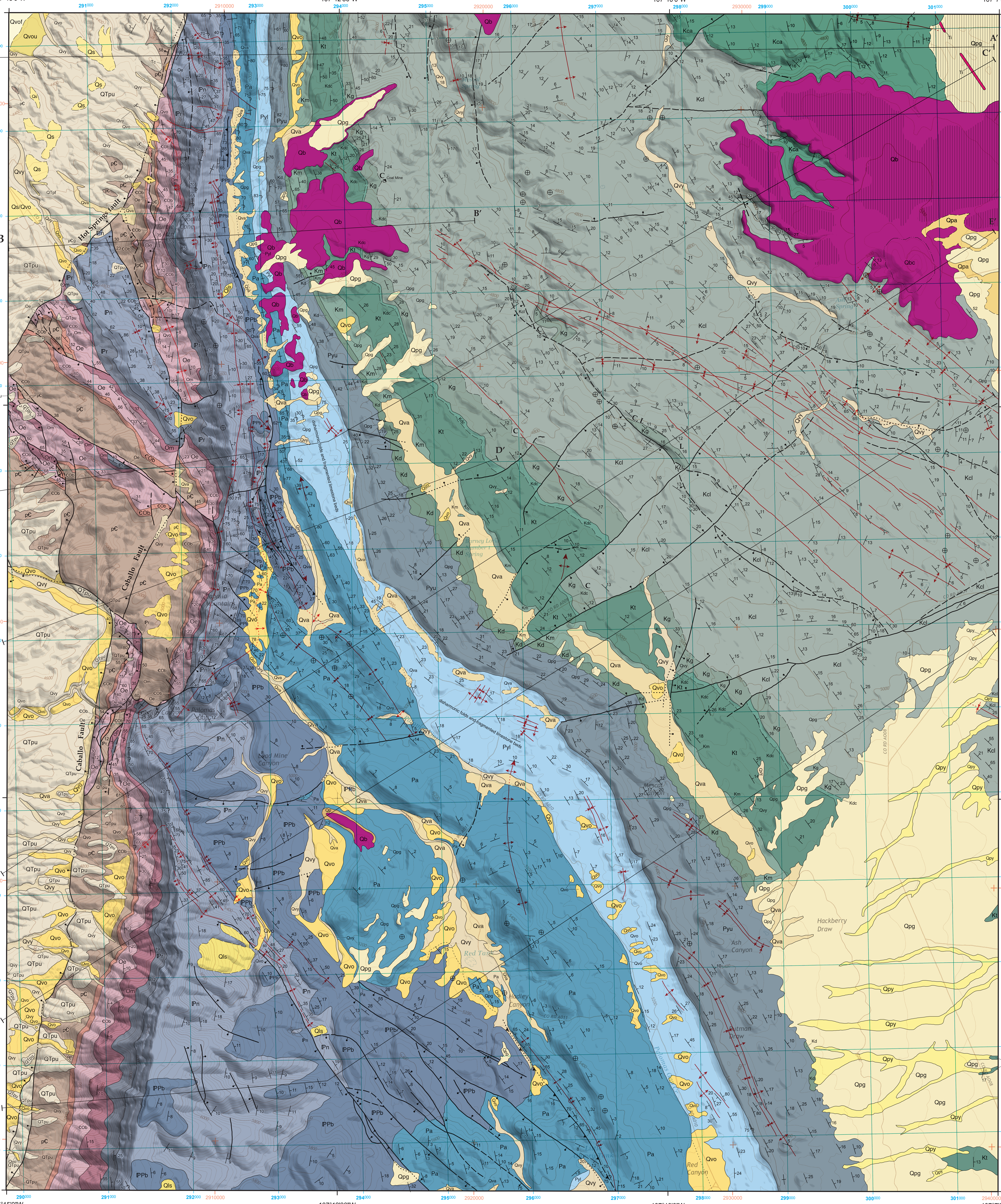
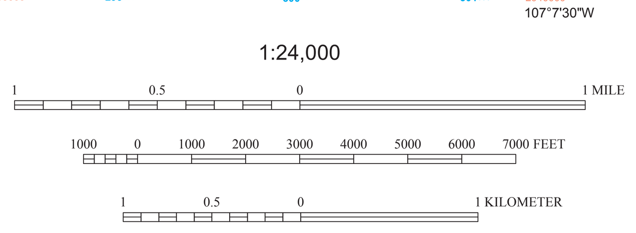


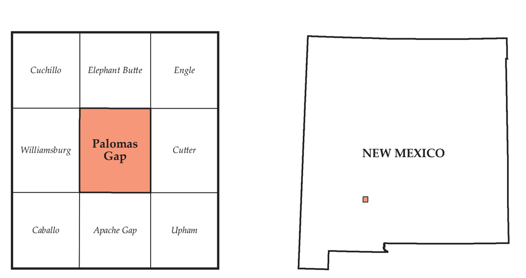
Base map from U.S. Geological Survey 2010.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 13S shown in blue.
10,000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in red.

Roads....................©2006-2010 Tele Atlas
Names....................GNIS, 2008
Hydrography....................National Hydrography Dataset, 2005
Contours....................National Elevation Dataset, 2000

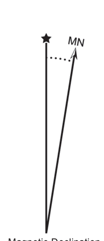
New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 260

Mapping of this quadrangle was funded by the New Mexico Bureau of Geology and Mineral Resources, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Associate Director for Mapping Programs*).





Quadrangle Location



Magnetic Declination
November, 2014
8°50' East
At Map Center

Geologic Map of the Palomas Gap 7.5-MinuteQuadrangle, Sierra County, New Mexico

July, 2015

by
William R. Seager

Department of Geological Sciences, New Mexico State University, Las Cruces, New Mexico 88003

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

[575] 835-5490

This and other STATEMAP quadrangles are available
for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

Digital layout and cartography by the NMBGMR Map Production Group:
Phil L. Miller
David J. McCraw
Elizabeth H. Roybal

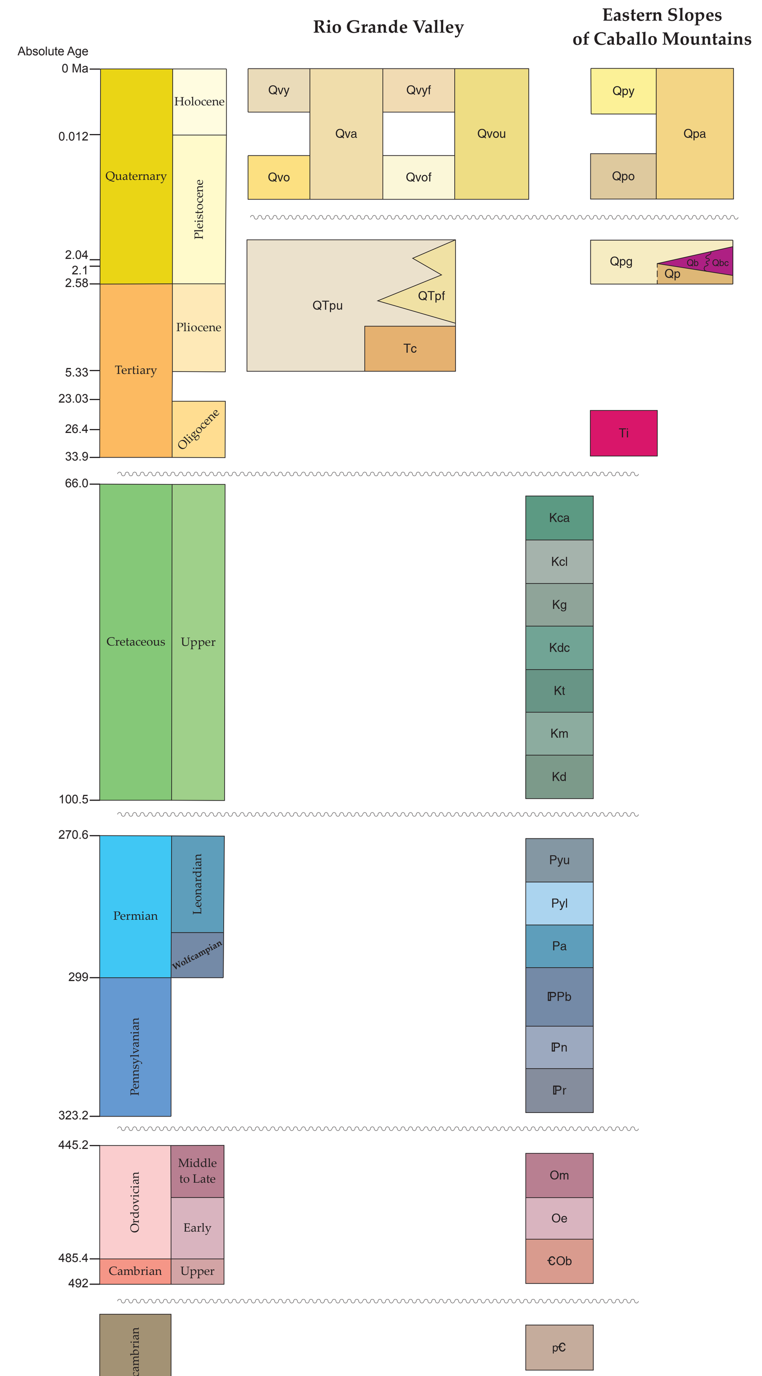
COMMENTS TO MAP USERS

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.

