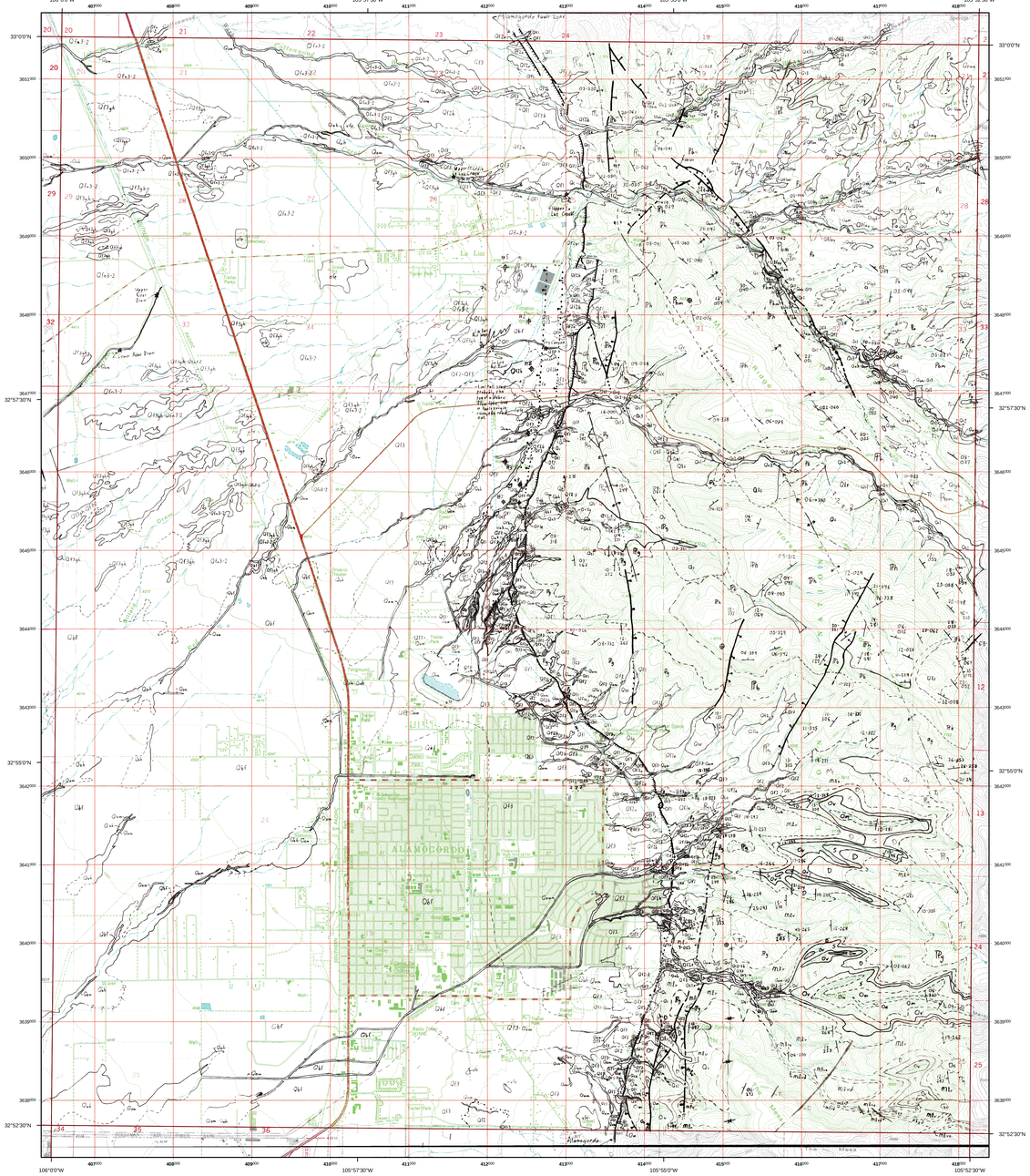
NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A DIVISION OF NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY

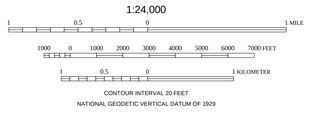
NMBGMR Open-file Geologic Map 153

Last Modified 22 May 2007



Base from U.S.Geological Survey 1981, from photographs taken 1972 and field checked in 1975. Map edited in 1981
1027 North American datum, UTM projection – zone 13N
1000- meter Universal Transverse Mercator grid, zone 13, shown in red

QUADRANGLE LOCATION



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

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

DRAFT

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
Earth Science for the 21st Century

STATEMAP

Preliminary geologic map of the Alamogordo North quadrangle, Otero County, New Mexico.

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by
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New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map **153**

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

COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

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.

