

Preliminary Geologic Map of the Albuquerque West Quadrangle, Bernalillo County, New Mexico

By

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May, 1998

**New Mexico Bureau of Geology and Mineral Resources
*Open-file Digital Geologic Map OF-GM 17***

Scale 1:24,000

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Albuquerque West 7.5' quad
OF-DM17



**PRELIMINARY GEOLOGIC MAP OF THE
ALBUQUERQUE WEST
7.5' QUADRANGLE, BERNALILLO COUNTY,
NEW MEXICO**

by

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May 1998

COMMENTS TO MAP USERS

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This quadrangle map has been Open-Filed in order to make it available as soon as possible. The map has not been reviewed according to NMBMMR standards, and due to the ongoing nature of work in the area, revision of this map is likely. As such, dates of revision are listed in the upper right corner of the map and on the accompanying report. ***The contents of the report and map should not be considered final and complete until it is published by the NMBMMR.***

A geologic map graphically displays information on the distribution, nature, orientation, and age relationships of rock and surficial units and the occurrence of structural features such as faults and folds. Geologic contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic map are based on field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation.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. Significant portions of the study area may have been mapped at scales smaller than the final map; therefore, the user should be aware of potentially significant variations in map detail. 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 everywhere.

Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. The information provided on this map cannot be substituted for site-specific geologic, hydrogeologic, or geotechnical investigations. The use of this map to precisely locate buildings relative to the geological substrate is not recommended without site-specific studies conducted by qualified earth-science professionals.

The cross-sections in this report are constructed based on surficial geology, and where available, subsurface and geophysical data. The cross sections are interpretive and should be used as an aid to understand the geologic framework and not used as the sole source of data in locating or designing wells, buildings, roads, or other structures.

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SUMMARY OF NEW GEOLOGIC MAPPING OF THE ALBUQUERQUE WEST 7.5-MINUTE QUADRANGLE, BERNALILLO COUNTY, NEW MEXICO

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The Albuquerque West quadrangle straddles the Rio Grande valley in the City of Albuquerque, Bernalillo County, New Mexico. The geologic map (Connell et al., 1998a) is a new compilation of surface and subsurface geologic mapping of the Albuquerque Civic center and vicinity and also illustrates how geologic mapping may be enhanced by integrating subsurface (lithologic and borehole geophysical) data. The Albuquerque area was first mapped by Bryan (1909) who recognized two distinct types of ancestral Rio Grande deposits, his older Rio Grande beds (now called upper Santa Fe Group), and his younger inset Rio Grande gravels (post Santa Fe Group). Lambert (1968) completed the first detailed geologic mapping

of the Albuquerque area and was also the first to incorporate subsurface data (i.e., driller's logs) into geologic mapping of this area. He extended Bryan and McCann's (1937) "upper buff" stratigraphic unit into the map area. Kelley (1977) later designated Lambert's "upper buff" member as the Ceja Mbr of the Santa Fe Fm.

New geologic mapping incorporates stratigraphic revisions proposed by Connell et al. (1999) for the Santa Fe Group to the north, and refines and expands on Lambert's (1968) ancestral Rio Grande terrace stratigraphy. According to Connell et al. (1999), the Santa Fe Group can be divided into western basin-margin fluvial deposits derived from the eastern Colorado Plateau and Sierra Nacimiento (Arroyo Ojito Fm), and the ancestral Rio Grande axial-fluvial system (assigned to the Sierra Ladrones Fm by Lucas et al., 1993). The western 3/4 of the map contains exposures of sand and pebbly sand correlated to the Ceja Mbr of the Arroyo Ojito Fm. To the east, these deposits overlie, and may interfinger with, Plio-Pleistocene sand and pebbly to cobbly sand of the ancestral Rio Grande. A laterally extensive 83-110 m thick interval of reddish-brown mudstone and sandstone, designated as the Atrisco member (Connell et al., 1998), is recognized in drillholes beneath the study area (Hawley et al., 1995; Connell et al., 1998a, b; Stone et al., 1998). The Atrisco member is an important subsurface unit that also marks an important hydrostratigraphic boundary between overlying highly permeable sand and gravel of Hawley et al.'s (1995) upper Santa Fe Group hydrostratigraphic unit (USF) and the less permeable muddy sandstone of the middle Santa Fe Group hydrostratigraphic unit (MSF). The underlying MSF deposits contain muddy sandstone with scattered volcanic clasts indicating deposition by an older fluvial system (Stone et al., 1998).

