

Geologic Map of the Fort Bayard Quadrangle, **Grant County, New Mexico.**

May 2007

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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 Director).



QUADRANGLE LOCATION

1927 North American datum, UTM projection -- zone 12N

00-meter Universal Transverse Mercator grid, zone 12, shown in red

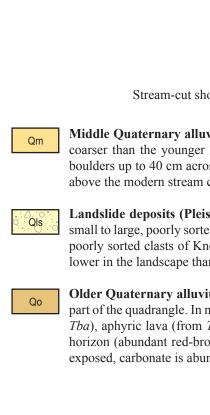
READING MOUNTAIN	TWIN SISTERS	ALLIE CANYON
SILVER CITY	FORT BAYARD	SANTA RITA MINE
TYRONE	HURLEY WEST	HURLEY EAST

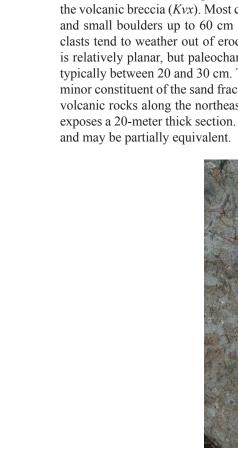
COMMENTS TO MAP USERS

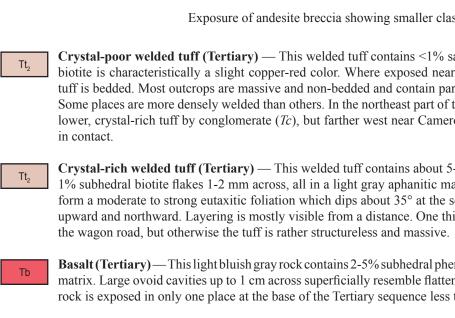
A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic 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map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation.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.



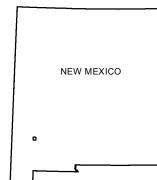




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EXPLANATION OF MAP SYMBOLS

Geologic contact. Solid where exposed or known, dashed where

approximately known, dotted where concealed or inferred.

Location of geologic cross section.

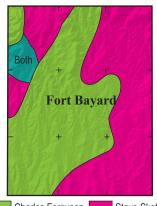
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Normal fault, ball-and-bar on downthrown side. Solid where exposed, dashed where approximately known, dotted where concealed.		
Trace of axial plane of anticline, dashed where approximately known, dotted where concealed.		
Trace of axial plane of syncline, dashed where approximately known, dotted where concealed.		
Strike and dip of bedding, horizontal bedding.		
Strike and dip of joints, vertical joints.		
Mineralized joints.		
Flow foliation of volcanic rocks.		
Eutaxitic foliation of volcanic rocks.		

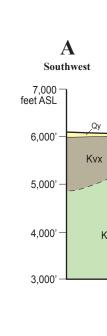
Eolian cross-bed flow direction. **EXPLANATION OF DIKE SYMBOLS**

Pyroxene porphyritic rocks. Rhyolite porphyritic rocks. Granodiorite porphyritic rocks. Plagioclase porphyritic rocks. Feldspar megacrystic rocks.

INDEX TO GEOLOGIC MAPPING



Charles Ferguson Steve Skotnicki



7,000 --feet ASL

6,000'

5,000' –

4.000'

DESCRIPTION OF MAP UNITS

Quaternary Surficial Deposits

Younger Quaternary alluvium (Holocene) — These deposits are comprised of mostly unconsolidated, locally laminated, silt and sand, with subordinate gravel and clay. Gravel commonly forms relatively thin beds between about 10 and 30 cm thick. In good stream-cut exposures, paleosol horizons are visible. These are darker, non-bedded, clay-rich horizons exhibiting vertical cutan formation. Also in stream-cut exposures, 10 to 50 cm thick shallow paleochannels are common and are filled with gravel or sand. The unit forms very flat deposits along the modern stream valleys that have almost everywhere been dissected and entrenched by the modern streams. In the southern part of the quadrangle dissection is between 2-3 m, while in the north it is up to 8-10 m.



Stream-cut showing Holocene sedimentary deposits. Note low-angle cross-bedding and soil horizons.

