Geologic Map of the Baldy Mountain Quadrangle, Colfax County, New Mexico

By

Charles A. Ferguson and Steven J. Skotnicki

May, 2006

New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 125

Scale 1:24,000

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INTRODUCTION

The Baldy Mountain quadrangle straddles the southwestern margin of the Raton basin in north-central New Mexico (Cather, 2004). The Cimarron Range, a south-southeasterly projecting branch of the Sangre de Cristo Mountains that delimits the western margin of the basin, runs along the western edge of the quadrangle. The Raton basin is an intra-foreland basin filled with Paloecene alluvial rocks that grade from pebble-cobble conglomerate with rare claystone intervals to medium- to coarse-grained sandstone, with abundant siltstone, shale and coal to the east. The Cimarron Range crest corresponds approximately with the thrust front. Its local low point, Mills Divide at 2975m (9750 feet), is the location of a newly recognized north-vergent reverse fault that runs southeast-northwest through the northern slopes of Baldy Mountain placing TK transition beds, which make up the peak, against Paleocene conglomerate to the north. The north-vergent fault's age relationship with the east-vergent thrust front is unknown because its projected intersection lies approximately 2km west of the map boundary. Both fault zones are cut by an Oligocene dike swarm and a granitic stock that forms the main mass of Baldy Mountain.

Drainage to the west of the range crest feeds into the Cimarron River (Mississippi basin) through Moreno Valley in the southwest, and into the Rio Grande to the northwest via Valle Creek. East of the divide, tributaries of Poñil Creek form a deeply incised, gently east-dipping tableland with extensive mesa-top interfluves that host several fairly large natural lake basins, all of which are associated with dikes (Beatty Lakes) or sills (Wilson Mesa). Total relief in the quadrangle is over 1400m (4,650').

The quadrangle is densely forested with ponderosa, juniper, piñon, and oak on the lower slopes and fir, spruce, white pine, and aspen above 3000m (10,150 feet). Sub-alpine, open grassland and tundra occur above 3700m (12,140 feet). Open grassland is also present in narrow strips of valley bottom park lands and meadows in the vicinity of Mills Divide, on Wilson Mesa, around the Beatty Lakes, and in the Valle Vidal.

The quadrangle was mapped during the summer of 2006. Mapping was supplemented by color air photographs in the northeastern part of the map area.

John Kimberlin from the Poñil Ranch, Mark Anderson from Philmont Boy Scout Ranch, and Jim Hollis kindly allowed access to large (and small) expanses of private land in the map area. Tracy Parker of the National Forest Service loaned color air photos of a portion of the map area. Dr. Douglas J. Nichols, USGS, Denver evaluated palynological samples from coal-bearing sequences. Mike Timmons, New Mexico STATEMAP Director and Richard Chamberlin of the New Mexico Bureau of Mines provided logistical assistance. Gretchen Hoffman and Steve Cather critically reviewed the map and manuscript.

STRATIGRAPHY

The Poison Canyon Formation

The Paleocene Poison Canyon Formation (Pillmore and Flores, 1990) is the dominant map unit in the quadrangle. Up to 500m (1650') thick, the formation is an alluvial unit consisting, in order of abundance of sandstone, siltstone, claystone, pebbly sandstone, and pebble-cobble conglomerate. Thick-bedded sequences of mostly amalgamated, channelized-trough, and wedge-planar cross-stratified sandstone dominate. Tabular-planar sets are also present, but subordinate. Easterly paleoflow is indicated by an average azimuth of 083° derived from 189 paleocurrent measurements. Maximum grain size decreases rapidly to east from 35cm to 4mm, with most of the change occurring across the central part of the quadrangle. The sandstone is feldspathic to rarely arkosic, argillaceous, and micaceous. Clasts in the conglomeratic units are well-rounded to rounded and dominated by vein quartz, quartzite, chert, and quartz sandstone, especially to the east. Other types, more abundant to the west, consisting of leucogranite, sericitic schist, sillimanite (fibrolite) schist, and felsic to intermediate volcanics indicate a Proterozoic provenance. The quarzite and leucogranite clasts resemble outcrops along the western edge of the quadrangle. and the schist and volcanic clasts resemble other Proterozoic units know from elsewhere in northern New Mexico.

