Geologic Map of the
Valle Grande Peak Quadrangle,
Rio Arriba County, New Mexico.

By

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Open-file Digital Geologic Map OF-GM 180

Scale 1:24,000

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Geology of the Valle Grande Peak 7.5-Minute Quadrangle,

Rio Arriba County, Northern New Mexico

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Location and Geologic Setting

Geologic mapping of the Valle Grande Peak 7.5-minute quadrangle was conducted in the fall of 2007 and spring of 2008. The quadrangle is located north of the town of El Rito and includes the western portion of the Ortega Mountains. Elevations range from 7220 to 8807 feet above sea level and the land consists of a mixed conifer pine ecosystem. A 9 quadrangle digital elevation model (DEM) compilation is presented.

Figure 1. Digital Elevation Model of 9 7.5-minute quadrangles showing select geographic landmarks. The Valle Grande Peak quadrangle (center) is outlined in black.
in Figure 1, showing the regional topography and select geographic landmarks. The Valle Grande Peak quadrangle lies along the boundary of the Colorado Plateau and the Rio Grande rift. NNW-SSE-trending faults define the margin between these provinces, imposing a profound structural and erosional fingerprint to the landscape. The strata throughout the region are generally tilted to the east, as this portion of the Rio Grande rift is part of the San Luis Basin, an eastward-tilting graben.

Figure 2. DEM of the Valle Grande Peak 7.5-minute quadrangle.

Figure 2 shows the DEM for only the Valle Grande Peak quadrangle. The Ortega Mountains form the highest peaks in the quadrangle and trend WSW-ENE. Resistant
quartzite ridges connect many of the peaks, representing steeply dipping beds on the flanks of anticlines and synclines. Much of their topographic expression mimics glacial erosion (bowl-shaped cirques, ridgeline aretes, and steep-walled valleys), although glaciation is not known to have occurred in the area.

A drainage divide trends diagonally across the quadrangle from the northwest to southeast. Arroyos and creeks along the southern and western margins of the quadrangle feed El Rito Creek, and include several major canyons (Cañada del Potrero, Arroyo Seco, and El Rito Creek Canyon). Drainages along the north and eastern portion of the quadrangle feed Vallecitos Creek to the east of the quadrangle. Tributary canyons and drainages of El Rito Creek mostly follow a NNW-SSE structural grain imposed by basin and range faulting at the eastern margin of the Colorado Plateau. These drainages flow southward and have incised relatively deep canyons. The Vallecitos Creek tributaries, however, flow eastwards and are not as deeply incised. Superposed stream examples occur throughout the quadrangle, where streams have cut through resistant basement bedrock (Ortega quartzite) because their course was established at a higher level, on more uniform rock, before downcutting began.

**Summary of Geologic History**

The rocks exposed on the Valle Grande Peak quadrangle reveal multidimensional glimpses into the geologic past of northern New Mexico. The oldest rock unit in the quadrangle, exposed only along the eastern base of Arroyo Seco canyon, belongs to the Vadito Group, a succession of Proterozoic metasedimentary and metavolcanic rocks. This rock is a metavolcanic schist that may have originally been deposited as a rhyolitic ash flow tuff. The presence of this rock may suggest that nearby exposures of Proterozoic Ortega quartzite belong to the base of this unit, which is known to overlie rocks of the Vadito Group. Karlstrom and Bowring (1991) interpret rocks of the Vadito Group to represent a diverse suite of island arc volcanics, very young crustal material that was accreted onto the margin of Laurentia between 1.8 to 1.6 Ga.
The Ortega quartzite overlies the Vadito Group rocks, although this relationship is not observed in the Valle Grande Peak quadrangle (but can be observed in the La Madera quadrangle to the east). The Ortega quartzite protolith is believed to represent a clean, quartz sand deposited in a fluvial or tidal environment during more stable continental conditions. Some facies may even represent eolian deposition. To the east of the Valle Grande Peak quadrangle, both the Ortega Quartzite and the Vadito Group are intruded by the Tres Piedras Granite at ~1.69 Ma, suggesting a return to active margin tectonics during or after deposition of the Ortega Quartzite (Koning et al., 2007). During metamorphism, both the Vadito Group and the Ortega Quartzite were subjected to polyphase ductile deformation, evidenced by multiple generations of folding and faulting in these rocks, and lower greenschist to upper amphibolite grade metamorphism (Karlstrom and Bowring, 1991). Exposures in the Ortega Mountains reveal two anticlinal and synclinal axes in the Ortega quartzite, trending northwest, including the La Madera syncline described by Koning et al (2007).

