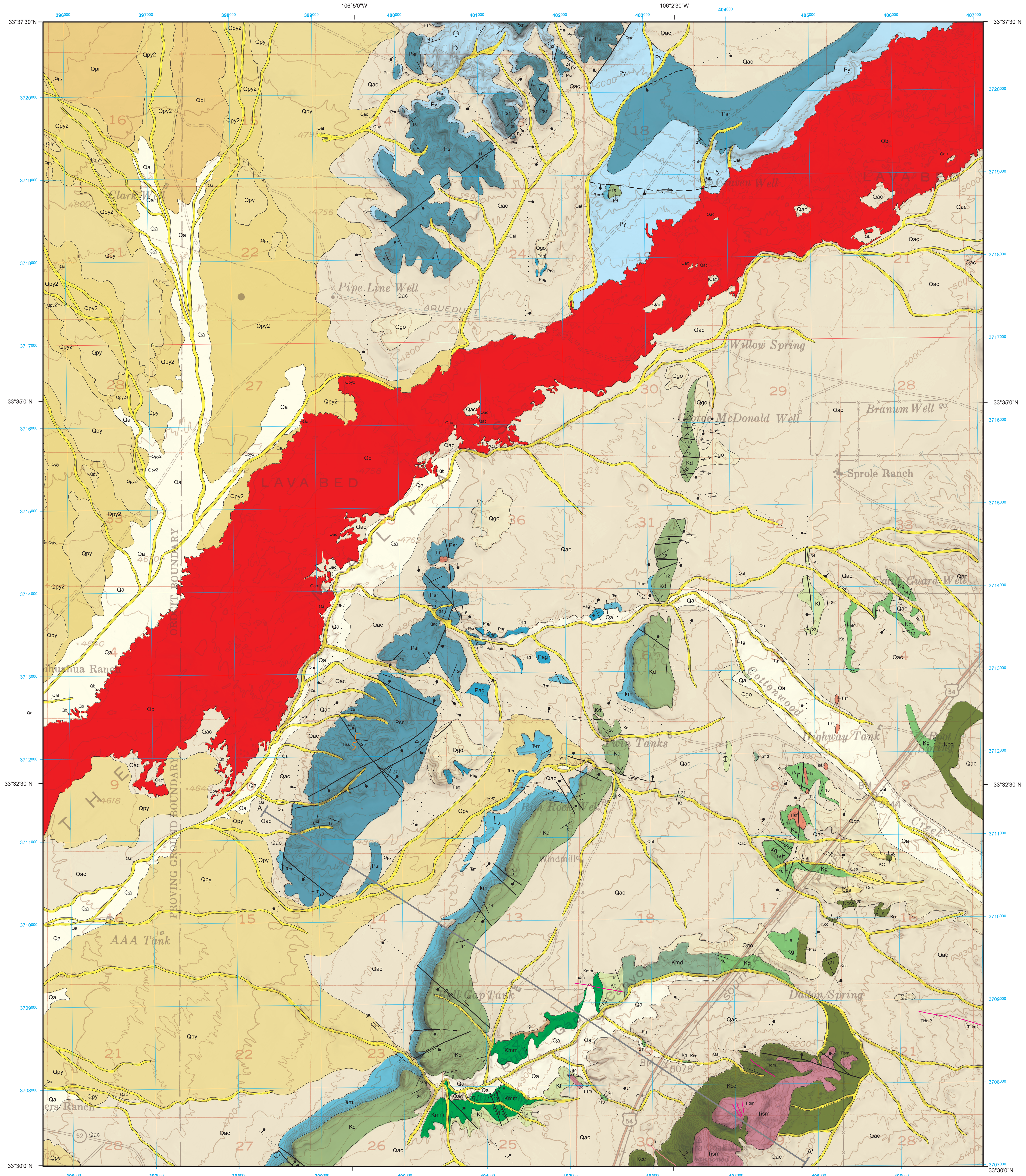
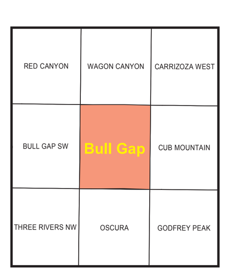
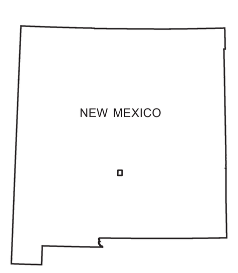


Base map from U.S. Geological Survey 1966, from photographs taken 1958, field checked in 1964, edited in 1966.
Polyconic porjection, 1927 North American datum,
Projected to 1927 North American datum, UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in red





QUADRANGLE LOCATION

Magnetic Declination
May, 2002
13° 0' East
At Map Center

1:24,000

1 MILE — 1000 — 7000 FEET — 1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 210

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

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

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

Geologic map of the Bull Gap quadrangle, Lincoln County, New Mexico.

