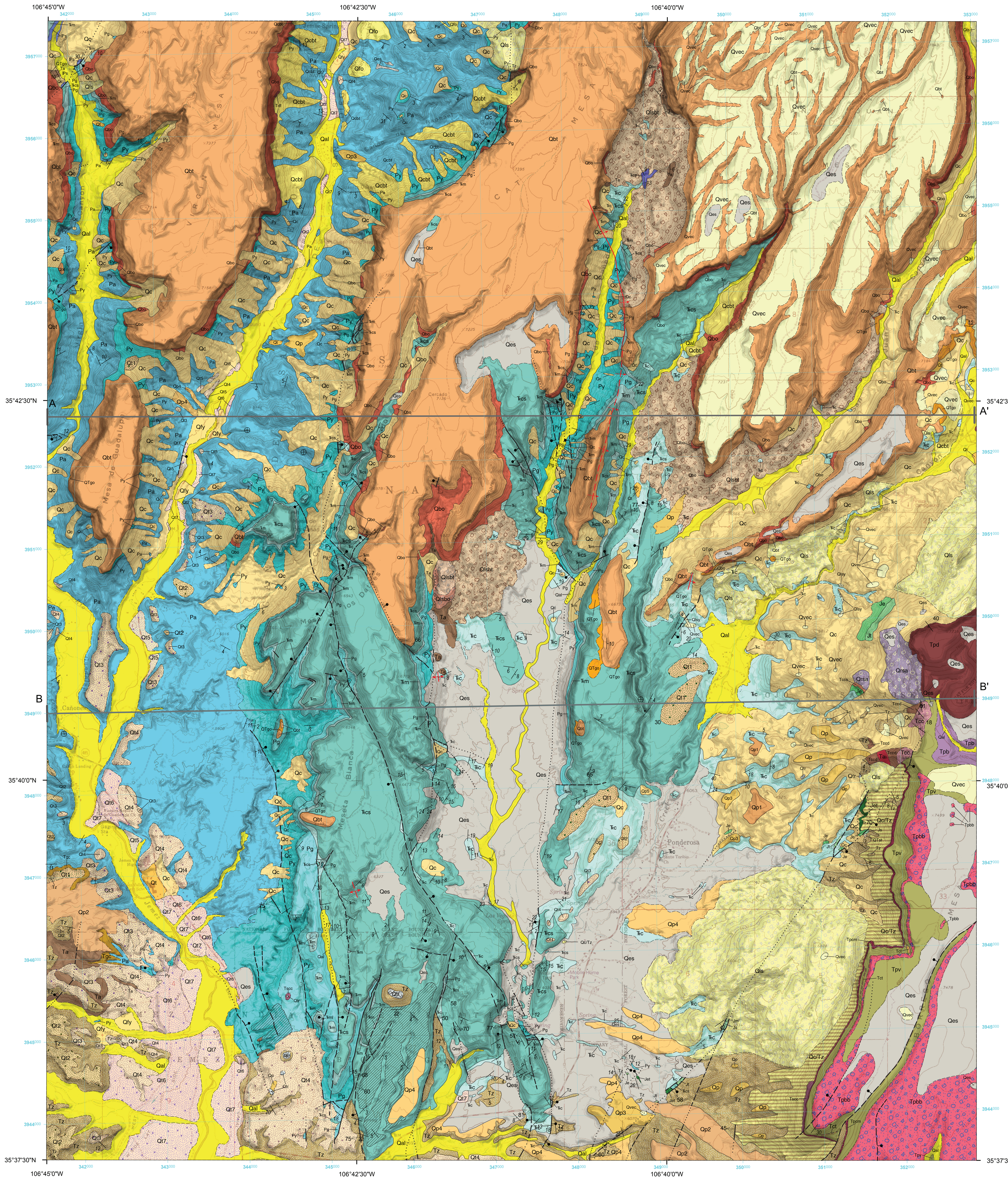
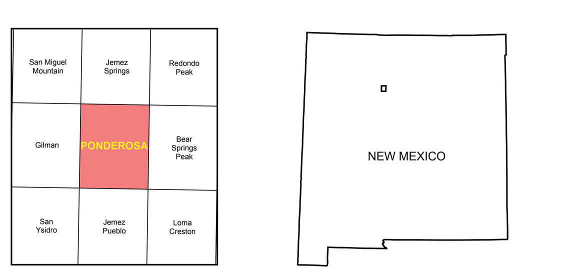
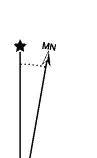


Base map from U.S. Geological Survey 1970, from photographs taken 1965, field checked in 1970, edited in 1993.
1927 North American datum, UTM projection -- zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in blue



QUADRANGLE LOCATION



Magnetic Declination
May 2004
10º 25' East
At Map Center

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

[575] 835-5490

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

http://geoinfo.nmt.edu

1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 57

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*).

Geologic map of the Ponderosa quadrangle, Sandoval County, New Mexico.

May 2002

by

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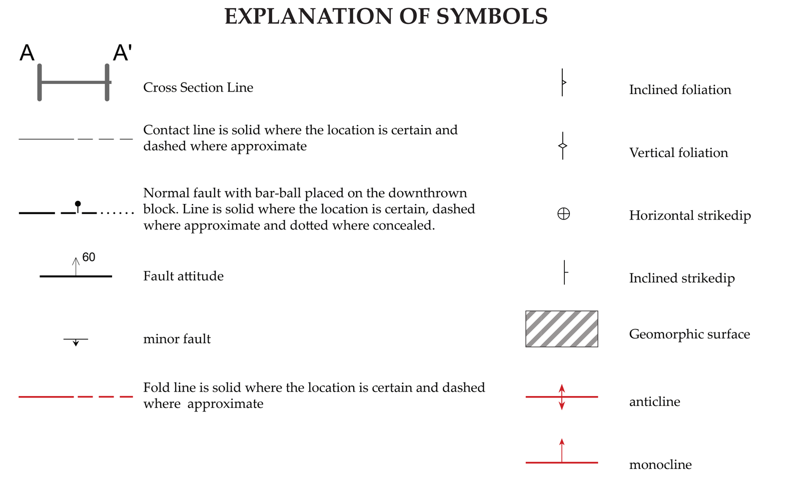
EXPLANATION OF SYMBOLS

