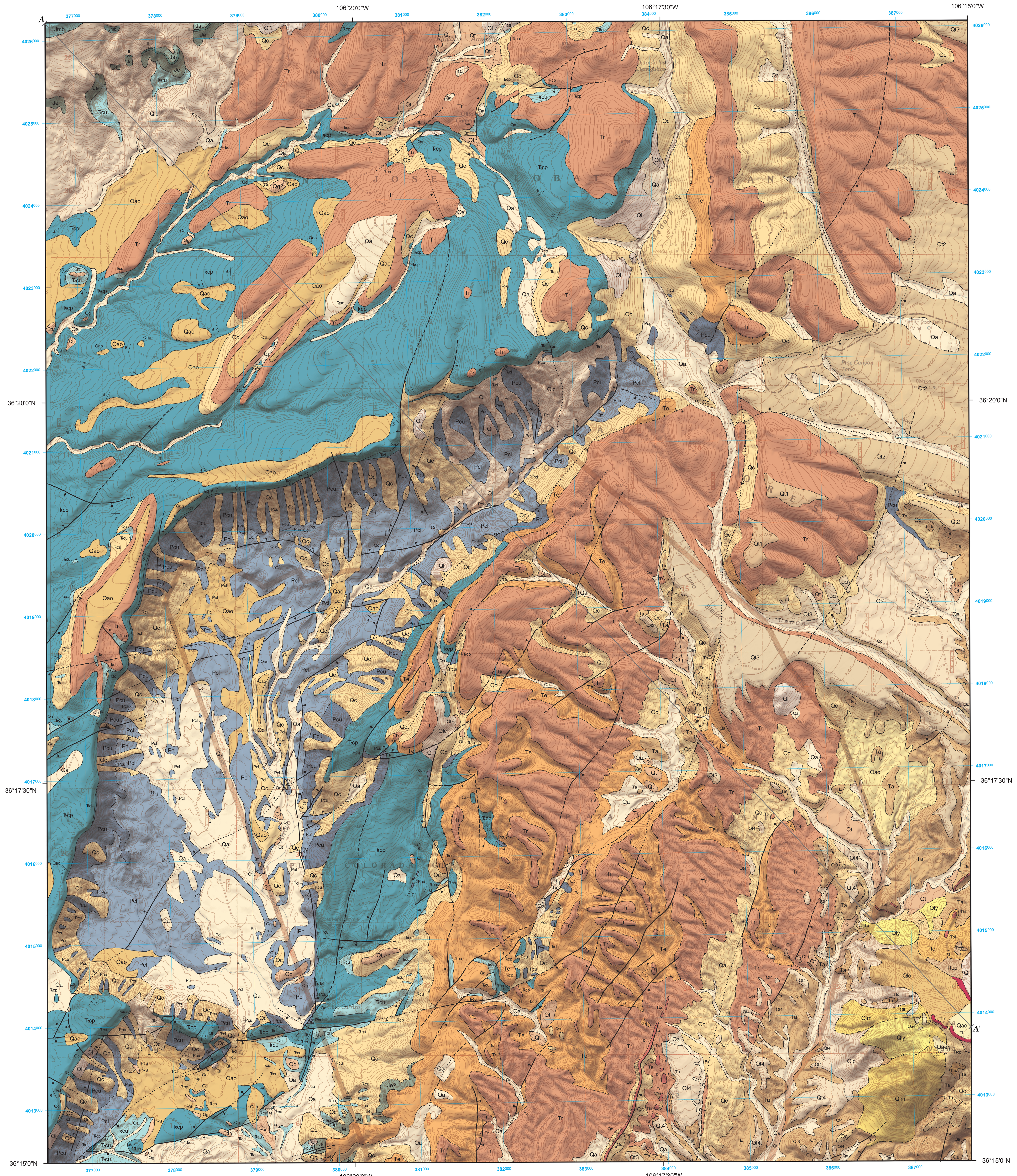
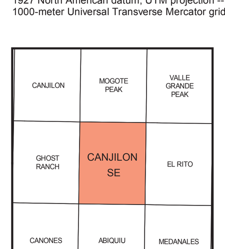
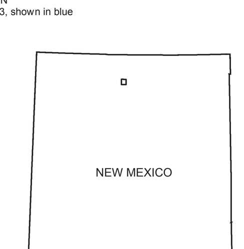