Well over a billion years of earth history is missing in the Valle Grande Peak quadrangle, as the next youngest rock exposed is the Arroyo del Agua Formation of the Early Permian Cutler Group. These sedimentary siltstones and sandstones were deposited in a humid, swampy environment during the time of Pangea, when northern New Mexico was barely above sea level and lay near the equator. The limited exposure of a red sandstone nonconformably resting upon Ortega quartzite at the Potrero canyon waterfall (interpreted as Arroyo del Agua Formation), could represent the initial covering of Proterozoic basement rock in the area following several hundreds of millions of years of widespread erosion throughout northern New Mexico, effectively peneplaining the landscape to near sea level. The exposures of Arroyo del Agua Formation in El Rito canyon are tilted in angular unconformity with overlying Tertiary strata, suggesting a pre-El Rito structural event (perhaps in the Early Eocene).

Another large gap in geologic time occurs above the Permian Arroyo del Agua Formation in the Valle Grande Peak quadrangle, as the entire sequence of Mesozoic strata is missing. These strata, which are still preserved on the Colorado Plateau immediately west of the quadrangle, include the Triassic Chinle Group, Jurassic Entrada,
Todilto and Morrison Formations, and several formations related to the Late Cretaceous seaway.

The aforementioned absence of Mesozoic strata in the Valle Grande Peak quadrangle is interpreted to be due to erosion related to the Brazos uplift and Laramide tectonic forces during the Early Tertiary. A synorogenic basin (El Rito Basin) formed between the rising Brazos and Nacimiento uplifts (Cather, 2004) resulting in the deposition of the Eocene El Rito Formation (Logsdon, 1981; Smith et al., 1961). In the Valle Grande Peak area, the El Rito Formation includes breccia and boulder to cobble conglomerates derived from uplifted blocks of Proterozoic Ortega quartzite. In several localities in the quadrangle basal El Rito conglomerate rests nonconformably on Ortega quartzite (and in one section, Vadito metarhyolite). Although most of the El Rito Formation consists of well rounded quartzite cobbles and boulders, the percentage of angular quartzite clasts increases near the contacts with Proterozoic rocks. Field observations from this study suggest that the El Rito deposition blanketed much of the Valle Grande Peak quadrangle with approximately 100 meters of conglomerate, surrounding Ortega quartzite highlands. The physical characteristics of the El Rito Formation, including poor sorting, lack of bedding, extreme roundness of cobbles and boulders, and clast supporting, suggest a rapid depositional history in highly energetic fluvial conditions.