DESCRIPTION OF MAP UNITS

QUATERNARY UNIT DESCRIPTIONS

COLLUVIUM, SLOPEWASH, AND LANDSLIDES

Qcv **Colluvium incorporating reworked eolian sediment (Holocene) –** Angular, locally derived pebbles and minor cobbles in a pink to very pale brown (7.5-10YR 7/8-8/4) silt and very fine- to fine-grained sand matrix that is highly gypsiferous. Minor medium to very coarse sand. Sand is subrounded to subangular and composed of gypsum, calcite, and limestone; coarse to very coarse sand fraction is all limestone. Estimated 1-5 m-thick.

Qc **Colluvium (Holocene) –** Pink to light brown (7.5YR 7/3-6/4) to gray, massive, matrix-supported, gypsiferous silty-clayey very fine- to fine-grained sand mixed with medium to very coarse sand and gravel in various proportions. Subangular gravel. Gravel includes pebbles, cobbles, and boulders that are angular to subangular and poorly to very poorly sorted. Unit includes colluvium where recognized below fault scarps (probably more common than shown on the map). Thickness generally 1-5 m.

Qcwg **Gypsiferous slopewash (Pleistocene to Holocene) –** Pink to light brown (7.5YR 7/3-6/4) to white to grayish brown (2.5Y 5/2), gypsiferous silt and very fine- to lower medium-grained sand. Estimate 1-5% upper-medium to very coarse sand and very fine to fine pebbles. Deposit is massive, weakly consolidated, and locally underlain by sandy pebbles to cobbles. Gypsum precipitate, 20-30 cm-thick, may lie on top of the unit. There may be strong, buried gypsic horizons about 10-30 cm-thick. Estimated thickness of 2-5 m.

Qc-sw **Both Qc and Qswg deposits are present in broad swales (Holocene) –** See descriptions of these two deposits above.

Qls **Landslide deposits (Pleistocene to possibly Holocene) –** Chaotic, jumbled assemblage of angular gravel (with abundant boulders) in a clayey-silty sand matrix. Color is variable. Moderately consolidated and non-cemented. Thickness is highly variable; landslides in lower Dry Canyon appear to attain thicknesses as great as ~ 30 m.

STREAM TERRACE DEPOSITS IN MOUNTAIN CANYONS

Qa3 **Lower stream terrace deposit (late Holocene) –** Sandy gravel terrace deposits inset below the terrace deposits of **Qa2** and **Qa1**. The sandy gravel is clast-supported, commonly imbricated, and in very thin to medium beds. Debris-flows are minor and matrix-supported. Gravel is subrounded to subangular, poorly sorted, and composed of pebbles with 1-3 cobbles and minor boulders of predominantly carbonate clasts. Sand is very pale brown to pale brown (10YR 6-7/3), very fine to very coarse-grained, and poorly sorted. Surface has bar and swale topography and a stage I calcic-gypsic soil horizon up to ~50 cm-thick. Debris-flow deposits are less common in this unit than in **Qa2**, and the unit does not generally coarsen upwards. Correlates with unit **Qf3** on the alluvial fans. Locally, it is possible that this deposit may be a Qa2c or Qa2b deposit with no recognizable surface. Loose to weakly consolidated and 2 m-thick.

Qa2 **Intermediate stream terrace deposit (early to middle Holocene) –** Sandy gravel that generally coarsens upwards. Inset below the **Qa1** terrace deposit. Lower and middle parts of this unit are characterized by stream-flow deposits of clast-supported, imbricated, sandy pebbles and 20% cobbles. Beds are in 5-cm-thick and thicker debris-flows or very thin to medium, lenticular to broadly lenticular beds. Gravel are subrounded to subangular and poorly sorted. Sand is pale brown (10YR 6/3), poorly sorted, and fine- to very coarse-grained. Debris-flow beds (typically matrix-supported) are more common in the upper part of the deposit; they contain abundant cobbles and boulders. Like the alluvial fans, locally two stream terrace deposits of this deposit, described below. This deposit is generally coarser-grained than **Qa1**. 2-3 m-thick.

Qa2a **Intermediate stream terrace deposit with approximate original aggradational surface is preserved –** Surface lacks bar and swale topography, has a desert pavement, and its topsoil has a calcic-gypsic horizon possessing an apparent stage I+ to II carbonate morphology. Correlates with unit **Qf2a** on the alluvial fans. 2-3 m thick.

Qa2b **Intermediate stream terrace deposit with a significantly eroded surface –** Same deposit as unit **Qa2a**, but commonly has a lag of boulders on its surface due to erosion of the upper sediments of the initial **Qa2** deposit. Surface is marked by these boulders, bar and swale topography, and the presence of an apparent stage I+ calcic-gypsic soil horizon. Correlates with unit **Qf2b** on the alluvial fans. About 2 m-thick.