Correlation of Map Units



Explanation of Map Symbols

Contact—Identity and existence certain; location accurate where solid, approximate where dashed, and concealed where dotted.

Internal contact—Identity and existence certain, location approximate.

Fault—Identity and existence certain; location accurate where solid, approximate where dashed, and concealed where dotted.

Normal Fault—Identity and existence certain; location accurate where solid, approximate where dashed, and concealed where dotted. Bar and ball on downthrown block.

Thrust fault—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted. Sawteeth on upper plate.

Dike—Identity and existence certain; location accurate where solid and approximate where dashed.

Anticline—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted.

Syncline—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted.

Overturned anticline—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted.

Overturned syncline—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted.

Monocline, anticlinal bend—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted. Shorter arrow is on the steeper limb.

Monocline, synclinal bend—Identity and existence certain; location accurate where solid, approximate where dashed and concealed where dotted. Shorter arrow is on the steeper limb.

A A′ Cross section line

79 Inclined fault

Plunge direction on fold trace.

Horizontal bedding

10 Inclined bedding

Vertical bedding

79 Overturned bedding

Coal Mine

Description of Map Units

Rio Grande Valley

Qvy **Younger valley-fill alluvium**—Gravel, sand, silt and clay deposits of arroyo floors, terraces, and alluvial fans that are graded to or within a few meters of the Rio Grande floodplain. As much as 15 m (49 ft) thick.

Qvyf **Younger fluvial alluvium**—Sand, gravel, clay and silt deposited by the Rio Grande on its modern floodplain. Approximately (70 ft) thick.

Qs **Eolian sand**—Dunes and sheets of sand locally overlying **Qtpu** and **Qvo** alluvial fans on the western piedmont slopes of the Caballo Mountains. As much as 3 m (9 ft) thick.

Qvo **Older valley-fill alluvium**—Gravel, sand, silt and clay that comprise at least three generations of terraces or alluvial fans whose surfaces are graded to approximately 13 m (40 ft), 33 m (108 ft) and 50 m (164 ft) above the floodplain of the Rio Grande. Pedogenic carbonate (stage II to stage IV) cements uppermost parts of the deposits, especially the higher deposits. As much as 30 m (98 ft) thick.

Qvof **Older valley-fill fluvial deposits**—Sand and cobble gravel with lesser silt and clay deposited by the Rio Grande. Deposits are generally unconsolidated except for the upper 0.5–1.0 m (1–3 ft) which may be cemented with stage II carbonate. Unit interfingers with **Qvo** alluvial fan deposits and forms terraces approximately 13 m (40 ft) above the floodplain of the Rio Grande. As much as 13 m (40 ft) thick adjacent to the Rio Grande.

Qvou **Older valley-fill fluvial deposits undifferentiated**—Undifferentiated **Qvo** and **Qvof**.

Qva **Valley-fill alluvium undifferentiated**—Undifferentiated **Qvo** and **Qvy**.

Jornada del Muerto and Eastern Piedmont Slopes of the Caballo Mountains

Qpy **Younger piedmont-slope alluvium**—Sand, gravel, silt, and clay of modern, shallowly incised drainageways, alluvial fans at the mouths of such drainageways, and broad but thin pediment veneers. Deposits are graded to the surfaces of playas and alluvial flats near the center of the Jornada del Muerto. As much as 6 m (20 ft) thick.

Qpo **Older piedmont-slope alluvium**—Gravel and gravelly sand deposits of arroyos, alluvial fans, and pediment veneers that are intermediate in position between higher Palomas (**Qpg**) and lower (**Qpy**) alluvium. At least two generations of **Qpo** deposits are locally present. Upper part of **Qpo** deposits are cemented by stage II to stage IV pedogenic carbonate. As much as 7 m (23 ft) thick.

Qpa **Piedmont-slope alluvium**—Undifferentiated **Qpo** and **Qpy**.

Northern Caballo Mountains

Cuchillo Surface—Constructional upper surface of the Palomas Formation, as well as pediment surfaces graded to the top of the Palomas Formation.

Qpg **Palomas Formation, upper piedmont-slope facies**—Boulder to cobble conglomerate and gravelly sandstone forming thin alluvial fans and pediment veneers along the eastern slopes of the Caballo Mountains; contains zones of stage III or stage IV pedogenic carbonate, especially at the top of the unit beneath the Cuchillo surface; overlies **Qb** locally. As much as 25 m (82 ft) thick in paleocanyons near the mountain front, thinning to a pediment veneer a few meters (15 ft) thick or less downslope.

Qb, Qbc **Alkali-olivine basalt**—Flows, cinders, and cinder cones (**Qbc**) that underlie **Qpg** and locally overlie **Qp** on the eastern piedmont slopes of the northern Caballo Mountains. Stage III to IV caliche is widely developed on the surface of the flows. Generally 10 m (33 ft) thick or less, but as much as 35 m (115 ft) thick where flows have filled paleovalleys. Dates from nearby basaltic volcanoes or flows with similar erosion profiles are 2.1 and 2.04 Ma (Bachman and Mehnert 1978; Esser, 2003).

Qp **Palomas Formation**—Boulder conglomerate and conglomeratic sandstone underlying **Qb** and overlying pedimented Paleozoic rocks southeast of Palomas Gap. Clasts are entirely Paleozoic limestone and sandstone. Approximately 15 m (49 ft) thick.

QTpu **Palomas Formation, piedmont-slope deposits,undifferentiated**—Tan to light gray to red boulder to cobble conglomerate, conglomeratic sandstone and interbedded red sandstone/siltstone. Stage III or stage IV pedogenic carbonate is prominent at the top of the formation, but much of the conglomerate facies is tightly cemented by groundwater carbonate. Clast composition consists almost entirely of Paleozoic and Precambrian rock types derived from the footwall of the Caballo and Hot Springs faults. The strata were deposited as alluvial fans, pediment veneers, and alluvial-flat sediments on the hangingwalls of the Caballo and Hot Springs faults; faulted, relatively thin erosional remnants of the formation also cover parts of the footwall of these faults. Tongues of fluvial sandstone (**Qtpf**) are locally interbedded with fanglomerate. Unit is at least 137 m (450 ft) thick in the hangingwall of the Caballo fault and 12 m (40 ft) to at least 61 m (200 ft) thick in the hangingwall of the Hot Springs fault. On pedimented surfaces on the footwall of these faults, remnants of **QTpu** fans are variable in thickness owing to deposition on paleotopography, but are generally less than 30 m (98 ft) thick.

QTpf **Palomas Formation, fluvial facies**—Gray, yellow, tan, ochre, and white sandstone, pebbly sandstone, and sand deposits of the ancestral Rio Grande. Unit occurs in the Palomas Gap quadrangle only as discontinuous, thin (15 m; 49 ft) tongues within **QTpu** at elevations of 4370-4420 ft and at 4580 ft.

Tc **Palomas (?) Formation**—Boulder conglomerate and conglomeratic sandstone. Clasts up to 0.4 m in diameter consisting largely of intermediate-composition volcanic porphyries, possibly derived from the McRae Formation, with lesser amounts of limestone cobbles and pebbles. Only an acre or two in outcrop size and located within the northern Hot Springs fault zone. Approximately 25 m (82 ft) thick, top eroded.

