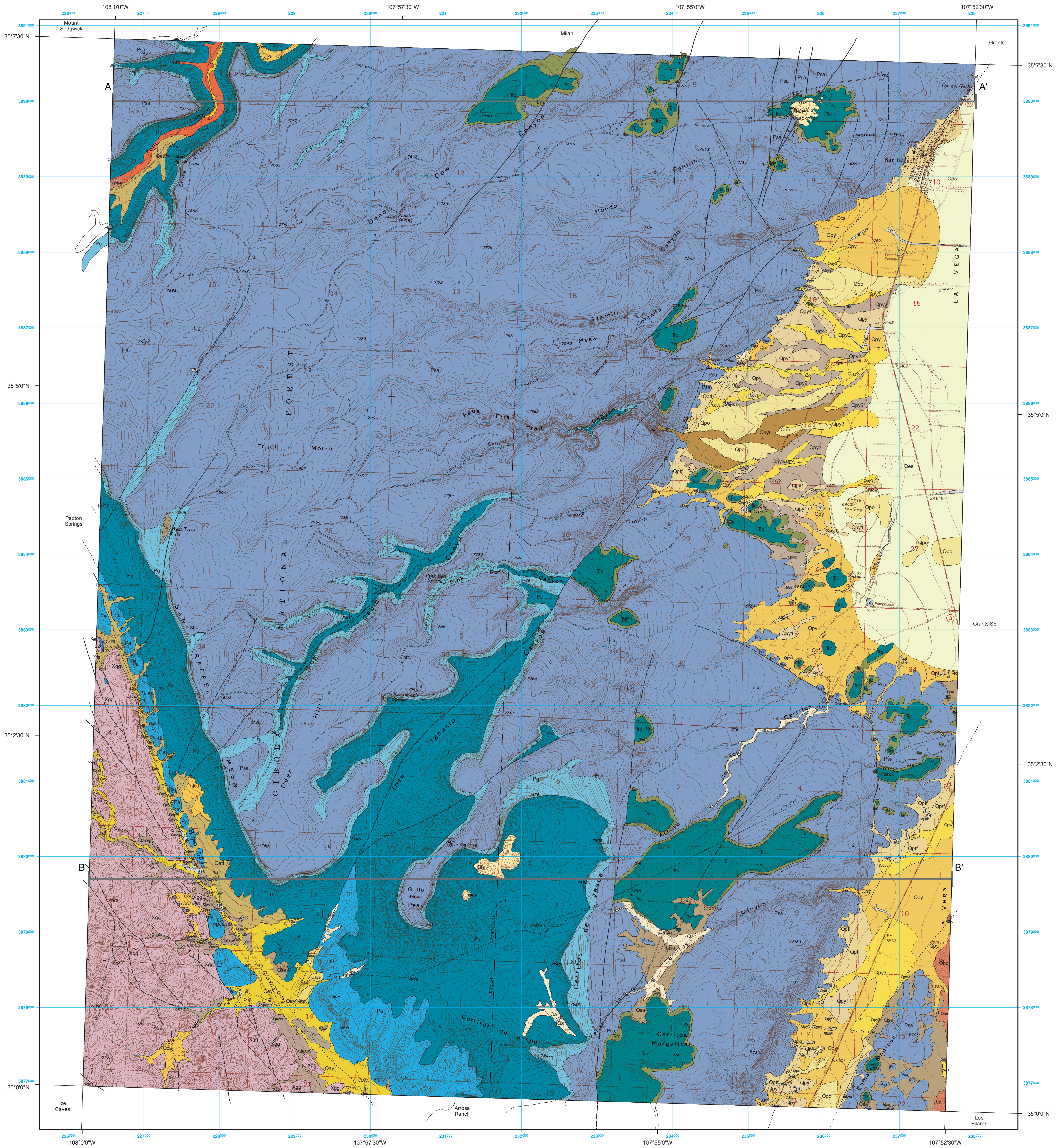
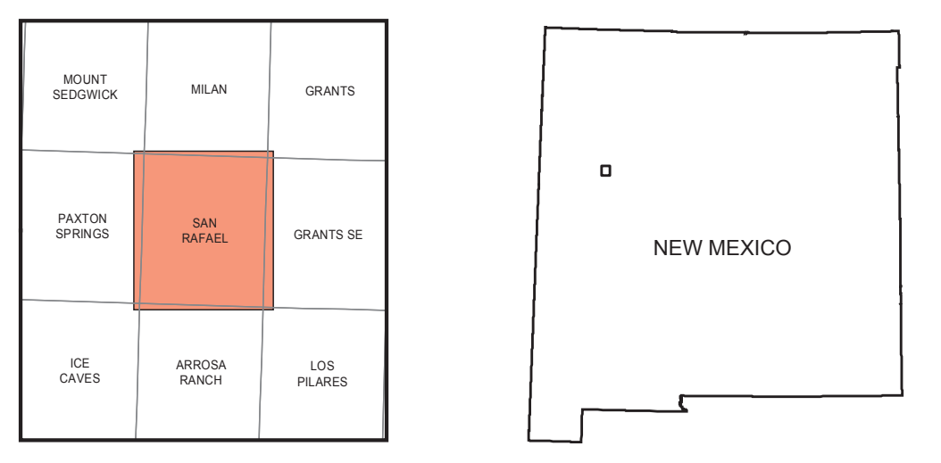
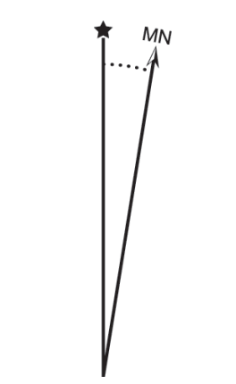


