NMBGMR Open-file Geologic Map 127 NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A DIVISION OF NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY **Last Modified August 2012**

Quaternary Eolian and Slopewash Deposits

been reworked by slopewash processes. 0.5 to 5(?) m-thick.

Moderately to well consolidated. 10 m to greater than 40 m-thick.

The Chimney Rock trail ascends this landslide. 30-60 m thick.

elect to use the more recent name of Canjilon Creek.

including Comanche Canyon and Bull Canyon. Loose and 1-9 m-thick.

heights above modern stream grade. Loose and 1-2 m-thick.

test our preliminary correlations and age estimates.

CRETACEOUS

Quaternary Colluvium and Landslide Deposits

well consolidated. 1 to 30 m-thick.

Quaternary Alluvial Deposits

Eolian silty-clayey sand, reworked as or mixed with sheetflood deposits of sand and minor pebbly sand (Holocene to latest Pleistocene)-Light brown to light yellowish brown, silty-clayey, very fine- to fine-grained

sand, with minor medium-grained sand; generally massive; moderately to well consolidated and very weakly

cemented by calcium carbonate. Very minor, very thin to thin lenses of clast-supported, poorly sorted, sandy

pebbles (locally minor cobbles) derived from local sources. Soil developed on surface has a calcic horizon(s)

possessing a 10-40 cm-thick stage I (most common) to stage II carbonate morphology. Buried soils may be

present but are less developed than surface soil. Unit has developed on relatively higher interfluve surfaces and

over terrace deposits, and is interpreted to reflect cumulic aggradation of eolian deposits that have generally

Slopewash deposits (Holocene)–Sand, mud, and/or gravel deposited as a sheet-like deposit at the foot of strep

Colluvium and talus (Holocene to Pleistocene)-Generally massive deposits consisting of very poorly sorted

gravel, sand, and mud. Gravel ranges in size from pebbles to boulders and consists of locally derived, very

poorly sorted, angular to subangular blocks of Mesozoic strata (particularly cemented sandstone). Deposit

found on moderate to steep slopes of buttes and the flanks of Mesa Montosa and Mesa del Yeso. Moderately to

Undifferentiated landslide deposits (Pleistocene)-Landslide deposits consisting of a chaotic, non-bedded

assemblage of very poorly sorted gravel, sand, and mud. Gravel contains large, boulder-size, angular to

subangular blocks of Jurassic or Cretaceous strata (particularly cemented sandstone). Also present are meter-scale blocks of Jurassic and Cretaceous strata that have been displaced more or less together but are

mangled, contorted, and brecciated. Deposit found along the flanks of Mesa Montosa and Mesa del Yeso.

Individual landslide complex (Pleistocene)–Similar to unit Qlsu, but consisting of a single landslide complex

that is inferred to have moved, more or less, as one deformed body. Deposits occur as large lobate geomorphic

features along the flanks of Mesa Montosa and Mesa del Yeso. Moderately to well consolidated. 10 m to greater

Ghost Ranch landslide complex (Pleistocene)–Prominent landslide deposit immediately west of Ghost Ranch.

Younger alluvium (Holocene)-Sand--with subordinate pebbly sand, clay-silt, and gravel beds -- occupying

valley bottoms. Gravel consists of pebbles with minor cobbles and boulders. Color and composition of sand

and gravel depends on the source area of a particular drainage. The gravel is dominated by Mesozoic

sandstone, but locally limestone, gypsum, or quartzite is common. Loose to weakly consolidated. Lower

contact has up to 2 m of relief. Deposit is overall finer-grained than Pleistocene terrace gravel deposits (such as

Older alluvium in tributaries to Canjilon Creek and the Rio Chama (Pleistocene)-Sand and gravel, along

with very minor clay-silt beds, preserved as terrace deposits along smaller drainages draining the flanks of

Mesa Montosa and Mesa del Yeso. Gravel consists of pebbles through boulders that are dominated by Mesozoic

detritus (sandstone, limestone, and gypsum) and locally minor quartzite. Sand is very fine- to very

coarse-grained but mostly very fine- to coarse-grained. Deposits commonly fine-upwards (and silt or clay

content increases) and buried soils become more common up-section. These buried soils are typified by Bt soil

horizons (horizons marked by transported clay) overlying whiter calcic horizons possessing stage I to II+

carbonate morphologies. Along Arroyo del Yeso, the aforementioned sediment commonly overlies a sandy

gravel that is 2-6 m-thick. Weakly to well consolidated and non-cemented. 2 m to 20 m-thick. Note: We use the

name of Canjilon Creek for the major southeast-flowing stream in the western part of the quadrangle; in older

maps (including the base map for this geologic map) this drainage has been referred to as Arroyo Seco but we

Gravelly terrace deposits (upper to middle Pleistocene)-Sandy gravel dominated by quartzite clasts that

flanks the courses of modern-day streams. Gravel is composed of pebbles through boulders (mostly pebbles).