To the east, Poison Canyon Formation grades into Raton Formation, a finer grained, largely age-equivalent, basinward facies consisting of alternating thick-bedded sandstone and micaceous, silty claystone, dark gray to green shale, claystone, and coal. In fact, all of the strata shown as Poison Canyon Formation in the eastern third of this quadrangle might just as easily be named Raton Formation. The transition is gradual and occurs across a poorly constrained north-south trending boundary that extends across the eastern third of the map area. Although the two units are differentiated on the easterly adjacent Abreu Canyon map sheet (Skotnicki and Ferguson, 2006), we could not come to a consensus about how to depict the transition in this map area[1].

Wanek et al. (1964) mapped a lens of Raton Formation along the lower slopes of Middle Poñil Creek in the southeast part of this quadrangle, but in reality, tongues of similar strata occur well above the canyon bottom throughout this part of the map area. The Raton Formation is known to span the TK boundary to the east of the map area (eg.Wanek et al., 1964; Pillmore and Torres, 1990), but there is no indication that any Raton Formation occurs at depth in the western part of this quadrangle.

Upper Cretaceous units

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[1]Ferguson thinks that any depiction of Poison Canyon Formation versus Raton Formation in this part of the Raton basin would merely be a differentiation of sandstone-rich versus mudstone-rich strata and that this would be inconsistent with how both units are mapped in their type areas. Thick sandstone units within the Raton Formation at Raton Pass are essentially identical to the sandstone units mapped as Poison Canyon in this area, yet they are not differentiated at Raton Pass. Likewise, mudstone units in the Poison Canyon along the western edge of this map area are not mapped as Raton. An accurate depiction of sandstone-rich versus mudstone-rich variation is neither feasible nor necessary in this part of the Raton basin.

In the southwest and northwest Poison Canyon Formation overlies the Upper Cretaceous Trinidad Formation (Flores and Tur, 1982). The Trinidad (**Kt**) is a marine shore face sequence approximately 60m thick consisting of gray to green shale and laminated siltstone interbedded with parallel laminated to low-angle cross-stratified and locally hummocky cross-stratified sandstone. The Trinidad is present (with certainty) only in the northwest. The Vermejo Formation was not recognized in the map area, but there is no reason to conclude that is not present at depth in the eastern part of the map area. The Vermejo is represented on cross-sections as a combined Vermejo – Trinidad Formation (Kv-t) which is shown gradually changing into Trinidad Formation (Kt) to the north. To the southwest both units are apparently represented by a much thicker (at least 250 to 300m) hybrid unit (containing lithologic elements of the Trinidad, possibly the Vermejo and the Poison Canyon formations) herein informally referred to as the unit of Baldy Mountain.

The unit of Baldy Mountain (**TKb**) is dominated by parallel laminated to low-angle cross-stratified, medium- to thick-bedded, fine- to medium-grained, well-sorted, argillaceous quartz sandstone interbedded with dark argillite. In this regard it is very similar and probably a facies of the Trinidad Formation. However, the unit also includes several intervals throughout its thickness, each up to 30m thick, of medium- to thick-bedded, clean (non-argillaceous) medium- to coarse-grained quartz sandstone and pebbly sandstone. Pebbles are mostly light and dark gray chert. The unit of Baldy Mountain is much thicker (at least 250m) than the Trinidad Formation. Along the southern edge of the quadrangle the unit of Baldy Mountain thins dramatically to the east so that just to the east of Baldy Town it pinches out and Poison Canyon Formation directly overlies the Pierre Shale. A similar unconformity has been recognized farther north in the central part of the Raton basin (Pillmore and Flores, 1987; Speer, 1976). To the west, in the Mills Divide area, the unit of Baldy Mountain is absent. Although it might be argued that this is due to faulting, it appears, despite poor exposure, that the Pierre Shale – Poison Canyon contact is undisturbed. The unit of Baldy Mountain appears to fill a narrow trough that coincides roughly with the position of the Baldy Mountain massif.