Base map from U.S. Geological Survey 1957, from photographs taken 1955, field checked in 1957.
1927 North American datum, New Mexico coordinate system, central zone (Transverse Mercator). Reprojected to UTM projection -- zone 13.
1000-meter Universal Transverse Mercator grid, zone 13, shown in blue.



QUADRANGLE LOCATION



Magnetic Declination
July, 2011
9º 37' 10" East
At Map Center

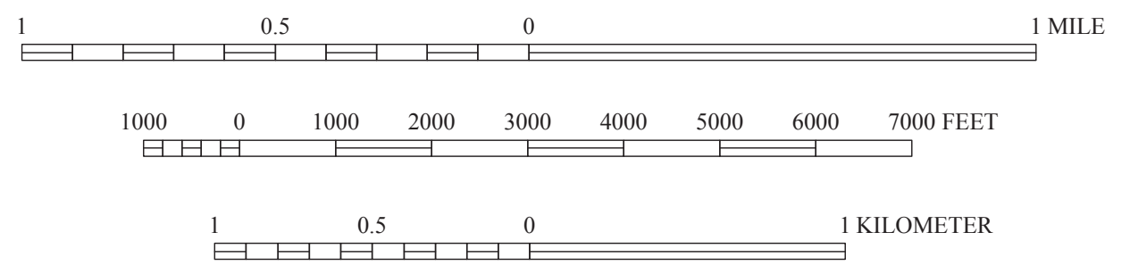
New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico
87801-4796

[575] 835-5490

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

http://geoinfo.nmt.edu

1:24,000



CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 232

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

Geologic map of the San Rafael quadrangle, Cibola County, New Mexico

August, 2012

by
J. Michael Timmons, and Colin T. Cikoski

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

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

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.