June 2010

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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map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation.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.

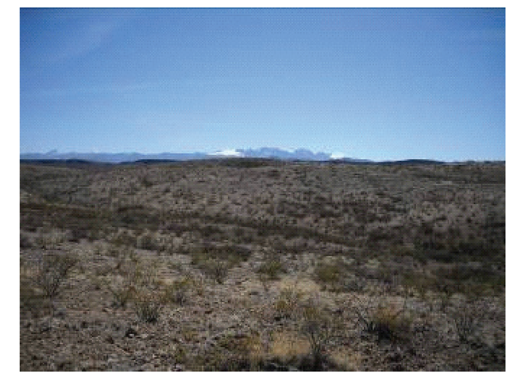
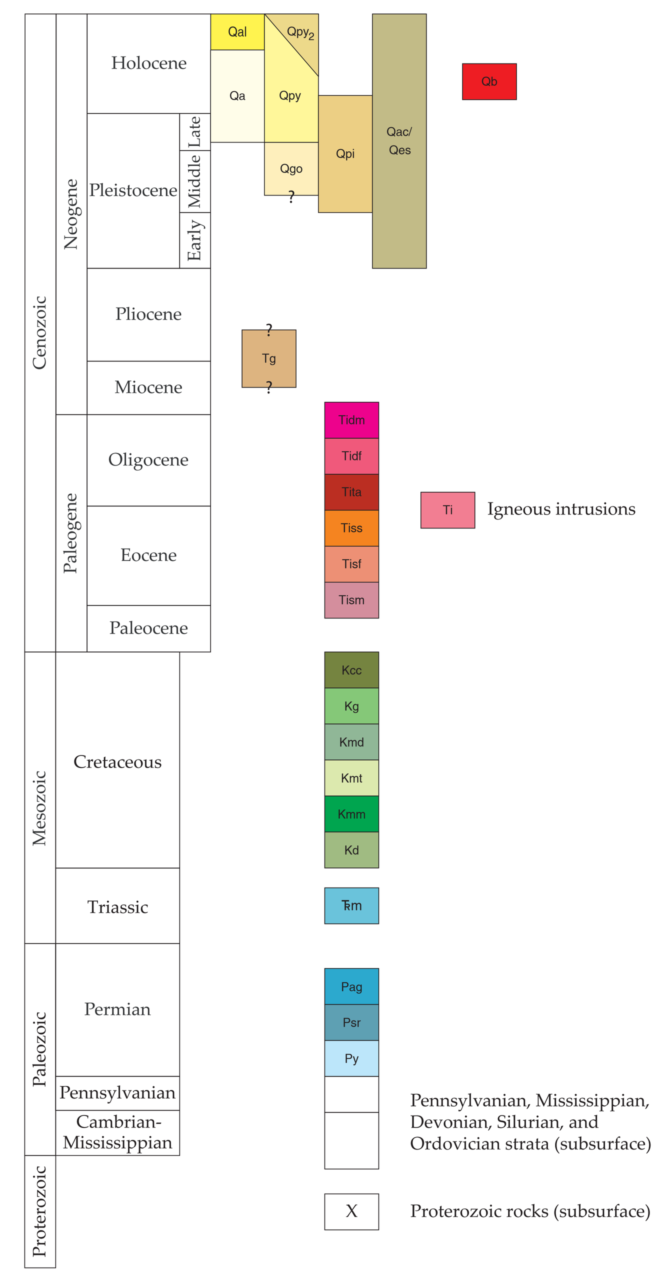


FIGURE 1–Sinkhole in Permian San Andres Formation. Sierra Blanca is in the background.



MAP SYMBOLS

Contact–Solid where exposed or known; dashed where approximately located; queried where uncertain.