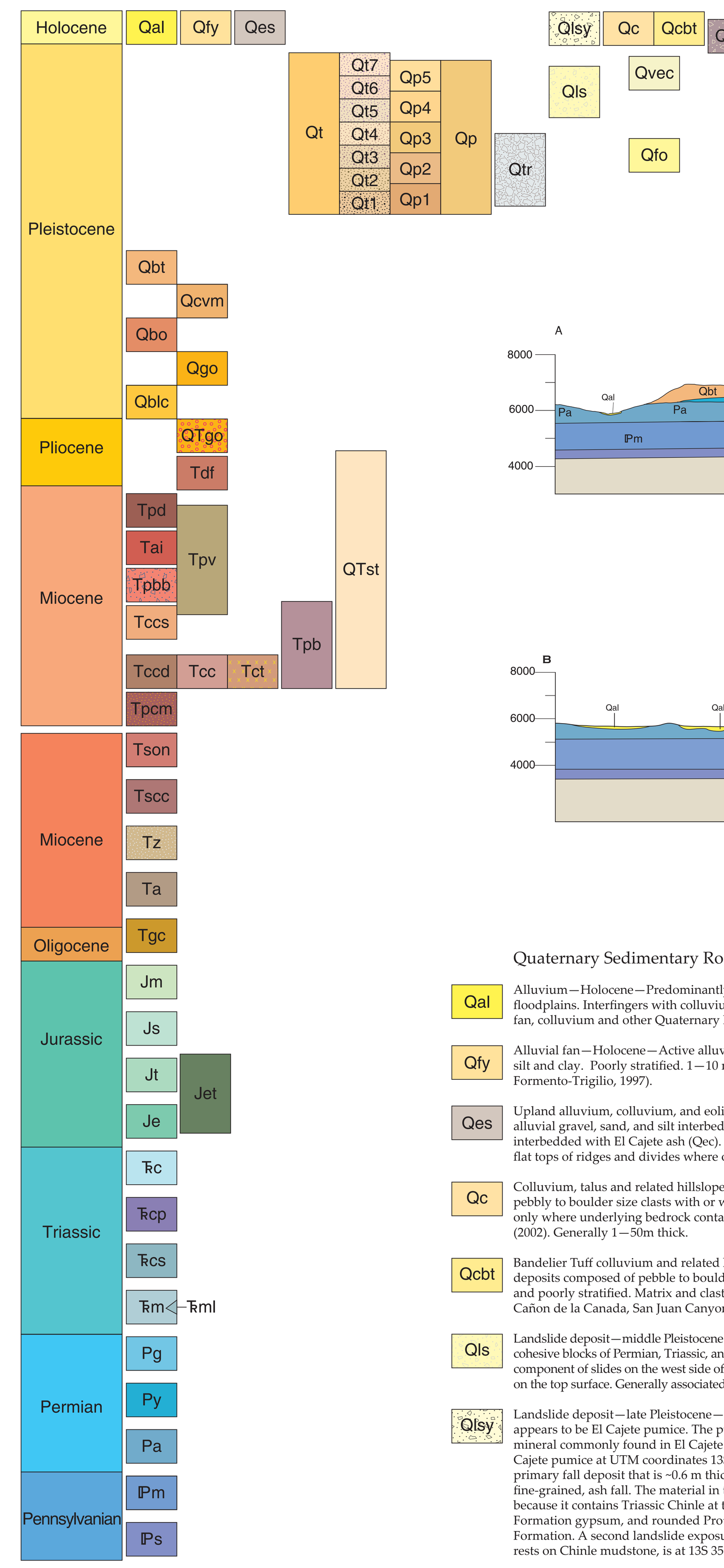


COMMENTS TO MAP USERS

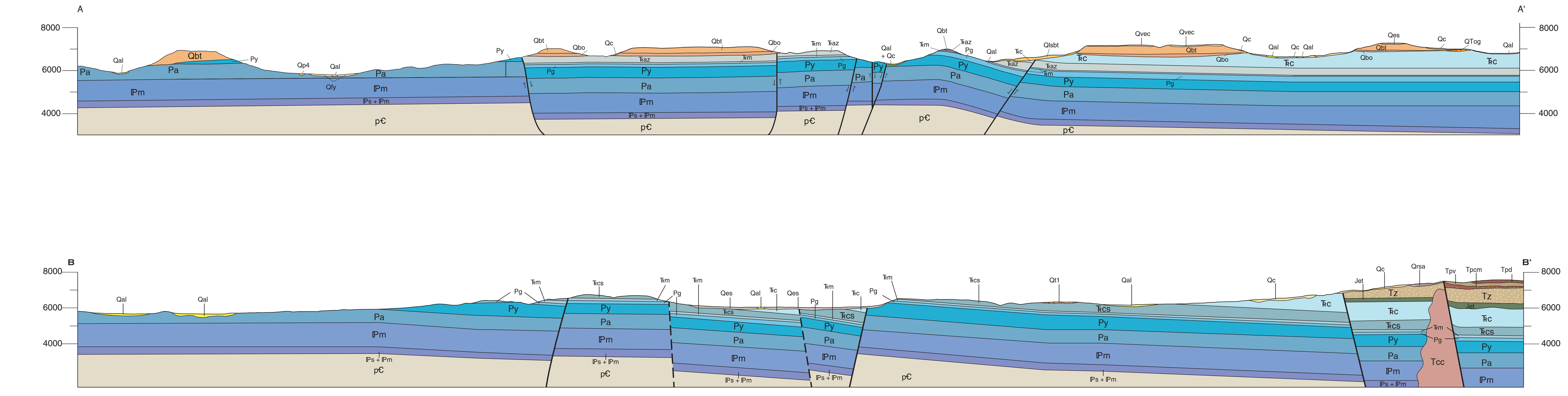
A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic 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.

CORRELATION CHART



CROSS SECTIONS



UNIT DESRIPTIONS

Quaternary Sedimentary Rocks

Qal Alluvium—Holocene—Predominantly gravel, sand, silt, and clay underlying modern drainage channels and floodplains. Interfingers with colluvium toward drainage side-slopes. Locally contains small amounts of alluvial fan, colluvium and other Quaternary lithotypes. Generally < 3m thick.

Qfy Alluvial fan—Holocene—Active alluvial fans composed primarily of cobble and boulders with matrix of sand, silt and clay. Poorly stratified. 1—10 m thick. One is dated at 1660 ± 70 radiocarbon years BP (Beta # 85445; Formento-Trigilio, 1997).