EXPLANATION OF SYMBOLS

A ├─┤ A' Cross Section Line

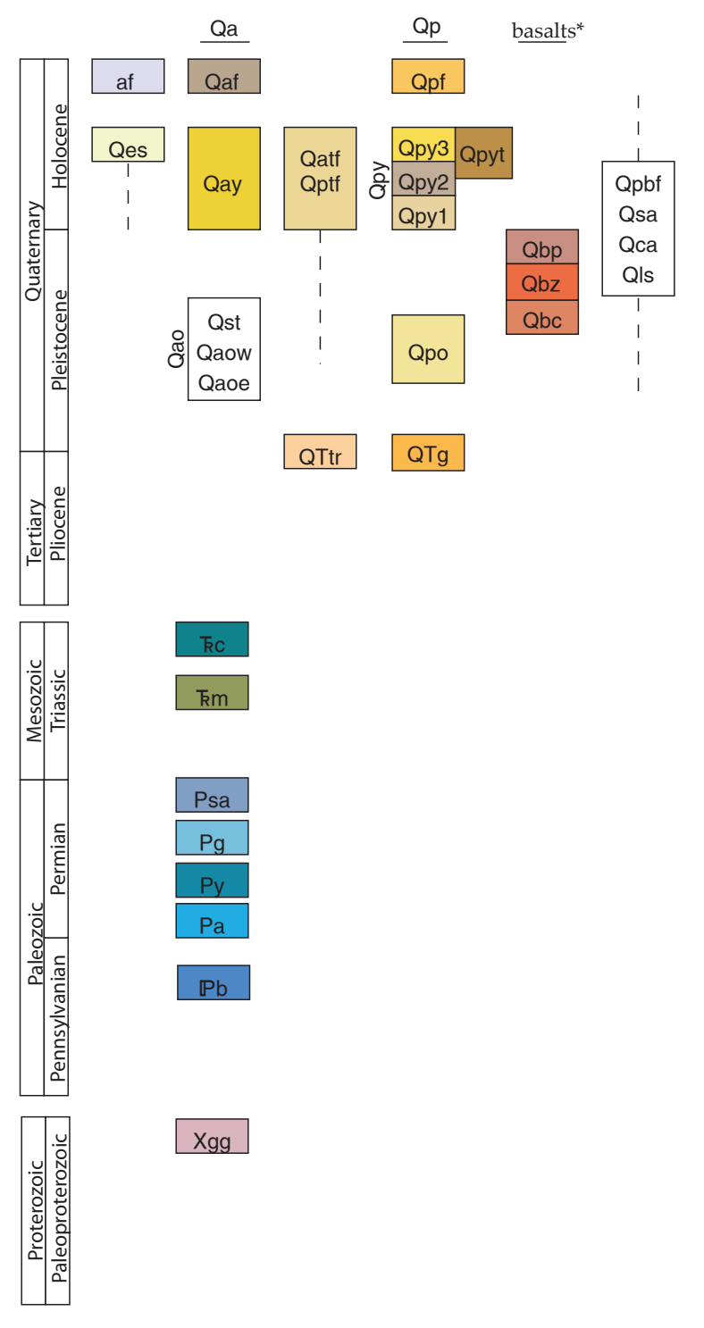
——— — —?— Contact line is solid where the location is certain, dashed where approximate, dotted where concealed, and querried where uncertain.

——— —•— ··?·· Normal fault with bar-ball placed on the downthrown block. Line is solid where the location is certain, dashed where approximate and dotted where concealed, and querried where uncertain.

⊕ Horizontal bedding

├ Inclined bedding with dip

CORRELATION DIAGRAM



*Basalt-alluvium correlations based on imprecise radiometric ages and age estimates from soil development, not field relationships, and hence are not certain.

MAP UNIT DESCRIPTIONS

Quaternary units

(Note – Colors are after Munsell Color (2009) and carbonate horizon stages are after Gile et al. (1965) and Machette (1985).)

Alluvium of the Zuni Mountains interior

Qa Alluvium of the Zuni Mountain interior, undivided – Sand, silt, and lesser gravel associated with streams within the Zuni Mountains. Typically subdivided based on age and geomorphic characteristics. Undivided unit used for small streams with multiple subunits present.

Qaf Active gully-mouth fans – Sand, silt, and rare gravel of historic gully-mouth fans. Fans emanate from present-day arroyos. No soil development. No exposure, but likely up to 1 m thick.