Subsurface mapping delineates the location of the buried Atrisco-Barelas zone (A-B zone) of Hawley et al. (1995). The A-B zone is a northwest-trending monoclinical structure that is recognized in the subsurface by an abrupt thickening of post-Atrisco mbr deposits to the northeast, and generally coincides with a northeastward increase in well productivity (Connell et al., 1998a). Map and cross section relationships do not support the presence of the Rio Grande fault (RGf) of Russell and Snelson (1994). The RGf, according to Russell and Snelson (1994), is a post-Miocene intrabasinal fault that is buried by younger alluvium.

Five terrace deposits of the ancestral Rio Grande are delineated in the quadrangle. These terrace deposits record episodes of incision and aggradation during early middle Pleistocene through middle Holocene time. The terrace stratigraphy of Lambert (1968) has been clarified and extended by Connell, Love and Maldonado (this volume). Integration of soil survey data (Hacker, 1977) in the Rio Grande floodplain allows for the delineation of characterized clayey soils that may be deleterious to foundations if not properly recognized and mitigated during construction.

INTRODUCTION

The Albuquerque West 7.5-minute quadrangle comprises an area of about 158 km² (61 mi²) along Rio Grande Valley in Bernalillo County, New Mexico. The study area encompasses portions of the southwest and northwestern quarters of the City of Albuquerque, including the Albuquerque Civic Center. Several industrial sites and some of the oldest residential neighborhoods in Albuquerque are also within the study area. Early work in the study area and vicinity began in the early part of the twentieth century and involved regional reconnaissance studies of the Albuquerque Basin and Sandia Mountains (Bryan, 1909 and Herrick and Johnson, 1900). Later studies of the basin-fill deposits east of Albuquerque were conducted by Bryan and McCann (1936, 1937 and 1938) and Wright (1946), who divided the Santa Fe Group basin fill into lower gray, middle red and upper buff units. Lambert (1968) extended the stratigraphic concepts of Bryan and McCann eastward into the Albuquerque area and delineated and named several Quaternary deposits that unconformably overlie the Santa Fe Group. Kelley (1977) summarized much of the Albuquerque Basin stratigraphy and structural geology; however, no detailed geologic mapping of the Albuquerque area had been attempted at a scale of 1:24,000. Recent studies of the hydrogeology of the Albuquerque Basin (Hawley and Haase, 1992; Hawley and others, 1995; Hawley, 1996) primarily involved studies of subsurface data gathered from drilling records, cuttings, and borehole geophysical logs. The geologic map (Plate I) and cross sections (Plate II) are the result of field reconnaissance mapping and incorporation of borehole data that has refined the structure and stratigraphy of this part of the Albuquerque Basin.

The topographic base for the geologic map is the Albuquerque West quadrangle, 7.5-minute topographic series, published by the United States Geological Survey at a scale of 1:24,000 (one inch equals 2000 feet). Development of gravel pits along the western margin of the quadrangle and residential and commercial growth throughout the City of Albuquerque and vicinity has obscured many exposures. Lambert (1968) produced a geologic map (scale of 1:48,000) of the region prior to significant ground disturbance. Portions of this map are incorporated onto the geologic map where surface disruption is considerable. Areas of extensive disturbance are also evaluated using several vintages of aerial photography (1935, 1951, and 1996).