The Pierre Shale (**Kp**), at least 600m thick, consists mostly of monotonous, black sulfidic shale. Its upper 150m is characterized by sparse septarian nodules up to 1 meter and rare, thin- to medium-bedded micritic limestone beds containing molluscan shell debris. At deeper stratigraphic levels, calcareous strata were not recognized. The upper unit is informally referred to as the calcareous zone of the upper Pierre Shale (**Kpc**). It serves as a valuable marker unit that helps define the trace of the South Poñil Creek fault in the western part of the map area just south of Mills Divide.

Older units, Proterozoic basement and the conglomerate of Mills Divide

Older units are found only in the hangingwall of a pair of east-vergent thrust sheets that bound the western edge of the quadrangle. The westernmost sheet carries foliated, micaceous quartzite (**Xq**) and fine- to medium-grained, weakly foliated leucogranite (**Xg**). Its basal thrust dips approximately 30 degrees to the west.

The lower thrust sheet, herein called the Mills Divide thrust sheet, carries a poorly exposed red conglomerate and pebbly sandstone unit, herein informally referred to as the conglomerate of Mills Divide (**T-Pmd**). The unit probably correlates, for the most part, with the Sangre de Cristo Formation, an ancestral Rocky Mountain (Pennsylvanian) foreland basin coarse-grained conglomerate and sandstone up to 900m thick (Baltz and Myers, 1999; Kues and Giles, 2004). The conglomerate of Mills Divide is sedimentologically and petrographically very similar to the Poison Canyon Formation which it structurally (and/or depositionally?) overlies. The Mills Divide is differentiated only by its coarser grain size (maximum clasts are typically 40-80cm) and red color. Clast types are virtually identical, as is their degree of rounding. The conglomerate crops out only in the western part of the thrust sheet where it consistently dips moderately to steeply to the west. Along the eastern edge of the thrust sheet, the unit is only known from loose colluvial material. The contact is easily traceable on south-facing slopes based on an abrupt color change and sudden increase in maximum clast size from east to the west. Also, outcrops of light green to tan Poison Canyon conglomerate and sandstone are abundant just to the east of the contact. The colluvium that overlies and conceals the conglomerate of Mills Divide in the eastern edge of its outcrop belt includes up to 5% clasts of well-rounded, micaceous, argillaceous, feldspathic quartz sandstone. The clasts are are difficult to correlate with any known older Paleozoic or Proterozoic unit. Instead, they strongly resemble the Poison Canyon Formation. To the north, in the northerly adjacent Ash Mt quadrangle, the western part of the same thrust sheet consists of dark red pebbly sandstone and pebble-cobble conglomerate of probable Paleozoic age that dips moderately to the west, but, similar to its counterpart to the south, no outcrops occur in the eastern part of the thrust sheet. Here, it contains abundant very large (up to 2m) boulders of quartz sandstone that strongly resemble the Dakota Sandstone (of Upper Cretaceous age).

Presence of clasts that may have been derived from Mesozoic and/or Paleocene units in the eastern part of the Mills Divide thrust sheet suggests a more complex origin for the unit as a whole. Western outcrops of the conglomerate of Mills Divide probably correlate with the Sangre de Cristo Formation, although it is possible that they might represent a western, coarser-grained equivalent of the Poison Canyon. In the east, the unit might include zones of younger, possibly Laramide-aged, fault generated, coarse-grained conglomerates and breccias of Paleogene age that might also be interleaved with slivers of The Poison Canyon Formation.

STRUCTURAL GEOLOGY

Folds and thrusts

Strata throughout most of the map area are gently folded into a broad, assymetric, east-vergent syncline that probably represents the southwesterly continuation of the La Veta syncline (Tyler et al., 1995). The broad syncline, along with a paired broad anticline strike north-northeasterly from just north of Baldy Mountain, roughly parallel to the main swarm of mid-Cenozoic dikes. To the southeast, a series of minor, weakly west-vergent (long eastern limbs are paired with short western limbs) folds converge and die out to the south. The folds are defined weakly by sporadic strike and dip control, but fairly well by the shape of a post-folding, mid-Cenozoic sill that holds up Wilson Mesa.