Middle Quaternary alluvial deposits (middle to late Pleistocene) — Interbedded silt, sand, and gravel. These deposits are typically coarser than the younger Holocene deposits (map unit O_V) and contain abundant subrounded to rounded cobbles and locally small boulders up to 40 cm across. Many of the clasts are Tertiary volcanic rocks. These deposits form elevated terraces from 5 to 10 meters above the modern stream channels, and commonly have moderately developed argillic horizons.

Landslide deposits (Pleistocene) — This deposit was mapped in the far southeast corner of the quadrangle where it is composed of small to large, poorly sorted blocks of Kneeling Nun Tuff (*Ttnx*). It is not clear if this unit is related to the breccia deposits also containing poorly sorted clasts of Kneeling Nun Tuff, but it appears to post-date the north-northeast-striking fault in the same area. Because it is lower in the landscape than map unit *Qo* it may be younger than *Qo*.

Older Quaternary alluvium (early Pleistocene) — This unit forms a thin, sheet-like deposit capping the highest hills in the southern part of the quadrangle. In most areas it contains volcanic clasts almost exclusively, which are composed mostly of basaltic andesite (from *Tba*), aphyric lava (from *Tva*), vesicular basalt, and occasional clasts of welded tuff. The unit contains a very well-developed argillic horizon (abundant red-brown clay) and appears dark brown in color. Most surface clasts are moderately varnished and, where rarely exposed, carbonate is abundant in the matrix below the argillic horizon.

Tertiary Volcanic and Sedimentary Rocks in the North

Aphyric lava (Tertiary) — These light purple-tan lava flows are nearly aphyric except for minute phenocrysts <1 mm altered to d opaque minerals. Outcrops are typically very platy and resistant. Individual flows are visible because of vegetation bands on the mountain northeast of the northeast corner of the map. North of the quadrangle they appear to form a thick sequence several hundred feet that is overlain by a light tan unit that resembles a tuff from a distance.



Outcrop of aphyric lava, NE corner of quad.

Basaltic andesite (Tertiary) — This volcanic rock contains 30-40% tabular/rectangular euhedral plagioclase phenocrysts up to 6 mm long, and 2-5% green glassy pyroxene also up to 6 mm long, and small crystals <1 mm across altered to red opaques that may be olivine altered to iddingsite, all in a dark gray aphanitic matrix. Commonly vesicular. This unit forms a prominent dark cliff and bench where the overlying conglomerates have eroded back. These lava flows pinch out eastward north of Avalanche Peak.

Conglomerate and sandstone (Tertiary) — Conglomerate and sandstone. Nearly flat-lying to gently dipping (<10°) thin to medium bedded sandstone and conglomerate containing mostly clasts of pyroxene porphyry derived either from dikes of map unit *TKh* or from the volcanic breccia (*Kvx*). Most clasts are angular to subrounded. Locally, the unit is dominated by subrounded to rounded large cobbles and small boulders up to 60 cm across composed of crystal-rich welded tuff that resembles the Kneeling Nun Tuff (*Ttn*). These tuff clasts tend to weather out of eroded slopes and give the impression that the slope is an exposure of welded tuff. Bedding in this unit is relatively planar, but paleochannels up to 1 meter deep are common. The largest clasts are between 40 and 60 cm across, but more typically between 20 and 30 cm. The sand fraction is composed of lithic fragments of the same rock types listed above. Quartz is a very minor constituent of the sand fraction. The unit is almost everywhere moderately cemented with calcite, and is interbedded with Tertiary volcanic rocks along the northeast side of the quadrangle. The best exposure is on the west side of Avalanche Peak, where a cliff face exposes a 20-meter thick section. Overall this unit closely resembles the older conglomerate (*Tco*) in the southern part of the quadrangle



Crystal-poor welded tuff (Tertiary) — This welded tuff contains <1% sanidine and 2-5% subhedral biotite flakes 1-3 mm wide. The biotite is characteristically a slight copper-red color. Where exposed near the north end of Cameron Creek, the basal 3 meters of the tuff is bedded. Most outcrops are massive and non-bedded and contain partially flattened pumice fragments several centimeters across. Some places are more densely welded than others. In the northeast part of the quadrangle this tuff is separated from the stratigraphically lower, crystal-rich tuff by conglomerate (*Tc*), but farther west near Cameron Creek the conglomerate pinches out and the two tuffs are