Principal contributions and revisions to previous work include refinement of Lambert's (1968) mapping, including the reinterpretation of his fluvial terrace stratigraphy. Other notable contributions include the incorporation of subsurface data from numerous water-supply and groundwater-monitoring wells in the region, the assignment and differentiation of facies within the Sierra Ladrones Formation (upper buff formation of Lambert, 1968) and the delineation a locally correlative stratigraphic interval informally called the Atrisco member of the middle red formation (Connell and others, 1998) in the subsurface (Plates II and III).

DESCRIPTION OF MAP UNITS

Post-Santa Fe Group Deposits (Quaternary System)

Quaternary surficial deposits are a mixture of poorly to moderately consolidated, poorly to well sorted gravel, sand and silt, deposited by perennial and ephemeral streams, debris flow, wind, and mass movement processes. Correlations of mapped units are illustrated on Figure 1. Alluvial deposits unconformably overlie basin-fill deposits of the Santa Fe Group and are divided into three major classes:

Valley-fill alluvium of the ancestral Rio Grande (QHvr and Qvr subunits) — Stream (floodplain and channel) deposits that are restricted to former and current positions of the Rio Grande.

Valley-fill and Valley-border alluvium (QHva and Qvy subunits) — Stream (floodplain and arroyo-terrace) and fan deposits restricted to major entrenched tributary valleys, such as Tijeras Arroyo.

Piedmont-slope alluvium (Qpm subunit) — Alluvial deposits on constructional and erosional parts of piedmont slopes associated with drainages (e.g., Embudo Arroyo) originating from the western front of the Sandia Mountains. Units include coalescent piedmont-fan and alluvial-slope deposits, debris-flow deposits and shallow-valley fills that are not graded to major entrenched arroyo systems.

Valley-floor and valley-border alluvium

Valley-fill and valley-border deposits unconformably overlie fluvial deposits of the Santa Fe Group basin fill sequence. Deposits are primarily light gray-brown, brown, yellowish-brown and reddish-brown (5 to 10YR hues) sand, gravelly sand, and gravel with minor silt and clay. Clast lithology is variable and reflects the character of local (recycled basin fill and basin-margin rocks) and distant (extrabasinal) source terrains. Clasts along the eastern margin of the study area, north of Tijeras Arroyo, are dominated by subangular to subrounded granite and rare subrounded limestone derived from drainages (e.g. Embudo Canyon) that originate along the western front of the Sandia Mountains. Clasts associated with Tijeras arroyo are composed of variable proportions of subangular to subrounded granite, greenstone, gneiss, limestone and sandstone derived from the eastern slope of the Sandia Mountains. Deposits associated with the modern (floodplain and channel) and ancient valley floors (fluvial terraces) of the Rio Grande Valley are primarily composed of subrounded quartzite and welded tuff with subordinate granite and basalt. Descriptions of the inner valley floodplain and channel alluvium are modified from a soil survey of the Rio Grande Valley (Nelson and others, 1914; see also Hawley, 1996). Deposits along the western margin of the study area contain subangular clasts of red granite, white, black, and orangish-brown chert and basalt recycled from hillslopes underlain by basin fill of the Santa Fe Group.