Base map from U.S. Geological Survey 1970, from photographs taken 1965, field checked in 1970, edited in 1993.
1927 North American datum, UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in blue





QUADRANGLE LOCATION

Magnetic Declination
March 2006
9° 50' East
At Map Center

1:24,000

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geologic map of the Canjilon SE quadrangle, Rio Arriba County, New Mexico.

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 150

May 2007

by
Kirt Kempter [1], Kate Zeigler [2], Dan Koning [3], and Spencer Lucas [4]

[1] *Independent Consultant, 2623 Via Caballero del Norte, Santa Fe, NM, 87505*
[2] *Zeigler Geologic Consulting, Albuquerque, NM, 87123*
[3] *New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Pl., Socorro, NM, 87801*
[4] *New Mexico Museum of Natural History and Science, Albuquerque, NM, 87104*

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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

Map Symbols

Geologic contact– solid where exposed or known, dashed where approximately known, dash-dotted where probable, dotted where concealed, queried where uncertain.

Normal fault-bar-and-ball on downthrown side. Solidwhere exposed, dashed were approximately known, dotted where concealed.

Strike and dip of bedding.

A |—| A' Location of geologic cross section.

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.

Map Unit Descriptions

QUATERNARY

Qa — **Alluvium—**Late Pleistocene to Holocene. Alluvial deposits in modern drainage bottoms and elevated basins. Deposits include conglomerates, sands, and silts. Holocene terrace deposits less than 2 meters above drainage bottoms are also included. Maximum thickness is estimated to be less than 5 meters.

Qae — **Alluvium—**Late Pleistocene to Holocene. Same as **Qa** but with a significant eolian sand component. Fine-to medium-grained sand. Thickness less than 2 meters.

Qc — **Colluvium—**Late Pleistocene to Holocene. Poorly-sorted talus, debris, and other rock fragments derived from local volcanic and sedimentary rocks. Often occurs as wedge-shaped hillslope deposits (*Figure 2). The poorly-consolidated Ritito Conglomerate is typically expressed at the surface as colluvial clasts and often obscures the contact with the El Rito Formation below. Also, cobble and boulder alluvial facies of the El Rito Formation produce significant colluvium. Clasts from both the Ritito Conglomerate and the El Rito Formation form extensive colluvial lag on hillslopes throughout the central and eastern areas of the quadrangle. Although pervasive throughout the quadrangle, colluvium was seldom mapped. Maximum thickness is approximately 8 meters.

Qac — **Alluvium and Colluvium—**Late Pleistocene to Holocene. Mix of alluvial and colluvial deposits, mostly on low angle slopes. Maximum thickness is estimated to be less than 2 meters.

Ql, Qly, Qlm, Qlo, Qlb — **Landslides—**Pleistocene to Holocene. Unsorted, chaotic debris emplaced during a single detachment event from a steep slope or cliff, generally containing a sediment matrix. Also, slump or block slides, especially along the flanks of steep hillslopes such as the slopes of Cañon de Cobre and Sierra Negra. **Qlb** represents landslide material composed dominantly of blocks of basalt. Fan-shaped deposits occur where debris spread out on valley floor. On the western flank of Sierra Negra, the relative ages of major landslide events are indicated by **Qly** (youngest), **Qlm** (intermediate), and **Qlo** (oldest). Thickness can exceed 20 meters.