A pair of east-vergent thrusts carrying Paleoproterozoic crystalline rocks and probable Pennsylvanian conglomerate occur along the western edge of the map area. Both structures dip gently to the west. The lower Mills Divide thrust has a scalloped shape suggesting that it is fluted in a northwesterly direction and implying eastsoutheasterly motion. The thrusts cut the Paleocene Poison Canyon Formation, and are intruded by Mid-Cenozoic porphyritic dikes (**Tir** and **Tib**).

The South Poñil Creek fault

A north-side-down, sinuous fault, herein named the South Poñil Creek fault has been identified traversing the southern part of the map area. Up to 400m (1300 feet) of displacement is based on stratigraphic juxtaposition of units near Baldy Mountain where the top of the Pierre Shale (**Kp**) in the southern block is faulted against a "bottomless" section of gently north-dipping Poison Canyon Formation (**Tpc**) in the northern block. The dip direction is critical for determining whether the fault is reverse (south-dipping) or normal (north-dipping). Striking 285 at both ends, the fault curves to the south as it climbs through the massif of Baldy Mountain, a pattern that crudely approximates what should be expected from a gently north-dipping normal fault. In the high country however, and where exposures are more definitive, the pattern is reversed. The contact bends to the north as it climbs over the high ridge just south of Copper Park.

The reverse interpretation is based on better outcrop control, and seems more likely. However, if it is a reverse fault, the deflection of the fault at lower elevations implies a broad convex-up hump of the fault surface corresponding with the massif of Baldy Mountain. A normal fault interpretation based on the deflection of the fault at lower elevations, seems less likely, but interestingly, it also implies a convex-up hump (of shorter wavelength than the hump for a reverse fault) that coincides with the Baldy Mountain massif. A convex-up hump of the fault surface, regardless of its kinematics, across the Baldy Mountain massif is explained possibly by an irregularity, of similar wavelength, in the area's structural multi-layer. The unit of Baldy Mountain forms a 300m deep trough filled with relatively resistant quartz sandstone oriented (probably) at a high angle to the fault. The trough therefore represents a structural keel along the bottom of at least 500m of resistant, thick-bedded sandstone (the Poison Canyon Formation) overlying at least 600m of incompetent Pierre Shale. Refraction of a fault through such a boundary, forming a pair of lateral ramps that converge to form a hump coinciding with the trough, should be expected.

The question of which interpretation to favor is addressed by applying the best field data to the problem. The exposures in the high country, limited though they are, are in a much better position both geometrically and in terms of stratigraphy for drawing a structural cross-section perpendicular to the regional (and local) strike of the fault. Assuming a planar fault striking 285 through the Baldy Mountain – Copper Park area, the field data indicate a southerly dip in the range of 40-70 degrees. This interpretation, indicating reverse motion is shown in cross-section C-C'.

If a north-dipping normal fault is responsible for the map pattern, the fault's convex-up hump would have to be narrower, coinciding precisely with the fault trace's climb through the high country, but it would also have to be a low-angle fault in the lower country, dipping north on the order of 20 degrees or less. Since low-angle normal faults are typically associated with strata dipping steeply into the fault, and the opposite is true for the South Poñil Creek fault, the normal fault interpretation is not favored.

The trace of the South Poñil Creek fault along Mills Creek as it leaves the map area to the west is based on the interpretation that the stratigraphic level of the Pierre Shale (**Kp**) to the south of the fault is several hundred meters below the calcareous upper zone of the Pierre Shale (**Kpc**) to the north of the fault. The exposure is poor on the heavily vegetated north facing slopes to the south of the fault, but to the north several limestone beds and abundant septarian nodules are present.