Qes Upland alluvium, colluvium, and eolian deposits, undivided—Holocene to upper Pleistocene (?)—Poorly sorted alluvial gravel, sand, and silt interbedded with fine-grained, well-sorted eolian sand and silt. May be locally interbedded with El Cajete ash (Qec). Commonly found in flat, broad areas adjacent to major drainages on the flat tops of ridges and divides where other alluvial units are not mapped. Generally < 10 m thick.

Qc Colluvium, talus and related hillslope deposits—Undivided hillslope deposits consisting of locally derived pebbly to boulder size clasts with or without finer matrix. May be clast or matrix supported. In general, mapped only where underlying bedrock contacts were obscured. Extensively subdivided by Frankel and Pazzaglia (2002). Generally 1—50m thick.

Qcbt Bandelier Tuff colluvium and related hillslope deposits—middle Pleistocene to Holocene (?)—Hillslope colluvial deposits composed of pebble to boulder size clasts of Bandelier Tuff derived from mesa cap rocks. Poorly sorted and poorly stratified. Matrix and clast supported. Significant accumulations found in Cañon de San Diego, Cañon de la Canada, San Juan Canyon, and Paliza Canyon. Generally from ~5—50 m thick.

Qls Landslide deposit—middle Pleistocene to Holocene—Undivided landslide deposits composed of locally derived, cohesive blocks of Permian, Triassic, and Miocene bedrock, and Bandelier Tuff. The Zia Formation is a common component of slides on the west side of Borrego Mesa; these slides commonly have reworked El Cajete pumice (Qvec) on the top surface. Generally associated with a head scarp in their source area. Varies in thickness from ~5—50 m.

Qlsy Landslide deposit—late Pleistocene—Two landslide deposits just northeast and east of Ponderosa overlie what appears to be El Cajete pumice. The pumice, which has not been dated at these localities, contains biotite, a mineral commonly found in El Cajete pumice. Thus, the landslides are likely to be younger than 60 ka. The El Cajete pumice at UTM coordinates 13S 351329 3950183 (NAD27) on National Forest land, is a weakly- stratified primary fall deposit that is ~0.6 m thick . In an exposure just to the south, the El Cajete Pumice is overlain by a fine-grained, ash fall. The material in this slide is different than the debris in the other landslides in the area because it contains Triassic Chinle at the base, overlain by Jurassic Entrada Sandstone, Jurassic Todilto Formation gypsum, and rounded Proterozoic granite and quartzite clasts that are likely from the Cerro Conejo Formation. A second landslide exposure, with Chinle mudstone sliding over El Cajete pumice, which in turn rests on Chinle mudstone, is at 13S 350758 3948958 (NAD 27) on private land.

Qrsa Andesite rockslide deposit—middle Pleistocene to Holocene—Rockslide composed of cobble to house size clasts of andesite. Generally related to a prominent head scarp along the west side of Borrego Mesa. Poorly stratified. Generally 5—50 m thick.

Qt Terrace deposits—middle Pleistocene to Holocene—Alluvial silt, sand, cobble, and boulder deposits of volcanic, sandstone, and granitic provenance overlying distinct straths and underlying discrete treads related to the large modern drainages of the Jemez River and Vallecito Creek. Commonly exhibits a coarse, fine, coarse alternating Pleistocene stratigraphy.

Qt7 Terrace deposits—Holocene—Red to tan, fine-grained silt and sand alluvial fill with locally well-rounded cobbles. Treads are up to ~3 m above modern drainages. Strath is ~1—2 m above active channel. Age of deposit along the Jemez River is 3160 ± 60 radiocarbon years (LLNL # 24692; Formento-Trigilio, 1997) and 4530 ± 40 radiocarbon years (Beta # 160851) along Vallecito Creek. ~1—5 m thick. Qt6 of Formento-Triglio (1997).

Qt6 Terrace deposits—Holocene—Fine grained, red to tan alluvial silt and sand alluvial fill. Strath is < 8 m above active channel. Qt5 of Formento-Trigilio (1997). ~1—5 m thick.

Qt5 Terrace deposits—late Pleistocene—Coarse grained gravel and and boulder material interbedded with pebbly sand. Clasts are composed of 24% Bandelier Tuff, 20% Tertiary volcanics, 14% Banco Bonito (~60 ka) in the Jemez River valley (Reneau et al., 1996, Formento-Trigilio, 1997). Qt4a of Formento-Trigilio (1997). Strath is ~10 m above active channel. ~8—10 m thick.

Qt4 Terrace deposits—middle to late Pleistocene—Alluvial sands and gravels composed of 34% Bandelier Tuff, 20% Madera Limestone, and 13% Precambrian granite with lesser amounts of Permian sandstone and Tertiary volcanics in the Jemez River valley. Locally cemented by calcium carbonate. A late Pleistocene/early Holocene soil is developed in an eolian deposit on the terrace tread that buries a Bk soil horizon with Stage II carbonate development. ~9 m thick. Highly variable strath topography ranging from 4 to 36 meters above active channel (Formento-Trigilio, 1997).

Qt3 Terrace deposits—late to middle Pleistocene—Coarse, stratified, sandy gravel deposit composed of 41% Bandelier Tuff, 17% Madera Limestone, 17% Precambrian granite and lesser amounts of Permo-Triassic sandstone in the Jemez River valley. Strath exhibits up to 1 m of relief and ranges from 30 to 63 m above modern channel. ~10 m in thickness. An Ochric A soil horizon overlies a Bk soil horizon with Stage II—III carbonate development beneath the tread. (Formento-Trigilio, 1997).

Qt2 Terrace deposits—middle Pleistocene—Coarse-grained sand and gravel interbedded with fine-grained, cross-bedded, sand and silt. Deposit is ~13 m thick. Gravels are composed of 32% Bandelier Tuff, 17% Madera Limestone, 19% Precambrian granite and lesser amounts of Permo-Triassic sandstones in the Jemez River valley. Strath is characterized by up to 1 m of relief and ranges from 61 to 84 m above active channel. Tread exhibits an incomplete K soil horizon with Stage III+ carbonate development. (Formento-Trigilio, 1997).