Alluvium of the Rio Grande

- QHvrg** Stream alluvium (historic) — Unconsolidated sand and gravel within the active channel of the Rio Grande.
- QHvra** Stream and floodplain alluvium (historic) — Unconsolidated coarse-grained sand and pebbly sand; channel deposits.
- QHvrb** Stream and floodplain alluvium (historic) — Unconsolidated medium-grained sand and loamy sand; channel and floodplain deposits.
- QHvrc** Stream and floodplain alluvium (historic) — Unconsolidated fine-grained sand, silt and clay; forms sloughs.
- QHvrd** Stream and floodplain alluvium (historic) — Unconsolidated fine-to medium-grained sand, silt and clay; fine-grained floodplain deposits.
- Qvrg** Stream and floodplain alluvium, undivided (uppermost Pleistocene through historic) — Unconsolidated fine-to medium-grained sand, and gravel with silt and clay lenses. Unit is up to 20- to 24-m thick and forms the alluvium of underlying the inner valley of the Rio Grande. Unit is shown in cross section only (Plate II).
- Qvry** Alluvium of the Primero Alto terrace (upper Pleistocene) — Poorly consolidated deposits of sandy pebble to cobble gravel. Clasts are primarily rounded quartzite and volcanic rocks. Unit rests unconformably on the Los Duranes formation and forms the Primero Alto terrace of Lambert (1968). Surface is discontinuously overlain by a 1- to 2-m thick veneer of light-brown eolian sand. Soil development is very weak with stage I to II carbonate morphology (Machette and others, 1997, site numbers 14 and 15). Unit is approximately 3 to 6 m thick.
- Qvrl** Los Duranes formation (upper(?) to middle Pleistocene) — Moderately consolidated deposits of light-brown, very pale-orange and grayish-orange sand with scattered interbeds of silt, clay and small pebbly sand. Forms a broad fairly continuous terrace (Segundo Alto terrace of Lambert, 1968) west of the inner valley escarpment of the Rio Grande (locality LD, Plate I). Unit is covered by discontinuous veneer of light-brown eolian sand with scattered small pebbles. Base is not exposed; top is approximately 43 m above the Rio Grande floodplain. Soils are weakly developed with stage II carbonate morphology. Stratigraphic relationship to basalt flows of the Albuquerque Volcanoes field is not clear; however, unpublished map relations to the north suggest that basalt flowed across a paleovalley escarpment inset by the Los Duranes Formation. An informal unit defined by Lambert (1968). Estimated thickness is up to 53 m.
- Qvrm** Alluvium of Menaul Blvd. (upper Pleistocene) — Poorly consolidated deposits of yellowish-brown pebble conglomerate and pebbly sand derived from the ancestral Rio Grande. Clasts are dominated by rounded quartzite that are generally smaller in size than clasts associated with Qvre. Forms discontinuous exposures east of the inner valley escarpment of the Rio Grande. The base is approximately 30 m above Rio Grande floodplain and buries unit Qvre. Soils associated with piedmont alluvial overlying this unit are weakly developed with stage II carbonate morphology (see Connell, 1996). This is an informal term named by Lambert (1968) for exposures along Menaul Boulevard. Lambert (1968) interpreted that this unit is inset against the Los Duranes formation; however, on the basis of stratigraphic position, height above the Rio Grande floodplain, and weak soil development, this unit probably a gravelly lens associated with the Los Duranes alluvium. Thickness is generally less than 2.65 m.

Qvre Alluvium of Edith Blvd. (middle Pleistocene) — Poorly consolidated deposits of pale-brown to yellowish-brown conglomerate, sand and sandy clay derived from the ancestral Rio Grande. Forms a upward fining sequence consisting of a basal quartzite-rich, cobble conglomerate that grades up-section into a yellowish-brown sand, and reddish-brown silty clay. Rare clasts of welded Bandelier Tuff are locally recognized. Unit unconformably overlies the Sierra Ladrones Formation and is overlain by Qpm. Forms extensive outcrops along the inner valley escarpment of the Rio Grande. The base is approximately 18 m above the floodplain of the Rio Grande. This is an informal term defined by Lambert (1968) for exposures along Edith Boulevard (Lambert, 1968). Lambert correlated this unit with the Primero Alto terrace gravels on the west side of the Rio Grande and estimated a latest Pleistocene age for these deposits. Lambert (1968), Lucas and others, (1984 and 1988) also report Rancholabrean fossils (notably, *Bison*) and assign the Edith alluvium to the late Pleistocene. However, moderately developed soils on unit Qpm, which conformably overlies unit Qvre, (see Connell, 1996; 1997) suggest that Qvre is much older than Qvry. The stratigraphic range of *Bison* and the Rancholabrean land mammal age extend into the middle Pleistocene in the northern Great Plains (Wayne and others, 1991, p.458-459), therefore, Qvre is interpreted to be middle Pleistocene in age and is probably unconformably overlain by the Los Duranes formation. Thickness is variable and ranges from 3.3 to 12 m.