In addition to quartzite, there are subordinate clasts of Mesozoic sedimentary rocks and lesser metarhyolite

clasts. These terrace deposits are generally found along drainages in the eastern part of the quadrangle,

High-level gravelly terrace deposits (lower Pleistocene to Pliocene)-Sandy gravel dominated by quartzite

clasts that is present at relatively high topographic levels and not clearly associated with modern-day streams.

Gravel consists of pebbles through boulders. In addition to quartzite, there are subordinate clasts of Mesozoic

sedimentary rocks and ~1% granite clasts. In the southwest corner of the quadrangle, clasts are composed of

quartzite with trace-2% basalt. The straths (bases) of these terrace deposits are found at several different relative

Undifferentiated terraces in the western part of the quadrangle (Pleistocene)-Sandy gravel, reworked from

Sandy gravel deposited by Canjilon Creek (Pleistocene)-Terrace deposits of sandy gravel deposited by

Canjilon Creek during the Pleistocene. The gravel is clast-supported and consists of pebbles, subordinate

cobbles, and lesser boulders. Clasts are composed of quartzite and Mesozoic sandstone; only 1-5% limestone +

siltstone clasts and trace-2% red-orange metarhyolite clasts. Sand is fine- to very coarse-grained. The sandy

gravel is generally overlain by thin (about 1 m or less) eolian and slopewash deposits of silt and very fine-to

fine-grained sand; the underlying gravel may be mixed with this fine sediment due to bioturbation. Clast

imbrication indicates a south-to-southeast paleoflow direction, consistent with the flow direction of the modern

These terrace deposits are generally in five main levels, so we have subdivided this deposit into six map units

representing these five main levels plus a unit that includes undifferentiated terrace levels. No age control of

this unit is available on this quadrangle, but we assign tentative ages by inferring that the five main terrace

levels here correlate to the five main terraces present along the lower Rio Chama and Rio Ojo Caliente (units Qt7

through Qtc3 of Koning et al., 2004), whose ages have been constrained by Dethier and McCoy (1993), Dethier

and Reneau (1995), and Koning et al. (2011). A terrace profile between this area and the lower Rio Chama would