Ti **Dikes**—Dark gray to black basaltic, andesitic or andesite porphyry dikes in a northwest-trending swarm cutting Cretaceous rocks on the eastern piedmont slope of the northern Caballo Mountains. Some of the longer dikes in the south-central part of the quadrangle appear to occupy faults whereas others do not. Most are late Oligocene in age (26.9 my; 40Ar/39Ar; Esser, 2003) but some, which cut Pennsylvanian and Permian rocks along the northern backbone of the range, are more basaltic in composition, are associated with alkali-olivine basalt lava flows and cinders, (Qb) and may be Pliocene in age. Dike thicknesses range from less than a meter (3 ft) to 3 m (10 ft).

Upper Cretaceous

Kca **Crevasse Canyon Formation, Ash Canyon Member**—Predominately thick-bedded, pale tan, yellowish-gray, reddish-yellow to light-gray, multi-storey, channel-form beds of sandstone and conglomeratic sandstone. Sandstones are coarse to medium grained, cross-bedded and quartz rich although a variety of volcanic and other rock types comprise part of the sand. Brown to greenish-brown sandstone, mudstone and shale are interbedded with the sandstone but comprise a lesser volume compared to the lower part of the Crevasse Canyon Formation. Petrified wood and plant molds are common; fluvial in origin. Basal beds intertongue with the lower member of the Crevasse Canyon Formation. Basal contact is difficult to identify and has been placed at different positions in the Crevasse Canyon section by different mappers. In the Palomas Gap quadrangle a thick section of probable Ash Canyon sandstones was mapped only in the northeastern corner of the quadrangle although the member may extend farther east and south. Tongues of Ash Canyon sandstone are present along the northeastern margin of the quadrangle within lower Crevasse Canyon strata, but were not mapped. Maximum thickness, measured from cross sections, is approximately 610 m (2000 ft).

Kcl **Crevasse Canyon Formation, lower member**—Interbedded gray and light-tan, medium- to thick-bedded, cross-bedded, channel-shaped bodies or accretionary wedges of sandstone; brown to olive-brown, thin- to medium, even-bedded sandstone containing large concretions; and greenish-gray to brown mudstone and black shale; local, thin (5–15 cm) seams of lignite and coal (L and/or C on geologic map) are especially persistent a few meters above the Gallup Sandstone; many molds of leaves and other woody material; fluvial in origin; intertongues upward with Ash Canyon Member; may be as much as 396 m (1,300 ft) thick, or more.

Kg **Gallup Sandstone**—Two or three, thick-bedded, tan to pale-yellowish-brown marine sandstone units containing *Ophiomora* and other marine burrows, as well as marine fossils, largely pelecypods. Sandstone units are separated by thinner-bedded, bioturbated, greenish-brown siltstone, fine sandstone and gray shale; lenses of pelecypod coquina are common as are large, brown, sandstone concretions containing marine fossils; grades abruptly upward into Crevasse Canyon Formation. Approximately 80 m (262 ft) thick.

Kdc **D-Cross Tongue of Mancos Shale**—Dark gray to brown fine siltstone and shale containing sparse marine fossils, mostly pelecypods; grades upward into Gallup Sandstone. Approximately 20 m (68 ft) thick.

Kt **Tres Hermanos Formation**—Lower marine Atarque Member consists of brown and greenish-brown, fossiliferous, burrowed sandstone, siltstone, and shale, followed upward by brown sandstone and olive-green mudstone of the fluvial Carthage Member, and capped by brown, fossiliferous, burrowed sandstone of the marine Fite Ranch Member; grades upward into D-Cross Tongue of Mancos shale; thickness varies dramatically from 106–198 m (350–650 ft) depending on the presence or absence of multistory, channel-shaped sandstone beds in the Carthage Member.

Km **Mancos Shale**—Thin-bedded to fissile, fine siltstone and gray, marine shale with at least 5 ash beds, each 6–12 cm (2–5 in) thick. Also present in the upper third of the formation is the Bridge Creek Limestone Member of the Greenhorn Formation which includes three limestone beds, each approximately 0.3 m (1 ft) thick; the Mancos grades upward into the Tres Hermanos Formation. Approximately 120 m (394 ft) thick.

Kd **Dakota Sandstone**—Upper marine shale and cross-bedded, marine sandstone overlies yellow-brown to white, cross-bedded, fluvial, quartzose sandstone; grades upward into Mancos Shale. Approximately 45–76 m (150–250 ft) thick, the variation a result of deposition on paleotopography on upper Yeso strata.

Permian

Pyu **Upper Yeso Formation**—Includes the two upper members of the Yeso Formation: the upper sandstone-dolomite member and lower limestone member. Upper sandstone-dolomite member consists of approximately 198 m (650 ft) of interbedded gray, medium-bedded, fossiliferous limestone and dolomite and yellow to red sandstone, with local beds of gypsum; top of this member is a major regional unconformity. Lower limestone member consists of approximately 30 m (100 ft) of medium-bedded, fossiliferous, dark-gray to black limestone that forms a prominent, almost continuous hogback. Approximate total thickness of both members is 228 m (750 ft) but varies because of pre-Dakota erosion.

Pyl **Lower Yeso Formation**—Includes the two lower members of the Yeso Formation: the upper red siltstone-dolomite member and lower Meseta Blanca Member. The red siltstone-dolomite member, approximately 137 m (450 ft) thick, includes at least three ledge-forming limestone/dolomite units (each approximately 10–15 m thick; 33–50 ft) within a sequence of interbedded massive gypsum, thin-bedded limestone, and red to yellow sandstone and siltstone. Thickening and thinning of this member is locally extreme because of flowage of gypsum, which also has caused limestone beds to be chaotically folded and dismembered; the member grades abruptly upward into the limestone member of the upper Yeso Formation. The basal Meseta Blanca Member consists of approximately 76 m (250 ft) of brick red to orange-red sandstone and siltstone with thin interbeds of gray and greenish-gray shale. Approximate total thickness of both members is 213 m (700 ft) except where the red siltstone-dolomite has been drastically thickened or thinned by gypsum flowage.

Pa **Abo Formation**—Red to tan channelform, fluvial sandstone interbedded with red to purple overbank shale and siltstone; grades abruptly upward into Meseta Blanca Member of the Yeso Formation. Approximately 152 m (500 ft) thick.

Pennsylvanian and Permian

PPb **Magdalena Group, Bar B Formation**—The upper 50 m (165 ft) consists of interbedded purple and red siltstone and shale, gray limestone, and limestone-pebble conglomerate, correlative with the Bursum Formation (Wolfcampian), which grades upward into the Abo Formation. Lower part of the formation consist of interbedded gray or purplish-gray marine shale and ledges of gray, tan, and orange limestone; burrow traces, marine fossils, and chert are abundant in some beds. Formation thickens southward. Approximately 119 m (390 ft) thick.

Pennsylvanian

Pn **Magdalena Group, Nakaye Formation**—Very thick-bedded, ledge and cliff-forming, gray or tan-weathering limestone interbedded with thin-bedded limestone, as well as reddish, green, or gray shale. Limestones are fossiliferous and many contain abundant black or gray chert as nodules, thin beds, or reticulated networks; top of the formation is marked by the lowest prominent (10m thick, 33ft) marine shale of the Bar B Formation. Approximately 191 m (625 ft) thick.

Ordovician

Om **Montoya Formation**—The formation is divided into four members, widely recognized across south-central New Mexico. Upper Cutter Dolomite Member is mostly light- to medium-gray, medium-bedded dolomite, approximately 40 m (130 ft) thick in the southern part of the quadrangle. Medial Aleman Dolomite Member consists of medium- to dark-gray dolomite containing conspicuous and abundant nodules, lenses, and ribbons of dark-gray chert, approximately 47 m (155 ft) thick in the southern part of the quadrangle. Lower Upham Dolomite Member is very thick-bedded, dark-gray dolomite, approximately 20 m (65 ft) thick. Basal Cable Canyon Sandstone is grayish-tan to yellowish-brown, coarse-grained, quartzose sandstone, as much as 5 m (16 ft) thick, typically forming a conspicuous dark-brown cliff above the slopes of upper El Paso strata; locally, Cable Canyon sandstones are silicified. From south to north, the Montoya Formation is truncated downward by pre-Pennsylvanian erosion, and karst topography is locally well developed on upper Montoya strata; in the northern part of the quadrangle the formation is either missing entirely or only lower parts of the formation remain. Total thickness varies from 112 m (365 ft) in the southern part of the quadrangle to entirely absent locally in the northern part.