Qvro Alluvium of the Tercero Alto terrace (middle Pleistocene) — Moderately to well consolidated deposits of subrounded to rounded quartzite-bearing gravel containing rare occurrences of recycled clasts of the Bandelier Tuff. The base is not exposed; the top is ranges from approximately 60 to 100 m above the Rio Grande floodplain. Unit was locally differentiated by Lambert (1968) as Qus(?) as a probable high-level terrace or gravelly member of his upper buff formation. This unit may include two separate terraces, but exposures and urban development preclude a definitive division at this time. This terrace is overlain by the middle Pleistocene aged Albuquerque Volcanoes basalt at the northwestern corner of the quadrangle.

Valley-floor and valley-border alluvium

- QHva** Stream and piedmont alluvium, undivided (Holocene to historic) — Unconsolidated deposits of brown, light gray-brown, and yellowish-brown sand, sandy clay loam and gravel. Inset against Qvy and grades to the floodplain of the Rio Grande. Weakly developed soils exhibit trace accumulations of pedogenic carbonate and stage I carbonate morphology at depth. Unit commonly forms coalescent alluvial fans along valley margins. Unit is locally subdivided on the basis of inset relations and deposit lithology. Thickness is generally less than 22 m.
- QHva₁** Stream and piedmont alluvium (Holocene to historic) — Unit is locally differentiated where cut by QHva₂.
- QHva₂** Stream and piedmont alluvium (Holocene to historic) — Unit is locally differentiated where inset QHva₁.
- QHvat** Stream and piedmont alluvium of Tijeras Arroyo (uppermost Pleistocene(?) to historic) — Unconsolidated deposits of sand, silt and clay with scattered lenses of pebbly sand. Clasts are dominantly limestone and metamorphic rocks with subordinate granite and sandstone derived from the Tijeras Canyon drainage. A charcoal sample taken between 2.6 to 2.9 m below ground surface near the mouth of Tijeras Arroyo (TA-2; Beta 109129) yields a radiocarbon date of 4550±140 years BP. Thickness is at least 22 m at the mouth of Tijeras Arroyo.
- Qvy** Stream alluvium, undivided (uppermost Pleistocene through Holocene) — Poorly consolidated deposits of very pale-brown to light-brown sand to sandy clay loam and gravel. Unit is inset against Qpm and grades to fluvial terraces west of the Rio Grande. Weakly developed soils exhibit stage II carbonate morphology. Estimated thickness is less than 21 m.

Piedmont-slope deposits

- Qpm** Fan and stream alluvium (middle Pleistocene) — Moderately consolidated deposits of light- to strong-brown and very pale-brown to light-gray sand and gravelly sand. Surface is commonly moderately dissected and possesses moderately well developed soils with stage III carbonate morphology. Estimated thickness is at least 30 m along the eastern margin of the quadrangle.

Volcanic rocks

- Qb** Basalt of the Albuquerque volcanoes (middle Pleistocene) — Olivine tholeiite with pahoehoe texture (Kelley and Kudo, 1978). Basalt flows record a geomagnetic excursion during the Brunhes Chron (Geissman and others, 1990) that has been dated at 156±26 ka using ²³⁸U/²³⁰Th radiometric techniques (Peate and others, 1996).