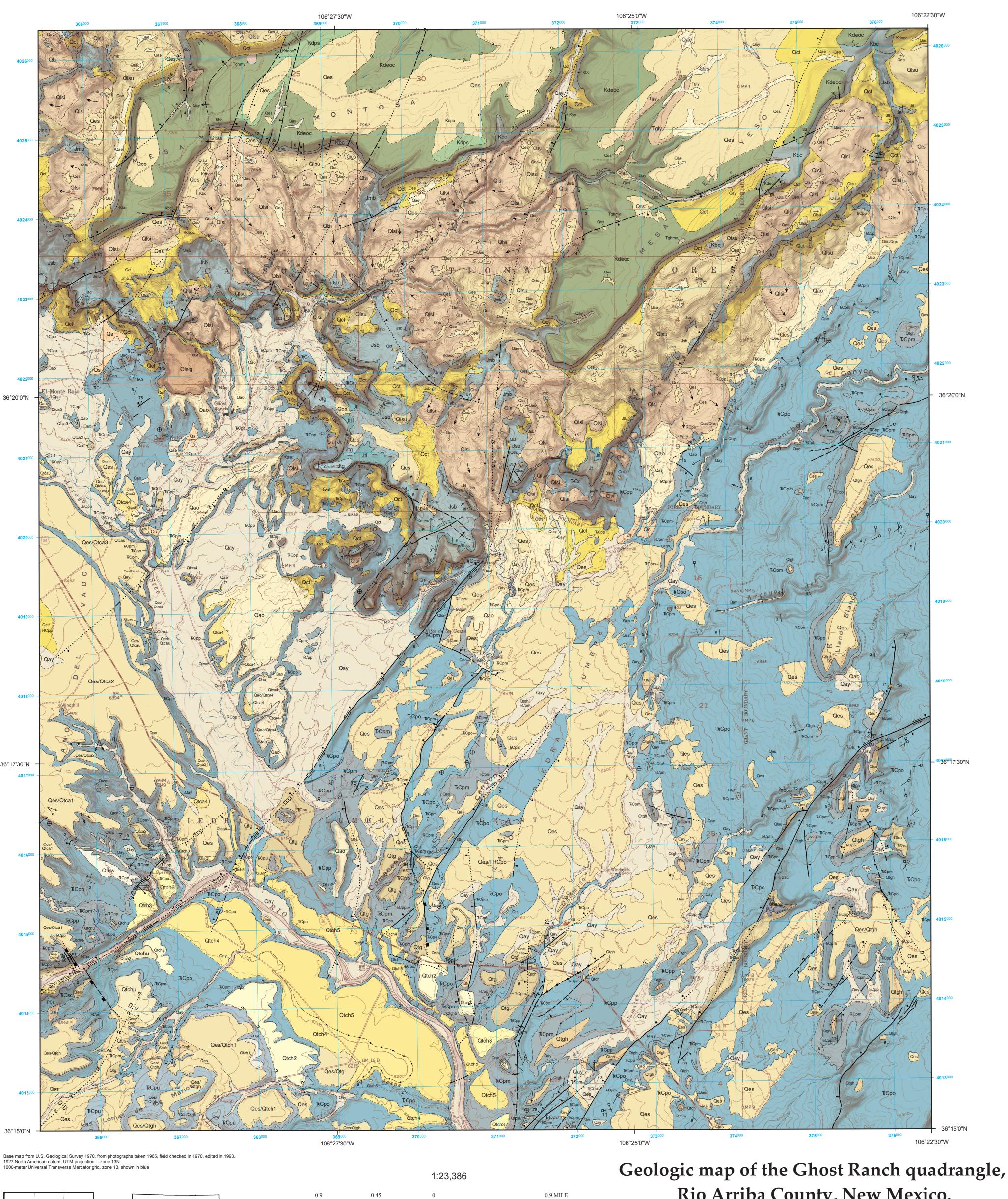
Correlation Diagram

Canjilon Creek. Weakly consolidated. Commonly 1 m to 2 m-thick, but locally as thick as 3 m.

Canjilon Creek terraces, near the western border of the quadrangle. Not described in detail. 1-10 m thick.

Qtg) but similar in texture to many older alluvial deposits (Qao). 1 m to 10 m-thick.

slopes; planar-bedded or else massive, with minor lenticular beds of coarser material. 0.5 to 2(?) m-thick



Rio Arriba County, New Mexico.

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CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources

Open-File Geologic Map 127

Mapping of this guadrangle 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).

1 KILOMETER

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 This and other STATEMAP quadrangles are available conditions should be verified by detailed surface mapping or subsurface exploration. Topographic for free download in both PDF and ArcGIS formats at: and cultural changes associated with recent development may not be shown.

Magnetic Declination

At Map Center

NEW MEXICO

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.

QUADRANGLE LOCATION

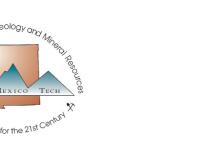
Comments to Map Users

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 contact – Solid where exposed, dashed where approximately located, dotted where concealed, queried where inferred. Normal fault-Showing dip, arrow shows trend and plunge of slickensides, solid where exposed, dashed where approximately located, dotted where concealed, bar-and-ball on downthrown side. Reverse fault—Showing dip, arrow shows trend and plunge of slickensides, teeth on upthrown side of hanging-wall block (combination of reverse fault teeth and bar-and-ball indicates interpretation of normal reactivation of a reverse fault), solid where exposed, dashed where approximately located, dotted where concealed.

Map Symbols

Monocline — Trace of axial plane; dashed where approximately located, dotted where concealed, queried where inferred. **✓** Slickensides on fault

Geologic cross section

Strike and dip of bedding Horizontal bedding Strike and dip of joint or fracture that dips greater than 75 degrees. Direction of landslide failure and surface movement.

rm = symetric ripple-marks, and cm = channel margin.

Water-supply well, including number assigned by the New Mexico Office of the State Engineer Paleoflow direction – Mono-directional; letters indicate measurement type: i=clast imbrication, tx = trough-crossbeds; rm = assymetric ripple-marks, and cm = channel margin (whose trend is similar to adjacent mono-directional data). Length of arrow is scaled to number of measurements (indicated by number in front of either i, tx, rm, or cm).