Qa1 **Higher stream terrace deposit (middle to late Pleistocene) –** Sandy gravel in thick terrace deposits. Sediment is generally clast-supported and consists of pebbles, cobbles, and minor boulders. Beds are medium to thick and lenticular to broadly lenticular to tabular. About 10% of the beds have abundant silty-clayey fine sand mixed with gravel that includes boulders (both clast- and matrix-supported); these are probably debris-flow deposits. Gravel is subangular to subrounded and poorly sorted. Sand is light gray to very pale brown (2.5Y 6/3-7/2) to light brown to pink (7.5YR 6/3-4 and 7/4), very fine- to very coarse-grained (mostly coarse- to very coarse-grained), and poorly sorted. Locally, the sand is mostly a clayey-silty, very fine to fine-grained sand with abundant medium- to very coarse-grained sand and very minor pebbles. Buried soils locally are observed. Surface generally lacks original bar and swale topography. Correlates with Qf1 on the alluvial fans. Up to ~15 m-thick.

Qtu **Highest and oldest stream terrace deposit (late to early Pleistocene) –** Deposit is the highest mapped in Marble Canyon, this deposit is similar to that of **Qt1** (described above) and may possibly represent the highest level of aggradation of **Qt1** prior to erosion of that unit to the level of the present tread of **Qt1**. Sediment has a well-developed buried Bt and/or Btk soil horizons and less common Bk and Btkj horizons. Deposit is generally a sandy gravel in thin to thick, lenticular beds. Gravel consists of clast-supported pebbles with 30-40% cobbles and minor boulders; gravel are subrounded to subangular and poorly sorted. Sand is very pale brown (10YR 7/3), very fine- to very coarse-grained, and poorly sorted. Weakly to well consolidated and approximately 15-20 m-thick. Tread lies 5-10 m above **Qt1** tread in Marble Canyon.

QTgh **High-level sandy gravel that caps ridges in the Sacramento Mountains (Pliocene to early Pleistocene) –** Sandy gravel that caps ridges in the northern part of the quadrangle, and in Dry Canyon. These deposits are very thin-bedded, clast-supported, and subangular to subrounded. Gravel are imbricated, clast-supported, composed primarily of limestone, and consist of very fine to very coarse pebbles with subordinate cobbles and lesser boulders. Gravel are poorly sorted and matrix-supported. Many of the **QTgh** are most common immediately east of a prominent, north-south-trending fault, and indicate a down-to-the-east sense of displacement. Thickness of 1-20 m.

Qpa **Undifferentiated terrace deposit (late Pleistocene to Holocene) –** Sandy gravel in terrace deposits that likely correlate to Qt1, Qt2, or Qt3; however, correlation to a particular terrace deposit is uncertain.

Qfay **Younger alluvium mapped in La Luz and Fresnal canyons (Holocene) –** This unit either forms low terraces or occupies the valley floor. It consists of yellowish red to brown, silty-clayey, very fine- to very coarse-grained, subangular, poorly sorted alluvial(?) sand. Top soil is marked by gypsum accumulation in the upper 60-70 cm of the unit. 25-60% of the sediment consists of sandy gravel in very thin to medium, lenticular beds. Gravel generally consists of very fine to very coarse pebbles with minor fine cobbles. The gravel are subrounded to subangular, moderately to poorly sorted, and composed of Paleozoic carbonate clasts with minor quartzite, chert, sandstone, and siltstone clasts. Approximately 10-20% of sediment is silty-clay and very fine- to lower-fine-grained sand in thin, lenticular beds. Moderately to well consolidated. Unit probably correlates with **Qa3**, **Qa2**, or both **Qa2** and **Qa2**.

Qa3-Qa2 **Older alluvium mapped in La Luz and Fresnal canyons (Pleistocene) –** Sandy gravel consists of pebbles and cobbles. Clasts are subrounded to subangular, poorly sorted, and composed of Paleozoic carbonate clasts with minor quartzite, chert, sandstone, and quartz monzonite. Generally we can correlate this unit against an inset Tread of this unit is approximately 2 m above the tread of unit Qlfay. Probably correlates to unit Qa3 but this is somewhat uncertain. Generally 1-3 m-thick.

Both Qa3 and Qa2 deposits are present in broad swales; Qa3 deposits are more common and Qa2 deposits exceed 10% by area (Holocene) – See descriptions of these two deposits above.

ARTIFICIAL FILL AND EXCAVATIONS

afe **Artificial fill and excavations (modern) –** Used to designate excavations and fill associated with gravel and sand quarries, of which there are many on the quadrangle. Some abandoned quarries have been converted to parks.