Oe **El Paso Formation**—Following Kelley and Silver (1952) two members of the El Paso Formation were recognized, lower Sierrite member and upper Bat Cave member. The Sierrite member consists of approximately 47 m (155 ft) of light-brown to grayish-brown, medium- bedded, dolomitic limestone. Discontinuous, silty and siliceous laminae distinguish many of the beds as do numerous burrows and general bioturbation. The Bat Cave member includes approximately 75 m (245 ft) of pale-tan to light grayish-tan dolomite in thick to medium beds, discontinuous beds of fossiliferous, stromatolitic, blue-gray limestone, and minor chert-bearing dolomite. Tectonic brecciation is pervasive in areas of closely spaced faulting, and karst brecciation is locally present at the top of the formation where the Montoya Formation is either thin or absent. Total thickness is approximately 122 m (400 ft).

Cambrian and Ordovician

€Ob **Bliss Formation**—Coarse-grained, arkosic sandstone; green, micaceous, fine-grained sandstone; maroon to black oolitic ironstone; gray quartzite; and minor, thin beds of fossiliferous limestone. Sandstone beds exhibit cross bedding, horizontal laminae, marine burrows, and scattered phosphatic brachiopods; forms dark, nearly black cliffs or ledgy slopes at the base of the Paleozoic section. Grades upward into El Paso Formation. Approximately 30–40 m (98–131 ft) thick.

Precambrian

p€ **Precambrian**—Red to tan granite, granitic gneiss, and gneissic granite with lesser volumes of mica schist, amphibolite, and metadiorite.

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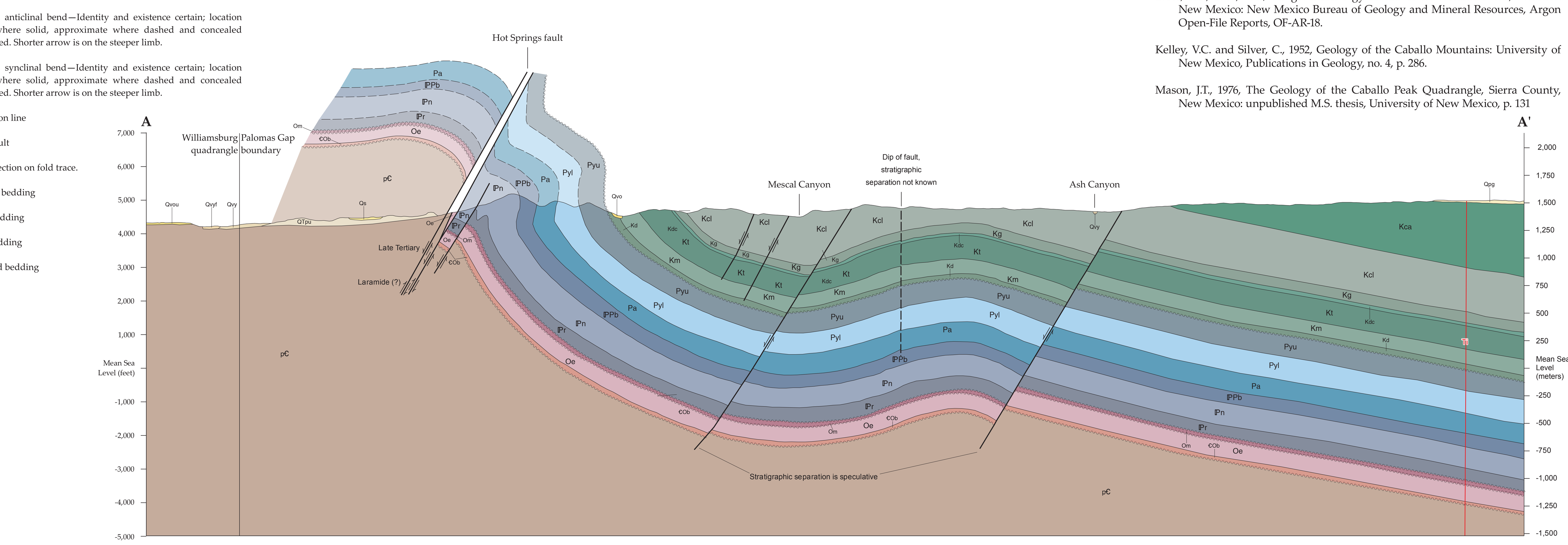
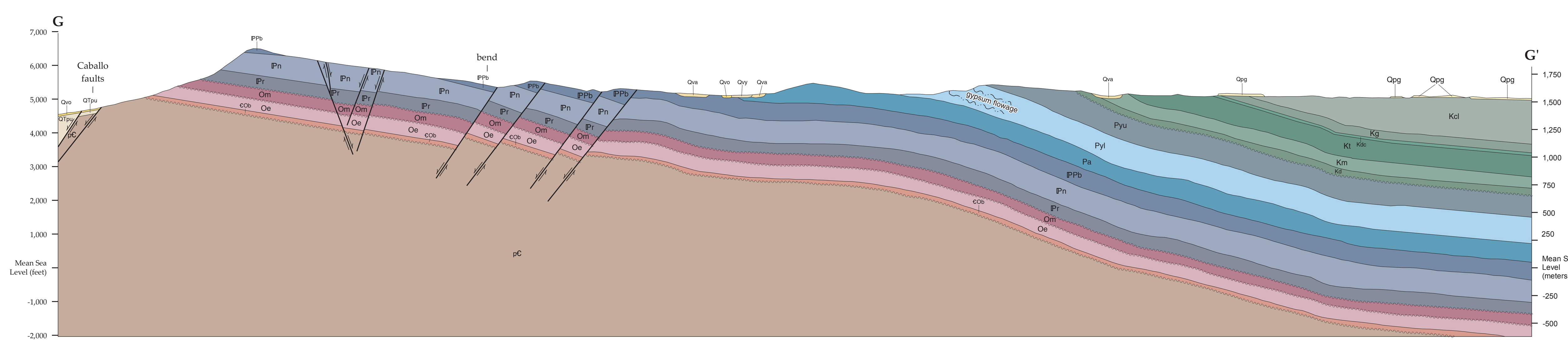
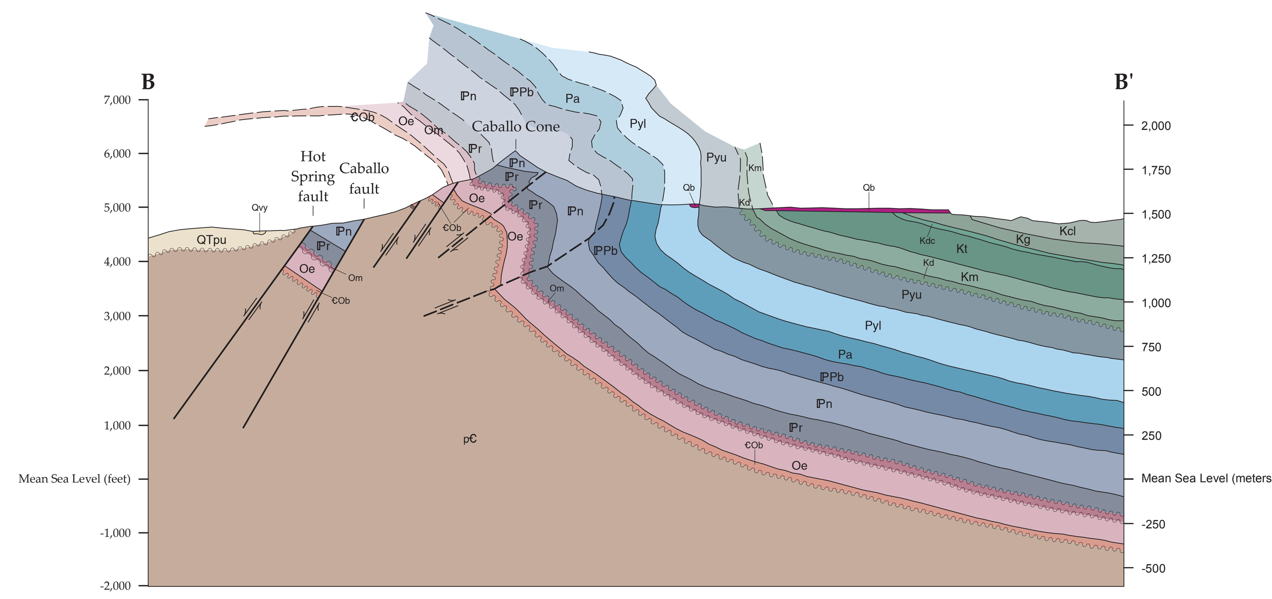