Artificial fill, colluvial and eolian deposits

- af** Artificial fill (Historic) — Dumped fill and areas effected by human disturbances. Mapped where deposits are areally extensive. Unit not mapped everywhere on quadrangle.
- daf** Disturbed areas and artificial fill, undivided (Historic) — Dumped fill and areas effected by human disturbances, including gravel quarry sites. Mapped where disturbance is areally extensive. Unit not mapped everywhere on quadrangle.
- Qsw** Slopewash deposits (Holocene) — Unconsolidated sand and silt with scattered pebbly sand interbeds. Associated with low-order drainages developed on short, steep slopes and terrace risers. Unit not mapped everywhere on quadrangle.
- Qae** Eolian and alluvial deposits, undivided (Holocene) — Poorly consolidated fine-to-medium-grained sand and silty sand with scattered pebbles that commonly form a relatively thin (2 m thick) discontinuous mantle over upland areas west of the Rio Grande. Mapped where areally extensive. Unit not mapped everywhere.
- Qcb** Colluvium (upper Pleistocene to historic) — Apron of angular pebble-to boulder-sized basalt clasts associated with slopes developed below basalt flows.

Basin-Fill Deposits of the Santa Fe Group (Quaternary and Tertiary Systems)

The Santa Fe Group comprises the syntectonic sedimentary fill and associated volcanic rocks of basins within the Rio Grande rift of central Colorado, New Mexico and northern Chihuahua (Bryan, 1938; Chapin and Cather, 1994). Only the upper part of the Santa Fe Group is exposed in the study area. The Santa Fe Group is divided into the Sierra Ladrones Formation (Machette, 1978; Hawley, 1996; Connell and others, 1998), and middle red formation (Lambert, 1968). The Sierra Ladrones Formation is the uppermost unit of the Santa Fe Group and contains coarse-grained sand and gravel deposited by thoroughgoing perennial streams of the ancestral Rio Grande fluvial system. The Sierra Ladrones Formation is divided, in the study area, into four facies on the basis of stratigraphic position and clast lithology: 1) an upper quartzite-bearing facies with recycled pumice clasts of the lower Pleistocene Bandelier Tuff (QTsab); 2) a sand and gravel sequence dominated by clasts of granite, basalt and chert (QTsc), assigned to the Ceja Member of Kelley (1977); 3) an interfingering quartzite dominated facies (QTsar) that interfingers with the Ceja Member; and 4) a buried fine-grained sand, silt and clay sequence provisionally assigned to the Atrisco member (Tma) of the middle red formation (Connell, 1998).

The upper quartzite dominated sequence (QTsab) contains abundant subrounded pumice clasts of the Otowi Member of the Bandelier Tuff (1.62 Ma, Mcintosh, oral communication, 1997; Lambert, 1968). The top of this sequence marks the Sunport geomorphic surface (QTsasp) and marks the top of the Santa Fe Group. The Ceja Member (QTsc) contains coarse-grained sand and gravel dominated by subangular clasts of granite, chert (notably the black and white-colored Pedernal chert of the Abiquiu Tuff; Church and Hack, 1939) and basalt derived from the northwestern margin of the basin (Rio Chacra fluvial system of Bryan and McCann, 1937). This unit coarsens section and interfingers with quartzite-dominated sand and gravel of unit QTsar to the east. Examination of cuttings, core and borehole geophysical logs (Plate III) from selected water-supply and groundwater monitoring wells, in and adjacent to the study area, delineate a buried, 85-to 100-m thick sequence of fine-grained sand, silt and clay defined as the Atrisco member (Tma, Plate II) of the middle red formation by Connell and others (1998). Fine-grained sand, silt and clay with rare pebbles (Tmu) are recognized below Tma (Plate II). Correlations of mapped units are illustrated on Figure 1.

Sierra Ladrones Formation (upper Miocene to middle(?) Pleistocene) — Horizontal to subhorizontally stratified fluvial sand and gravelly sand with minor silt and clay. Deposits contain Blancan (Pliocene) and Irvingtonian (early to medial Pleistocene) fossils at the mouth of Tijeras Arroyo (locality TA1, Plate I) (Lucas and others, 1993).