BASIN FLOOR DEPOSITS

Qbf **Sheetwash and eolian deposits (Holocene; buried deposits are as old as Oligocene?) –** Silty-clayey, very fine- to fine-grained sand with 1-5% thin lenses of sandy pebbles. Color ranges from pale brown (10YR 6/3) to light brownish gray (2.5-10YR 6/2) to light yellowish brown (10YR 6/4) to light brown (7.5YR 6/4). Beds are vague, medium to thick, tabular, and either massive or bioturbated and flat planar- to ripple-laminated. Locally, there is minor medium- to very coarse-grained sand. Common buried soils having minor gypsum accumulation, weak to moderate ped development, and weak illuviation (as films on ped faces or bridges between grains). Weakly to moderately consolidated. Deposit underlies gentle slopes west of the steeper alluvial fans. A sparse cover of lag gravel may be present. A stratigraphic section of this unit is presented in Romero and Koning (2006). Inferred thickness of 300-600(?) meters under the basin floor.

ALLUVIAL FAN DEPOSITS

Qam **Sandy gravel associated with modern drainages on the alluvial fans (0-50 yrs old) –** Sandy gravel in recent bars and swales having up to 0.5 m of relief. Gravel includes pebbles, cobbles, and boulders. Clasts are subrounded to subangular, commonly clast-supported, and very poorly sorted. Sand is grayish brown to light brownish gray (2.5Y 5/4-5/2) and pale brown (10YR 6/3). Sand is mostly upper-fine- to upper-very coarse-grained. Relatively sparsely vegetated. No soil development, desert pavement, or clast varnish. Generally less than 2 m-thick.

Qah **Historical deposition of sandy gravel along modern drainages of alluvial fans (50-200 yrs) –** Deposits similar to those of Qam but whose surfaces support moderate vegetation. There is no evidence on its surface of significant fluvial aggradation in recent time. No observable soil development, desert pavement or clast varnish.

Qf3 **Sand, gravelly sand, and subordinate sandy gravel (late Holocene) –** This unit is designated for thin, relatively sandy deposits that appear slightly inset into **Qf2**s on the proximal alluvial fans. Unit generally 1-3 m-thick, vague beds of silty very fine- to lower-medium-grained sand, and minor upper-medium to very coarse sand. At the mountain front, this unit is gravelly (pebbles and cobbles). Sediment is pale brown to very pale brown (10YR 6-7/3) to light yellowish brown (10YR 6/4) to yellowish brown (10YR 5/4) and moderately to poorly sorted. Within this finer sand may locally be scattered very fine to medium pebbles of Paleozoic sedimentary clasts. There is subordinate thin to thick, lenticular beds of sandy gravel. The gravel are typically clast-supported, subrounded to subangular, poorly sorted, and consist of very fine to very coarse pebbles with up to 25-30% fine to coarse cobbles. Sand in the coarse channel-fills is typically pale brown to very pale brown (10YR 6-7/3), fine- to very coarse-grained, and poorly sorted. The relatively charcoal-rich, grungy "G-unit" depicted in the stratigraphic sections of Figure 3 is useful in identifying this unit in the northern part of the quadrangle. The lack of a coarsening-upward trend and its more sandy texture helps in differentiating this unit from **Qf2** deposits. The surface is generally not as bouldery and cobbly as that associated with **Qf2b**, but yet commonly has a pebble to fine cobble gravel lag indicating erosion of the surface. The surface has slight bar and swale relief of 0.5 m. Soil development is commonly weak clast varnish. Soil development is characterized by a stage I calcic soil horizon. In the medial to proximal parts of the alluvial fan, the surface is moderately dissected by gullies about 2 m-deep. In the distal parts of the alluvial fan, this unit becomes an extensive, albeit relatively thin, deposit. Unit generally corresponds to Qf3 of Koning (1999) and Koning et al. (2002). Generally less than 2 m-thick.

Qf3gh **Gravel-capped, slightly dissected remnants of Qf3 (late Holocene) –** This is a subunit of **Qf3** mapped in the distal to medial parts of the La Luz Creek alluvial fan in the northern part of the quadrangle. It consists of a remapped, surface clast armor of very fine to very coarse pebbles overlying a 20-70 cm-thick layer of gypsiferous, silty, very fine to fine-sand (minor medium sand and locally 1-25% coarse to very coarse sand and scattered pebbles).

Qf3gh-Qfs3-2 **A composite unit containing >10% each of Qf3gh and Qfs3-2 (Holocene) –** See **Qf3gh** and **Qfs3-2** entries for their respective detailed descriptions.