Geologic Cross Section B–B'



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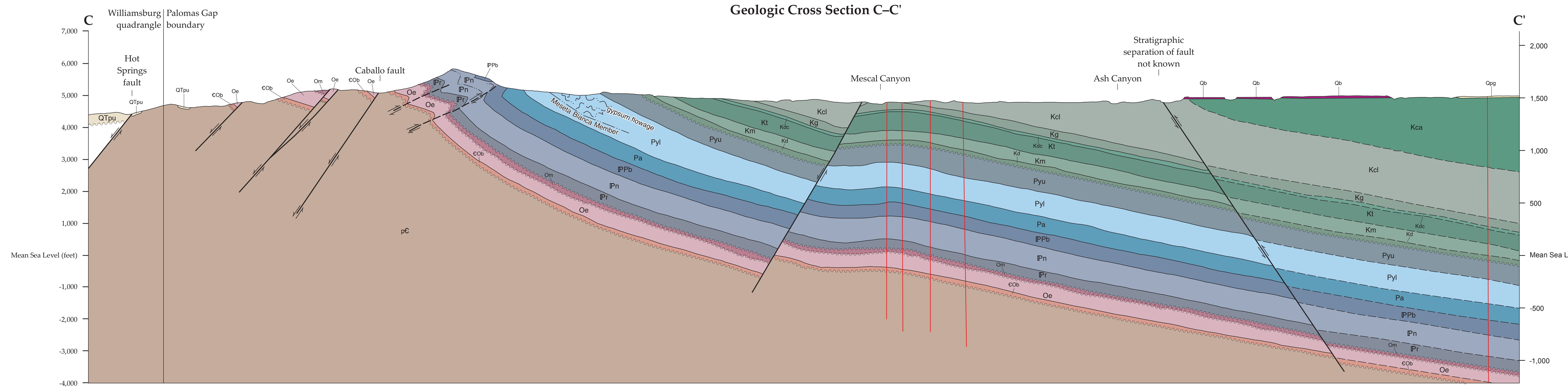

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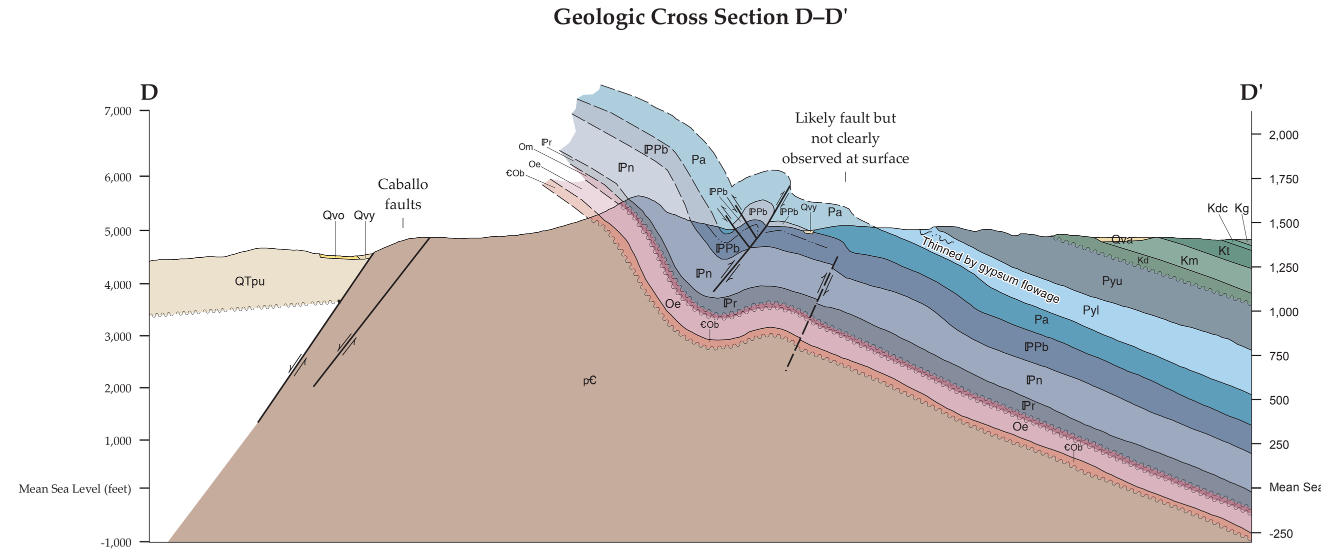
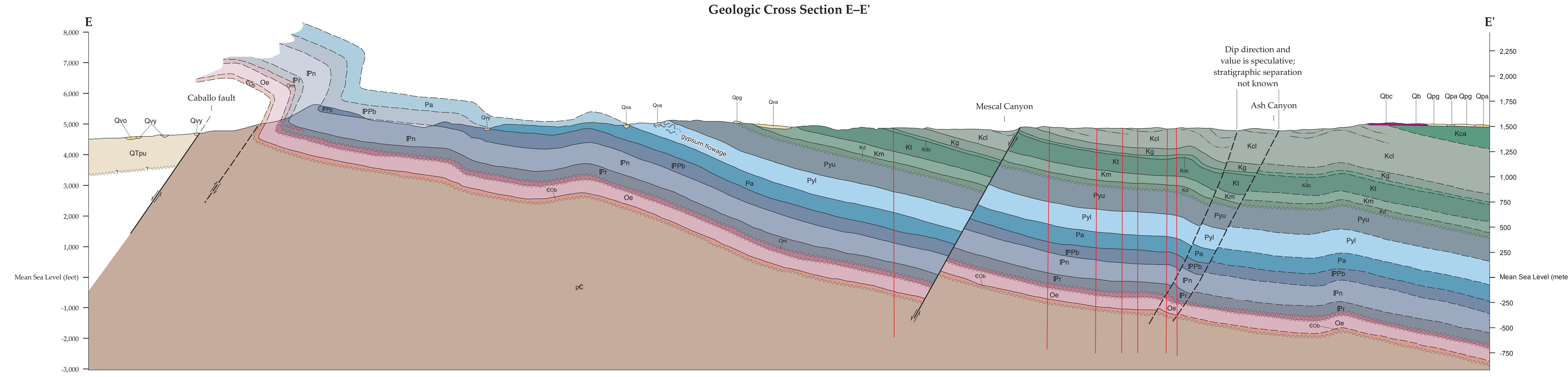
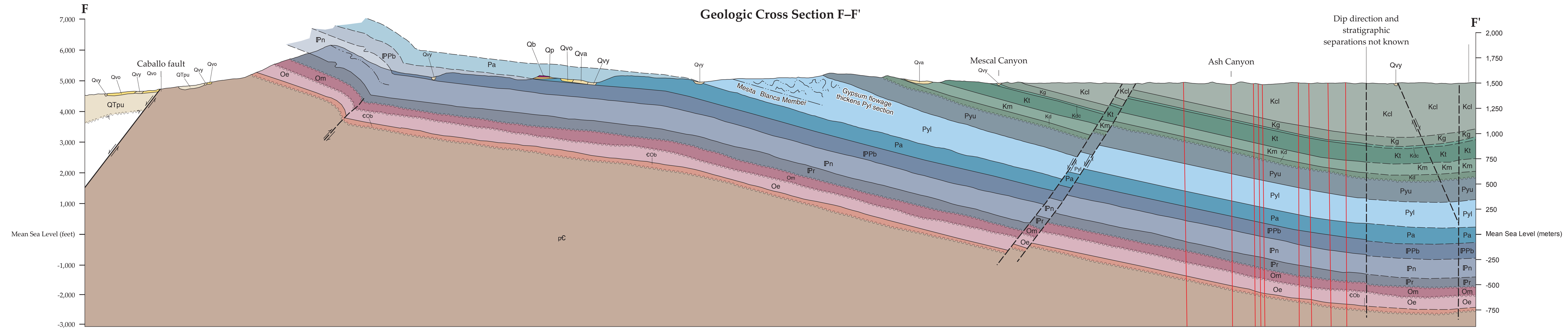


Geologic Cross Section E–E'



Geologic Cross Section F–F'



Description of Map Units

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Qvou — **Older valley-fill fluvial deposits undifferentiated**—Undifferentiated **Qvo** and **Qvof**.