Qt1 Terrace deposit—middle Pleistocene—Coarse sand and gravel interbedded with fine-grained silt and sand. Deposit is ~14 m thick Gravels are composed of 27% Madera Limestone, 27% Bandelier Tuff, and 23% Precambrian granite with lesser amounts of Tertiary volcanics, quartzite, and chert in the Jemez River valley. Locally cemented by calcium carbonate. Reworked Lava Creek B ash (640 ka; Dethier, 2001) is locally present in fine-grained layers. Tread exhibits an incomplete K soil horizon with Stage III+ carbonate development. Strath ranges from 83—100 m above modern channel (Formento-Trigilio, 1997).

Qp Pediment deposits—early to late Pleistocene—Alluvial deposits of various clast compositions relating to source in ephemeral tributary drainages. Generally composed of cobble to boulder size clasts. Deposits are of variable thickness and have straths of variable topography that is often obscured by colluvium derived from the pediment deposit. Treads of deposits are relatively flat and grade back towards mesas.

Qp5 Pediment deposit—middle to late Pleistocene—Piedmont alluvial deposits found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of Triassic bedrock and basalt from Borrego Mesa as a function of source area and drainage. Deposit is ~5—10 m thick. Correlative with Qt5 terrace elevations.

Qp4 Pediment deposit—middle to late Pleistocene—Piedmont alluvial deposits found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of Triassic bedrock, Bandelier Tuff, and basalt from Borrego Mesa as a function of source area and drainage. Deposit is ~5—10 m thick. Correlative with Qt4 terrace elevations.

Qp3 Pediment deposit—early to middle Pleistocene—Piedmont alluvial deposits found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of Triassic and Permian bedrock, Bandelier Tuff and basalt derived from Borrego Mesa as a function of source area and drainage. Deposit is ~10—15 m thick. Correlative with Qt3 terrace elevations.

Qp2 Pediment deposit—early to middle Pleistocene—Piedmont alluvial deposits found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of Tertiary (Miocene) bedrock and basalt derived from Borrego Mesa as a function of source area and drainage. Deposit is ~10—15 m thick. Correlative with Qt2 terrace elevations.

Qp1 Pediment deposit—early to middle Pleistocene—Piedmont alluvial deposits found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of basalt derived from Borrego Mesa. Deposit is ~5—10 m thick. Correlative with Qt1 terrace elevations.

Qp Pediment deposit—early to late Pleistocene—Undivided piedmont alluvium found on relatively flat treads grading back towards mesas. Composed of cobble to boulder size clasts of Bandelier Tuff, Triassic and Permian bedrock, and basalt as a function of source area and drainage. Ranges in thickness from ~5—15 m.

Qtr Travertine deposit—Middle to late Pleistocene—Light gray irregularly bedded limestone or travertine. One travertine deposit overlies pink to tan fluvial sandstones of uncertain age (Arroyo Ojito Formation?) on the south-dipping Glorieta Sandstone surface east-southeast of Red Rocks. Further south, travertine sits on the pediment gravel and is reworked into the base of the Qt4 terrace gravel. This relationship suggests that the travertine is older than 150,000 ± 50,000 years, the estimated age of the Qt4 terrace (Formento-Trigilio and Pazzaglia, 1998) and is younger than the pediment gravel. The elevation of the pediment gravel appears to correspond to 400,000 ± 100,000 year Qp2 (Formento-Trigilio and Pazzaglia, 1998). A second, more extensive travertine deposit is located north of Vallecitos Creek and rests on Zia Sandstone. A small deposit of banded travertine with alternating, millimeter scale, white, brown, and gray layers is located east of Ponderosa. 1—3 m thick.

Qfo Old Alluvial Fan—middle to late Pleistocene (?)—Old, inactive alluvial fans perched at positions in landscape above modern streams. The fan is composed of generally stratified silt to boulder size alluvium containing clasts of rounded Abo and Yeso sandstone, with some Bandelier Tuff, especially near the base of the deposit, and quartzite pebbles recycled out of the Abo Formation. Unit is underlain by Permian Abo Formation and is locally overlain by Bandelier Tuff colluvium. ~ 5 - 10 m in thickness.

Quaternary Volcanic and Volcaniclastic Sedimentary Rocks (Tewa Group)

Qvec El Cajete pumice (El Cajete Member of Valles Rhyolite)—middle to late Pleistocene—White to tan, moderately sorted, pyroclastic fall deposits of vesicular pumice containing sparse phenocrysts of quartz, biotite, and plagioclase with rare microphenocrysts of hornblende and clinopyroxene; Qec originated north of map area from E1 Cajete crater in southern moat of Valles caldera (Bailey et al., 1969; Smith et al., 1970; Gardner et al., 1986; Self et al., 1988; Wolff and Gardner, 1995); unit dated at about 50—60 ka (Toyoda et al., 1995; Reneau et al., 1996). Maximum exposed thickness about 10 m in northeast part of map area, where the unit forms extensive mesa top cover on San Juan Mesa. Primary fall deposits that are 1—2 m thick are locally preserved under landslides and colluvium northeast and northwest of Ponderosa. In the eastern and southeastern parts of the map area, the El Cajete pumice is thin (~15 cm) and has been fluvially reworked.

Qbt Bandelier Tuff , Tshirege Member—early Pleistocene—White to orange to pink non-welded to welded rhyolitic, ash-flow tuff (ignimbrite). Qbt, which originated from catastrophic eruptions that formed the Valles caldera, forms conspicuous orange to tan mesa-capping cliffs. The tuff contains abundant phenocrysts of sanidine and quartz, rare microphenocrysts of black clinopyroxene and trace microphenocrysts of hypersthene and fayalite. The sanidine typically displays blue iridescence. A thin (<2 m) laminated, pumice fall and surge deposit (Tsankawi Pumice Bed) that contains ~1% hornblende dacite pumice (Bailey et al., 1969) is present at the base of unit. The tuff consists of multiple flow units in a compound cooling unit (Smith and Bailey, 1966; Broxton and Reneau, 1995). Cooling units that likely correlate to units 1g, 1v, 2, and 3 on the Pajarito Plateau (Broxton and Reneau, 1995) are present on the tuff-capped mesas on the quadrangle. Welded unit 2 forms the pronounced dark gray band in the tuff cliffs of San Juan Canyon and Cañon de San Diego. The white tuff (unit 3?) on top of the mesas in the northern part of the Ponderosa quadrangle contains 5—10% accidental lithic fragments of older country rock entrained during venting and pyroclastic flow. 40Ar/39Ar age is 1.25 ± 0.01 Ma (Phillips, 2004). Maximum observed thickness ~140 m.