Capping the El Rito Formation is the Ritito Formation, an alluvial conglomerate composed of Proterozoic clasts, both poorly sorted and consolidated. Previously classified as the Ritito conglomerate (Bingler, 1965), and as the lower Abiquiu Formation (Smith, 2002), recent studies have proposed this unit to be named the Ritito Formation. Although this unit contains abundant Ortega quartzite, a variety of other metamorphic rocks related to the Vadito Group are also present. Clasts are generally not as well rounded as in the El Rito Formation. Although the Ritito rests unconformably upon the El Rito Formation there does not appear to be much, if any, angular unconformity. The incorporation of Vadito Group clasts suggests that by this point in time, several of the uplifted source areas had stripped away the Ortega quartzite, exposing older Vadito Group metamorphic rocks.
The age of the Ritito Formation is not firmly constrained. This unit in the Las Tablas quadrangle to the north is overlain by basalt flows ranging in age from 24-27 Ma (Barker, 1958; Koning et al., 2007). A basalt sample from this study has been submitted for geochronologic analysis. The basalt caps the Ritito Formation, and thus may provide an important upper time constraint for this unit. Possibly, the uplifted western margin of the early Rio Grande rift instigated deposition of this unit in the same basin that accommodated the El Rito Formation. Field investigations suggest this unit covered most of the Valle Grande Peak area, capping the El Rito Formation with up to 50 meters of poorly consolidated conglomerate consisting almost entirely of metamorphic rock fragments. The uppermost part of this unit, however, has an ashy, tuffaceous matrix, suggesting an initial influx of volcanic material from the Latir volcanic field to the northeast (Smith et al., 2002).

Rapid blanketing of the Valle Grande Peak quadrangle by the Abiquiu Formation is likely related to voluminous rhyolitic volcanism in the Latir volcanic field at approximately 25 Ma, highlighted by the Questa caldera eruption of the Amalia Tuff (Smith et al., 2002). Indeed, fluvial clasts of the densely welded Amalia Tuff are common in the upper half of this unit. Much of the Abiquiu Formation is planar bedded, reworked volcanic ash and tephra, suggesting a sheet flood mode of deposition over a very flat landscape.

The thickness of the Abiquiu Formation in the Valle Grande Peak quadrangle varies over relatively short distances. This may be related to an irregular depositional surface developed on the underlying Ritito Formation, early deformation related to the rift, or due to erosion prior to the deposition of the overlying Cordito Member of the Los Pinos Formation. The upper Abiquiu Formation becomes increasingly gravely, with lenticular conglomerate beds that include a variety of silicic volcanic clasts, including crystal-poor and crystal-rich rhyolite lavas, dacite lavas, and moderately to densely welded tuffs (including the Amalia Tuff). The gradual increase in clast-supported gravels, and decrease in tuffaceous matrix, represents the transition to the overlying Cordito Member of the Los Pinos Formation.

The increasing gravel component of volcaniclastic sediments in the area likely coincides with the development of the Plaza volcanic center to the northeast, plus isolated
silicic centers in the adjacent La Madera quadrangle. Studies by Ekas et al (1985) indicate that the main development of the Plaza volcanic center occurred between 21-23 Ma, providing an approximate age date for this unit. Southwesterly paleocurrent data for this unit in the Valle Grande Peak area also support an origin from the Plaza center. In the northern portion of the Valle Grande Peak quadrangle, the Cordito is surprisingly thick (exceeding 100 meters), thinning noticeably to the south (<50 meters). Moderately consolidated layers in this unit now form eastward-tilted mesas in the northern and western portions of the quadrangle.

The youngest Tertiary unit in the Valle Grande Peak area is the Tesuque Formation, overlying the Cordito gravels. Rift-related structural lows have preserved this deposit in the southern portion of the quadrangle. These sandstones, silts, and gravels exhibit the characteristic orange color of the Tesuque Formation throughout the Española Basin. Dacite lava clasts with large phenocrysts of plagioclase are abundant in this unit, derived perhaps from late-stage eruptions associated with the Plaza volcanic center. The composition of the volcanic gravel appears to be consistent with that of the Plaza lithosome of Ingersoll et al. (1990), derived from a source north of Servilleta Plaza. In addition, the monolithic character of the volcanic clasts, plus the lack of Amalia tuff, are consistent with this interpretation. The nature of the bedding is consistent with a high-energy alluvial fan or alluvial slope depositional environment.