Paleoflow direction—Bi-directional; letters by arrow indicate type of measurement: tx = trough-crossbeds;

Undifferentiated terrace deposit of Canjilon Creek

Upper middle terrace deposit of Canjilon Creek-Strath is located approximately 50 m above the modern stream grade. Relatively extensive deposit. Comparison of this strath height with Koning et al. (2011, table 3 and figures 5-6) and correlations of Gonzales (1993) suggest an age range of 200-380? ka. This terrace correlates

Map Unit Descriptions

Middle terrace deposit of Canjilon Creek-Strath is located 22-27 m above the modern stream grade. Comparison of this strath height with Koning et al. (2011, table 3 and figures 5-6) and correlations of Gonzales (1993) suggest an age range of 100-280? ka. This terrace probably correlates with unit Qtch3. Lower middle terrace deposit of Canjilon Creek–Strath is located 15-22 m above the modern stream grade near

Highway 84, but this height increases to 27 m near the confluence with the Rio Chama. Relatively extensive deposit and overlain by thick Qao in the center of the quadrangle. Correlated to the 20-40 m terrace deposit of Koning et al. (2011), which has an age of 100-160 ka. This terrace correlates with unit Qtch5 or Qtch4. Lower terrace deposit of Canjilon Creek-Strath is located 13-17 m above the modern stream grade.

Comparison of this strath height with Koning et al. (2011, text, table 3 and figures 5-6) suggests an age range of 20-100 ka. This terrace correlates with unit **Qtch5**. Sandy gravel deposited by the Rio Chama (Pleistocene)–High-level terrace deposits of sandy gravel deposited by the Rio Chama during the Pleistocene. The gravel is clast-supported and consists of pebbles and cobbles with

very minor boulders. Gravel is composed of quartzite and volcanic rocks (intermediate to basaltic) with subordinate (estimate 5-25%) clasts of Mesozoic sandstone, 1% granite + metarhyolite clasts, and trace to 1% chert clasts. The presence of volcanic rocks serves as a convenient way to distinguish the Rio Chama gravel from gravel deposited by Canjilon Creek. Sand is fine- to very coarse-grained. Minor medium, tabular beds of reddish gravelly sand. Loose. 1 m to 9 m-thick.

Undifferentiated terrace deposit of the Rio Chama.

Highest terrace deposit of the Rio Chama – Strath is located approximately 72 to 80 m above the modern stream grade. Comparison of this strath height with Koning et al. (2011, table 3 and figures 5-6) and correlations of Gonzales (1993) suggest an age range of 330-470? ka. This terrace correlates with unit Qtca1.

Qtca3 on the northwest shores of Lake Abiquiu. Comparison of this strath height with Koning et al. (2011, table

3 and figures 5-6) and correlations of Gonzales (1993) suggest an age range of 100-280? ka. This terrace probably

Upper middle terrace deposit of the Rio Chama–Strath is located 40-55 m above the modern stream grade. Comparison of this strath height with Koning et al. (2011, table 3 and figures 5-6) and correlations of Gonzales (1993) suggest an age range of 200-380? ka. This terrace correlates with unit Qtca2. Middle terrace deposit of the Rio Chama – Located 27-30 m above the modern stream grade. Grades into unit

correlates with unit Qtca3. Lower middle terrace deposit of the Rio Chama-Located 22-26 m above the modern stream grade. Mostly submerged by the waters of Lake Abiquiu. Based on its strath height, it may correlate to the 20-40 m terrace deposit of Koning et al. (2011) and have an age of 100-160 ka. This terrace may correlate with unit Qtca4.

Lower terrace deposit of the Rio Chama–Located 16-20- m above the modern stream grade. Submerged by the waters of Lake Abiquiu. Comparison of this strath height with Koning et al. (2011, text, table 3 and figures 5-6) suggests an age range of 20-100 ka. This terrace may correlate with unit Qtca5.

Mixed eolian and alluvial Quaternary deposits **Mixed eolian and alluvial deposits (Holocene to upper Pleistocene)**–Sediment that is a mixture of units Qes and Qay (see descriptions for those units). Deposited in small arroyos on Mesa del Yeso and along its southern

slopes. Thickness is unknown. Pliocene-Miocene(?) Alluvial Deposits Lower gravel on Mesa del Yeso-Boulder conglomerate composed exclusively of Proterozoic quartzite, granite,

metavolcanic, and metasedimentary clasts derived from the Tusas Mountains to the northeast. The conglomerate is not cemented, and the matrix is tan colored, suggesting that these are clasts recycled out of the Eocene El Rito Formation. Rests on Dakota Sandstone. Up to 12 m thick. The base of this deposit is located about 30 m below the base of unit Tghmy.