Qf2 **Sandy gravel and gravelly sand (early to middle Holocene) –** Representing a period of relatively coarse, Holocene-age, alluvial fan aggradation, this map unit is the most areally extensive of the mapped alluvial fan units. It includes the Qf2, Qf2a, and part of the Qf3m units of Koning (1999) and Koning et al. (2002) and probably correlates with the Organ I alluvium of the Desert Project (although near Alamogordo its age extends to 9-10 ka, according to Koning et al., 2002). Near the mountain front on alluvial fans that experience debris-flow deposition, this unit commonly coarsens-upwards from a clast-supported, imbricated sandy gravel to bouldery debris-flows intercalated with sandy gravel. On the La Luz and Cottonwood alluvial fans, alluvium is generally sand, clayey-silty sand, and pebbly sand that has a reddish color and a somewhat higher clay content due to having a source area with Abo Formation. After the culmination of aggradation in the middle(?) Holocene, this deposit experienced net erosion until the present. Below, we have differentiated this unit into two subunits marked by different surface characteristics and geomorphic position; these are called Qf2a and Qf2b. Note that these denote the same deposit and overlain by different surfaces. Unit is generally 2-5 m thick and weakly consolidated, but locally exceeds 8 m in thickness (such as at the mouth of Marble Canyon).

Qf2a This is applied to the deposit under the highest aggradational surface associated with unit **Qf2.** Its topsoil is characterized by having calcic-gypsic horizons up to 50 cm-thick with an apparent stage I+ to II morphology, and no (locally very weak) illuviated clay horizons (Bt soil horizons). Generally, the surface has a desert pavement developed on it and is marked by a varnished and moderate to dense clast armor. Bar and swale topography has a relief of less than 30 cm of relief. This was called Qf2 by Koning (1999) and Koning et al. (2002).

Qf2b This is applied to the deposit under the younger aggradational surface associated with unit **Qf2.** Erosion of the upper sediment has left a boulder to cobbly lag gravel with significant bar and swale topography (30-70 cm of relief). Soil development is marked by a stage I+ calcic soil horizon and no recognizable illuviated clay. Its desert pavement has only a moderate clast armor and relatively weak clast varnish. Pedestalled yucca appear to prefer growing on this surface compared to surfaces on **Qf2a** and **Qf1**. This was mapped as Qf3u, Qf3m, and Qf2 by Koning (1999) and from Koning et al. (2002).

Qf2-c **Both Qf2 and Qc deposits are present; Qf2 deposits are more common and Qc deposits exceed 10% by area.**

Qfs3-2 **Northern alluvial fan sediment consisting of unit QF3 with subordinate Qf2 sediment (Holocene) –** This unit is applied to most of the La Luz Creek alluvial fan in the northern part of the quadrangle. Here, the alluvium is generally sand that locally **Qf3** is less than 0.5 m-thick and unit **Qf2** is relatively near the surface. Sediment of this fan has a remarkably red color (pink to reddish yellow; 7.5YR 7/4-6) due to erosion of Abo Formation upstream. Unit **Qf2** in the distal part of this fan commonly consists of very fine to fine sand, with local medium to very coarse-grained sand and pebbly sand (1-3% pebbles) that is horizontally laminated to planar- to lenticular-very thinly bedded, cross-laminated, or massive. Sand is moderately sorted (see description of lower Ritas Draw stratigraphic section). Locally, **Qf2** may consist of silty-clayey very fine- to fine-grained sand overprinted by thin soil development (see description of upper Ritas Draw stratigraphic section). 1.5-3 m-thick.

Qf1 **Clayey-silty very fine- to medium-grained sand, and subordinate gravelly sand and sandy gravel (latest Pleistocene to early Holocene; 257 to 9-10 ka) –** This is generally a fine-grained deposit that overlies the prominent soil developed on top of Qf1. However, near the mountain-front this unit has subordinate pebbles and cobbles. Sediment in this unit may be a sandy gravel, but the dominant feature of this unit is the presence of thick and moderate, medium gray (10YR 5/1) beds in the middle part of this unit. Limestone beds increase towards the upper part of the unit and is interbedded with layers of black shales. Locally, the black shales contain pyrite. Some beds present a distinctive reddish and yellowish color of alteration. Mostly medium bedded, but very massive to instantaneously resistant to erosion. It is poorly exposed and commonly covered by colluvium. 15-30 meters (50-100 feet) thick (mostly ~ 30 m-thick). The upper contact is a disconformity.

S **Fusselman Formation (Silurian) –** Dark-colored, cherty dolomite and very minor siliciclastics. Fresh samples very in color from light gray to dark gray or are olive to brownish gray. Fine to medium crystalline. Bedding is obscure. Chert is abundant and it is present as irregular nodules. Locally medium- to thick-bedded (>100 cm-thick), sparingly to conglomeratic units are locally present. Deposit is a dissolution breccia at the basal contact (Pray, 1961). These units contain abundant dissolution breccias, dolomite, quartz and chert particles that vary in size from sand to pebbles. The Fusselman formation is very resistant to erosion which has allowed for the formation of steep cliffs, ledges, and dip slopes that are commonly covered by angular rock fragments from the mountain front. Exposures are of the escarpment. Both, the lower and upper contacts are sharp disconformities. The nature of the contacts is reflected in the variation of thickness of the unit, ~372-30 m thick (US-100 ft). Description taken in part from Romero and Koning (2006).