- QTsasp** Sunport geomorphic surface (lower to middle Pleistocene) — Fluvial and alluvial deposits with a thin (2 m thick) discontinuous veneer of eolian sediments capping basin-floor deposits of the Sierra Ladrones Formation; Sunport surface of Lambert (1968), northern edge of Llano de Manzano surface of Machette (1985). Unit exhibits well developed calcic soil with stage III+ carbonate morphology (Machette and others, 1997, site numbers 16 and 17); however, local occurrences of laminar carbonate (stage IV carbonate morphology) are recognized south of Tijeras Arroyo.
- QTsa** Axial river deposits, undivided (lower Pleistocene through Pliocene) — Light-gray to yellowish-brown sand and gravelly sand. Sand is typically crossbedded. Clasts are dominated by quartzite and volcanic rocks with subordinate chert, granite, gneiss, sandstone, siltstone, limestone, schist, phyllite and pumice. Mudstone is rare and ranges in color from light brown to grayish green.
- QTsab** Axial river deposits of the ancestral Rio Grande (lower Pleistocene) — Sand and gravel with minor silt and clay deposited by the ancestral Rio Grande. Clasts in are dominated by quartzite and volcanic clasts with subordinate chert, granite, gneiss, sandstone, siltstone, limestone, schist, phyllite and pumice. Mudstone is rare and ranges in color from light brown to grayish green. Deposits contain fossils indicative of Irvingtonian land mammal age (Lucas and others, 1993) and clasts of Bandelier Tuff (Lambert, 1968; W.C. McIntosh, 1996, oral communication).
- QTsar** Axial river deposits — Subhorizontal, moderately consolidated to weakly cemented sand and gravel deposited by the ancestral Rio Grande fluvial system. Clasts are dominated by quartzite and volcanic rocks with subordinate granite and basalt. Unit interfingers with Ceja Member to the west.
- QTsc** Ceja Member — Subhorizontally stratified sand and pebbly sand with subordinate silt and clay. Clasts are dominated by subangular to subrounded red granite, basalt, and chert with minor quartzite. Deposits presumable derived from the western and northwestern margins of the basin. Kelley (1977) used this term for coarse-grained gravel and sand recognized along the eastern margin of the Rio Puerco Valley. The name Ceja Member is expanded here to include all deposits having a western and northwestern provenance. Unit interfingers with deposits of the fluvial system of the ancestral Rio Grande (QTsar) to the east.

Middle red formation (upper Miocene to Pliocene) — Moderately consolidated, subhorizontal to slightly tilted stratified fluvial sand with thin rare pebbly sandstone interbeds. Unit is buried in the study area and is shown in cross section only (Plate II).

Tma Atrisco member of the middle red formation (upper Miocene to Pliocene) — Sequence of yellowish-brown to yellowish-red, fine-grained silty sand and clay. Unit marks the base of an upward coarsening megasequence in the overlying Sierra Ladrones Formation. Shown in cross section only (Plate II). Unit is approximately 85- to 100-m thick.

Tmu Middle red formation, undivided (upper Miocene to Pliocene) — Fine- to coarse-grained sand with interbedded compact clay with scattered pebbly sand interbeds. Shown in cross section only (Plate II).

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EXPLANATION OF MAP SYMBOLS

Compound unit description. Unit in numerator describes discontinuous thin veneer that covers unit in denominator.

Strike and dip of bedding.

Horizontal bedding.

Water-supply well.

Geologic contact, approximate. Dotted where concealed, queried where poorly constrained or inferred.

Approximate location of geologic contact within disturbed areas (daf).

Fault, showing and up- and down-thrown sides. Dotted where concealed, queried where poorly constrained or inferred.

Atrisco-Barelas zone of Hawley (1996). Arrows indicate direction of throw or plunge.

Selected localities.

Approximate eastern boundary of the “tercero alto” terrace (Qvro).

Approximate eastern boundary of the “segundo alto” terrace (Qvrld).

Approximate eastern boundary of the “primero alto” terrace (Qvry).

Location of preliminary geologic cross sections (Plate II).

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