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Jornada del Muerto and Eastern Piedmont Slopes of the Caballo Mountains

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Northern Caballo Mountains

Cuchillo Surface—Constructional upper surface of the Palomas Formation, as well as pediment surfaces graded to the top of the Palomas Formation.

Qpg — **Palomas Formation, upper piedmont-slope facies**—Boulder to cobble conglomerate and gravelly sandstone forming thin alluvial fans and pediment veneers along the eastern slopes of the Caballo Mountains; contains zones of stage III or stage IV pedogenic carbonate, especially at the top of the unit beneath the Cuchillo surface; overlies **Qb** locally. As much as 25 m (82 ft) thick in paleocanyons near the mountain front, thinning to a pediment veneer a few meters (15 ft) thick or less downslope.

Qb, Qbc — **Alkali-olivine basalt**—Flows, cinders, and cinder cones (**Qbc**) that underlie **Qpg** and locally overlie **Qp** on the eastern piedmont slopes of the northern Caballo Mountains. Stage III to IV caliche is widely developed on the surface of the flows. Generally 10 m (33 ft) thick or less, but as much as 35 m (115 ft) thick where flows have filled paleovalleys. Dates from nearby basaltic volcanoes or flows with similar erosion profiles are 2.1 and 2.04 Ma (Bachman and Mehnert 1978; Esser, 2003).

Qp — **Palomas Formation**—Boulder conglomerate and conglomeratic sandstone underlying **Qb** and overlying pedimented Paleozoic rocks southeast of Palomas Gap. Clasts are entirely Paleozoic limestone and sandstone. Approximately 15 m (49 ft) thick.

QTpu — **Palomas Formation, piedmont-slope deposits,undifferentiated**—Tan to light gray to red boulder to cobble conglomerate, conglomeratic sandstone and interbedded red sandstone/siltstone. Stage III or stage IV pedogenic carbonate is prominent at the top of the formation, but much of the conglomerate facies is tightly cemented by groundwater carbonate. Clast composition consists almost entirely of Paleozoic and Precambrian rock types derived from the footwall of the Caballo and Hot Springs faults. The strata were deposited as alluvial fans, pediment veneers, and alluvial-flat sediments on the hangingwalls of the Caballo and Hot Springs faults; faulted, relatively thin erosional remnants of the formation also cover parts of the footwall of these faults. Tongues of fluvial sandstone (**Qtpf**) are locally interbedded with fanglomerate. Unit is at least 137 m (450 ft) thick in the hangingwall of the Caballo fault and 12 m (40 ft) to at least 61 m (200 ft) thick in the hangingwall of the Hot Springs fault. On pedimented surfaces on the footwall of these faults, remnants of **QTpu** fans are variable in thickness owing to deposition on paleotopography, but are generally less than 30 m (98 ft) thick.

QTpf — **Palomas Formation, fluvial facies**—Gray, yellow, tan, ochre, and white sandstone, pebbly sandstone, and sand deposits of the ancestral Rio Grande. Unit occurs in the Palomas Gap quadrangle only as discontinuous, thin (15 m; 49 ft) tongues within **QTpu** at elevations of 4370-4420 ft and at 4580 ft.

Tc — **Palomas (?) Formation**—Boulder conglomerate and conglomeratic sandstone. Clasts up to 0.4 m in diameter consisting largely of intermediate-composition volcanic porphyries, possibly derived from the McRae Formation, with lesser amounts of limestone cobbles and pebbles. Only an acre or two in outcrop size and located within the northern Hot Springs fault zone. Approximately 25 m (82 ft) thick, top eroded.

Ti — **Dikes**—Dark gray to black basaltic, andesitic or andesite porphyry dikes in a northwest-trending swarm cutting Cretaceous rocks on the eastern piedmont slope of the northern Caballo Mountains. Some of the longer dikes in the south-central part of the quadrangle appear to occupy faults whereas others do not. Most are late Oligocene in age (26.9 my; 40Ar/39Ar; Esser, 2003) but some, which cut Pennsylvanian and Permian rocks along the northern backbone of the range, are more basaltic in composition, are associated with alkali-olivine basalt lava flows and cinders, (Qb) and may be Pliocene in age. Dike thicknesses range from less than a meter (3 ft) to 3 m (10 ft).

Upper Cretaceous

Kca — **Crevasse Canyon Formation, Ash Canyon Member**—Predominately thick-bedded, pale tan, yellowish-gray, reddish-yellow to light-gray, multi-storey, channel-form beds of sandstone and conglomeratic sandstone. Sandstones are coarse to medium grained, cross-bedded and quartz rich although a variety of volcanic and other rock types comprise part of the sand. Brown to greenish-brown sandstone, mudstone and shale are interbedded with the sandstone but comprise a lesser volume compared to the lower part of the Crevasse Canyon Formation. Petrified wood and plant molds are common; fluvial in origin. Basal beds intertongue with the lower member of the Crevasse Canyon Formation. Basal contact is difficult to identify and has been placed at different positions in the Crevasse Canyon section by different mappers. In the Palomas Gap quadrangle a thick section of probable Ash Canyon sandstones was mapped only in the northeastern corner of the quadrangle although the member may extend farther east and south. Tongues of Ash Canyon sandstone are present along the northeastern margin of the quadrangle within lower Crevasse Canyon strata, but were not mapped. Maximum thickness, measured from cross sections, is approximately 610 m (2000 ft).

Kcl — **Crevasse Canyon Formation, lower member**—Interbedded gray and light-tan, medium- to thick-bedded, cross-bedded, channel-shaped bodies or accretionary wedges of sandstone; brown to olive-brown, thin- to medium, even-bedded sandstone containing large concretions; and greenish-gray to brown mudstone and black shale; local, thin (5–15 cm) seams of lignite and coal (L and/or C on geologic map) are especially persistent a few meters above the Gallup Sandstone; many molds of leaves and other woody material; fluvial in origin; intertongues upward with Ash Canyon Member; may be as much as 396 m (1,300 ft) thick, or more.

Kg — **Gallup Sandstone**—Two or three, thick-bedded, tan to pale-yellowish-brown marine sandstone units containing *Ophiomora* and other marine burrows, as well as marine fossils, largely pelecypods. Sandstone units are separated by thinner-bedded, bioturbated, greenish-brown siltstone, fine sandstone and gray shale; lenses of pelecypod coquina are common as are large, brown, sandstone concretions containing marine fossils; grades abruptly upward into Crevasse Canyon Formation. Approximately 80 m (262 ft) thick.

Kdc — **D-Cross Tongue of Mancos Shale**—Dark gray to brown fine siltstone and shale containing sparse marine fossils, mostly pelecypods; grades upward into Gallup Sandstone. Approximately 20 m (68 ft) thick.

Kt — **Tres Hermanos Formation**—Lower marine Atarque Member consists of brown and greenish-brown, fossiliferous, burrowed sandstone, siltstone, and shale, followed upward by brown sandstone and olive-green mudstone of the fluvial Carthage Member, and capped by brown, fossiliferous, burrowed sandstone of the marine Fite Ranch Member; grades upward into D-Cross Tongue of Mancos shale; thickness varies dramatically from 106–198 m (350–650 ft) depending on the presence or absence of multistory, channel-shaped sandstone beds in the Carthage Member.

Km — **Mancos Shale**—Thin-bedded to fissile, fine siltstone and gray, marine shale with at least 5 ash beds, each 6–12 cm (2–5 in) thick. Also present in the upper third of the formation is the Bridge Creek Limestone Member of the Greenhorn Formation which includes three limestone beds, each approximately 0.3 m (1 ft) thick; the Mancos grades upward into the Tres Hermanos Formation. Approximately 120 m (394 ft) thick.

Kd — **Dakota Sandstone**—Upper marine shale and cross-bedded, marine sandstone overlies yellow-brown to white, cross-bedded, fluvial, quartzose sandstone; grades upward into Mancos Shale. Approximately 45–76 m (150–250 ft) thick, the variation a result of deposition on paleotopography on upper Yeso strata.