Higher gravel on Mesa Montosa and Mesa del Yeso-Pebbles to cobbles of rounded Mesozoic sandstone, Proterozoic quartzite and granite from the Tusas Mountains, and in places quartzite and chert recycled out of the Cretaceous Burro Canyon Formation, sitting on Dakota Sandstone, usually the Paguate Member. 1 to 2 m

Dakota Sandstone, upper Paguate Member (Upper Cretaceous)-White quartz sandstone; thin- to mediumbeds that are internally laminated; moderately bioturbated. Coarse sandstone near base, medium grained at top. Caps the highest knobs on Mesa Montosa and Mesa del Yeso. 2 to 3 m thick. Dakota Sandstone, Paguate Member sandstone and siltstone (Upper Cretaceous)-Grayish yellow, thin-

bedded sandstone and siltstone. Thin (<0.1 m) sandstone beds common in the lower third of the unit; unit becomes more silty near the top. Rare pelecypod and fragmentary ammonite fossils described in report (from Lucas et al., 2009). Best exposed on the south side of Mesa Montosa; elsewhere covered by Quaternary eolian sand. Approximately 15 m thick.

Dakota Sandstone-Encinal, Oak Canyon, and Cubero members (Upper Cretaceous) - Tan to yellow-brown quartzose sandstone, dark gray and brown carbonaceous shale, and minor greenish gray mudstone and bentonite. Members include, from lowest to highest (oldest to youngest): Encinal Canyon, Oak Canyon, and Cubero. The Encinal Canyon Member is highly variable in thickness, ranging from 0 to 18 m and averaging 2 to 4 m. This tan cross-bedded quartz sandstone, with thin to medium bedding, commonly has woody plant impressions at the upper contact. Bioturbation is not common in the Encinal Canyon Sandstone. The Oak Canyon Member is a black, muddy siltstone interbedded with thin (<1 m) beds of ledgy and often lenticular, white to orange, cross-bedded, bioturbated sandstone. Local, poorly to moderately preserved leaf and twig fossils. The Cubero Member contains three subunits. The lower subunit consists of a white, massive, thick-bedded, bioturbated sandstone that is 7-8 m thick. The middle subunit is a black sandy shale to shale with thin (2-3 cm) beds of ripple-laminated sandstone that is 1-3 m thick. The upper subunit is composed of orange to tan, fine-to medium-grained sandstone. The upper subunit is often intensely bioturbated, but in places remnant cross-bedding, ripple marks, and thin to thick bedding is preserved. The Cubero Member forms a bold cliff along exposed escarpments of Mesa Montosa that is 25-30 m thick. The entire thickness of Dakota Sandstone is 40 m to 56 m.

Burro Canyon Formation (Lower Cretaceous)–White, light yellow and buff, conglomeratic sandstone with thin lenses of pale green and pink mudstone (Saucier, 1974). Small-scale trough cross-bedding is associated with the conglomeratic channels, which are more common near the base of the unit in the Ghost Ranch area. Conglomerate clasts are mostly varicolored quartzite and chert pebbles up to 2.5 cm in diameter, with minor sandstone and limestone clasts. Laminar low-angle wedge and high-angle planar wedge cross-bedding is common in the sandier portions of the unit. Chert gravel is rare near the top of the unit, but green and red mud rip-up clasts are common. Up to 40 m thick.

Brushy Basin Member of the Morrison Formation (Upper Jurassic)-Variegated pale greenish gray, grayish yellow green, pale olive, yellowish brown, and pale reddish brown bentonitic mudstone with a few beds of trough-crossbedded pebbly sandstone. Locally, the base of the Morrison Formation is a thin (up to 8 m thick) interval of trough-crossbedded sandstone and interbedded mudstone. Above that interval, the formation is mostly mudstone. Greenish white, medium-bedded sandstones with cross-bedding and mud-rip up clasts and thin tabular sandstones are present in a few places near the top of the unit. The basal sandy interval is likely correlative to the Salt Wash Member of the Morrison Formation to the west and south. However, this interval is neither thick enough, persistent enough, nor lithologically distinctive enough to separate from the Brushy Basin Member. 41 m to 68 m thick.

Combined Summerville Formation (Middle Jurassic) and the Bluff Sandstone (Upper Jurassic)-The Summerville Formation is thinly and cyclically-bedded and composed of the following: maroon, grayish red and yellowish gray siltstone, sandy siltstone, fine gypsiferous sandstone, and mudstone. In the Chama Basin, the Summerville Formation is readily divided into two informal members, lower and upper. The lower member is 12 to 15 m thick and is repetitively-bedded gypsiferous sandstone and siltstone that forms a ribbed cliff or slope. It is the same unit that Goldman and Spencer (1941) termed the "Bilk Creek Sandstone Member" in southwestern Colorado. The upper member is 61 to 96 m of siltstone and thinly-interbedded gypsiferous sandstone and mudstone that forms a thick, grayish red and white, banded slope. Strata we term Summerville Formation were assigned to the Morrison Formation by Smith et al. (1961) and Ridgley (1977), though Ridgely (1989) did assign what we term the lower member of Summerville Formation to the Wanakah Formation. 74 m to 111 m thick.