Normal fault–Bar and ball on downthrown side; solid where exposed or known; dashed where approximately located; dotted where concealed.

Strike-slip fault–Showing relative horizontal separation; solid where exposed or known; dashed where approximately located; dotted where concealed.

Strike and dip of inclined bedding.

Horizontal bedding.

Vertical bedding.

Geologic cross section.

FIGURE 2–Pahoehoe texture, Carrizozo lava flow.

Acknowledgements

Funding for the mapping of Bull Gap Quadrangle was provided by the State Map Program, which is jointly supported by the U.S. Geological Survey and the New Mexico Bureau of Geology and Mineral Resources. I thank Dr. J. Michael Timmons for logistical support, and Stacy Timmons and Cathie Eisen for contact information for local land owners. Land owners who graciously granted permission for work on their property include the Hooten family and Ms. Carol McDonald. Fieldwork was conducted by standard methods, except in the few cases where land could not be accessed adequately – in these instances, geologic data was obtained and extrapolated from previous geologic maps, air photography and adjacent geology.

Quaternary Deposits

Qal **Alluvium**—Modern alluvium in stream and arroyo bottoms. Contains cobbles and pebbles of Permian and Cretaceous clasts, as well as abundant material from the Sierra Blanca volcanic field.

Qes **Eolian Sheet Deposits**—Very fine-grained sand to silt deposited by wind and subsequently reworked by sheet flow across the surface. Ranges in thickness from less than 0.5 m to over 2 m and can include pebbles of local bedrock, as well as of Sierra Blanca volcanic material.

Qac **Undivided Alluvium and Colluvium**—Holocene to Middle Pleistocene (?). Silt, sand, gravel and clay in various proportions, generally unconsolidated, deposited in a variety of depositional settings. Includes relatively thin accumulations of unconsolidated alluvial, colluvial, and eolian deposits on hillslopes, drainages, and dip-slopes underlain by bedrock; interfingers with differentiated alluvium (e.g., Qp and Qa) along valley floors. Older deposits may exhibit accumulation of pedogenic gypsum and calcium carbonate. Unit also includes areas of unmapped bedrock and differentiated alluvium. Up to a few meters thick.

Qa **Alluvium of Valley Floors and Adjacent Lowlands**—Holocene to Upper Pleistocene (?). Fine-grained (silt, sand, and clay) alluvium and small channels of poorly-to moderately-sorted pebbly sand. Relief between channels and surrounding alluvium is generally less than 1 m, but locally exceeds 4 m in larger arroyo cuts. Deposits are generally structureless, very pale brown to light reddish brown, and exhibit little to no soil development. May be up to 3 m thick or more.

Qpy **Younger Piedmont Alluvium**—Holocene to Upper Pleistocene (?). Silt, sand and clay with locally abundant pebble to boulder gravel. Coarse-grained clasts (gravel and boulders) are more common in areas proximal to surrounding bedrock uplands. Over most of the map area, unit is generally structureless, pale-reddish brown, and fine grained (silt, sand, and clay), exhibits little soil development, and contains thin, discontinuous beds of clast-supported, angular to subrounded gravels. In the northwestern part of the map area, unit is divided into older piedmont alluvium (Qpy), which is commonly capped with a moderately developed desert pavement, and younger, inset, deposits (Qpy2) that display little to no pavement development. Up to several meters thick.

Qpy2 **Younger Piedmont Alluvium**—Northwestern part of map area. Holocene. Silt, sand, and clay with local accumulations (lenses) of pebbly sand. Generally structureless, with little evidence of soil development. Inset below older piedmont alluvium (Qpy and Qpi) or buries older deposits in distal piedmont areas. Up to a few meters thick.

Qpi **Intermediate Piedmont Alluvium**—Lower Holocene (?) to Middle (?) Pleistocene. Pebbly to cobbly sand, silt, and clay, with abundant boulders of Paleozoic bedrock in northwestern map area. Upper surfaces of unit are commonly gravely lags (desert pavements), and range up to several meters above active drainages. Deposits are weakly dissected to extensively stripped, depending on locality. Unit commonly exhibits pedogenic accumulation of gypsum a few decimeters below the surface. In areas where the deposit has been stripped, pedogenic gypsum horizons have been exposed and weathered to form a hard gypsum crust at the surface. Up to 5 m thick or more.