In the southeast corner of the map area, where the South Poñil Creek fault juxtaposes slightly different facies of the Poison Canyon Formation (strata to the north are significantly coarser-grained), the fault is poorly defined, and its offset is unknown. Since there is no evidence of such a fault farther southeast, it is interpreted to die out in this direction. Its trace, however, is shown tentatively along the floor of South Poñil Creek canyon all the way to the southeast corner of the map where it is shown climbing up the southern canyon wall and being responsible for the abrupt southern termination of the Wilson Mesa sill. The sill, forming an extensive uninterrupted body to the north suddenly terminates to the south along a line that is interpreted to be the intruded fault trace. It is suggested that the abrupt termination is because a unit unfavorable for sill intrusion occurs to the south of the fault.

The South Poñil Creek fault appears to be intruded by the granitic stock of Copper Park (**Tg, Tgx, Tgxx**). If any motion postdated emplacement it would have to be minimal since the internal zonations within the stock are not offset appreciably. All of the other intrusive bodies in the Baldy Mountain area do not cross the fault. In fact, they seem to die out and terminate before they get close to the fault, as if the structure represented a barrier to continued dike and or sill emplacement. The fault also acts as a boundary between types and orientations of intrusive bodies.

At Mills Divide, a west-striking sill of biotite-rich porphyry (**Tib**) intrudes the contact between the upper Pierre Shale calcareous unit (**Kpc**) and the Poison Canyon (**Tpc**), a contact that is interpreted to lie in the footwall of the fault. This contact might also be a fault, but there is no evidence of shearing or brecciation along the contact in the limited areas where it is exposed and not intruded by the sill. A dike projecting out of the sill cuts across the nearby contact (interpreted as a thrust) between the Poison Canyon Formation (**Tpc**) and the overlying conglomerate of Mills Divide (**T-Pmd**). The Mills Divide thrust is intruded by another biotite-rich porphyry dike to the north (**Tib**).

The age of the South Poñil Creek fault is constrained by the youngest unit it cuts, the Paleocene Poison Canyon Formation (**Tpc**) and the igneous units that intrude it (**Tgx**). The fault might be related therefore to Laramide deformation or to emplacement of the igneous rocks. For example, inflation of the Upper Cretaceous section to the south of the fault by an extensive swarm of sills on the western flank of Baldy Mountain might have contributed to south-side-up motion along the fault. The age relationship between the South Poñil Creek fault and the Mills Divide thrust is not known.

IGNEOUS ROCKS

Three sets of intermediate to felsic porphyritic stocks, dikes, sills are identified in the map area. The igneous suite is dominated by intermediate composition monzonite porphyries with hornblende as the primary mafic phase. The most common type of intrusive rock is a fine-grained monzonite porphyry (**Tim**) that forms a radial dike swarm projecting to the north and northeast and emanating from the Baldy Mountain complex. Major dikes in the northern part of the quadrangle are of this type. To the east and west of the dike swarm, the same or similar monzonite porphyry forms sills; to the east a major sill that holds up Wilson Mesa, and to the west a pair of sills that intrude the upper calcareous zone of the Pierre Shale. Below these two sill complexes a pair of distinctive porphyritic varieties of monzonite porphyry form a complex set of sills that intrude the main body of the Pierre Shale; to the west, a hornblende-porphyritic complex of sills (**Ttm**) near the Deep Tunnel Mine, and to the east, a plagioclase-porphyrititc complex of stubby dikes and lacolith-shaped sills near French Henry Camp (**Tfh**).

The Baldy Mountain area is held up by a composite stock of probable granitic to quartz monzonite composition (**Tg, Tgx, Tgxx**). The stock is zoned from fine- to medium-grained around its margin through a coarse-grained intermediate zone to a megacrystic, potassium feldspar-porphyritic core. The stock intrudes the South Poñil Creek fault, but a connection between the stock and any of the surrounding sills and dikes could not be identified at the surface. This relationship of a radial dike swarm that appears to emanate from, but never connects with a central stock, is also recognized in the Spanish Peaks area ().

A suite of northwest-striking dikes occur to the north. These dikes are coarser grained, more felsic, and strongly porphyritic. The main dikes of this swarm contain up to 20% 5-8mm quartz, and potassium feldspar phenocrysts with biotite as the primary mafic phase (**Tir**). One of these dikes changes into a sill to the east where it crosses into the easterly adjacent Abreu Canyon map area (Skotnicki and Ferguson, 2006). To the west, dikes of this type intrude the Mills Divide thrust. Two minor sub-divisions of the northwest-striking dikes are a biotite-rich variety (**Tib**), and a single, thin biotite lamproite in the northwest (**Tibl**).