Qcvm Virgin Mesa Member, Cerro Toledo Formation—early Pleistocene—Not shown on map, but exposed in cliff walls in Virgin Canyon and Cañon de San Diego east and west of Virgin Mesa. This gravel is also exposed on the west side of Mesa de Guadalupe. Fluvial gravel and sandstone deposits underlying the Tsankawi Pumice Bed of the Tshirege Member of the Bandelier Tuff and overlying the Otowi Member of the Bandelier Tuff. At southern tip of Mesa de Guadalupe, this gravel lies beneath the Tshirege Member of the Bandelier Tuff and contains rounded pieces of lithic-rich tuff interpreted to be the Otowi Member of the Bandelier Tuff. Clasts from the west side of Mesa de Guadalupe include Proterozoic granite (1—60%), Proterozoic quartzite (0—10%), Pennsylvanian Madera Limestone (0—5%), Permian (Abo, Yeso, Glorieta) sandstone (0—15%), Paliza Canyon Formation andesite, dacite, and basalt (10—45%), flow-banded rhyolite (0—5%), Pedernal chert (0—5%), and lithic-rich tuff (5—50%). The Proterozoic component of the gravel is as high as 70% on the west side of Mesa de Guadalupe and drops off to 1% toward the south and east (Scholle and Kelley, 2003). Much of this material is derived from erosion of the Sierra Nacimiento to the west. Clasts in the Cañon del Raphael Gallegos area include Proterozoic quartzite (0—10%), Permian sandstone (20—40%), Paliza Canyon Formation andesite, dacite, and basalt (30—45%), flow-banded rhyolite (10—15%), obsidian (0—10%), and pumice (0—10%). In some cases the volcanic clasts appear to be lithic fragments recycled from the Otowi Member; the pumice and obsidian is also from the Otowi Member (Scholle and Kelley, 2003). The sandstone clasts are often well-rounded, while the volcanic clasts are variably angular to well-rounded. Pebble imbrications indicate flow to the south (Scholle and Kelley, 2003). This unit is stratigraphically equivalent to the Cerro Toledo Interval epiclastic sediment and tephra deposits of Broxton and Reneau (1995). Ranges in thickness from ~1—6 m.

Qbo Bandelier Tuff, Otowi Member—early Pleistocene—White to pale pink, unwelded, weakly indurated rhyolitic ash-flow tuff that contains abundant (10—20%) accidental lithic fragments. Qbo, which originated from catastrophic eruptions that formed the Toledo caldera, forms conspicuous white cliffs or white slopes below Qbt. Qbo discontinuously fills in rugged topography that developed on a pre-Toledo caldera age volcanic surface and can form spectacular tent rocks; upper surface quite undulatory due to erosion. Phenocrysts of sanidine and quartz are common, and mafic phenocrysts are sparse. The sanidine may display a blue iridescence. The stratified pumice fall and surge deposit at base of unit (Guaje Pumice Bed) is generally not found in this area; in places (e.g., Cañon del Raphael Gallegos area) the pumice is <0.5 m thick. The top of the Otowi Member is vapor-phase altered and has a vapor-phase notch in San Juan Canyon in the northeastern corner of the quadrangle. The Otowi Member is difficult to distinguish from the Tshirege Member in hand sample. The Otowi Member is characterized by a poorer degree of welding, a greater tendency to form slopes instead of cliffs, more abundant lithic fragments, less abundant iridescent sanidine, and stratigraphic position beneath the Tsankawi Pumice. 40Ar/39Ar ages are 1.61 ± 0.01 to 1.62 ± 0.04 Ma (Izett and Obradovich, 1994; Spell et al., 1996). Maximum exposed thickness about 100 m.

Qgo Fluvial gravel and sandstone—early Pleistocene—Not shown on map, but exposed in cliff walls of Cañon de San Diego east of Virgin Mesa. Tan fluvial sandstone and gravel deposit between the Otowi Member and the La Cueva Member of the Bandelier Tuff. The gravel is mainly composed of imbricated Paliza Canyon Formation andesite, basalt, and dacite boulders and pebbles (~60%; Scholle and Kelley, 2003). Other clasts include Proterozoic granite (0—5%), Permian sandstone (5—20%), Pedernal chert (0—5%), and eroded La Cueva Member and pumice (5—10%). Maximum of 4 m thick.

Qblc La Cueva Member—early Pleistocene—Not shown on map, but exposed in cliff walls in Cañon de San Diego east of Virgin Mesa down to the southern end of Virgin Mesa. Gray to white, nonwelded to poorly welded ash flow tuff containing phenocrysts of quartz and sanadine with trace pyroxene and magnetite. The deposit consists of two units (Tuberville and Self, 1988). The lower unit (A) is nonwelded and is comprised of abundant lithic fragments. The lithic fragments are dominantly basalt and andesite from the underlying Paliza Canyon Formation, with minor Proterozoic plutonic and metamorphic components (Tuberville and Self, 1988). The maximum size of the lithic fragments is 25 cm (Tuberville and Self, 1988). The upper unit (B) is nonwelded to slightly welded and contains large pumice clasts characterized by vesicles with high aspect ratios. A third unit not previously recognized is present near the northern boundary of the quadrangle on the west wall of Cañon de San Diego. Locally, the units are separated by fluvial gravels and mudstones, but the sedimentary packages are too thin (< 2 m) and too discontinuous to show on the map. Clasts in the gravel include Paliza Canyon Formation andesite, dacite, and basalt, Permian (Glorieta, Yeso, Abo) sandstone, eroded La Cueva Member, flow-banded rhyolite, Proterozoic granite and quartzite, Pedernal chert, and Madera Limestone. Clasts are generally sub-rounded to well rounded to angular, and are pebble to boulder size. One of the best exposures of fluvial gravel between the units is located near the northern edge of the quadrangle on the west side of Cañon de San Diego. The tuff is underlain by a Pliocene(?) debris flow in the northern part of the area and by Tog at the south end of Virgin Mesa. Spell et al. (1996) calculated a 40Ar/39Ar age of 1.85 ± 0.07 Ma for the tuff. Thickness ranges from 2—20 m.