Qgo **Old Gravel Deposits**—Long, low mounds with flat tops that sit on the modern land surface and consist primarily of cobbles to boulders of Sierra Blanca volcanic material. Presumed to be the erosional remnants of material shed off the western escarpment of the northern Sacramento Mountains. Mounds have no internal stratification and no evidence of older bedrock. Up to 2 m thick.

Quaternary Extrusives

Qb **Carrizozo Basalt Flow**—Alkalic to transitional olivine basalt. Black to dark-gray, aphanitic, vesicular basalt with rarely-visible phenocrysts of olivine. Texture is predominantly pahoehoe, but locally a'a texture prevails. Dated at ~5000 years old (Dunbar, 1999).

Tertiary Deposits

Tg **Gravel**—Well-cemented cobble to boulder conglomerate. Clasts are Sierra Blanca volcanic fragments, as well as occasional siltstone and sandstone fragments, all of which are subrounded to well rounded. Matrix is a very coarse sandstone that is subrounded to subangular, poorly sorted with high proportion of silt and clay and more than 80% lithics. Unit is locally incised into underlying Cretaceous strata and usually buried beneath modern deposits. Basal contact is locally an angular unconformity with Cretaceous strata.

Tertiary Intrusives

Tidm **Intermediate Dikes**—Vertically-oriented intrusions that are andesitic in composition with equigranular matrix and phenocrysts of pyroxene and occasionally feldspar. Phenocrysts are 2-5% of the rock and range in length from 1-2 mm to 1 cm. In one dike, pyroxenes are up to 6 cm in length and are 10% of the rock.

Tidf **Fine Grained Intermediate Dikes**—Green to dark-green syenogabbros with pyroxene phenocrysts usually less than 1 cm in length and comprising up to 2% of the rock. Outcrop exposures tend to be short in length, never exceeding 0.75 km and usually much shorter. Also usually pervasively altered.

Tita **Trachyandesite Dike**—Comprised of zoned feldspar in a matrix of feldspar and pyroxene. Phenocrysts are plagioclase feldspar and are up to 3 mm across.

Tiss **Syenite Sill**—Reddish-brown sill with plagioclase and potassium feldspar. No quartz was observed. Phaneritic texture, 2-3 m in thickness.

Tisf **Fine Grained Intermediate Sills**—Pinkish-brown or pale-green aphanitic with very rare phenocrysts of pyroxene or feldspar. Occasionally platy in appearance and less than 1 m in thickness.

Tism **Megacrystic Sills**—Andesitic in composition with equigranular matrix and phenocrysts of pyroxene. Phenocrysts are 2-5% of the rock and range in length from 1-2 mm to 1 cm.

Cretaceous Strata

Kcc **Crevasse Canyon Formation**—Fine-to medium-grained, well-rounded, well-sorted with up to 20% lithic fragments that include chert grains. These sandstones contain relatively abundant clay matrix and thus are generally classified as lithic wackes. The dominant sedimentary structures are trough crossbeds, though planar tabular bedding and massive beds are also present. Color of the sandstone varies from brown to pale-green to yellow. Muscovite mica is a common component of the shales, which are yellow-gray and contain siderite nodules and can be carbonaceous.

Kg **Gallup Sandstone**—Yellow quartz arenite/wacke that is relatively poorly cemented. The sandstone is fine-to medium-grained, subrounded, moderately-well sorted, though some beds are well-sorted, well-rounded quartz arenites. Trough crossbedding is the dominant sedimentary structure and fossils found in this unit include "razor oysters" and the bivalve Cardium sp. In the lower third of the unit, medium-to thick-bedded sandstones are interbedded with thin shale intervals that occasionally include large, orange siderite concretions.

Kmd **D Cross Tongue, Mancos Shale**—Dark, yellowish-gray shale with common siderite concretions that are up to 0.5 m in diameter. Occasional sandstone concretions with shell fragments are also present. In the upper third of the unit, very thin laminar or massive fine-grained sandstone lenses may occur, reflecting the gradational contact between the upper Mancos and the overlying Gallup Sandstone.