Qay Younger interior alluvium – Sand, silt, and gravel of and graded to the current Bonita Canyon floor. West of Bonita Canyon, consists of dark-brownish gray silty-sand matrix-rich fine granite pebbles, with rare fine-grained mafics and quartzite; colors of 7.5 YR 3/2 to 4/3 were measured. On east side, consists of yellowish-red weakly-bedded silty sand, with pebbles and cobbles in paleochannels; colors of 5 YR 4/6 to 5/6 were measured. Along Bonita Canyon axis, consists of brown-silty sands, with sparse-fine pebbles; colors of 5 YR to 7.5 YR 4/4 were measured. 0.5 to 1.5 m thick.

Qao Older interior alluvium – Alluvium grading to levels above the current Bonita Canyon floor. Divided into western/axial and eastern map units, due to significant variability in tread heights and characteristics.

Qaow Western and axial older alluvium – Reddish-brown silty sands with rare to abundant pebbles underlying terrace treads 2-4 m above local streams along and to the west of Bonita Canyon. Axial sediments mainly of massive silty sands with up to Stage I carbonate horizon morphology, with rare thin lenses of pebbles; colors of 5 YR 4/3 to 5/4 were measured. Western sediments mainly granite pebbles with abundant silty sand matrix and no visible carbonate accumulation; a more yellowish color, 5 YR 4/6, was measured. Maximum exposed thickness of 1.1 m, likely at least 4 m thick.

Qaoe Eastern older alluvium – Dark to pale reddish brown sands, muds, and gravels underlying terrace treads 5-7 m above local streams tributary to Bonita Canyon from the east. Dominantly of massive clayey silty sands, with paleochannels of pebbles to local boulders of siltstone, quartz sandstone, and rare limestone. Contains at least four buried soils defined by darkened A horizons and/or up to Stage II+ carbonate horizons. Active soil has a Stage III carbonate horizon. 5 YR 4/4 to 6/6 colors were measured in unaltered material. Maximum exposed thickness of 7 m.

Qst Strath terraces – Pebbles to boulders of strath terraces overlying bedrock in the Zuni Mountains. Gravels are very-poorly-sorted and angular, and locally matrix-supported in debris flow bars. Gravel compositions are mainly limestone, with lesser quartz sandstone and red siltstone. No evidence of soil development, but tread projects to that of Qaoe. 0-2 m thick.

Qatf Tributary fan alluvium of the interior – Sand, silt, and gravels of small, overlapping alluvial fans tributary to the larger drainages. Used for small fans with no appreciable features separating older and younger alluvium. Mainly younger alluvium at the surface, and includes local colluvium. At least 3 m thick.

Alluvium of the Zuni Mountains piedmont

Qp Alluvium of the Zuni Mountain piedmont – Sand, silt, and gravel of fans and terraces extending eastward from the Zuni Mountains. Typically subdivided based on sedimentary and geomorphic characteristics.

Qpf Active gully-mouth fans – Sand, silt, and rare gravel of historic gully-mouth fans. Fans emanate from present-day arroyos. No soil development. No exposure, but likely up to 1 m thick.

Qpy3 Youngest piedmont alluvium – Brown silty fine to coarse sands with little soil development. Includes rare matrix-supported fine pebbles. Typically massive (bioturbated). Contains sparse very fine carbonate nodules, exhibiting up to Stage I carbonate horizon development. Colors of 5 YR 6/4 to 7.5 YR 5/3 were measured. Maximum exposed thickness of 65 cm.

Qpy2 Medial young piedmont alluvium – Dark-grayish-brown fine-sandy muds with little soil development. Includes rare, thin lenses of very-fine pebbles. Massive (bioturbated). Contains common very-fine carbonate nodules and thin veinlets, commonly exhibiting Stage I and locally Stage II carbonate horizon morphology. Colors of 7.5 YR to 10 YR 4/2 were measured. Maximum exposed thickness of 1.1 m.

Qpy1 Older young piedmont alluvium – Brown silty fine to coarse sands with little to moderate soil development. Includes sparse matrix-supported pebbles. Typically massive (bioturbated). Contains common very-fine carbonate nodules and veinlets, with common Stage I and local Stage II carbonate horizon morphology. Colors of 5 YR 4/3 and 7.5 YR 4/3 were measured. Maximum exposed thickness of 1 m, likely as much as 2 m thick where found at the surface.