Since the deposition of the Tesuque Formation in the Valle Grande Peak area, Rio Grande rift-related faulting has profoundly affected the region’s geography. The accompanying cross section to this report traverses the quadrangle from west to northeast (including a bend in the section), roughly perpendicular to the dominant structural grain, including the Proterozoic fold axes. The largest fault in the quadrangle (unnamed) trends NNW-SSE along the eastern Arroyo Seco canyon wall. This fault traverses the entire quadrangle, exiting to the north in the upper reaches of the Cañada del Potrero canyon. Maximum estimated throw on this fault is ~225 meters. This fault provides superb exposures of consolidated El Rito Formation (cliffs famous among the rock climbing community), and its basal contact with Proterozoic Vadito metarhyolite and Ortega quartzite.
Drainages in the western portion of the quadrangle are strongly impacted by this NNW-SSE structural grain, which include many down-to-the-west normal faults. The regional DEM map in Figure 1 clearly shows that several of the faults in the northwest portion of the quadrangle continue northwards for many miles. The end result of these extensional faults has been to produce an overall tilt direction to the east for individual blocks between west-down faults. Generally, the average tilt of Tertiary strata in the quadrangle is between 10-15 degrees to the east.

The second largest fault in the Valle Grande Peak quadrangle trends NE-SW from the intersection of Cañada del Potrero and Arroyo Seco canyons towards the western portion of the Ortega Mountains. This fault also provides superb exposures of the El Rito Formation, and produced some slickensides indicating oblique motion. Faults crosscutting the Abiquiu Formation and Cordito gravels were difficult to trace due to their poor exposure at the surface and abundance of colluvial float.

Severe incision of the landscape by streams has occurred since the later part of the Pliocene epoch. The highest terrace in the El Rito area, believed to represent a Late Pliocene surface (Koning, in progress), is preserved in the southwestern corner of the quadrangle. Remnants of this terrace are preserved approximately 1 km west of the intersection of Cañada del Potrero and Arroyo Seco canyons, at elevations between 7800 and 7900 feet. The modern Cañada del Potrero and Arroyo Seco streams have carved downwards at 400 feet since that time. Cañada del Potrero and other streams in the quadrangle display superb examples of superposition, as they have carved downward into mounds of Proterozoic Ortega quartzite, despite the existence of softer rock adjacent to these exhumed mounds.

Unit Descriptions

Listed below are physical descriptions of the mapped rock units in the quadrangle. Mapping was conducted primarily in the field, utilizing the USGS 7.5-minute topographic base map, GPS, and aerial photographs. In addition, one week was spent utilizing the PG-2 photogrametric plotter at the national USGS center in Denver. Surface deposits less than 1 meter in thickness were not mapped. In general, colluvium was
mapped only in areas of structural complexity, typically covering faults or uncertain stratigraphic boundaries.

**Quaternary Units**

**Qal – Alluvium.** Late Pleistocene to Holocene. Alluvial deposits in modern drainage bottoms and elevated basins. Deposits include conglomerates, sands, and silts. They are typically beige to light gray and consist mostly of fine to medium-grained sands with lesser amounts of silt and conglomerates. Composition of clasts varies depending on source areas. Holocene terrace deposits less than 2 meters above drainage bottoms are also included. Maximum thickness is estimated to be less than 5 meters.

**Qt – Holocene terrace deposits.** Late Pleistocene to Holocene. Terrace deposits adjacent to modern creek bottoms, though more than 2 meters above the drainage bottom. Most are fill terrace deposits of sand, silt and gravel < 10 m above modern drainages. These deposits include sand, gravel, and conglomerate. Thickness less than 5 meters.

**Qc – Colluvium.** Late Pleistocene to Holocene. Poorly sorted talus, debris, and other rock fragments derived from local metamorphic and sedimentary rocks. Often occurs as wedge-shaped hillslope deposits. Poorly consolidated units, including the Ritito and Abiquiu Formations, are typically expressed at the surface as colluvial clasts and often obscure contacts between units. Also, cobble and boulder alluvial facies of the generally well consolidated El Rito Formation produce significant colluvium. Although pervasive throughout the quadrangle, colluvium was seldom mapped. Maximum thickness is approximately 5 meters.

