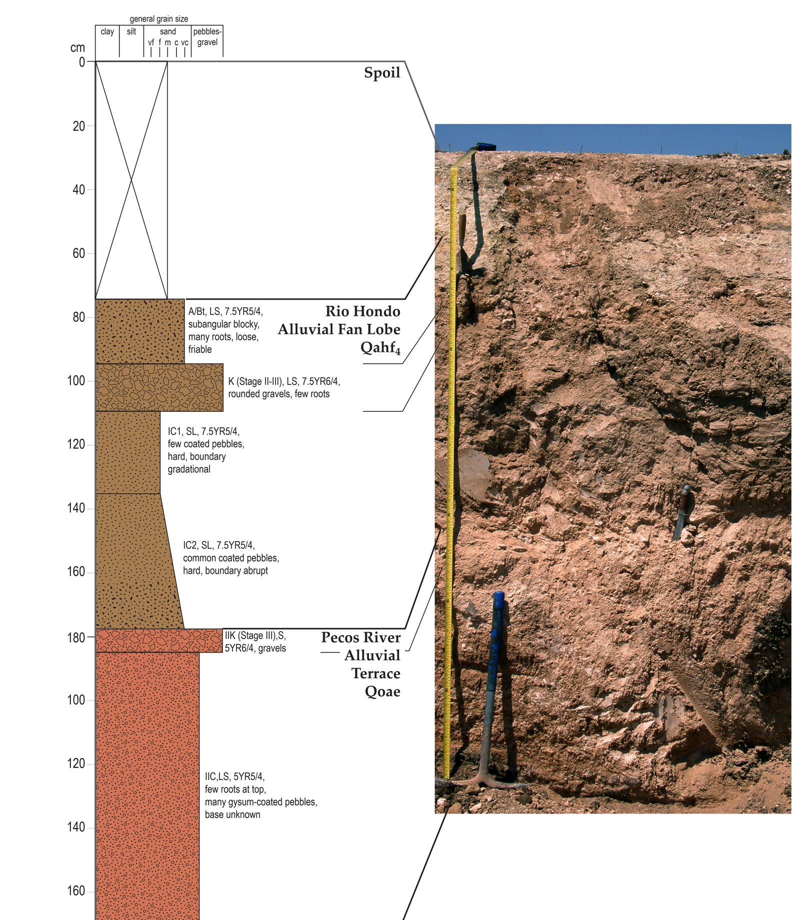
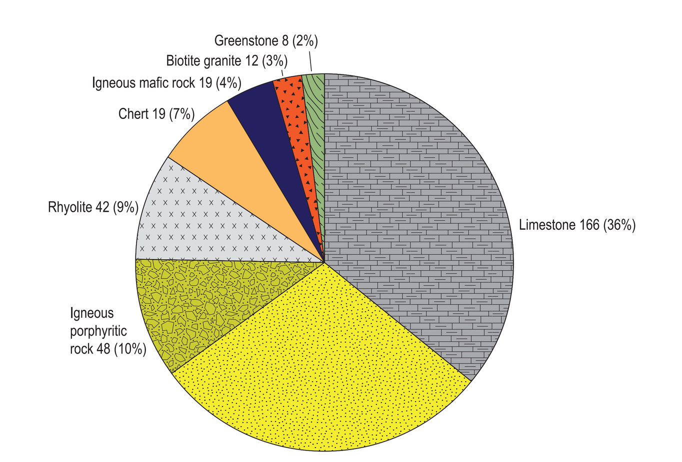
CORRELATION OF MAP UNITS





Description of trench wall near the distal edge of the Rio Hondo alluvial fan, showing fan sediments ($Qahf_4$) overlying Pecos River Orchard Park alluvial terrace (*Qoae*) sediments.

Gravel Clast Count
Rio Hondo Alluvial Fan Unit $Qafc_1$
n = 460



Gravel clast count derived from western wall of an active gravel pit developed in an old Rio Hondo fan channel ($Qahc_1$) (from locality depicted in upper left photo).