The overlying Bluff Sandstone is a light gray, very fine grained, well sorted sandstone with crossbeds in thick sets. This unit consists of two members not mapped separately. The lower, Junction Creek Member comprises most of the formation (30-40 m thick) and is mostly pale yellowish green and light olive gray, very fine grained, well sorted sandstone with crossbeds in thick sets. These are primarily eolian deposits similar to the type section of the Junction Creek Member near Durango, Colorado (Goldman and Spencer, 1941). The overlying Recapture Member is 6 to 14 m thick and is mostly maroon, pale brown, grayish red, and light greenish gray gypsiferous siltstone, fine-grained sandstone, and mudstone. Recapture strata lithologically resemble underlying Summerville strata. Their fine-grained gypsiferous lithotypes indicate that these strata do not belong to the Morrison Formation (contra Ridgely, 1977), but instead are correctly assigned to the Recapture Member of the

Bluff Sandstone (Lucas and Anderson, 1997, 1998; Lucas et al., 2005). 44 m to 47 m thick.

Todilto Formation (Middle Jurassic)-The Todilto Formation consists of a lower, limestone-dominated interval (Luciano Mesa Member) overlain locally by a gypsum interval (Tonque Arroyo Member) (Lucas et al., 1985, 1995; Kirkland et al., 1995). The Luciano Mesa Member is 2 to 8 m thick and consists mostly of thinly laminated, dark gray or yellowish gray, kerogenic limestone. Beds near the base of the member are usually sandy, and microfolding of the thin limestone laminae is common. The 30 m-thick, overlying Tonque Arroyo Member consists of white to light gray gypsum interbedded with carbonate. In localized areas east and west of Chimney Rock, a thin limestone bed (<1 m) is deposited on the gypsum of the Tonque Arroyo Member. Note that the Todilto Formation is always present between the Entrada Sandstone and Summerville Formation, but commonly is not depicted on the map because it occupies a cliff face. Up to 38 m thick.

Todilto Formation that is dominated by limestone (Luciana Mesa Member)—See Todilto Formation description above. Todilto Formation that is dominated by gypsum (Tonque Arroyo Member)-See Todilto Formation

description above. Entrada Sandstone (Middle Jurassic)-Trough cross-bedded and cross-laminated, in addition to ripple laminated, sandstone that forms a prominent cliff in the northern part of the quadrangle. Only the Slick Rock Member is present in the Chama Basin (Lucas et al., 2005a), and consists of very fine- to medium-grained, moderately well sorted sandstone. Colors

are shades of yellow, light brown, orange, and grayish orange. 60 m to 76 m thick.

Chinle Group (Upper Triassic)

Sandstone. Up to 70 m thick.

Rock Point Formation (Upper Triassic)–Reddish brown to grayish red to red to reddish yellow to yellowish red beds of siltstone and very fine- to fine-grained sandstone. Subordinate reddish brown mudstone. Massive or else in thin to medium, tabular beds that are internally planar- to ripple-laminated. The interbedded sandstone and siltstone beds form a ribbed cliff where the Rock Point outcrop is not deeply weathered. Where weathered, the Rock Point Formation has an orange slope. The Rock Point base is the first persistent bed of sandstone above slope-forming mudstone of the Painted Desert Member of the Petrified Forest Formation. Locally, where sandstones are absent at the base, the contact was mapped where the mudstones and siltstone change to an orangish color and where the mudstones became less bentonitic. The top of the Rock Point is a sharp, unconformable contact with overlying eolian sandstone of the Slick Rock Member of the Jurassic Entrada

Petrified Forest Formation, undivided (upper Triassic)–Mostly reddish-brown bentonitic mudstone that forms extensive slopes and dissected badland areas where exposed. Lucas et al. (2003, 2005b) divided the Petrified Forest Formation in the Chama basin into two members, which are generally mapped as separate units and described separately below. However, in areas of poor exposure or for areas under Lake Abiquiu we have mapped this undivided unit. Up to 200 m-thick.