Permian

Pyu — **Upper Yeso Formation**—Includes the two upper members of the Yeso Formation: the upper sandstone-dolomite member and lower limestone member. Upper sandstone-dolomite member consists of approximately 198 m (650 ft) of interbedded gray, medium-bedded, fossiliferous limestone and dolomite and yellow to red sandstone, with local beds of gypsum; top of this member is a major regional unconformity. Lower limestone member consists of approximately 30 m (100 ft) of medium-bedded, fossiliferous, dark-gray to black limestone that forms a prominent, almost continuous hogback. Approximate total thickness of both members is 228 m (750 ft) but varies because of pre-Dakota erosion.

Pyl — **Lower Yeso Formation**—Includes the two lower members of the Yeso Formation: the upper red siltstone-dolomite member and lower Meseta Blanca Member. The red siltstone-dolomite member, approximately 137 m (450 ft) thick, includes at least three ledge-forming limestone/dolomite units (each approximately 10–15 m thick; 33–50 ft) within a sequence of interbedded massive gypsum, thin-bedded limestone, and red to yellow sandstone and siltstone. Thickening and thinning of this member is locally extreme because of flowage of gypsum, which also has caused limestone beds to be chaotically folded and dismembered; the member grades abruptly upward into the limestone member of the upper Yeso Formation. The basal Meseta Blanca Member consists of approximately 76 m (250 ft) of brick red to orange-red sandstone and siltstone with thin interbeds of gray and greenish-gray shale. Approximate total thickness of both members is 213 m (700 ft) except where the red siltstone-dolomite has been drastically thickened or thinned by gypsum flowage.

Pa — **Abo Formation**—Red to tan channelform, fluvial sandstone interbedded with red to purple overbank shale and siltstone; grades abruptly upward into Meseta Blanca Member of the Yeso Formation. Approximately 152 m (500 ft) thick.

Pennsylvanian and Permian

IPPb — **Magdalena Group, Bar B Formation**—The upper 50 m (165 ft) consists of interbedded purple and red siltstone and shale, gray limestone, and limestone-pebble conglomerate, correlative with the Bursum Formation (Wolfcampian), which grades upward into the Abo Formation. Lower part of the formation consist of interbedded gray or purplish-gray marine shale and ledges of gray, tan, and orange limestone; burrow traces, marine fossils, and chert are abundant in some beds. Formation thickens southward. Approximately 119 m (390 ft) thick.

Pennsylvanian

IPn — **Magdalena Group, Nakaye Formation**—Very thick-bedded, ledge and cliff-forming, gray or tan-weathering limestone interbedded with thin-bedded limestone, as well as reddish, green, or gray shale. Limestones are fossiliferous and many contain abundant black or gray chert as nodules, thin beds, or reticulated networks; top of the formation is marked by the lowest prominent (10m thick, 33ft) marine shale of the Bar B Formation. Approximately 191 m (625 ft) thick.

Ordovician

Om — **Montoya Formation**—The formation is divided into four members, widely recognized across south-central New Mexico. Upper Cutter Dolomite Member is mostly light- to medium-gray, medium-bedded dolomite, approximately 40 m (130 ft) thick in the southern part of the quadrangle. Medial Aleman Dolomite Member consists of medium- to dark-gray dolomite containing conspicuous and abundant nodules, lenses, and ribbons of dark-gray chert, approximately 47 m (155 ft) thick in the southern part of the quadrangle. Lower Upham Dolomite Member is very thick-bedded, dark-gray dolomite, approximately 20 m (65 ft) thick. Basal Cable Canyon Sandstone is grayish-tan to yellowish-brown, coarse-grained, quartzose sandstone, as much as 5 m (16 ft) thick, typically forming a conspicuous dark-brown cliff above the slopes of upper El Paso strata; locally, Cable Canyon sandstones are silicified. From south to north, the Montoya Formation is truncated downward by pre-Pennsylvanian erosion, and karst topography is locally well developed on upper Montoya strata; in the northern part of the quadrangle the formation is either missing entirely or only lower parts of the formation remain. Total thickness varies from 112 m (365 ft) in the southern part of the quadrangle to entirely absent locally in the northern part.

Oe — **El Paso Formation**—Following Kelley and Silver (1952) two members of the El Paso Formation were recognized, lower Sierrite member and upper Bat Cave member. The Sierrite member consists of approximately 47 m (155 ft) of light-brown to grayish-brown, medium- bedded, dolomitic limestone. Discontinuous, silty and siliceous laminae distinguish many of the beds as do numerous burrows and general bioturbation. The Bat Cave member includes approximately 75 m (245 ft) of pale-tan to light grayish-tan dolomite in thick to medium beds, discontinuous beds of fossiliferous, stromatolitic, blue-gray limestone, and minor chert-bearing dolomite. Tectonic brecciation is pervasive in areas of closely spaced faulting, and karst brecciation is locally present at the top of the formation where the Montoya Formation is either thin or absent. Total thickness is approximately 122 m (400 ft).

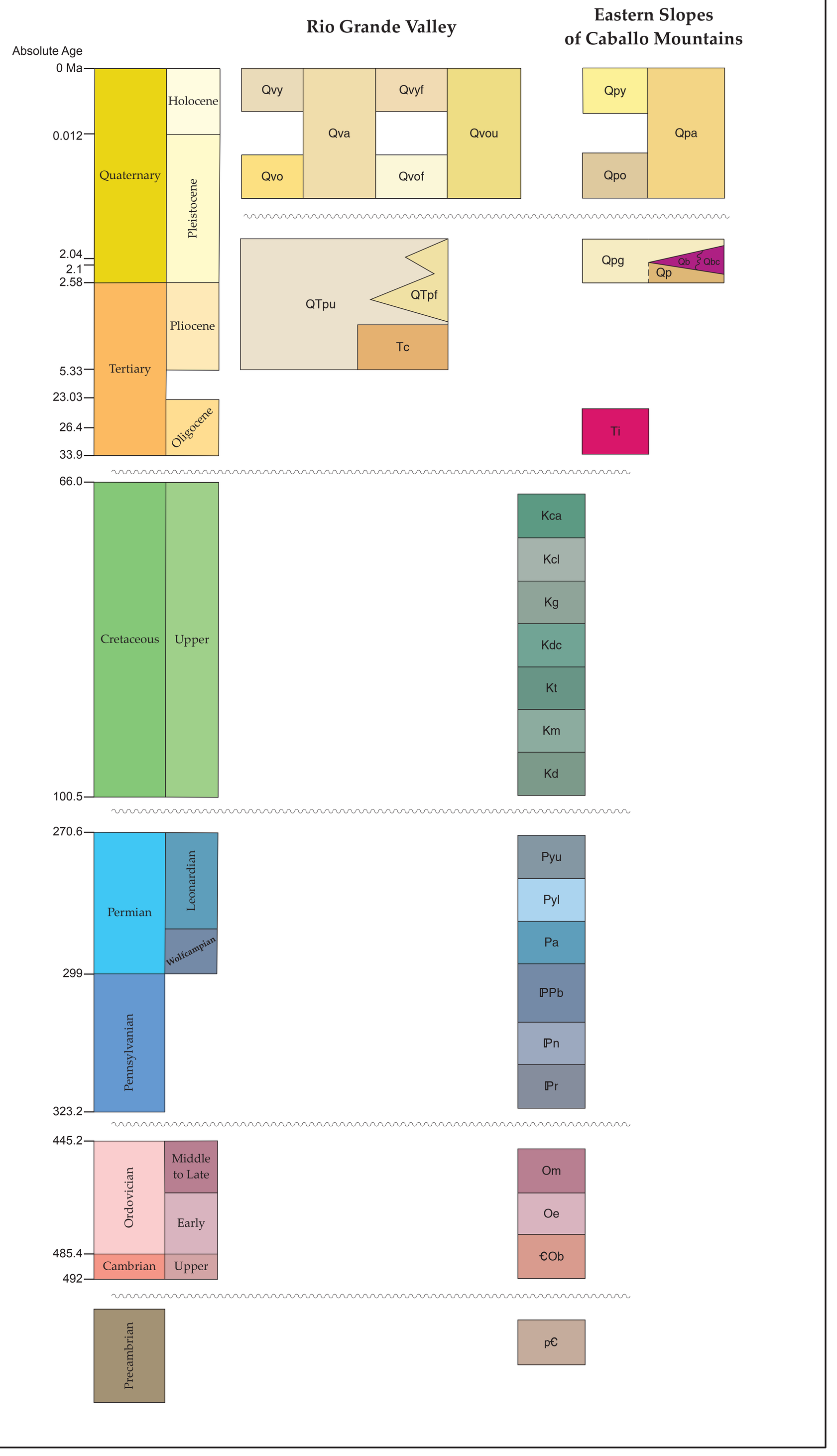
Cambrian and Ordovician

€Ob — **Bliss Formation**—Coarse-grained, arkosic sandstone; green, micaceous, fine-grained sandstone; maroon to black oolitic ironstone; gray quartzite; and minor, thin beds of fossiliferous limestone. Sandstone beds exhibit cross bedding, horizontal laminae, marine burrows, and scattered phosphatic brachiopods; forms dark, nearly black cliffs or ledgy slopes at the base of the Paleozoic section. Grades upward into El Paso Formation. Approximately 30–40 m (98–131 ft) thick.