QTgo Old fluvial gravel—late Pliocene (?)—Alluvial to fluvial gravel and sandstone deposits underlying the La Cueva Member or the Otowi Member of the Bandelier Tuff. Clasts are generally sub-rounded to well rounded, and are pebble to boulder size. Clasts are in a silty to medium sand size matrix or are clast supported. Sand grains in matrix are angular and poorly sorted. Gravel is usually present at the base of the deposit and red-brown fine-grained sandstone is present at the top. The sandstone locally contains abundant pumice clasts from early tephra eruptions that occurred prior to the eruption of La Cueva Member. The gravel clasts are composed predominantly of Paliza Canyon Formation andesite, dacite, and basalt and Permian sandstone, with occasional flow-banded rhyolite, Proterozoic granite and quartzite, Pennsylvanian Madera Limestone, and rare Abiquiu Formation sandstone, Pedernal chert, and obsidian (Kelley and Scholle, 2003). The gravels are well exposed on the east side of Virgin Mesa and in Virgin Canyon, but they are not shown on the map because they are in a cliff. These gravels are common beneath the Otowi Member on the northwest side of Paliza Canyon. These deposits could be equivalent to gravels of the Quaternary/Tertiary Cochiti Formation (Smith and Lavine, 1996), which contains predominantly rounded, volcanic clasts. Varies in thickness from ~1—12 m.

QTst Sinter deposit—Pleistocene—Miocene—Chalcedony and opal cementing Zia Formation sandstone and Entrada Sandstone along the Jose fault zone. Outcrop is about 10 m wide.

Tpd Debris flow deposit—Pliocene—A reddish to yellowish tan, matrix-supported sandy debris flow resting on angular, brecciated blocks of Paliza Canyon Formation andesite. This discontinuous deposit overlies Permian Abo Sandstone and lies beneath Tog on the west side of Cañon de San Diego near the northern quadrangle boundary. This unit is likely a southward continuation of the debris avalanche deposit exposed between La Cueva and Jemez Springs, as described by Kelley et al. (2007). Maximum exposed thickness 1—2 m.

Keres Group Volcanic and Vocaniclastic Sedimentary Rocks (Miocene)

Tdf Paliza Canyon Formation dacite—Dark gray, dense lava containing a few percent plagioclase phenocrysts and sparse but distinctive acicular hornblende phenocrysts. Lava forms mesa cap and small knobs on northern extent of Borrego Mesa on this map and several of the large coherent masses mapped as rock slide deposits on the mesa slopes. Gardner (1985) determined the geochemistry of this flow, which plots in the trachydacite field.

Tpv Paliza Canyon Formation volcaniclastic gravel—Volcaniclastic sediments interbedded with and overlying the volcanic rocks of Borrego Mesa. Consists of tan to brown sandstones and conglomerates. Contains well-rounded to subrounded clasts of volcanic rocks, mostly of mafic to intermediate composition. Some rhyolite and obsidian pebbles and cobbles are locally present, as are thin pumice and ash beds (Tct). 0—70m.

Tai Paliza Canyon Formation andesitic intrusive—Miocene—Light-to dark-gray, fine-grained rock with sparse plagioclase and pyroxene phenocrysts. Pieces of Canovas Canyon dacite are included in the intrusive along the margin and the older dacite is altered and iron-stained along the contact.

Tpbb Basalt of Bodega Butte. Paliza Canyon Formation—Miocene—Dark gray olivine basalt, massive to vesicular, moderately porphyritic with phenocrysts of plagioclase, olivine and pyroxene. Phenocryst content is typically < 10% with olivine commonly altered to reddish-brown iddingsite. Chamberlin and McIntosh (2007) determined an average age of 9.14 ± 0.12 Ma from four samples of this widespread basalt on the Loma Creston quadrangle to the southwest. 5—10m thick.

Tpb Paliza Canyon Formation basalt—Miocene—Medium to dark gray porphyry with 15—20 % phenocrysts of plagioclase and < 3% pyroxene. Underlies the olivine-rich basalt (basalt of Bodega Butte) and is intercalated with volcaniclastic sediments. 3—5 m thick.

Tccs Canovas Canyon sediments—Miocene—Localized deposit of volcaniclastic fluvial sandstone and conglomerate that appears to have been deposited at the same time as the Chamisa Mesa Member of the Zia Formation. This deposit lies northwest of the rhyolite/dacite intrusion, sits on the Jurassic Entrada Sandstone, and is capped by thin Paliza Canyon Formation volcaniclastic sediments (< 5 m, too small to show on the map) and rockslide debris. The basal part of the exposure is poorly indurated fine-grained, well-sorted sandstone with angular grains interbedded with very fine-grained sandstone. This 3 m thick deposit is overlain by well-cemented sandstone and conglomerate. The fine- to medium- grained sandstone has cross-bedding (low angle); the sand grains are well-rounded and moderately sorted. The clasts in the conglomeratic intervals are aphyric pumice and vesicular clasts of dacite with hornblende and biotite. Approximately 12 m thick

Tccd, **Tcc** Canovas Canyon dacite/rhyolite intrusion and flow—Miocene—Small plug and associated flow of dacitic to rhyolitic composition. The dominant lithology is a dark to light gray biotite- and hornblende-rich, quartz-free dacite with feldspar phenocrysts. The dacite grades into pink to reddish brown flow-banded rhyolite (Tcc), which forms the notable knob east of Ponderosa. The crystal-poor rhyolite contains biotite, feldspar, and small quartz phenocrysts (< 3% phenocrysts). A chilled glassy margin is present at some intrusive contacts and at base of the rhyolite flow on the east side of the knob. 40Ar/39Ar ages of 9.37 ± 0.16 and 9.41 ± 0.24 Ma were determined for the intrusion and glassy margin, respectively.

Tct Canovas Canyon ignimbrite and tephra—Miocene—White to pink pyroclastic flows and ash fall deposits. Two tuff beds are exposed on Borrego Mesa between the upper olivine basalt and the lower Chamisa Mesa basalt. The upper tuff is pink and massive with about 10% lithics of flow-banded rhyolite and obsidian. The pumice is aphyric. The lower tuff is pink and massive with about 15% lithics of flow-banded rhyolite and obsidian. The pumice has phenocrysts (< 1%) of quartz and hornblende. A tephra below the lower tuff and above the basalt of Chamisa Mesa has two cycles of graded bedding and the pumice contains phenocrysts of biotite. Thin beds of tephra are interlayered in volcaniclastic sandstone, conglomerates and basalt on the west side of Borrego Mesa. Individual tuff beds are 3—4 m thick, and the tephra beds are 0.5—2 m thick.