Kt **Tres Hermanos Formation, Mancos Shale**—Series of interbedded poorly-cemented pale-yellow crossbedded sandstones and much more indurated dark-brown lithic arenites that contain shell debris and chert fragments. The yellow sandstones are trough crossbedded quartz-to lithic-wackes that are medium grained, moderately well-sorted and with subrounded grains. The dark brown sandstones are medium-to coarse-grained, subrounded, moderately-sorted with up to 30% chert and 70% quartz. These beds are 0.5 m in thickness and either planar-tabular bedded or massive. In places, lenses of bioturbated yellow-brown sandstone occur that often include dense lenses of oyster and bivalve fragments, as well as ammonites that range in size from 10 cm in diameter to over 0.3 m in diameter.

Kmm **Mancos Shale**—Lower Mancos shale consists of interbedded thin sandstone beds and dark-gray shale with multiple white-to gray-white bentonite beds in the lower part. Up-section, there are no sandstone beds and fewer bentonite layers. The Bridge Creek Beds include three limestone units, each of which consists of a single limestone bed that is never more than 0.5 m thick. Each limestone bed is separated from the one above by less than a meter of gray shale. The lower unit is a dark-gray (fresh), densely crystalline micrite with that is nodular and weathers dark-yellow. Locally this unit is fossiliferous, though the majority of the material is broken shell fragments. Recently, a rare specimen of Picnodonte newberryi was collected from this area. The second limestone is laminated dark-gray micrite and the third limestone is similar to the first, though does not appear to contain fossils. Above the Bridge Creek Beds is gray shale.

Kd **Dakota Formation**—Quartz arenite to quartzite that ranges in color from white to yellow to pale-purple. It is medium-grained, well-sorted and has well-rounded grains with little to no matrix. Beds are usually massive, though occasionally display trough crossbedding. The lower part of the unit is thick bedded, though bed thickness becomes more variable in the upper part where the sandstone interfingers with thin dark-gray shale layers. Locally, significant accumulations of manganese have collected on bedding planes and joint surfaces, turning large parts of the outcrop to a dark-metallic-purple color and include small accumulations of boernite (?).

Trm **Moenkopi Formation**—Purple-gray and consists of interbedded-pebble conglomerates and very-coarse to fine sandstones. Sandstones are usually coarse-to very-coarse grained, but thin beds of very-fine grained sandstone are also present. Composition varies between lithic arenite and quartz arenite with lithic fragments including chert. Dominant sedimentary structures in sandstone beds are planar crossbedding and tabular crossbedding. Rarely, high angle trough crossbedding was observed. Grains are well rounded and range from poorly sorted to well sorted. Conglomerates are primarily matrix-supported quartzite and chert pebble conglomerates that often have faint planar crossbeds. Both sandstone and conglomerate beds frequently contain red, purple or yellow mud rip-up clasts that are well rounded.

Permian Strata

Pag **Grayburg Formation, Artesia Group**—Red-orange, very-fine-to fine-grained quartz arenite/wacke with well-sorted, well-rounded grains. Heavily bioturbated such that most original sedimentary features were obliterated though laminations and ripple laminations can be observed in places. Common to abundant pale-green reduction mottles and streaks. Locally beds are bleached nearly white.

Psr **Rio Bonito Member, San Andres Formation**—Thin beds of dolomite with rare, medium beds of dark-gray micrite. No fossils are preserved. Locally the unit is heavily brecciated, probably by later karsting. Modern karst features including large sinkholes developing along the tops of the ridges that are up to 15 m in diameter. Represents only the lower third of the Rio Bonito Member, as no medium-bedded, dark-gray wacke-packstone beds were observed.

Py **Yeso Formation**—Very pale-reddish-brown to light-brown. Predominantly gypsum with minor limestone/dolomite. No sandstone or mudstone beds were observed. Gypsum is faintly laminated in places, though bedding is usually contorted. Very rarely, near-alabaster quality gypsum was observed. Limestone beds are less than 0.3 m thick, are dark-brown-gray in color and appear to be intensely bioturbated, though no fossils are preserved (suggesting partial dolomitization of these units).

FIGURE 3–Partial ammonite from Cretaceous Tres Hermanos Formation, Mancos Group.

FIGURE 4–Gypsum in the uppermost Yeso Formation. view is to the north.

FIGURE 5–Outcrop of Permian Grayburg Formation (Artesia Group). View is to the north.

FIGURE 6–Crossbedding in Cretaceous Crevasse Canyon Formation.