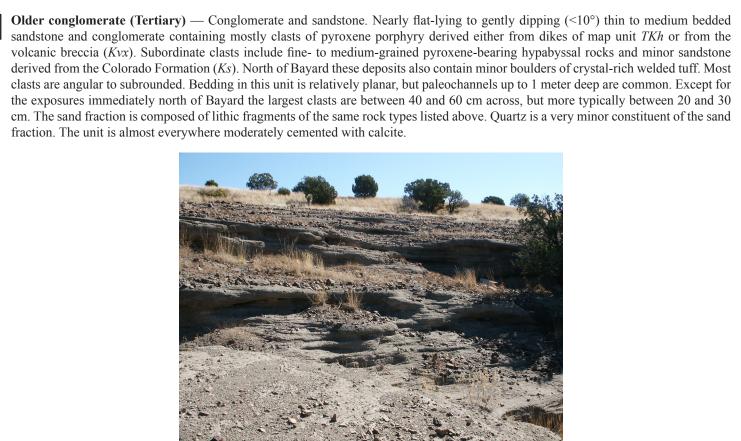
Crystal-rich welded tuff (Tertiary) — This welded tuff contains about 5-15% subhedral sanidine and quartz from 1-2 mm across and 1% subhedral biotite flakes 1-2 mm across, all in a light gray aphanitic matrix. Abundant flattened pumice fragments up to 10 cm long form a moderate to strong eutaxitic foliation which dips about 35° at the southern margin (the base of the unit) and becomes less steep upward and northward. Layering is mostly visible from a distance. One thin, 1-2 meter, thinly bedded air-fall tuff interval is exposed in

Basalt (Tertiary)—This light bluish gray rock contains 2-5% subhedral phenocrysts all altered to red opaque minerals in a microcrystalline matrix. Large ovoid cavities up to 1 cm across superficially resemble flattened pumice but are mostly vacant and are likely vesicles. This rock is exposed in only one place at the base of the Tertiary sequence less than one mile west of Century Hill.

Tertiary Volcanic and Sedimentary Rocks in the South

Younger conglomerate (Tertiary) — This unit everywhere overlies the welded tuff breccia (*Ttnx*) but is nowhere well-exposed. The unit contains abundant subangular to subrounded clasts of greenish-gray sandstone and clean quartzite derived from the Colorado Formation (Ks) and Beartooth Quartzite (Kb). In the east these clasts dominate. In the west the unit contains more abundant pyroxenerich hypabyssal rocks derived from dikes or from the volcanic breccia (*Kvx*). In all areas, more so in the east, dark, dense iron clasts from 1-40 cm across are abundant and diagnostic. Also in the east the unit contains abundant subangular clasts derived from the hornblende quartz diorite (*TKqd*), which are commonly fresher than nearby exposures of the intrusive unit. Rounded, lighter colored clasts of crystal-rich welded tuff (resembling the Kneeling Nun Tuff) are locally common, particularly in the east, where they occur as cobbles to large boulders over 1 meter across. Forms smooth rounded hills in the southern part of the map area.

Welded tuff breccia (Tertiary) — This unit contains very poorly sorted clasts of crystal-rich welded tuff (*Ttn*) from sand-size to large boulders >10 meters across. Eutaxitic foliation, visible in the larger clasts, is rotated mostly randomly with respect to foliation in the neighboring clasts. In some of the exposures north of Bayard a consistent eutaxitic foliation in some outcrops dips northwest between 30° and 50°. Where visible, the matrix also appears to be composed of the same crystal-rich welded tuff, or sand derived from it. This unit caps the hill north of Bayard and superficially resembles and intact flow. Elsewhere it forms a thin layer a few meters thick that is



quite pervasive stratigraphically. Although Jones and others (1970) originally interpreted this unit as having formed from removal of the

softer crystal-poor welded tuff below and collapse of the Kneeling Nun Tuff, intact exposures of the crystal-poor tuff below outcrops of the welded tuff breccia suggest a different genesis. Pervasive jointing in the Kneeling Nun Tuff, and the proximity of breccia deposits

to steep outcrops of Kneeling Nun Tuff in the extreme southeast corner of the map, suggest that the breccia deposits may have been