**Qca – Colluvium and alluvium.** Late Pleistocene to Holocene. Mapped only in a few valley sides and bottoms where colluvial and alluvial facies are intermixed. Sandy alluvial beds with minor gravel and muddy beds preserved as terrace-like features on top sandstone benches and capping Tertiary units. Thickness ranges from 0.5 to almost 2 meters.
**Ql Landslide.** Pleistocene to Holocene. Unsorted, chaotic debris emplaced during a single detachment event from a steep slope or cliff, generally containing a sediment matrix. Can also occur as a block detachment along the flanks of a steep hillslope. Fan-shaped deposits occur where debris spread out on valley floor. Thickness can exceed 20 meters.

**Qta Alluvium and terrace deposits.** Pleistocene to Holocene. Holocene alluvium and terrace deposits undifferentiated along modern drainage bottoms. Thickness is less than 5 meters.

**QTg High-level alluvium and terrace deposits.** Late Pliocene to Pleistocene? Sand, silt, and conglomerate deposited on high-level surfaces more than 15 meters above modern drainages. In the southwestern portion of the quadrangle, these include strath terrace deposits that correlate to the Qt2 terrace mapped in the Canjilon SE quadrangle (Kempter et al., 2007), and to the highest terrace in the El Rito quadrangle currently mapped by Koning et al., (in progress). Guaje tephra from the Toledo Caldera eruption at ~1.6 Ma deposited on the El Rito high terrace suggests a minimum age for these deposits and surfaces in the Valle Grande Peak quadrangle. Older alluvial deposits along the southern portion of Borracho Canyon, west of Vallecitos, are also included in this unit. Actual thickness of sediment can vary from 1 to 15 meters.

**Ttp Tesuque Formation** - Coarse-grained Plaza lithosome deposits (middle Miocene to upper Oligocene) – Slightly tuffaceous, pebbly sand and sandy pebbles in thick channel-fills possessing very thin to medium, lenticular to planar beds and laminations. Local planar cross-stratification 25 cm-thick. Gravel are matrix- to clast-supported, subrounded, poorly sorted, and consist of very fine to very coarse pebbles and minor cobbles and boulders. Clasts consist of purplish gray, porphyritic dacite (possible rhyodacite or andesites may also be present); light gray, white, and pinkish white dacites that often are weathered and have 10-15% mafic phenocrysts and less than 15% plagioclase phenocrysts; 1-20% quartzite; and less than 10% rhyolite and welded tuffs.
Channel-fill sand is brown to light gray (10YR 5/4-7/2; 10YR 6/2-3), very fine to very coarse-grained but mostly medium- to very coarse-grained, and poorly sorted. Medium to very coarse sand is subrounded to subangular and composed of volcanic grains with 10-25% quartz and plagioclase. Very fine to medium sand consists of subangular plagioclase and quartz, 7-15% mafic grains, and 1-5% volcanic grains. Channel-fill sand may include 0-2% clay and silt and 1-5% tuff. Unit includes minor beds of pink to reddish yellow (7.5YR 7/3-4 and 6/6) very fine- to medium-grained sand and clayey-silty very fine- to medium-grained sand beds that are medium to thick, tabular, and internally massive to planar-laminated; these beds may include minor (1-20%), scattered medium to very coarse, subrounded, dacite(?) sand grains (and locally up o 2% volcanic pebbles). This relatively fine sand is subangular to subrounded, moderately to poorly sorted, and consists of quartz and plagioclase with 15-25% potassium feldspar or orange-stained quartz, 3-5% mafic grains, and 1-5% volcanic grains. The fine sand beds are well consolidated and perhaps weakly cemented. Well consolidated and weakly to moderately cemented by calcium carbonate and calcium carbonate. Imbrication and channel-margin data indicate west to southwest paleoflow directions. The term “Plaza lithosome” is slightly modified from the Plaza petrosoome of Ingersoll et al. (1990), and may in the future be proposed as a member of the Tesuque Formation. Volcanic clasts in the Plaza petrosoome returned K/Ar ages of 21-23 m.y. (Ekas et al., 1985; Ingersoll et al., 1990), so this unit probably post-dates 20 Ma. The heterolithic upper unit of the Plaza lithosome (Koning et al., 2008) is not found on this quadrangle, so what is preserved is probably the lower to middle parts of the Plaza lithosome. These particular strata appear to pre-date the Pojoaque white ash zone (13.2-14.0 Ma; Koning et al., 2007), as discussed in Koning (2008). Thickness of 80-90 m present in the southeastern part of the quadrangle, but that does not represent the complete thickness of the unit.