Qlc — **Landslides plus Colluvium—**Pleistocene to Holocene. Mix of colluvium and landslide material, mostly on the flanks of Sierra Negra. Maximum thickness is approximately 5 meters.

Qt, Qt1, Qt2, Qt3, Qt4 — **Terrace deposits—**Pleistocene to Holocene. Alluvial deposits near the margins of modern streams or older perched floodplain deposits. Holocene, low terraces (< 10 meters above modern drainages) are typically fill deposits of sand, silt and gravel, and are mapped as **Qt**. Ancestral versions of Madera Creek and its tributaries are believed to have created several strath terraces as Quaternary erosion in the Rio Chama valley progressed. The highest and oldest terrace is labeled **Qt1**. Accordingly, the youngest and lowest terrace is labeled **Qt4**. These terraces typically are characterized by 1 to 3 meters of alluvial sand to conglomerate, capping tilted and beveled Tertiary strata. Maximum thickness is less than 5 meters.

Qao — **Alluvium—**Late Pleistocene to Holocene. Mapped in the Cañon de Cobre area where it is older than **Qa** in the canyon and in the NW portion of the quadrangle. Sandy alluvial beds with minor gravel and muddy beds preserved as terrace-like features on top sandstone benches and capping Tertiary units. Thicknesses range from 0.5 meters to almost 2 meters. Usually more heavily vegetated than **Qa** units.

Qg — **Alluvium—**Middle to Late Pleistocene. Alluvial gravels that cap hills along the western and southern rims of Cañon de Cobre. Deposits include reworked and remobilized **Tr** deposits. Sandy-pebble and conglomerate lenses with lesser amounts of silt and mud. Maximum thickness is approximately 2 meters.

TERTIARY

Tb, Tbi — **Mafic volcanic rocks—**Late Oligocene to Early Miocene. Dark gray to black mafic lavas or dikes. Lavas are generally crystal-poor, with phenocrysts of olivine and plagioclase (less than 5%). Dikes are similarly crystal-poor, although a mafic dike that traverses the western rim of Cañon de Cobre (*Figure 6) contains abundant olivine phenocrysts. Cerritos de la Ventana is a major dike that intruded a northeast-trending fault plane. In places the dike splits, forming two parallel strands. Along the north-and northwestern-flanks of Sierra Negra, mafic dikes intrude the Abiquiu Formation (*Figure 7) while mafic lavas cap a western mesa (on the quadrangle) and eastern mesa (off the quadrangle). A major basaltic dike just north of Sierra Negra (UTM 0387500, 4015500) may be a source of these flows. The eastern mesa includes at least 3 successive flows that occur with brecciated basal horizons. An $^{40}Ar/^{39}Ar$ sample from the lowest flow yielded an age of 5.0±0.15 Ma (Appendix II). To the west there is only one flow. Maximum thickness of flow on the western mesa of Sierra Negra is approximately 15 meters.

Ttc — **Chama–El Rito Member, Tesuque Formation, Santa Fe Group—**Miocene. (**Ttcp**) Light-pink to reddish-brown floodplain deposits of siltstone, mudstone, fine-grained sandstone and thin channels of low-angle crossbedded channel gravels. Fluvial channels contain rounded volcanic pebbles of intermediate-and felsic-composition, poorly-to moderately-sorted. These channels are typically cemented by calcium carbonate. Exposures occur only on the flanks of Sierra Negra. Brownish-phreatomagmatic deposits are intercalated with the regular sediments, containing bombs and other altered tephra of mafic composition (*Figure 9). A large phreatomagmatic crater is well preserved on the north-flank of Sierra Negra (*Figure 10). Maximum thickness is approximately 185 meters.