The southernmost northwest-striking (**Tir**) dike displays conflicting age relationships with the north-northeast-striking dikes (**Tim**). To the west the **Tir** dike is intruded by a major north-striking monzonite porphyry (**Tim**) dike, but towards the central part of the swarm the same dike intrudes several north-striking monzonite porphyry dikes (**Tim**). The relationship indicates that emplacement of the north-striking set occurred first in the central part of the swarm and that propagation of the westernmost dike occurred after emplacement of the northwest-striking dike.

SUGGESTIONS FOR FURTHER WORK

The age relationship of the South Poñil Creek fault and the Mills Divide thrust is not known, but might be addressed by mapping farther to the west of the Mills Divide area. Detrital zircon geochronology of the conglomerate of Mills Divide might be employed to determine the minimum age of the unit, and determine if the unit is entirely Paleozoic in age. Refinement of our structural cross-sections in the Baldy Mountain area, and a more precise determination of the geometry of the South Poñil Creek fault and the granitic stock of Copper Park at depth might be achieved by evaluating the geology in the extensive network of tunnels, shafts, and drifts that penetrate the Baldy Mountain mining district. Geochronology, detailed petrology, and geochemistry of the mid-Cenozoic igneous rocks are essential for refining the timing constraints on both of the map area's major fault zones.

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Unit Descriptions
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H Disturbed areas (Holocene) Mostly earthen dams

Qy Alluvium (Holocene) Active and recently active alluvial deposits

Qfy Young alluvial fans (Holocene) Alluvial fans that merge with and/or overlie active alluvial, valley bottom deposits.

Qcg Cienega deposits (Holocene) Long-lived deposits of perpetually wet younger alluvium in the Valle Vidal. The soil in these areas is black and very loamy.

Qyl Alluvium and lacustrine deposits (Holocene to Pleistocene) Mostly silt and clay with interbeds of fine-grained to coarse-grained sand and locally granular gypsum. Deposits fill a series of small lacustrine basins in the northeast corner of the quadrangle.

Qls Landslide deposits (Holocene to Pleistocene) Disorganized masses of landslide debris, in both instances consisting mostly of unit of Baldy Mountain. The areas of each map unit are characterized by irregular topography including numerous fine-grained sediment-filled depressions.

Qs-pc Slumped mass (Holocene to Pleistocene) Semi-coherent mass of Poison Canyon Formation

Qs-b, p, i Slumped mass (Holocene to Pleistocene) Semi-coherent mass of unit of Baldy Mountain, Pierre Shale, and porphyry intrusions

Qt Talus and colluvium (Holocene to Pleistocene) Talus and colluvium-covered slopes.

Qo Older alluvium (Pleistocene) Pebble-cobble alluvium caps two small hills near the head of Mill Creek in the southwest central part of the map area.

Qf Alluvial fan deposits of Valle Vidal (Pleistocene) Undifferentiated alluvial fan deposits. In areas where subcrop is the unit of Mills Divide, very large boulders (up to 2 meters) of sillimanite schist, quartzite and felsic porphyry occur.

Tim Monzonite (Oligocene) Fine- to medium-grained monzonite porphyry with subhedral to euhedral plagioclase phenocrysts up to 3mm, but mostly less than 2mm. Mafics are typically altered, but mostly appear to be hornblende with lesser amounts of biotite and pyroxene. Locally, miarolitic cavities are present. Dikes of this kind consistently strike northerly or northeasterly. The dikes intrude and are intruded by the northwest-striking suite of quartz-feldspar porphyry dikes (**Tir**). In the southeast (Wilson Mesa), and southwest, the porphyry mostly forms sills.

Tr Rhyolite dikes (Oligocene) Light-colored, phenocryst-poor rhyolitic dikes containing less than 10% 2mm feldspar, quartz, and rare biotite phenocrysts. Mapped only on Ash Mountain quadrangle.