Qpyt Young piedmont alluvium of the Trail Canyon fan – Boulder- to cobble-rich alluvium emanating from Trail Canyon. Gravels are mainly of limestone with lesser quartz sandstone, decreasing in average size downstream. Matrix material is a brown (7.5 YR 5/4) silty fine to coarse sand. Likely as much as 2 m thick.

Qpy Younger piedmont alluvium, undivided – Silty sands and sandy silts with sparse gravels. Used where the younger alluvium subdivisions are not clear. Consists mainly of Qpy2 and Qpy3. Up to 1 m or greater thick.

Qpo Older piedmont alluvium – Pale- to medium-reddish-brown pebbles to boulders and silty sands with strong soil development. Very-poorly-sorted, subangular to subrounded gravels dominantly of limestone, with lesser quartz sandstone and rare pebble conglomerate, as massive-tabular bouldery beds by the mountain front, and as pebbles and cobbles in rare channels away from the front. Silty sands are massive (bioturbated), with uncommon to sparse matrix-supported pebbles. Stage III carbonate morphology is common in outcrop. Colors of 5 YR 5/4 to 8.5/2 were measured, with color strongly controlled by abundance of carbonate. Exposed thicknesses from 0 to 5 m, likely as much as 10 m or more thick.

Qptf Tributary fan alluvium of the piedmont – Sand, silt, and gravels of small, overlapping alluvial fans tributary to the larger drainages. Used for small fans with no appreciable features separating older and younger alluvium. Mainly younger alluvium at the surface, and includes local colluvium. At least 3 m thick.

QTg High-level piedmont gravels – Rounded boulders of limestone overlying Triassic rocks on hill tops. These boulders are interpreted to be the remains of a Pliocene or early Pleistocene terrace or fan deposit that has since been almost entirely removed by erosion.

Cover units

af Artificial fill – Consolidated sand, silt, clay, and gravel of artificial earthen structures. Dominantly earthen dams. Up to 6 m thick.

Qes Eolian sand sheet, undivided – Sands and silts accumulating on the eastern piedmont of the Zuni Mountains. Mapped where obscures underlying alluvial units and bedrock geology. No exposure, but likely as much as 2 m thick.

Qsa Slopewash alluvium – Sand and silt with rare pebbles, accumulating along broad shallow channels. Only mapped where expected to be thick or obscuring underlying geology. 0-1 m or more thick.

Qca Colluvium and alluvium, undivided – Sand, silt, and gravel accumulating below steep slopes. Only mapped where thick or concealing underlying geologic relationships. 0-2 m or more thick.

Qls Landslides – Large blocks and bouldery gravels associated with mass wasting. Likely as much as 30 m thick.

Basalt flows

Qbp Paxton Springs flow – Dark-gray to black blocky flow mainly uncovered by younger fines. Sparse (under 1%) fine (under 1 mm across) anhedral phenocrysts of green olivine and white plagioclase. Common vesicles and amygdules. 0-4 m thick.

Qbz Zuni flow – Dark-gray to black basalt flow largely concealed by younger eolian fines in Zuni Canyon. Sparse (under 1%) fine (under 1 mm across) green-olivine phenocrysts. Typically rare vesicles and amygdules. Unexposed base. Up to perhaps 5 m thick.

Qbc El Calderon flow – Dark-gray to black basalt flow largely concealed beneath younger eolian fines along the east margin of the quadrangle. Sparse, very-fine phenocrysts of olivine. Exact age uncertain, but constrained to 50-130 ka. Base unexposed.

Travertine

QTtr High-level travertine – Light- to medium-gray, fine-grained limestone capping Cerrito Colorado. Thinly (1 to 10 cm thick) bedded with planar to wavy beds. Very-fine granular texture in matrix, with common white spots up to 2 mm across. As much as 3 m thick.