Kneeling Nun welded tuff (Tertiary?) — This crystal-rich welded tuff contains about 30-50% anhedral to subhedral quartz and

sanidine, and 1-2% subhedral biotite flakes, all 1-3 mm across in a light tan to brown aphanitic matrix. The rock may contain rare

hornblende. Pumice clasts are partially flattened but eutaxitic foliation is difficult to discern, even on weathered surface. The base of

the unit is locally nonwelded and is light gray and nonbedded, but the same phenocryst assemblage is visible. Contains sparse angular

Green sandstone (Tertiary) — Thick sequence (100+ feet) of moderately well sorted sandstone, gravelly sandstone, and thinly bedded light tan-colored pumaceous (?) gravelly sandstone. The overall forest green color of this unit is quite striking. In all beds the larger

grains are dominated by fine-grained, light gray to maroon quartzite and other siliceous grains, some of which resemble flow-banded rhyolite. The sequence is thin to medium bedded. The light yellowish tan layers are sandy and commonly more gravelly than the greener

beds, and contain abundant siliceous, aphanitic gravel-size clasts that resemble pumice. Small channels less than 1 meter across and 20

Bedded lithic tuff (Tertiary) — These thinly bedded deposits form two distinct tuff units in the far southeast corner of the map area. The lowermost unit is thin, a few meters thick, and is interbedded with conglomerate rich containing clasts of pyroxene porphyry and/ or andesite (*Tc*). The uppermost tuff is considerably thicker (10+ meters), though exposures are poor, and is overlain by float of green sandstone (Ts). Beds are thin, platy, and light yellowish gray. Both tuff layers contain abundant subangular sand to small pebbles of

Sugarlump Tuff (Tertiary) — This welded tuff contains about 1% subhedral biotite and sanidine phocrysts up to 1 mm in a light bluish gray aphanitic to partially glassy matrix. Contains abundant flattened pumice fragments. The base is very sharp and planar and overlies a light pink clay-rich layer 1-2 meters thick that may be altered nonwelded tuff. This welded tuff unit appears to be one flow unit as no

Basalt (Tertiary) — This dark gray rock contains 1-2% phenocrysts of altered red opaque minerals (iddingsite) up to 2 mm across, in a medium to dark bluish gray aphanitic matrix. The rock weathers into thin robust platy outcrops that are very difficult to break with a

cm deep contain subrounded pebbles and cobbles, but the exposures were inaccessible so their composition is uncertain.

deposited as rock avalanches or debris flows shed from intact cliffs of welded tuff.

distinct flow breaks are visible and the unit forms one prominent cliff up to 5 meters high.

xenoliths 1-8 cm across composed of fine-grained maroon quartzite.

maroon to dark red quartzite.

Typical exposure of conglomerate (Tco). Dikes and other Intrusive Bodies

Rhyolite porphyry dikes and plugs (probably Tertiary) — Coarse-grained (up to 20 mm), euhedral to subhedral feldspar (potassium feldspar and plagioclase), typically strongly flow-foliated porphyry dikes locally with abundant 1-4 mm euhedral biotite. An isolated plug occurs in the southwest corner associated with a north-striking swarm of dikes that extend to north, nearly the entire length of the map area. The dikes and parts of the plug are typically crumbly, and weather into light-colored fragments, but locally, a dark grayish green vitric matrix is preserved. Ubiquitous biotite is typically very fresh, and the dikes are characteristally non-magnetic in contrast with most of the older dikes in the area. The unit also occurs along Twin Sisters Creek east of Fort Bayard as a north-striking chain of plugs. A minor swarm of west-northwest striking dikes occur to the northwest of the north end of this chain. The plugs in this area contain abundant xenoliths. The unit is locally differentiated into a flow-banded hypabyssal rock (*Trp*) and lithic breccia (*Trpx*).



Spheroidal weathering is common in dikes.

Formation (*Ks*). The unit resembles the megabreccia of some ash-flow tuffs, which it may grade into in some areas. Medium- to coarse-grained granite (Cretaceous or Tertiary?) — Central core of Piños Altos stock. Contains about 15% biotite+hornblende. Biotite is euhedral and up to 3 mm across. Hornblende is tabular and up to 6 mm long. Feldspar and quartz form a granular texture, and on weathered surfaces it is difficult to distinguish the two minerals. Locally, K-feldspar is very abundant and rectangular, up to 8 mm. Forms rounded to subangular bouldersand light rusty orange sandy soil.