Tir Quartz-feldspar porphyry (Oligocene) Strongly porphyritic felsic to intermediate dikes containing up to 20% 4-15mm euhedral to subhedral feldspar (mostly potassium feldspar) phenocrysts with hornblende and sparse biotite. Dikes of this variety, along with the biotite-red porphyry (**Tib**) and biotite-lamproites (**Tibl**) dikes consistently strike to the northwest. These dikes intrude and are intruded by the north to northeast-striking monzonite porphyry dikes (**Tim**).

Tib Biotite-rich intermediate porphyry (Oligocene) A distinctive subhedral-population of the northwest-striking suite of dikes containing abundant biotite (5-15% 1-3mm) and feldspar phenocrysts up to 6mm.

Tibl Biotite lamproite dike (Oligocene) A single northwest-striking dike (northernmost of the suite) of coarse-grained biotite lamproite, containing greater than 60% biotite.

Tfh Monzonite porphyry of French Henry Camp (Oligocene) A suite of fat, stubby, northwest-striking dikes and a lacolith-shaped stock in the vicinity of French Henry Camp, northeast of Baldy Mt. Similar to the monzonite porphyry in terms of mineralogy, containing plagioclase and mostly hornblende, but this porphyry is characteristically porphyritic with 2-10% plagioclase phenocrysts up to 5mm set in a groundmass that is virtually identical to the monzonite porphyry suite of dikes (**Tim**).

Tg Granite of Copper Park, fine- to medium-grained (Oligocene) The outer phase of a granitic stock centered on Copper Park, just to the north of Baldy Mt. The phase is similar mineralogically to the monzonite porphyry (**Tim**), except that the texture is more equigranular, the mafic content appears to be lower and it grades inward into a coarse-grained to megacrystic granite.

Tgx Granite of Copper Park, medium- to coarse-grained (Oligocene) Intermediate phase of the Copper Park stock containing feldspar phenocrysts ranging in size from 5mm to 4cm. Mafics, mostly biotite make up less than 15%.

Tgxx Granite of Copper Park, coarse-grained to megacrystic (Oligocene) Interior phase of the Copper Park stock containing euhedral to subhedral potassium feldspar phenocrysts up to 7cm.

Ttm Hornblende monzonite porphyry of Deep Tunnel Mine (Oligocene) A suite of sills in the southwest corner of the map area that contain conspicuous hornblende phenocrysts up to 1cm. The hornblende is concentrated in cumulate-like inclusions in a fine- to medium-grained matrix porphyry that otherwise resembles the monzonite porphyry suite of dikes and sills (**Tim**).

Tpc Poison Canyon Formation (Paleocene) Sandstone, pebbly sandstone, pebble-cobble conglomerate interbedded with lesser claystone, sparse shale, and rare coal seams. Eastern exposures are equivalent to the Raton Formation (**TKr**). The sandstone and conglomerate occur in medium- to thick-bedded, typically cross-stratified and channelized beds commonly amalgamated into sets greater than 20m thick. Trough and wedge-planar cross-stratified sets 20cm to 100cm thick are the most common, but tabular-planar sets are also present. An average paleocurrent azimuth of 083 was determined from 189 measurements, mostly from foresets. Mudstone interbeds, up to 20m thick, are typically massive, where not punctuated by siltstone intervals, poorly organized, and contain abundant detrital muscovite. Rare dark green and locally dusky red shale intervals are also present. The feldspathic (rarely arkosic) quartz sandstone is poorly- to moderately-sorted, argillaceous and micaceous. Clasts in the conglomeratic sandstone and pebble-cobble conglomerate are well-rounded to sub-rounded and dominated by vein quartz, micaceous quartzite, quartz sandstone, and chert throughout most of the map area. Towards the west, the maximum grain size increases to 25-30 cm and clasts of leucogranite, sericitic schist, sillimanite (fibrolite) schist, felsic to intermediate volcanics, and sparse amphibolite. At least 500 meters (1,600 feet) thick