Ta — **Abiquiu Formation—**Late Oligocene to Early Miocene. White to beige, fine-grained tuffaceous sandstones with interbedded shales and fluvial conglomerates that contain pebbles or cobbles of volcanic rocks and Proterozoic quartzites (*Figure 11). The distinctive bedding and presence of 25.1 Ma Amalia Tuff clasts and other $^{40}Ar/^{39}Ar$ age data indicate that the bulk of Abiquiu sedimentation occurred as pumiceous debris-flow deposits coincident with the eruption of the Questa caldera, along with pre- and post-caldera volcanism in the Latir volcanic field. (Smith et al., 2002). Porphyritic dacites, including phenocrysts of plagioclase and hornblende are the most common clast, although a variety of silica-rich lavas and tuffs occur as clasts. To the north this unit correlates with the Cordito Member of the Los Pinos Formation. In the study area the unit fines upwards with increasing volcaniclastic material. Maximum thickness is approximately 350 meters.

Tr — **Ritito Conglomerate—**Late Oligocene. Alluvial conglomerate and sandstone. Gray to pink fluvial deposits, commonly conglomeratic and arkosic, due to pink metavolcanic and granitic clasts. Typically poorly-consolidated with a calcified base up to 1 meter thick (Figure 12). Clasts include subequal amounts of quartzite and metarhyolite, with lesser amounts of schist, gneiss, vein quartz, and granite. The deposit is characteristic of a widespread piedmont alluvial fan derived from Proterozoic source regions. Previously, this unit was defined as the lower member of the Abiquiu Formation, however Maldonado and Kelley (2009) proposed to distinguish this unit based on its unique composition and age. The poorly-bedded nature of the deposit is suggestive of a depositional environment of braided streams and debris flows. In the northern half of the quadrangle clasts in the conglomerate are typically subrounded to rounded (up to 0.7 meters across), consisting of Proterozoic metarhyolite and metasediments (in particular blue-gray quartzite). To the south the gravels and conglomerates become subangular to angular and include a wider variety of Proterozoic clasts. The larger, subrounded granite and quartzite boulders diminish in abundance to the south. Maximum thickness is approximately 60 meters.

Te — **El Rito Formation—**Eocene. Siltstones, sandstones and conglomerates. Alluvial deposits dominated by quartzite conglomerate and quartzose sandstone (*Figure 13). Lesser amounts of siltstone and mudstone. Basal conglomerate is typically clast-supported with subrounded-to -rounded-bluish-gray cobbles to boulders. This basal unit was deposited on an irregular erosional surface of older Late Paleozoic to Mesozoic strata (*Figure 14). The sandstone units represent sheet-flow and channel-fill sediments in a braided stream environment. The age of these sediments is regarded to be Eocene (Logsdon, 1981; Smith et al., 1961) and the unit is thought to have been deposited in syn-orogenic basin between Laramide highlands in the Sierra Nacimiento to the west and the Tusas Mountains to the northeast. The sandstone units represent sheet-flow and channel-fill sediments in a braided stream environment. Maximum thickness is approximately 50 meters.

JURASSIC

Jmb — **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. Thickness ranges from 41 m to 68 m thick.

Jt — **Todilto Formation—**Middle Jurassic. Limestone and gypsum. 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 5 meters 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. Thickness is less than 5 meters.

Je — **Entrada Sandstone—**Middle Jurassic. Trough-crossbedded and ripple-laminated, cliff-forming sandstone. The Entrada Sandstone (only the Slick Rock Member is present in the Abiquiu region: Lucas et al., 2005a). The unit is very-fine- to medium-grained, moderately well-sorted sandstone that forms bold cliffs along escarpments and mesa tops. Trough crossbeds and ripple laminations are the dominant bedforms. Coloration is typically orangy-red base, beige middle, and yellow top. Up to 50 meters thick.

TRIASSIC

TRcu — **Petrified Forest and Rock Point Formations—**Poorly-exposed, thinly-bedded, pink-to-white shales, siltstones, and sandstones. Much of the backwasting of younger Mesozoic strata and cliffs across the eastern Colorado Plateau margin is due to this unit. Sandstone and conglomerate lenses are discontinuous and are more prevalent near the top of the unit. The best exposures of this unit in the quadrangle are west of Rincón Amarillo along the northern boundary of the quadrangle (*Figure 15). Maximum thickness is approximately 30 meters.