Triassic Strata

TRc Chinle Group Undivided – Variegated mudstones and white to pale-tan conglomeratic sandstones likely representing attenuated units from bottom to top; the Shinarump Formation, Bluewater Creek Formation through the Sonsela Member of the Petrified Forest Formation (after Heckert and Lucas 2003). The lower 15-18 m includes cross-bedded pebbly sandstones, with pebbles of dark-gray to brown chert and red to reddish-brown mudstones. The basal pebbly sandstone to pebble conglomerate typically forms a prominent ledge overlying soft Moenkopi strata that is visible on aerial imagery and slightly grayer than the underlying redder Moenkopi mudstones. Pebble content within this formation is quite variable and laterally discontinuous. The upper portion of this mapped unit is up to 20 m of pale brown to light-gray cross-bedded quartzose sandstones and limestone pebble conglomerates representing the Sonsela Member of the Petrified Forest Formation. Sandstones are thin- to medium- bedded, with common cross-bedding in both sandstones and limestone pebble conglomerates, though more vague in the later. Both occur as tabular beds and channels. Both have carbonate cement. Labeled as TRu in cross section.

TRm Moenkopi Formation – Poorly-exposed slope-forming unit that is red to reddish-brown mudstone and siltstone. Basal mudstones and silty mudstones are generally less than 5 meters thick, weak-red to dark-red, and weather into low, unvegetated slopes. Overlying silty sandstones are pale-red in color, thin- to very-thin-bedded, and calcareous. They are moderately-sorted, composed of 80% quartz and 20% chert, feldspar, and lithic fragments in medium- to fine-grained, sub-angular to sub-rounded groundmass. Labeled as TRu in cross section.

Paleozoic Strata

Psa San Andres Formation – Light- to dark-gray limestone and dolomite. Limestones and dolomites range from thin- to thick-bedded. Interbedded tan, pinkish-tan to very- light orange sandstones represent discrete tongues of the underlying Glorieta Sandstone. Sandstones are composed of medium- to fine-grained, rounded to subrounded quartz grains, are non-calcareous, and usually have distinct tabular cross-beds. A prominent sandstone tongue 7 – 8 meters above the Glorieta sandstone, visible in the walls of Zuni Canyon, is locally mappable but pinches out repeatedly. Additional variably discontinuous sandstone lenses are present higher in the section and can be seen in numerous incised valleys throughout the quadrangle. The top of the formation is a regional unconformity, paleokarst development at this unconformity has been reported (Colpitts, 1989).

Pg Glorieta Formation – White- to pale-orange to grayish-pink quartz sandstone. The sandstone is dominantly medium- to large-bedded quartz arenite, with well-rounded to sub-rounded grains, and well-sorted. The sandstone is at least 30 m thick and as much as 60 m thick as reported by Colpitts (1989). The formation intertongues with the overlying San Andres Formation and is gradational with the underlying Yeso Formation. The top of the formation is marked by the first occurance of carbonate beds of the San Andres Formation.

Py Yeso Formation – Reddish-orange to light-brown quartz sandstone with interbedded yellowish-gray to grayish-brown, medium- to thin-bedded carbonate beds. Associated with the carbonate beds are medium-thick beds of gypsum. Sandstone deposits are fine- to very-fine grained and vary from relatively-angular to sub-angular grains to moderately- to well-rounded grains. Sandstones consist of thin- to thick-planar tabular beds. The entire section is exposed at Gallo Peak and is subdivided into 3 members including from bottom to top, the Meseta Blanca, Torres, and Joyita Members. Colpitts (1989) reports a total thickness for the formation at Gallo Peak of about 380 meters.