**Tta Tesuque Formation** - Tuffaceous sand and pebbly sand similar to Abiquiu Formation but interbedded in lithosome P of the (lower Miocene) – White to light gray, very fine- to very coarse-grained sand and pebbly sand. Pebbles are very fine to very coarse, subrounded, poorly sorted, and consist of probable dacite (as in lithosome P) and subordinate quartzite; minor cobbles in this unit are of quartzite. Very minor pebbles of
weathered, biotite-bearing tuff. Sand is mostly subangular to subrounded, moderately to poorly sorted, and consists of quartz and plagioclase with 3-5% biotite (and other mafics) and 3-8% subrounded volcanic grains; estimate 1-15% tuff. Biotite grains are subhedral and fresh-looking. Moderately consolidated and non-cemented. Unit is interbedded in the lower lithosome P of the Tesuque Formation, and probably 18-20 Ma. Approximately 6 meters thick.

*Tlpc Cordito member, Los Pinos Formation.* Oligocene to Lower Miocene. Beige to light brown to orange gravelly sandstone and conglomerate. Gravel horizons are typically clast supported and poorly sorted, with planar and trough cross-stratification. Cementation is highly variable, ranging from poorly consolidated to well consolidated. Where consolidated, this unit can be well exposed, exhibiting bedding features and providing resistant surfaces for many eastward-tilted mesas in the quadrangle (Figure 3). Where unconsolidated, this unit is exposed primarily as hillslope colluvium. Volcanic clasts in this unit include crystal-poor, flow-banded rhyolite lava, crystal-rich rhyolite lava, Amalia Tuff, other volcanic tuffs, and dacite lava. Though variable throughout the section, a typical clast count yielded 40% quartzite, 12% schist, 5% quartz vein, 25% crystal-poor rhyolite, 5% crystal-rich rhyolite lava, and 12% dacite lava. The relatively abundant gray rhyolite and welded tuffs serve to distinguish this unit from the overlying Plaza lithosome of the Tesuque Formation. Paleocurrent indicators from this unit suggest transport in a westerly to southwesterly direction. Field mapping reveals this unit is gradational with the underlying Abiquiu Formation, which contains a more tuffaceous matrix. Dating of individual volcanic clasts by Ingersoll et al (1990) give K-Ar ages of 24-28 Ma, providing a general estimate for the age of this unit. Thickness is greatest in the northern portion of the quadrangle, estimated at approximately 100 meters.
Ta Abiquiu Formation. Oligocene to Upper Miocene. White to beige fine-grained tuffaceous sandstones with interbedded shales and fluvial conglomerates that contain pebbles or cobbles of volcanic rocks and Proterozoic Ortega quartzite. The distinctive presence of 25.1 Ma Amalia Tuff clasts and other Ar$^{40}$/Ar$^{39}$ age data indicate that the deposition of this unit was nearly coincident with major ignimbrite eruptions in the Latir field between 24-25.2 Ma (Smith et al., 2002). Though variable, a typical clast count from this unit yielded 30% Proterozoic rocks, 6% crystal-rich rhyolite lava, 12% volcanic tuff, and 52% crystal-poor rhyolite lava. Gravels and conglomeratic lenses increase towards the top of the unit, grading into the overlying Cordito Member of the Los Pinos Formation (Figure 4). The lower part of the unit consists of broadly lenticular and planar reworked tephra deposits with abundant volcanic ash (Figure 5). Occasional boulder
conglomerates (boulders up to 0.8 meters across) are interbedded with the sandstones, but are less than 2 meters thick. Boulders of quartzite, Amalia Tuff, and rhyolite lava are common. Crystals of quartz, feldspar and biotite are often well preserved in the tuffaceous sandstone. Gravel lenses also occur, with poorly sorted angular volcaniclasts less than 1 cm across with very little matrix. Paleoecurrent data imply a southwesterly flow for these deposits. Field evidence suggests the Abiquiu Formation thins to the north as the overlying Cordito Member thickens. Maximum thickness is approximately 75 meters.