Precambrian

p€ — **Precambrian**—Red to tan granite, granitic gneiss, and gneissic granite with lesser volumes of mica schist, amphibolite, and metadiorite.

Correlation of Map Units



Geologic Map of the Palomas Gap 7.5-Minute

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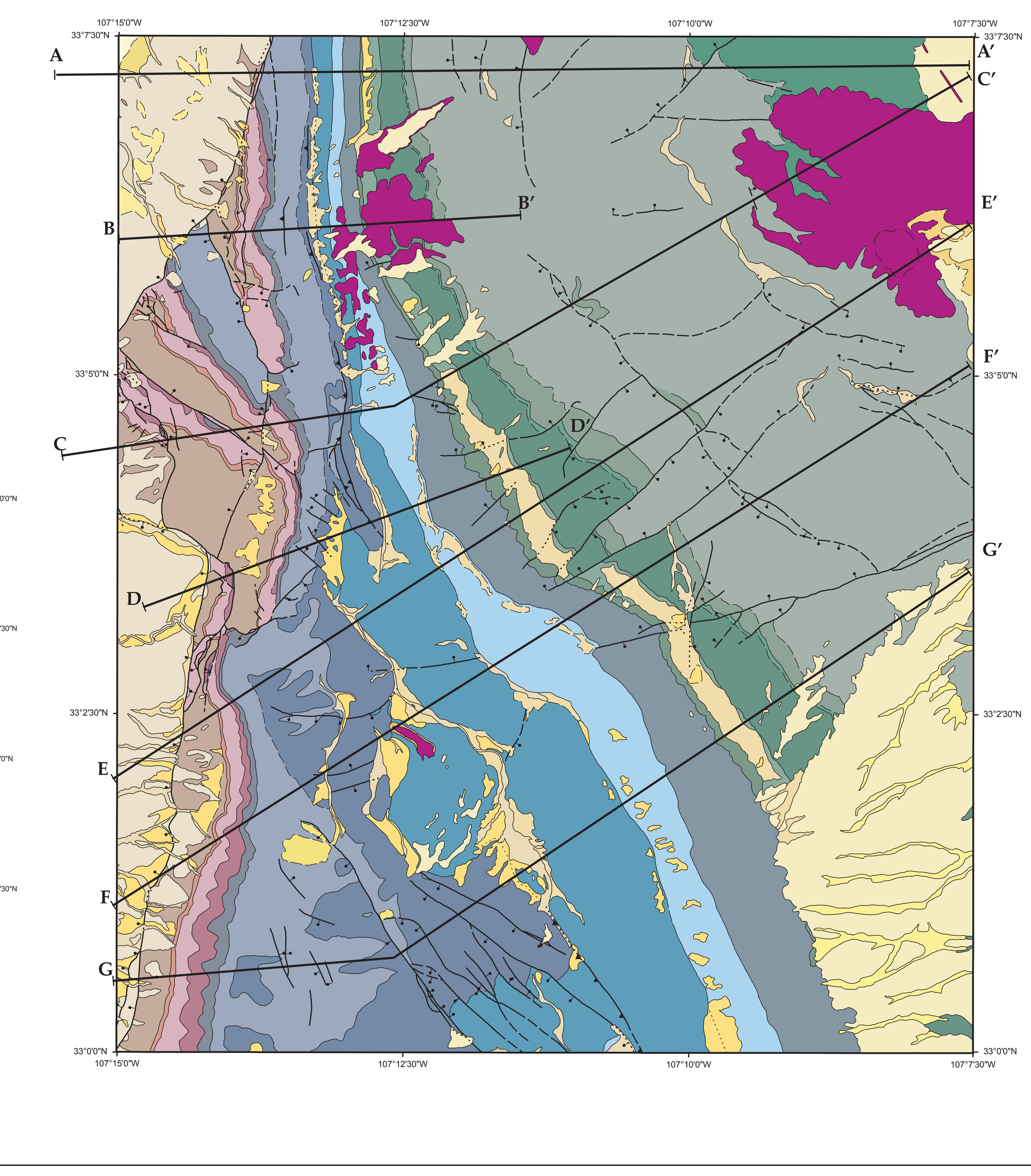

Base map from U.S. Geological Survey 2010.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 13S
10 000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in blue.

Roads.....©2006-2010 Tele Atlas
Names.....GNIS, 2008
Hydrography.....National Hydrography Dataset, 2005
Contours.....National Elevation Dataset, 2000

1:24,000

CONTOUR INTERVAL 40 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1988

Quadrangle Location

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

[575] 835-5490

This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

Digital layout and cartography by the NMBGMR Map Production Group:
Phil L. Miller
David J. McCraw
Elizabeth H. Roybal

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 260

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Geologic Map of the Palomas Gap 7.5-Minute Quadrangle, Sierra County, New Mexico

Additional Cross Sections

July, 2015

by
William R. Seager
Department of Geological Sciences, New Mexico State University, Las Cruces, New Mexico 88003

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.

Laramide Hot Springs Uplift

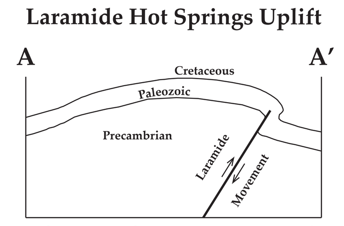

FIGURE 1—Segments of Laramide thrust faults may have been reactivated as normal faults during the late Tertiary uplift of the Caballo fault block. This observation seems to apply to a large segment of the Hot Springs normal fault where the late Tertiary movement has brought the Precambrian core of the Hot Springs uplift back down, juxtaposing it against younger strata in the footwall of the Hot Springs fault. See geologic map and cross section A–A′. Also, see Kelley and Silver (1952) and Mason (1976) for similar interpretations.

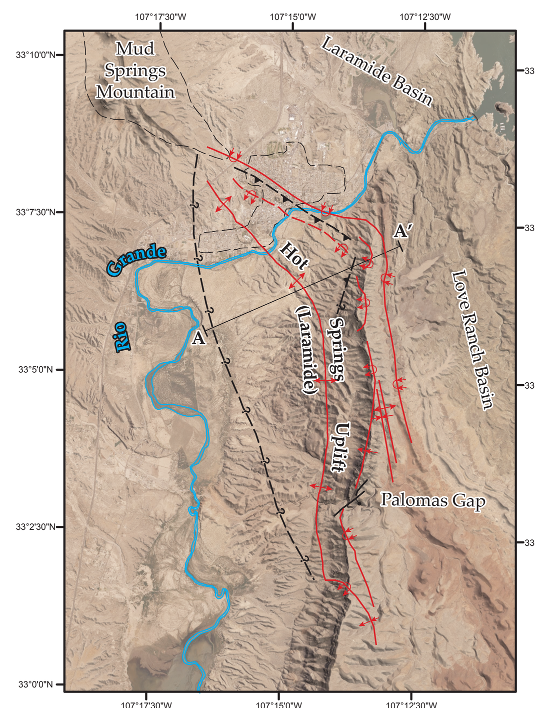

FIGURE 2—Folds in the northern Caballo and southeastern Mud Springs Mountain suggest a Laramide uplift (Hot Springs uplift) existed adjacent to these structures. See map.