Tpcm Basalt of Chamisa Mesa—Miocene—Basalt with well-developed interstitial texture. Dark gray to black, aphyric to phenochyst poor basalt with rare phenocrysts of olivine and plagioclase. Two basalt flows low in the sequence yield 40Ar/39Ar ages of 9.44 ± 0.45 and 9.37 ± 0.28 Ma. Chamberlin and McIntosh (2007) determined an average 40Ar/39Ar age of 9.9 ± 0.9 Ma for this flow based on two samples from the Loma Creston quadrangle to the southwest. Thickness probably 5—10 m.

Tertiary Sedimentary Rocks

Tscc Arroyo Ojito Formation of the Santa Fe Group (Navajo Draw Member)—Poorly exposed tan sandstone with rounded Proterozoic quartz and granite and Permian sandstone pebbles derived from the Sierra Nacimiento; underlies Quaternary travertine and rests on Permian Glorieta Sandstone at 13 S 344461 3944802 (NAD27). A second deposit of pinkish-tan conglomeratic sandstone and conglomerate containing rounded red granite, vein quartz, subrounded tan sandstone, and well-rounded volcanic pebbles and cobbles; lies ~10 m below the ~9.4 Ma Chamisa Mesa basalt on Borrego Mesa. May correlate to the Navajo Draw Member, but has a Sierra Nacimiento provenance. 10 m thick.

Tson Cerro Conejo Formation of the Santa Fe Group—Likely forms the slopes of Borego Mesa, but is poorly exposed.

Tz Zia Formation undivided—lower-middle Miocene: includes the Chamisa Mesa Member (middle Miocene)—Tan to white, massive tabular and cross-stratified sandstone interbedded with thin beds of red mudstone form the lower two thirds of Borrego Mesa. The cross-beds are generally low-angle; high angle crossbeds are less common. Ripple marks and burrowed horizons are present but rare. The sandstone is generally weakly indurated except in the vicinity of faults. Popcorn sandstone concretions near fault zones are common. The fine to medium sand grains are variably well-rounded to angular and are well to moderately sorted. Root casts are present in the more massive beds. 100 m thick.
Piedra Parada Member (lower-middle Miocene)—whitish-gray to pinkish-gray cross-stratified sandstone, cross-beds are meter scale, sand grains are rounded and well sorted. Eolian in origin; derived from sources to the west. This member of the Zia Formation forms the prominent white outcrops in the Red Rocks area in the southwest corner of the map; 30 m thick.

Ta Abiquiu Formation—White to tan, fine-grained sandstone that is alternately well-cemented and poorly cemented intercalated with very- fine-grained, white ash fall deposits. Contorted bedding caused by soft sediment deformation and cross-bedding is rare and is restricted to the top of the unit. The sand grains are angular and well sorted. The exposure north of Cañon del Raphael Gallegos includes thin red siltstone and shale beds. The tops of tabular beds in the upper Abiquiu Formation in northern Cañon de la Cañada are red and are laced with fine root casts. A biotite-rich ash bed from the upper Abiquiu Formation in Cañon de la Cañada yields a 40Ar/39Ar age of 20.61 ± 0.07 Ma, in the range of 17—25 Ma determined for equivalent strata to the north near Cerro Pedernal (Smith et al., 2002).

Tgc Gilman Conglomerate—Greenish gray, matrix-supported, pebble to cobble conglomerate. This conglomerate contains cobbles of intermediate composition volcanic rock, granite, quartz and sandstone. Precambrian material is concentrated at the base and at the top of the unit. Most of the clasts are dacitic to andesitic volcanics and dacitic intrusive rocks from an uncertain source and are <15—20 cm in diameter. Rare clasts contain quartz as phenocrysts. The cobbles yield 28—29 Ma 40Ar/39Ar ages (Kelley et al., 2007). The Gilman Conglomerate in the southwestern Jemez Mountains is ~60 m thick west of Cañon, and is ~57 m thick at Gilman. The conglomerate thins abruptly to the north and east and is generally represented by fluvial and debris flow deposits < 2 m thick that contain only Proterozoic granitoid and quartzite and Oligocene volcanic clasts and local 1 m thick carbonate cemented sandstone beds. Preliminary analysis of paleocurrent direction recorded by imbricated cobbles in the volcaniclastic conglomerate near Cañon indicates flow toward the northwest. The paleocurrent data and the decrease in thickness toward the north suggest a volcanic source to the south (Connell et al., 2007; Kelley et al., 2007).

Jurassic Sedimentary Rocks

Jurassic beds crop out only on the steep slopes of Borrego Mesa where they are largely buried by mass wastage deposits of various types. Exposures are discontinuous and poor. The situation is further complicated by structural disruption.

Jm Morrison Formation—yellowish to tan, iron-stained subarkosic to arkosic sandstones. Occurs only as small discontinuous outcrops along the Jose fault zone west of Borrego Mesa.

Js Summerville Formation—gray, maroon or pinkish-red siltstone and silty mudstone. Occurs only as small discontinuous outcrops along Jose fault zone west of Borrego Mesa.

Jt Todilto Formation—Brown to gray laminated, fetid limestone (Luciano Mesa Member) overlain by white gypsum (Tonque Arroyo Member). The Todilto Formation crops out in Paliza Canyon northeast of Ponderosa. The base is poorly exposed due to mass wasting, but limestone float can be observed. The top is not exposed because it is covered by a landslide. Elsewhere, the Todilto Formation is present as discontinuous outcrops in the Jose fault zone. Maximum thickness 25 m

Je Entrada Sandstone—White to yellow to red, fine- to medium-grained, well-sorted, well-rounded, cross-bedded quartzose sandstone. The Entrada Sandstone crops out in Paliza Canyon northeast of Ponderosa. The base not exposed. Cross-beds dip to the west. In the Jose fault zone, discontinuous exposures of the Entrada Sandstone are locally mapped with the overlying Todilto Formation (Jet). Maximum exposed thickness 25 m.