Figure 4. Upper part of the Abiquiu Formation where it is transitional with the Cordito Member of the Los Pinos Formation.
**Tb Basalt lava.** Oligocene. Weathered green to dark gray to black, olivine-bearing basalt. Only two exposures of this unit were found in the quadrangle and it is not known if they represent separate flows. Near Arroyo Seco springs, a phenocryst-poor basalt flow lies at the contact between the Ritito and Abiquiu Formations. This pervasively altered flow outcrops as greenish clay with residual cores of dark gray basalt that can be flow banded and vesicular (Figure 6). A red paleosol is typical at the top of the flow. The second exposure of basalt in the quadrangle occurs in the northeastern corner of the quadrangle along Cañada del Agua. This vesicular, flow-banded basalt is also phenocryst poor but not as pervasively altered. No rock unit could be found underlying this flow, so the stratigraphic position of this flow is uncertain. It may occur within the Abiquiu Formation and not at its base. Most likely these two flows correlate to the Hinsdale basalt and were emplaced sometime between 22-27 Ma. (Lipman and Mehnert, 1975 and 1979; Baldridge et al., 1980) A similar basalt flow near Ojo Caliente yielded an age of ~22 Ma (Baldridge et al., 1980). Maximum thickness of exposed basalt is ~20 meters.
Figure 6. Top of deeply altered basalt flow (green clay) near Arroyo Seco springs, capped by paleosol and the Abiquiu Formation.

**Tr Ritito Formation.** Oligocene. Gray piedmont alluvial fan deposits, commonly conglomeratic and mildly arkosic. Sandy matrix can be light brown, brown, to reddish brown. This unit is poorly consolidated throughout the quadrangle, exposed primarily as colluvial float on hillslopes. The poorly bedded nature of the deposit is suggestive of a depositional environment of braided streams and debris flows. Clasts in the conglomerate are typically subrounded to rounded (up to 0.7 meters across), consisting of Proterozoic Ortega quartzite, schists, metagranite, and a variety of metavolcanic rocks. Although quartzite is the dominant clast, the remaining metamorphic clasts typically make up 20 to 40% of the deposit. Locally, dacite lava clasts occur in the deposit, but were not observed to exceed 5% of the clast total. In the upper part of the deposit there is commonly a tuffaceous matrix, similar to the overlying Abiquiu Formation. Previously classified as the Lower Abiquiu Formation (references), Maldonado and Miggins (2007) have referred to this unit as the conglomerate of Arroyo del Cobre. The age of this unit is not well constrained at this point in time. Basalt flows that overly the Ritito Formation in
the Las Tablas quadrangle suggest an age of > 27 Ma (Koning et al, 2006). Maximum thickness of this unit is 50 meters.

**Te El Rito Formation.** Eocene. Red-stained quartzite conglomerate. Sub angular to very well rounded cobbles and boulders of quartzite. Remarkable boulder conglomerate facies with boulders up to 2 meters across are exposed in prominent cliffs along El Rito and Arroyo Seco canyons (Figures 7 and 8). At the base of these cliff exposures the basal contact of the conglomerate with underlying Proterozoic rocks is exposed (Figure 9).