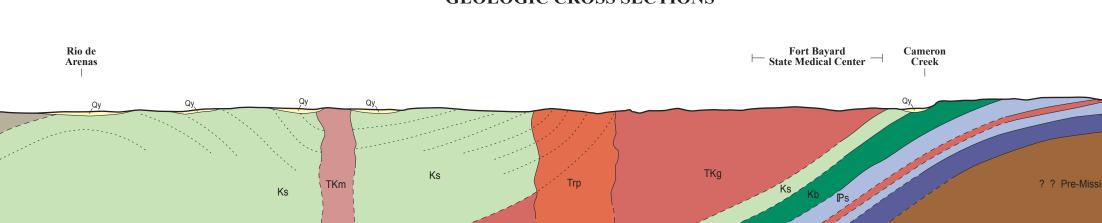
Outcrop of the Pinos Altos granite.

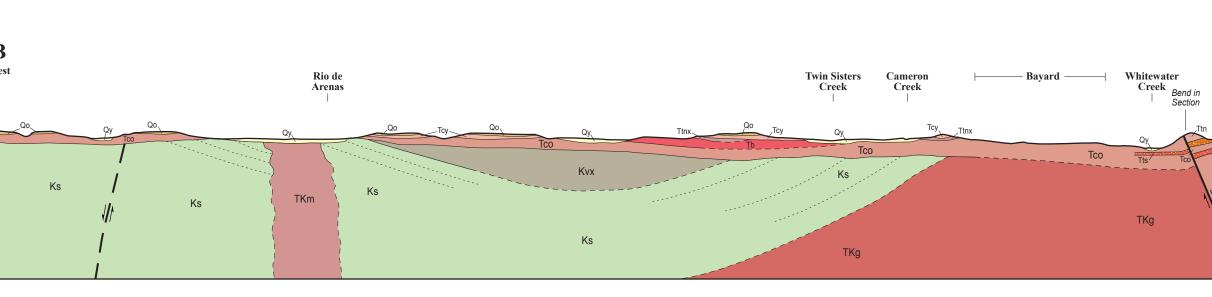
TKm Pyroxene and hornblende porphyritc quartz diorite to syenite (Cretaceous or Tertiary?). **Hornblende quartz diorite (Cretaceous or Tertiary?)** — This medium to light gray medium-grained granitic rock contains anhedral to subhedral light gray feldspar 1-3 mm across and about 15-30% euhedral biotite 1-3 mm across and subhedral hornblende 1-6 mm long, in a fine-grained granular matrix. Quartz and feldspar are difficult to distinguish from one other in hand-samples. On some weathered surfaces K-feldspar is abundant and is visible as nearly square, medium to light gray phenocrysts up to 8 mm across. The unit forms a sill-like body north of Bayard (the Fort Bayard stock), where it intrudes sandstone and shale beds of the Colorado Formation (Ks). Fresh road cut exposures, particularly along Highway 180, are light to medium gray in color, and reveal sparse rounded xenoliths up to about 6 cm across that have the same mineralogy but contain more hornblende and, thus, appear darker. This intrusive body exhibits several well-defined joint directions, locally mineralized. Outcrops are typically highly weathered and are rusty orange and crumble into sand, but rounded to subangular boulders are common on the surface.

Cretaceous and Paleozoic Sedimentary and Volcanic Rocks Volcanic breccia (Cretaceous?) — Composed of poorly sorted angular to subrounded clasts of pyroxene-bearing volcanic and hypabyssal rocks. The most extensive unit in the map area is a mixed andesitic lava, heterolithic andesitic breccia, and volcaniclastic