Painted Desert Member of the Petrified Forest Formation (upper Triassic)-Reddish brown and weak red (hues of 2.5YR and 10R), with subordinate dark grayish brown to light reddish brown, bentonitic mudstone and claystone intercalated with minor greenish gray to light greenish gray, pebbly sandstone channel-fills. Local reduction of the mudstone (approximately 1-2% of the unit) has resulted in cm-scale streaks and meter-scale beds of light gray, greenish gray, and light greenish gray. Locally there are minor intervals of ripple-laminated to planar-laminated, very fine- to fine-grained sandstone. The mudstone is in thick to very thick, tabular beds, with minor thin to medium, tabular beds. The greenish pebbly sandstone channel-fills occupy 1-7% of the unit, have up to 2.5 m of relief at their base, may be as much as 3 m thick, and are lenticular. The pebbles in these channel fills are composed of light gray to very dark gray limestone or calcrete pebbles with very minor mudstone-claystone rip-up clasts; these pebbles are typically up to 2 cm in diameter (locally up to 3 cm-diameter). The sand in these channel-fills is medium- to very coarse-grained and composed of the same type of limestone as the pebbles. Between the pebbles and sand grains is a greenish muddy matrix that imparts an overall greenish color to the entire channel-fill deposit. A few measured trends of the channels occupied by these fills are W-E and SW-NE. The mudstone is well consolidated but weakly cemented; the coarser channel-fills are locally cemented by calcium carbonate. The base of the unit corresponds to the highest sandstone ledge of the Mesa Montosa Member. Its top is a sharp, relatively planar contact with siltstone and sandstone of the Rock Point Formation Up to 180 m-thick.

Mesa Montosa Member of the Petrified Forest Formation (upper Triassic)-Very fine- to fine-grained sandstone with slightly lesser mudstone and siltstone that range in color from reddish brown (hues of 2.5-5YR) to moderate brown to light reddish brown. The unit occupies a gradation between the sandstone and pebbly sandstone of the underlying Poleo Formation and the mudstone-dominated overlying Painted Desert Member of the Petrified Forest Formation. As such, litharenite sandstone beds dominate near the lower part of the member and mudstone beds dominate in the upper part of the member. Sandstone beds are very thin to medium, tabular, and typically ripple-laminated to wavy-laminated to planar-horizontal-laminated. Ripple-marks and troughs commonly give a northwestward-to-southwestward paleoflow direction. The Mesa Montosa Member forms a ribbed slope where not covered by colluvium. The lower contact of the unit corresponds with the base of a thick bed of mudstone, siltstone, or silty fine sandstone bed associated with the reddish brown to brown, very fine- to fine sandstones that typify this unit. However, yellow to gray sandstone beds similar to those seen in the Poleo Formation are commonly found in the lower part of the Mesa Montosa Member as well. In addition, the lower 1-10 m of this unit may grade laterally into or interfinger with the uppermost Poleo Formation. 3 m to 24 m-thick.

Poleo Formation (Upper Triassic)–Sandstone and minor pebble-conglomerate in broadly lenticular, 0.5-4 m-thick, stacked channel-fills that are extensively cross-laminated or cross-bedded. Trough cross-stratification commonly gives a northwestward to westward paleoflow direction. Intercalated in medium to thick, tabular to broadly lenticular sandstone near the top of formation are 1-2 m-thick intervals of very thin to thin, horizontal-planar sandstone locally mined for flagstone. Poleo Formation sandstones are fine- to very coarse-grained, micaceous litharenites and are typically gray to yellow in color. Conglomerates are either intrabasinal (composed of siltstone and nodular calcrete clasts) or extrabasinal (chert, quartz, and quartzite clasts) Strongly cemented and indurated. The Poleo Formation has a sharp, scoured contact on the underlying Salitral Formation. It grades upward into the overlying Petrified Forest Formation and forms a light-colored bench, ledge or cliff. Up to 41 m-thick.