TRcp — **Poleo Formation—**Yellow-brown, medium to fine-grained, micaceous, cross-bedded, quartzose sandstone, conglomeratic sandstone and conglomerate (*Figures 16-18). Planar-and-trough cross-stratification common. Layers containing abundant petrified wood fragments are common (*Figure 16). The conglomerate in the Poleo Formation is often dark brown and contains both intrabasinal-siltstone and nodular-calcrete clasts and extrabasinal-siliceous (chert and quartzite) clasts. This unit forms prominent cliffs, in particular along the rim of Cañon de Cobre. The base of the unit is sharp (corresponds to the Tr-4 unconformity of Lucas (1993)) and the upper contact is gradational into the overlying Painted Desert Member of the Petrified Forest Formation. Maximum thickness is approximately 65 meters.

TRcl — **Shinarump and Salitral Formations—**The basal unit of the Chinle Group is called the Shinarump Formation (previously called the Agua Zarca Formation) and consists of white, coarse-grained to medium-grained, pebbly sandstone with conglomeratic lenses (*Figure 19). Low-to-medium scale channel crossbeds are common. Extrabasinal conglomerate includes clasts of quartz, chert, and quartzite. Where well exposed, the base of the unit disconformably overlies the Permian Arroyo del Agua Formation of the Cutler Group. Locally there is copper mineralization, consisting of copper sulfides that have replaced carbonaceous material and are surrounded by halos of copper carbonates (*Figure 20). Some petrified wood and plant fragments. Maximum thickness is exposed in the northern wall of Cañon de Cobre, where a Shinarump channel is approximately 25 meters thick. Locally, thin beds of the Salitral Formation overlie the Shinarump Formation along the western and northern rims of Cañon de Cobre. The Salitral Formation is a reddish-brown to mottled shale that is thin, discontinuous, and poorly-exposed. Due to its poor surface representation, this unit was only mapped in a few locations. Most likely, syndepositional deformation of overlying Poleo sandstone beds occurred along a detachment surface across Salitral shale beds (*Figure 18). Maximum thickness is approximately 7 meters.

PERMIAN

Pcu — **Arroyo del Agua Formation—**Early Permian. Orange siltstone, sandstone and minor intraformational and extraformational conglomerate. The siltstones are thick, slope-forming units with abundant calcrete nodules between thin sandstone sheets that are arkosic and trough-crossbedded. Up to 130 meters thick.

Pcl — **El Cobre Canyon Formation—**Late Pennsylvanian-Early Permian. Brown siltstone, sandstone and extraformational conglomerate that overlies Proterozoic basement in the subsurface and is conformably overlain by the Arroyo del Agua Formation. Siltstone beds of the El Cobre Canyon Formation contain numerous rhizoliths and comprise relatively thin, slope-forming units between multistoried sandstone beds that are arkosic, micaceous, coarse-grained and trough-crossbedded. The Canjilon SE quadrangle contains numerous vertebrate fossils, primarily of Late Pennsylvanian-Early Permian amphibians and reptiles (e.g., Langston, 1953; Berman, 1993; Lucas et al., 2005b). At least 111 meters thick.

*Figures and appendices referenced in the Map Unit Descriptions can be found in the CanjilonSEReport.pdf at geoinfo.nmt.edu.