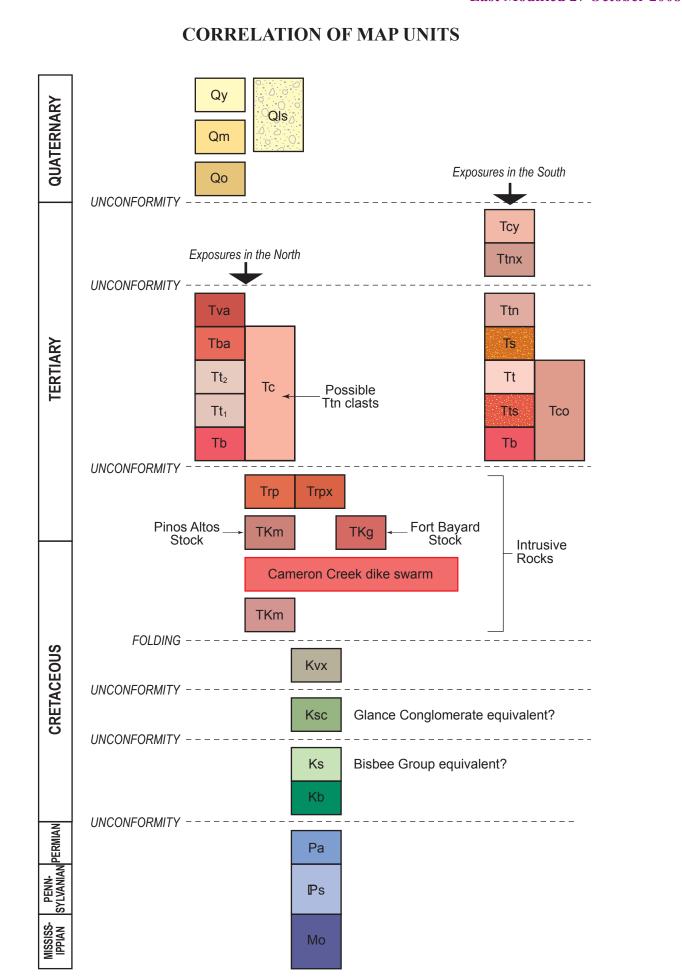
by intermediate to mafic dikes, the density ranging from less than 5% to greater than 80%. Three main varieties of lavas, based on phenocryst assemblages, abundances, sizes, and size ranges can be easily recognized from place to place, but due to poor exposure and the prevalence of cross-cutting dikes with similar phenocryst assemblages it would be impossible to regionally differentiate these. Most of the andesite is magnetite bearing. Three principle varieties are, in decreasing order of abundance: 1) fine-grained (<2 mm) plagioclase phenocryst-rich with subordinate mafics of hornblende and/or pyroxene, \pm olivine, 2) medium- to coarse-grained (2-6 mm, but up to 10 mm) hornblende-porphyritic and/or pyroxene-porphyritic, and 3) elongate, medium-grained (2-4 mm), sparsely plagioclaseporphyritite lava with very sparse mafics. Individual lava flows, consisting of massive coherent facies lava mixed to varying degrees with autobreccia, are complexly interbedded with a wide variety of heterolithic volcanic and epiclastic breccias, and lesser amounts of mafic volcaniclastic rocks. Clasts in the breccias and volcaniclastic rocks are dominated by andesite, but locally include sparse material

GEOLOGIC CROSS SECTIONS





NMBGMR Open-file Geologic Map 152 Last Modified 27 October 2008



derived from the Colorado Formation (Ks), and possibly older quartzite. Only one boulder-size clast of non-foliated coarse-grained granite was seen. This xenolith is similar to xenoliths found within the dike complex and along intrusive contacts within the fine-grained monzonitic unit of the Pinos Altos complex. In many areas the matrix and the clasts have a nearly identical composition, making distinction of the clasts from the matrix difficult

Pebbly conglomerate (Late Cretaceous?) — Interbedded medium- to coarse-grained sandstone and pebble conglomerate. The sand grains are composed mostly of moderately to poorly sorted subangular quartz and minor feldspar moderately cemented by silica. Pebbles are well rounded and composed of subrounded to well rounded of light to dark gray chert, light gray quartzite, and vein quartz commonly between 1-4 cm, but locally up to 10 cm across. Petrified wood is locally abundant and has been replaced by dark gray, fine-grained chert. Some pieces of petrified wood are well rounded, indicating they may have been eroded from an older rock unit. This unit forms a thin layer a few meters thick resting on top of the Colorado Formation (*Ks*). Locally, pebbly conglomerate is interbedded with the *Ks* less than about 10 meters from the top of the unit. If equivalent, exposures in the northwest corner of the map are close to 100 feet thick.