Ov **Valmont Dolomite (Ordovician) –** Sharply defined, thin to medium (3 to 60 cm-thick) beds of light to very light gray, finely crystalline, sublithographic dolomite and minor chert. Its typically very light-colored dolomite is consistent throughout the area. The lower contact with the cherty member of the Montoya formation is lithologically transitional. However, the Montoya formation is darker in color, coarser in texture, and its bedding more obscure compared to the Valmont Dolomite. The Valmont Dolomite is divided into an upper and lower member. Two argillaceous and shaly zones 60-150 cm-thick can be traced along the area about 25 m above the base of the unit, and represent the basal part of the upper member. Chert is more common in the lower member, where it is present in large nodules up to 10-15 cm thick and is light gray in color. In the upper part of the upper member, chert is also present in light brown masses in 5- 25 cm-thick. Formation is 45-58 m thick (150-190 ft). Description slightly modified from Romero and Koning (2006).

Om **Montoya formation (Ordovician) –** Almost entirely crystalline dolomite and cherty dolomite. About a meter of thick and massive beds of quartz sandstone and sandy dolomite marks the base of the section. Thick beds of chert (30-100 cm) mark the upper part of the unit. The dolomite ranges in color from medium dark gray to light olive gray. Formation is 57 to 69 m thick (190-225 ft). Description slightly modified from Romero and Koning (2006).

Or **El Paso Formation (Ordovician) –** Dolomites, sporadic sandy dolomites, and dolomitic quartz sandstones in thin to medium beds. Mostly light olive gray to light gray, very fine to medium crystalline dolomite. Dolomitic quartz sandstone is common in the upper half of the lower third of the section, as well as in the upper 30 meters of the section. This beds of sandy dolomites and dolomitic quartz sandstones are sporadically present in other parts of the section. This to medium, light- to medium-gray chert lenses, seams and nodules are common in the middle part. 131 m thick (430 ft). Description slightly modified from Romero and Koning (2006).

Ob **Bliss Sandstone (Ordovician) –** Quartz sandstone that does not appear on the Alamogordo North quadrangle, but was used in the cross section. ~34 meters thick (110 feet).

TERTIARY IGNEOUS ROCKS IN SACRAMENTO MOUNTAINS

Ti **Igneous intrusive rocks (middle to late Eocene) –** Igneous intrusive rocks that intrude Paleozoic strata. These rocks are predominantly grayish green and porphyritic, with phenocrysts of plagioclase, hornblende, and diopsidic augite (plagioclase seems to be the most prevalent on this quadrangle). The groundmass consists of plagioclase laths, interstitial chlorite, magnetite, minor orthoclase, and apatite (Asquith, 1974). These rocks have been characterized as nepheline normative trachybasalts, basaltic trachyandesites, trachydesites, and dacites by McManus and McMillan (2002), and as diorite (minor camptonite) by Asquith (1974). Where exposed, igneous rocks are hydrothermally altered to common secondary minerals. Small intrusive sheets, on the scale of 10s to 100s of meters, along with thinner dikes, occur in the northern and eastern parts of the quadrangle. Widespread sills and dome-shaped bodies, 1-10 meters thick, occur in the Lubera part of the quadrangle, mainly within the lower part of the Pennsylvanian Gobbler formation. $^{40}Ar/^{39}Ar$ ages of 44-36 Ma (McManus and McMillan, 2002).

SEDIMENTARY ROCKS IN SACRAMENTO MOUNTAINS

Pa **Abo Formation (Permian) –** Medium to dark reddish brown mudstones with minor coarse, arkosic sandstone lenses. Sandstones are commonly cross-bedded and individual grains are subangular to angular. The basal part of the Abo Formation contains thick conglomeratic beds that are composed of predominantly subrounded quartzite clasts. These conglomerates are interbedded with reddish-brown mudstone. ~100-120 m thick (330-400 ft).

Pbm **Bursum Formation** (Permian) – The Bursum Formation, as defined by Pray (1961), is composed of silty and sandy limestone interbedded with red mudstone together with minor fine quartz sandstone and limestone- to chert-bearing conglomerate. The amount of red mudstone in the Bursum Formation increases to the southeast on the Alamogordo North quadrangle. Limestone conglomerates in the southeastern part of the quadrangle contain Pennsylvanian lithologies, suggesting a syn-tectonic deposition with respect to movement along the Fresnal fault to the east in the High Rolls quadrangle. The Bursum formation terminology is used here because its upper contact with the Abo Formation, as defined by Pray (1961), is better defined in the map area than the upper contact of the Laborcita formation, as defined by Otte (1959). ~90-110 m thick (300-350 ft).