![Figure 7. Red cliffs of El Rito Formation conglomerate in Arroyo Seco canyon. Rock climber for scale (white arrow).](image)

Clasts are dominantly quartzite (typically ~90%), but can also include other Proterozoic rocks, in particular metavolcanics of the Vadito Group. The bluish-gray quartzite clasts are stained red on their outer surfaces. Although this unit is typically well consolidated, poorly consolidated exposures also occur. 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 a syn-orogenic basin between Laramide highlands in the Sierra Nacimiento.
to the west and the Tusas Mountains to the northeast. Near the top of the unit lenticular red sandstones can be interbedded with the conglomerate. Maximum thickness is approximately 100 meters.

Figure 8. Pilar of El Rito Formation conglomerate with rock hammer for scale.
**Pc  Cutler Group, Arroyo del Agua Formation (?).** Early Permian. Orange to red siltstone, sandstone and minor intraformational and extraformational conglomerate. Sandstone beds are arkosic and trough crossbedded. This unit underlies El Rito Formation conglomerates in the El Rito Creek canyon in the southwest corner of the quadrangle. Only the sandstone beds are exposed, tilting to the northwest and in angular unconformity with the overlying El Rito Formation. A second possible outcrop of this unit is exposed at the base of the Potrero canyon falls, where a red, arkosic sandstone overlies the Ortega quartzite. Maximum thickness of this unit in the quadrangle is ~70 meters.

**Xo  Ortega quartzite.** Proterozoic. Massive gray to bluish gray quartzite that often preserves original bedding structures (Figure 10). Medium to coarse-grained, vitreous cross-bedded quartzite consisting mostly of quartz with minor amounts of muscovite, kyanite, and layers of hematite. Some horizons are schistose and micaceous, with mica concentrated along bedding planes. Locally brecciated, especially near major faults and
fold axes. Vein quartz common. The quartzite has been subjected to polyphase ductile deformation, multiple generations of folding and faulting, and lower greenschist to upper amphibolite grade metamorphism. This unit forms all of the high peaks and ridges of the Ortega Mountains, but also occurs as small exhumed mounds in several valley bottoms, where superposed streams have cut narrow slot canyons through the quartzite (Figure 11). Williams et al (1999) interpret the primary metamorphic age of the Ortega quartzite to be ~1.65 Ga. Maximum exposed thickness in the quadrangle is ~200 meters, although this unit is interpreted to be over a kilometer in thickness (Koning et al, 2007).

Figure 10. Ortega quartzite showing remnant cross stratification bedding.
Xv Vadito Group Metavolcanic Schist. Proterozoic. White to light pink metarhyolite, consisting principally of fine-grained quartz, feldspar, muscovite, and opaques (Figure 12), with quartz and feldspar (?) porphyroblasts. This unit is only exposed along the uplifted eastern wall of Arroyo Seco canyon where it is overlain by the El Rito Formation conglomerate. Large blocks of the schist (up to 1 meter across) are incorporated into the basal El Rito conglomerate. This unit may correlate to the Cerro Colorado metarhyolite and the Arroyo Rancho metarhyolite (Bishop, 1997) found in the Ojo Caliente quadrangle, as well as to the Burned Mountain metarhyolite (Barker, 1958), and unit fs of Bingler (1965). The Cerro Colorado metarhyolite has been dated at ~1.70 Ga based on zircons (Bishop, 1997) and has been interpreted to have originally been ash flow tuffs (Just, 1937; Jahns, 1946; Treiman, 1977).
Figure 12. Vadito Group metavolcanic schist.
References


Lombardi, C.L., 1997, Proterozoic geology of the La Madera Quadrangle, north-central New Mexico [MS thesis]: University of Massachusetts, Amherst.