Colorado Formation (Late Cretaceous?) — Interbedded shale and sandstone. The lower part of this unit is mostly medium to dark gray, very fine-grained sandstone and siltstone, with subordinate shale. Sandstone beds are locally coarse-grained and contain well sorted subangular to subrounded quartz and subordinate feldspar grains. Coarse-grained beds in the lower part of the unit pinch and swell between 10 and 50 cm thick over a distance of about 10 meters, and typically grade downward to well rounded chert-pebble conglomerate with clasts up to 3 cm across. Some siltsone beds contain septarian concretions. Though rare on outcrop some weatheredout concretions are up to 40 cm across. Thinly laminated dark siltstones locally exhibit low-angle cross-beds in sets up to 2 cm thick. Sandstone beds dominate in the upper part of the unit, where they are also fine- to medium-grained subangular to subrounded quartz and subordinate feldspar, in tan-colored thin to medium beds. They locally exhibit planar to trough cross-beds in sets up to 70 cm thick. Thin, dark brown sandy limestone beds up to 20 cm thick form conspicuous, but mostly covered, outcrops in the upper part of the unit. Where siltstone and shale dominate the unit forms smooth, rounded hills and slopes with poor outcrop. Sandstone beds commonly form steps or small ledges a few feet high. May be equivalent to similar deposits beneath the Springerville volcanic field in east-central Arizona, or to the Bisbee Group in southern Arizona.

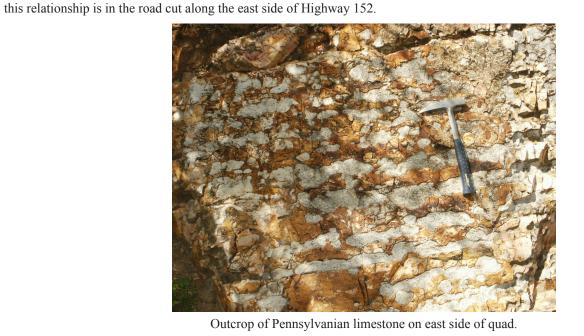
Beartooth Quartzite (Cretaceous) — This clean, light gray sandstone contains well sorted, fine-grained quartz grains that are partially to completely fused together to form protoquartzite and quartzite. Bedding is mostly medium to thick and commonly wavy. Ripple marks are locally visible and planar cross-beds are abundant in sets up to about 1 meter thick, but more commonly in sets 20-40 cm thick.



Abo Formation (Early Permian) — Interbedded fine-grained red sandstone, and red to purple sandstone and shale. Poorly exposed near the east side of the map area where it only locally crops out beneath the Beartooth Quartzite (*Kb*). Forms red-colored clay-rich slopes mostly mantled by clasts shed from the overlying quartzite. Small outcrops exposed by quarrying operations show thin bedding

Quarry-cut showing Beartooth Quartzite.

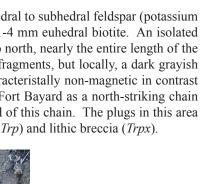
in the fine-grained red sandstones. Syrena Formation (Pennsylvanian) — Chert-rich limestone. This light blue-gray limestone is micritic to finely crystalline. Irregularly shaped, light yellowish tan chert stringers locally occupy 50% or more of the rock and weather out to cover the surface in a tan lag that superficially resembles float of fine-grained sandstone. The chert has incompletely replaced the host carbonate such that even the chert fizzes lightly with acid. Chert stringers are commonly roughly parallel to bedding, but also cut across bedding in irregular patterns. Bedding in this unit is thin to thick, and planar. Although mostly micritic, the unit is locally coarsely crystalline, and contains abundant crinoid stems, brachipods, and bryozoa, in some places silicified but in most areas are limestone. Fossils are most visible on weathered surfaces. Sequences of limestone are interbedded with purple shales that form poorly exposed slopes. The best place to see



Oswaldo Formation (Mississippian) — Medium to dark gray fossiliferous limestone. This unit contains almost no chert and possesses thick beds that are typically massive. Bedding is best visible from a distance. The best exposures are just outside the map area to the east in a large open-pit quarry operation. In these pits the apparent upper surface of the unit is deep red and appears karsted.

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Rhyolite porphyry lithic breccia (probably Tertiary) — Coarse-grained feldspar porphyritic, commonly flow-foliated lithic breccia containing 5-80% pebble to several meter-diameter xenoliths of volcanic breccia (*Kvx*) and sandstone-shale of probable Colorado



unit (the 'andesite breccia' of Jones et al., 1970). The unit consists of a wide variety of andesitic lavas that are invariably intruded