/Ph **Holder Formation (Pennsylvanian) –** A heterogeneous unit of dark and reddish shale, sandstone, nodular limestone, and limestone conglomerate. Well-developed algal bioherms are evident in the basal part of the formation, forming massive cliffs.(17-23 meters thick (50-75 feet), as in Dry Canyon. The lower contact is best defined by the presence of such bioherms. The lower part of the Holder Formation is dominated by marine carbonates and dark shales. The upper Holder Formation is marked by an increase in the amount of reddish shale, sandstone, nodular limestone, and limestone conglomerate. The upper contact is an abrupt change to quartz sandstone and pebble conglomerates of the Permian Bursum Formation. ~180-275 m thick (600-900 ft).

/Pb **Beeman Formation (Pennsylvanian) –** Thin beds of argillaceous limestone interbedded with calcareous shale. Locally sporadic, olive gray, feldspathic sandstones are found towards the base. A yellowish dolomitic unit and an upward transition to more feldspathic sandstones marks the base of the Beeman Formation, in contrast to the quartz sandstones of the underlying Gobbler Formation. ~110-150 m thick (350-500 ft). Description taken in part from Romero and Koning (2006).

/Pg **Gobbler Formation (Pennsylvanian) –** The lower few hundred meters of this formation exhibits minor coarse-grained sandstone, fine pebbly sandstone, and chert-bearing cobble conglomerate with a sandstone matrix that are interbedded with abundant dark gray to black shale and dark gray to black limestone. The middle part (Bug scuffle Member) consists almost entirely of calcarenites and calciliutites. This member also forms the highest and steepest cliff of the western escarpment of the Sacramento Mountains, and probably such that has a reddish color and a somewhat higher clastic component due to having a source area with Abo Formation. After the culmination of aggradation in the middle(?) Holocene, this deposit experienced net erosion until the present. Below, we have differentiated this unit into two subunits marked by different surface characteristics and geomorphic position; these are called Qf2a and Qf2b. Note that these denote the same deposit and overlain by different surfaces. Unit is generally 2-5 m thick and weakly consolidated, but locally exceeds 8 m in thickness (such as at the mouth of Marble Canyon.

Mlv **Lake Valley Formation (Mississippian) –** The lower mixed (Andrecito Member) consists of calcareous shale, mudstones to wackestones, thin-bedded argillaceous limestone, some well sorted, crinoidal grainstones, and minor quartzose siltstone. The middle part of the Lake Valley Formation is characterized by a succession of crinoid-bearing bioherm mounds. The bioherm mound interval includes the Alamogordo, Nunn, and Sierrita Members of Pray (1961) and Bowsher, 1949). The lower part of this interval consists of a ledge of medium-gray, cherty calcareous siltstones and shales developed in massive beds 8-300 cm in thickness (Alamogordo Member). Above these ledges are interbedded, friable or poorly cemented, crinoidal grainstones, and minor amounts of crinoidal wackestones (Nunn Member). Crinoidal grainstones and wackestones with large nodules of light colored chert are abundant in the upper part of this formation and characterize the Arcente Member. Here, the crinoidal grainstones and packstones are normally well-cemented. Lateral changes in thickness and facies as well as poor exposures posed a challenge in mapping the members of this formation. The Lake Valley Formation was therefore mapped as a single unit unless the upper, post-bioherm strata (Arcente and Dona Ana members) were clearly present. Outcrops of this unit from a maximum of nearly 80 m (250 ft) to a more prevalent 50 m (160 ft) in areas where it is near mounds, and becomes considerably thinner(15-20 m, 48-65 ft) away from the bioherm mounds.

Mlvd **Dona Ana Member of Lake Valley Formation (Mississippian) –** The upper 45 meters (150 feet) of the Lake Valley Formation above the Arcente Member is the Dona Ana Member. It consists of cherty, light gray, irregularly bedded crinoidal grainstones to packstones. This unit also thins and pinches out near bioherm mounds, and north of Marble Canyon was removed by pre-Pennsylvanian erosion or is indistinguishable from the underlying Lake Valley Formation strata. Thus It is not exposed across much of the map area. ~0-18 m thick (0-55 ft).

Mlva **Arcente Member of Lake Valley Formation (Mississippian) –** Dark calcareous shale and thin- to medium-bedded (<30 cm-thick), medium-gray, argillaceous limestone. The Arcente Member seems to level out some of the topographic relief caused by mound development in underlying strata. Approaching the mounds, this member shows abrupt thinning and locally pinches out. This unit is only recognizable on the south side of Marble canyon, and it thins out towards the north where it was probably removed by pre-Pennsylvanian erosion. ~0-25 m in thickness (0-80 ft).