Triassic Sedimentary Rocks

Ꞧc Petrified Forest Formation (Chinle Group)—Principally red mudstones with minor thin, tan thin-bedded, ripple-laminated to cross-laminated micaceous sandstones. Locally the mudstones may be black, purple, dark blue, especially near the lower contact. Interbedded sandstones are particularly common and persistent in the approximate stratigraphic position of the Poleo Sandstone and overlying Mesa Montosa Sandstone. These sandstones are particularly thick and persistent in two locations in Cañon de Cañada (approximately 39°49.5' and 39°55.4') and were mapped as TRcp. Elsewhere, near Ponderosa, strike and dip symbols mark the position of the < 5 m thick Poleo and Mesa Montosa sandstones.

Ꞧcs Shinarump Conglomerate (Chinle Group)—Tan to brown, medium- to coarse-grained quartzose sandstone. The sandstone is usually cross-stratified, often in trough geometries, and it is well cemented, making the unit a consistent ridge former. Coarse conglomerate beds, up to several m thick, containing siliceous pebbles and cobbles up to 15 cm, are common near the base. Clasts are predominantly white, gray, or red quartzite, chert, sedimentary rip-up clasts and petrified wood. Conglomerates often cemented with dark brown ferruginous material. Upper contact is mapped at upward increase in shale content. This increase is often abrupt and the overlying shale is often purple, black or dark blue, suggestive of Salitral Formation. In other places the contact is gradational into thin-bedded, ripple- and cross-laminated sandstones in the overlying Chinle Group. 30—60 m thick.

Ꞧm, **Ꞧml** Moenkopi Formation—Dark chocolate brown to reddish brown micaceous shale, silty shale and thin-bedded feldspathic sandstone. The proportion of shale and sandstone varies laterally, and in sand rich areas, the sandstones are medium-bedded. Underlain by a sharp contact with the white Permian Glorieta Sandstone. Overlain in sharp contact by the contrasting light-colored sands of the Shinarump Conglomerate. The Moenkopi Formation in the Red Rocks area is unique in that it contains a ~1 m thick layer of fossiliferous sandy limestone (TRml). Poorly preserved pelecypod fossils (unoids) are concentrated near the base of the limestone. In most exposures of the Moenkopi Formation on the ridge east of Red Rocks, the limestone is the topmost unit; however at one locality (13 S 345037 3945145), the limestone is capped by a cross-bedded red sandstone. Thickness varies from 6—12 m laterally perhaps due to erosion of upper beds beneath the Shinarump Conglomerate.

Permian Sedimentary Rocks

Pg Glorieta Sandstone—White to red, medium-bedded quartz arenite. Bedding varies from massive to planar to cross stratified. Sandstones are typically well sorted. Feldspathic red sandstones and some shale interbedded in subordinate amounts. 15 m thick.

Py Yeso Group—Red orange to dark red, fine to medium grained, quartzose sandstone. The Yeso Formation has traditionally been divided into two members in the southwestern Jemez Mountain region, the lower Meseta Blanca Member and the upper San Ysidro Member (Wood and Northrop, 1946; Stanesco, 1991; Mack and Dinterman, 2002). Lucas et al (2005), following the work of Baars (1962), applied the name De Chelly Sandstone to the Meseta Blanca Member and elevated the Yeso Formation to group status. In the Red Rocks area on Jemez Pueblo, the basal part of the De Chelley Sandstone consists of thinly bedded, orange sandstone that is cross-bedded with low angle to subhorizontal stratification. The basal unit pinches out north of Red Rocks. This unit is overlain by a reddish-orange, medium to thick-bedded tabular sandstone with thin shale interbeds, occasional fluvial channel structures, and rare mudcracks. This package of tabular sandstone thickens to the north of Red Rocks. The upper part of the De Chelly Sandstone is characterized by a distinctive eolian depsoit with meter-scale, tabular-planar, wedge-planar and trough cross-beds that record a paleo-transport direction generally to the south (Stanesco, 1991). This sandstone contains a thin (0.1—0.3 m thick), discontinuous pedogenic carbonate horizon that is present in the cliffs just the contact with the San Ysidro member. The San Ysidro Member of the Yeso Formation is primarily medium-bedded, tabular sandstone that is orange red near the base and red near the top. A continuous (1—2 m thick) limestone bed is present near the top of the unit. The sandstone under the limestone is altered and bleached due to weathering of the sandstone prior to the deposition of the limestone. The limestone exhibits soft-sediment deformation and fills in low spots in the underlying sandstone. The contact of the Yeso Group with the overlying Glorieta Sandstone is mapped at the transition to predominantly medium to course grained, white quartzose sandstone. The Yeso Group is 170 m thick in Cañon de San Diego (Stanesco, 1991) and is 156 m at Red Rocks.

Pa Abo Formation—Red to dark red, medium- and thin-bedded arkose or feldspathic, medium- to coarse-grained, fluvial channel sandstones, intraformational conglomerates, and fine-grained overbank deposit mudstones and shales. Green reduction spots and layers are common. The sandstones are cross-stratified (typically trough and wedge-planar geometries) and the finer grained rocks commonly have ripple cross-laminations. Mud-chip clasts and plant debris are common. Base is not exposed in map area. Upper contact with Yeso Formation mapped at abrupt change from medium-grained to coarse-grained arkosic sandstones to fine- to medium-grained quartzose sandstones. The contact between the Abo Formation and the overlying Yeso Formation is usually conformable (Woodward, 1987; Stanesco, 1991). Lucas et al. (2005) measured 492 ft (150 m) of Abo Formation, (base not exposed, but measured up to the Yeso Formation) south of Jemez Springs on the Ponderosa 7.5' quadrangle.

Pennsylvanian Sedimentary Rocks

ℙm Madera Formation—Light-gray, fossiliferous limestone, white to buff quartzose sandstones, course-grained arkose, light-gray shale with subordinate arkosic limestone. Overlies Sandia Formation. Upper contact not observed in this map area. Maximum exposed thickness 15 m.

ℙs Sandia Formation—Fine to coarse-grained, white to tan, quartzose sandstones interbedded with brown, red, green or gray shale and thin-bedded fossiliferous limestone. Minor arkosic sandstones also present. Base not exposed in this map area. Contact with overlying Madera Formation mapped at abrupt increase in proportion of limestone beds. Maximum exposed thickness 10 m.