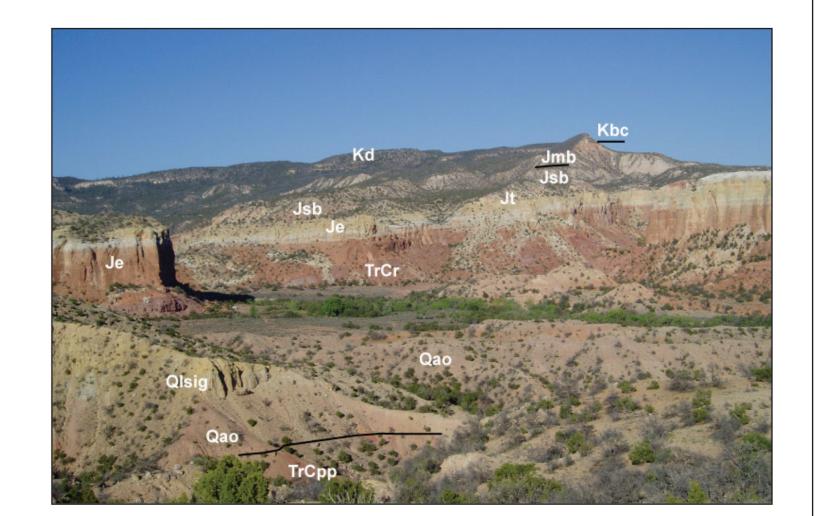
Combined Salitral and Shinarump formations (Upper Triassic)-The Salitral forms a bentonitic, mudstone-dominated slope between the cliff/ledge-forming sandstone of the Shinarump (below) and Poleo (above) formations. The Salitral Formation is divided into two members (Lucas et al., 2003, 2005b): a lower, Piedra Lumbre Member of reddish brown to light gray mudstone with a persistent sandstone bed (the El Cerrito Bed) at its top, and an upper, Youngsville Member, which mostly consists of reddish-brown mudstone. On this quadrangle, the El Cerrito Bed is located about 6 m above the base of the Salitral Formation, and the lower Piedre Lumbre Member may have inclusions of diagenetic, reddish chert. The El Cerrito Bed is 30-50 cm-thick bed, has a color of light gray to white to pale yellow, and consists of medium- to very coarse-grained, angular to subangular, moderately sorted sandstone composed of quartz with 1-3% possible feldspar. Other than the El Cerrito Bed, sandstone beds are generally not observed in the Salitral Formation on this quadrangle, but exposures are generally poor. The Salitral Formation contact with the underlying Shinarump Formation is a sharp surface where mudstone rests directly on sandstone or conglomeratic sandstone. The Poleo Formation contact on the Salitral Formation is a sharp, scoured surface where conglomerate/sandstone at the base of the Poleo is incised into underlying Salitral mudstone/siltstone. 1 to 11 m-thick.

The Shinarump Formation consists of quartzose sandstone and siliceous conglomerate. This formation has previously been called the Agua Zarca Formation (e.g., Wood and Northrop, 1946; Dubiel, 1989; Lucas and Hunt, 1992). It is only exposed locally near the eastern quadrangle boundary. Here, the lower 1.0-1.5 m consists of a thick bed of medium- to coarse-grained quartz sandstone with abundant matrix; white, purple, red, and pale yellow mottling is present on a large scale (mottles are laterally continuous for meters and about 20-30 cm-thick). Above this is cross-bedded sandstone, with 3-5 cm-thick beds, that appears nodular in places and is mottled yellow, orange, red, purple, and white. The upper 2 m has is also mottled but predominately white, and consists of: 1) a lower (about 1 m-thick) bed having low-angle, trough crossbedding, and 2) an upper conglomeratic sandstone interval having a vague sense of planar bedding but very nodular and bioturbated; the conglomerate consists of very fine pebbles of quartz grains hosted in a fine- to medium-grained quartz sandstone matrix. The Shinarump Formation usually forms a light-colored ledge where it is entirely exposed on a slope. Regionally, its basal contact is a sharp, erosional scour on underlying, finer-grained strata of the Cutler Group. Up to 6 to 7 m-thick.

Pennsylvanian-Permian Rocks

Cutler Group (Pennsylvanian-Permian)

Arroyo del Agua Formation (Lower Permian)-Orange sandstone, muddy sandstone, and mudstone. Minor intraformational and extraformational conglomerate has been reported in the vicinity but were not observed in the limited exposures on this quadrangle. Most of the Arroyo del Agua formation observed on this quadrangle consists of brown to yellowish brown, thick, tabular beds of clayey to slightly clayey, very fine- to fine-grained, arkosic sand. There are slightly subordinate, thick beds of yellowish red and red mudstone that are commonly bioturbated and locally reduced (cm-scale) to light greenish gray to light gray colors. There are about 10% 1-3 m-thick, lenticular beds of fine- to medium-grained, arkosic sandstone (minor coarse- and very coarse-grained sand). In the vicinity of this quadrangle, siltstones in this unit form thick, slope-forming units with abundant calcrete nodules between thin sandstone sheets that are arkosic and trough crossbedded. Up to 130 m thick, but only 1-18 m exposed on this quadrangle.



View to northeast of upper Triassic through upper Cretaceous rocks from the Chimney Rock trail at Ghost Ranch. Various map units are labeled on the exposed formations, and locally contacts are illustrated by black lines.