Pp **Pennsylvanian and Permian undifferentiated –** Dark gray to brownish gray silty dolomite, dolomitic siltstones, and very fine-grained quartz sandstones. Light gray calcareous shales are common towards the base and black, non-calcareous shales are common at the top of the section. Pebbly sandstones occur locally in basal beds. Gray calcareous shale and nodular, medium gray limestone are a locally prevalent feature of this unit in the middle part of this unit. Limestone beds increase towards the upper part of the unit and is interbedded with layers of black shales. Locally, the black shales contain pyrite. Some beds present a distinctive reddish and yellowish color of alteration. Mostly medium bedded, but very massive to instantaneously resistant to erosion. It is poorly exposed and commonly covered by colluvium. 15-30 meters (50-100 feet) thick (mostly ~ 30 m-thick). The upper contact is a disconformity.

Pfh **Fusselman Formation (Silurian) –** Dark-colored, cherty dolomite and very minor siliciclastics. Fresh samples very in color from light gray to dark gray or are olive to brownish gray. Fine to medium crystalline. Bedding is obscure. Chert is abundant and it is present as irregular nodules. Locally medium- to thick-bedded (>100 cm-thick), sparingly to conglomeratic units are locally present. Deposit is a dissolution breccia at the basal contact (Pray, 1961). These units contain abundant dissolution breccias, dolomite, quartz and chert particles that vary in size from sand to pebbles. The Fusselman formation is very resistant to erosion which has allowed for the formation of steep cliffs, ledges, and dip slopes that are commonly covered by angular rock fragments from the mountain front. Exposures are of the escarpment. Both, the lower and upper contacts are sharp disconformities. The nature of the contacts is reflected in the variation of thickness of the unit, ~372-30 m thick (US-100 ft). Description taken in part from Romero and Koning (2006).

Pfm **Montoya formation (Ordovician) –** Almost entirely crystalline dolomite and cherty dolomite. About a meter of thick and massive beds of quartz sandstone and sandy dolomite marks the base of the section. Thick beds of chert (30-100 cm) mark the upper part of the unit. The dolomite ranges in color from medium dark gray to light olive gray. Formation is 57 to 69 m thick (190-225 ft). Description slightly modified from Romero and Koning (2006).

Pfs **Sly Gap Formation (Devonian) –** Dark gray to brownish gray silty dolomite, dolomitic siltstone, and very fine-grained quartz sandstones. Light gray calcareous shales are common towards the base and black, non-calcareous shales are common at the top of the section. Pebbly sandstones occur locally in basal beds. Gray calcareous shale and nodular, medium gray limestone are a locally prevalent feature of this unit in the middle part of this unit. Limestone beds increase towards the upper part of the unit and is interbedded with layers of black shales. Locally, the black shales contain pyrite. Some beds present a distinctive reddish and yellowish color of alteration. Mostly medium bedded, but very massive to instantaneously resistant to erosion. It is poorly exposed and commonly covered by colluvium. 15-30 meters (50-100 feet) thick (mostly ~ 30 m-thick). The upper contact is a disconformity.

Pfu **Upper Fusselman Formation –** Dark-colored, cherty dolomite and very minor siliciclastics. Fresh samples very in color from light gray to dark gray or are olive to brownish gray. Fine to medium crystalline. Bedding is obscure. Chert is abundant and it is present as irregular nodules. Locally medium- to thick-bedded (>100 cm-thick), sparingly to conglomeratic units are locally present. Deposit is a dissolution breccia at the basal contact (Pray, 1961). These units contain abundant dissolution breccias, dolomite, quartz and chert particles that vary in size from sand to pebbles. The Fusselman formation is very resistant to erosion which has allowed for the formation of steep cliffs, ledges, and dip slopes that are commonly covered by angular rock fragments from the mountain front. Exposures are of the escarpment. Both, the lower and upper contacts are sharp disconformities. The nature of the contacts is reflected in the variation of thickness of the unit, ~372-30 m thick (US-100 ft). Description taken in part from Romero and Koning (2006).

Pp **Pennsylvanian undifferentiated –** Dark gray to brownish gray silty dolomite, dolomitic siltstone, and very fine-grained quartz sandstones. Light gray calcareous shales are common towards the base and black, non-calcareous shales are common at the top of the section. Pebbly sandstones occur locally in basal beds. Gray calcareous shale and nodular, medium gray limestone are a locally prevalent feature of this unit in the middle part of this unit. Limestone beds increase towards the upper part of the unit and is interbedded with layers of black shales. Locally, the black shales contain pyrite. Some beds present a distinctive reddish and yellowish color of alteration. Mostly medium bedded, but very massive to instantaneously resistant to erosion. It is poorly exposed and commonly covered by colluvium. 15-30 meters (50-100 feet) thick (mostly ~ 30 m-thick). The upper contact is a disconformity.

Pc **Precambrian –** Undifferentiated igneous and metamorphic rocks.

106° 0'
105° 52'30"
33° 0'
33° 52'30"
green line