Correlation of Map Units

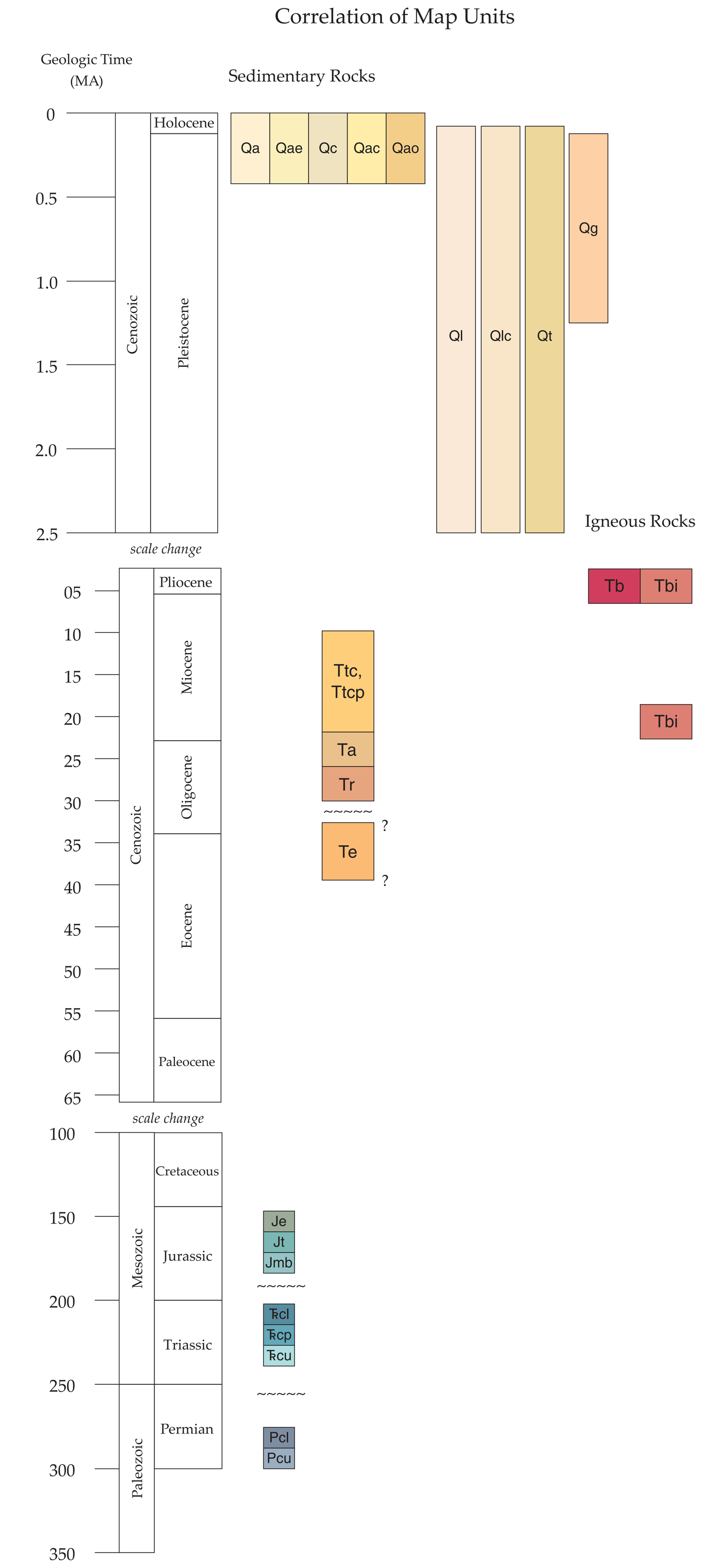

FIGURE 1—Giant quartzite boulders found scattered along the eastern margin of Cañon de Cobre.

FIGURE 2—Quaternary colluvium and landslide debris on Permian Arroyo del Agua Formation in the north rim of Cañon de Cobre.

FIGURE 3—Abiquiu Formation on the southwestern flank of Sierra Negra, dipping to the southeast.

FIGURE 4—Syndepositional deformation of Poleo sandstone beds in the western rim of Cañon de Cobre. Deformed beds are underlain by undeformed sandstones and conglomerates of the Shinarump Formation and are overlain by undeformed beds of upper Poleo Formation sandstone.