TKb Unit of Baldy Mountain (Paleocene - Upper Cretaceous) A complex unit exposed only in the vicinity of Baldy Mountain. The unit is typically hornfelsed or strongly silicified and poorly exposed, forming long talus slopes and large landslide and semi-coherent slump deposits. The unit is dominated by fine- to medium-grained, well-sorted, arenaceous quartz sandstone that is typically present in parallel laminated to low-angle cross-stratified, medium- to thick-beds. The sandstone is also interbedded with dark silicified argillite and in this regard is very similar and probably equivalent to the Trinidad Formation. However, the unit also includes several intervals, up to 30 meters thick, of medium- to thick-bedded, clean (non-argillaceous) medium- to coarse-grained quartz sandstone and pebbly sandstone. Pebbles are mostly light and dark gray chert. The unit is provisionally given a temporary, informal name due to its poor exposure, the lack of a well-defined upper contact, and the fact that the unit is several times thicker than the Trinidad Formation. At least 250 to 300 meters (800 to 1,000 feet) thick

Kt Trinidad Formation (Upper Cretaceous) Gray to green shale and laminated siltstone interbedded with thin- to thick-bedded fine-grained, well-sorted quartz sandstone, typically argillaceous. The sandstone beds are parallel laminated to low-angle cross-stratified and locally display hummocky cross-stratification. 60 meters (200 feet) thick

Kt-v Combined Trinidad – Vermejo Formations (Upper Cretaceous) A unit shown only on cross-sections. 125-155 meters (400-500 feet) thick

Kpc Pierre Shale, calcareous upper zone (Upper Cretaceous) Black shale with septarian nodules up to 1 meter and sparse, thin- to medium-bedded micritic limestone beds containing molluscan shell debris. 125-155 meters (400-500 feet) thick.

Kp Pierre Shale (Upper Cretaceous) Black shale undifferentiated. Greater than 600 meters (2,000 feet) thick

T-Pmd Conglomerate of Mills Divide (Paleocene - Pennsylvanian) A very poorly exposed unit composed of cobble-boulder, well-rounded conglomerate and pebbly sandstone. Clasts of vein quartz, micaceous quartzite, quartz sandstone, silicified argillite, chert, leucogranite, foliated leucogranite and gniess, sillimanite (fibrolite) schist, sericitic schist, and porphyritic intermediate to felsic igneous rocks are virtually identical to those found in the Poison Canyon, but much larger typically 2-3 times. Along the eastern edge of its outcrop belt, sparse clasts of micaceous, argillaceous, feldspathic quartz sandstone that strongly resemble the Poison Canyon Formation are present. Outcrops of this unit are rare, but consist of medium- to thick-bedded pebble-cobble, mostly clast-supported conglomerate and pebbly sandstone. One paleocurrent (170) was obtained. The unit is differentiated from the Poison Canyon Formation by dark red soil and maximum clast sizes that are typically greater than 60cm. Most of the unit probably correlates with the thick, dark red hematite-cemented, coarse-grained, Pennsylvanian conglomeratic (Sangre de Cristo Formation) units of the area. The presence of clasts that might have been derived from the Paleocene Poison Canyon Formation in the south, and a zone of very coarse-grained clasts (greater than 2m) of quartz sandstone that strongly resembles the Dakota Sandstone (of Upper Cretaceous age) along the eastern edge of the outcrop belt in the northerly adjacent Ash Mt 7.5' quadrangle, suggests a more complex origin for this unit. That the conglomerate might also include zones of younger, possibly Laramide-aged, thrust-front generated, coarse-grained lenses is a possibility that must be considered. That the thrust fault zone might have been reactivated as a normal fault is also a possibility. At least 200m (650 feet) thick.

Xg Foliated leucogranite (Paleoproterozoic) Fine- to medium-grained, foliated, leucocratic granitoid, locally intruded by undifferentiated amphibolite dikes

Xq Quartzite (Paleoproterozoic) Weakly to strongly foliated fine- to coarse-grained quartzite locally containing segregations of coarse-grained muscovite. Only shown on cross-section and on the westerly adjacent Red River Pass 7.5' quadrangle