Pa Abo Formation – A mixed siliciclastic formation composed of reddish-brown mudstones, reddish-brown siltstones, grayish-red sandstones, and pale- to moderate-redish brown conglomeratic beds. Sandstone beds are moderately sorted with angular to sub-rounded grains and grain size ranges from course to very fine grained. Sandstone beds are moderately- to thick-bedded. Conglomeratic beds are composed of pebble to granule clasts in a medium- to very-fine-grained sandstone. Conglomeratic beds are discontinuous and form channels at the base of some sandstone beds (Colpitts, 1989).

lPb Bursum Formation – Originally lumped with the basal Abo Formation (Colpitts, 1989), this formation is now assigned to the Oso Ridge Member of the Bursum Formation (Krainer et al, 2003) and consists of light-pink to redish-brown lithic arenite conglomerates, and light-gray limestone. Conglomeratic beds are very-immature with very-angular clasts, poorly-sorted, and almost exclusively derived from the underlying Proterozoic metamorphic rocks. Conglomerate beds are laterally discontinuous and tend to infill paleotopography on the metamorphic rocks. Carbonate beds tend to be thin-bedded carbonate mudstone and wackestone to medium-bedded fossiliferous wackestones. Fossil assemblages indicates a Virgilian age for these beds (Krainer et al., 2003).

Proterozoic Rocks

Xgg Granitic Gneiss – Foliated calc-alkaline granitoids that make up most of the exposed metamorphic rocks in the Zuni Mountains. The granitoids are dominately quartz monzanites (Strickland et al., 2003) and yield an age of 1655 Ma (Bowring and Condie, 1982). Deformation within these rocks are characterized by a penetrative foliation and an associated stretching lineation (Strickland et al., 2003). Within the map area foliations strike NW and dip steeply to the SW.

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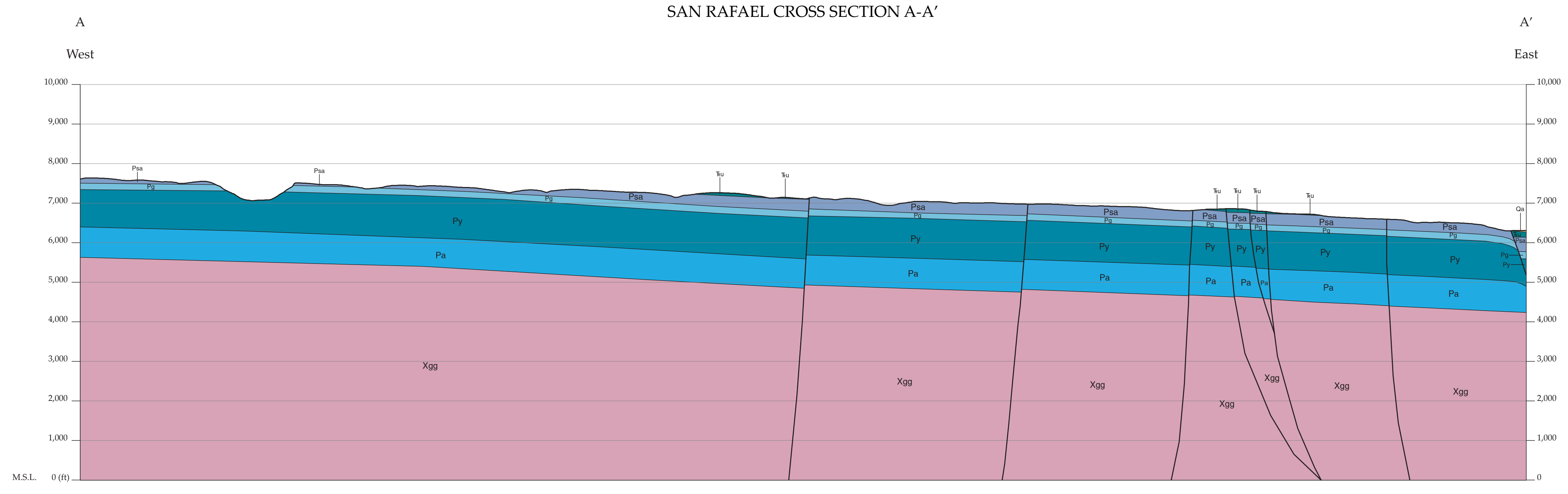
SAN RAFAEL CROSS SECTION A-A'



SAN RAFAEL CROSS SECTION B-B'