Geologic Map of the Angus Quadrangle, Lincoln County, New Mexico

By

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Open-file Digital Geologic Map OF-GM 095

Scale 1:24,000

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Mapped and compiled by Geoffrey Rawling

EXPLANATION OF MAP UNITS

Anthropogenic Deposits

af Artificial fill for stock tanks and highway embankments.

daf Heavily disturbed land and artificial fill. Mapped where extensive, underlying deposits are obscured, and/or geomorphic surfaces are extensively altered.

Quaternary and Tertiary Surficial Deposits

QHa Alluvium (Holocene to Historic) – Unlithified gravel and poorly to moderately sorted clay, silt, and sand in active stream channels and ephemeral arroyos. Generally incised into **Qvf** and terrace deposits. Only mapped where extensive; unit is otherwise lumped with **Qvf**. Thickness: 0 to 4? meters.

Qvf Valley fill (upper Pleistocene to Holocene) - Unlithified valley fill composed of poorly sorted clay, silt, and sand, commonly with angular to subrounded cobbles of local bedrock. Matrix material is light to dark brown. Grades into minor alluvial and colluvial fans on toes of hillslopes. Anthropogenic disturbance common in developed areas. Generally incised by active drainages, floored by sand and cobble to boulder gravel of **QHa**. Thickness: 0 to 12? meters.

Qaf – Alluvial fan deposits (middle to upper Pleistocene) – Alluvial fans composed of poorly sorted cobbles, boulders, sand, silt, and clay. Fans head in short, steep tributary canyons and interfinger with and/or spread out onto **Qvf** and terrace deposits. Stabilized by vegetation, apparently no longer active, and locally incised by drainages floored with **QHa**. Only mapped along major drainages where geomorphic expression is clear on aerial photos. Thickness: 0 to 8? meters.

Qbt2 – Lower terrace deposit of Rio Bonito (Holocene) – Poorly sorted alluvial deposits composed of interstratified fine to coarse, tan sand and sandy cobble to boulder gravel. Clasts are dominantly Bonito Lake stock (**Tbs**) and mixed volcanic and intrusive igneous rocks. Deposit forms a terrace whose tread is generally preserved and is within a few meters of present stream grade. Largely mapped from aerial photographs. Thickness: 0 to 3 meters.

Qbt1 – Upper terrace deposit of Rio Bonito (upper Pleistocene) - Poorly sorted alluvial deposits composed of interstratified fine to coarse, tan sand and sandy gravel of rounded cobbles and boulders. Clasts are dominantly Bonito Lake stock (**Tbs**) and mixed volcanic and intrusive igneous rocks. Deposit forms a terrace whose tread is generally dissected and is at least 5 to 6 meters above present stream grade. Grades into and/or is locally overlapped by hillslope colluvium. Largely mapped from aerial photographs. Thickness: 0 to 6? meters.

Qet2 – Lower terrace deposit of Eagle Creek (Holocene) – Poorly sorted alluvial deposits composed of interstratified fine to coarse, tan sand and sandy cobble to boulder gravel. Deposit forms a terrace whose tread is generally preserved and is within a meter of present stream grade. Largely mapped from aerial photographs. Thickness: 0 to 3 meters.

Qet1 – Upper terrace deposit of Eagle Creek (upper Pleistocene) - Poorly sorted alluvial deposits composed of interstratified fine to coarse sand and sandy gravel of rounded cobbles and boulders. Deposit forms a terrace whose tread is preserved and is 3 to 4 meters above present stream grade. In Eagle Creek canyon between the west end of Gavilan Ridge and Alto reservoir the terrace tread is continuous with remnants(?) of a strath terrace beveled on bedrock of Mancos Shale and Mesaverde Group sandstones and shales. Largely mapped from aerial photographs. Thickness: 0 to 5? meters.

Qg – Stream gravel deposits (lower (?) to middle Pleistocene) - Moderately lithified, crudely bedded, pebble to boulder gravel in Gavilan Canyon. Approximately 45 meters lower in elevation than **QTg** deposits. Poorly exposed, but appears to have smaller, more angular, and less weathered clasts than **QTg**. Postdates incision of modern drainages and is correlative to stream gravel unit (**Qg**) in the Ruidoso and Ruidoso Downs quadrangles to the south. Correlated by Moore et al. (1988a) to the Palomas gravel of the Tularosa basin. Thickness: 0 to 20? meters.

QTg – Pediment gravel deposits (Pliocene (?) to lower Pleistocene) – Moderately lithified, crudely bedded, pebble to boulder gravel with reddish clayey sand matrix and local lenses of sand and sandy clay. Largest boulders are 80 centimeters in diameter. Clasts are >90% Sierra Blanca volcanic rocks and associated intrusive igneous rocks. Clasts on surface of deposit are heavily weathered and fractured. Surface is partly stripped. Contains stage III to III+ carbonate soil near surface and local strong carbonate buildup (equivalent to stage IV carbonate soil development) at base of unit. Road cuts in the Sonterra Ranch area expose irregular blebs and lenses of subsurface carbonate cementation, possibly deposited by groundwater. Extensive downslope colluvium makes base of unit hard to define where not exposed in road cuts. Caps hills and broad flat mesas in the eastern third of the quadrangle. Base of deposit slopes east at >100 feet per mile. Deposited by steep gradient streams draining the Sierra Blanca, predating incision of modern drainages. Thickness: 0 to 30? meters.

Cenozoic Igneous Rocks

Tbs – Bonito Stock (upper Oligocene, 26.6 Ma) – Light-purple to gray, porphyritic–phaneritic syenite. Rock is dominantly potassium feldspar with 10–15% hornblende and biotite and <5% quartz. Propylitic alteration of mafic minerals to chlorite and epidote is common. Intrusive contact in Mineral Farms Canyon exhibits dikelets and apophyses of purple syenite with aphanitic cooling rind in dark-grey, aphanitic andesite of **Tdsc**. Extensive bleaching and silicification due to hydrothermal alteration is common along northern margin with **Tsv**. Remainder of margin is often marked by a variably bleached and iron-stained border facies of grayish-lavender, aphanitic-porphyritic or very fine-grained phaneritic-porphyritic syenite. Southwest of Villa Madonna the syenite grades into greenish gray monzonite with more plagioclase than potassium feldspar and extensive alteration of mafic minerals to chlorite. K-Ar age of 26.6 Ma (Thompson, 1972). Thickness: Base and top not exposed; ≥1200? meters.

Tad – Andesite/diorite dike, undivided (Oligocene) - Aphanitic to very fine-grained phaneritic or phaneritic-porphyritic dike rocks. Generally dark gray on fresh surface and brown to black on weathered surfaces. When phaneritic, often has a "salt and pepper" appearance due to fine-grained, equigranular, white feldspar and black to brown augite(?). Phenocrysts include augite, hornblende, and tabular intermediate(?) plagioclase. Tabular plagioclase phenocrysts are up to 4 centimeters in diameter and are usually aligned with the dike margins. Thickness: dikes are <1 to 5 meters wide.

Tm – Monzonite (?) dike (Oligocene) – Tan to brown, aphanitic to very fine-grained phaneritic dike rocks. Typically composed of approximately equal amounts of white feldspar and tan to brown mafic minerals with little or no quartz. Often weathers in a granular fashion resulting in a surface texture resembling sandstone. Feldspar is largely intermediate(?) plagioclase with lesser amounts of potassium feldspar and forms a felted network of interlocking crystals. Includes rocks ranging from syenite to diorite in composition. Thickness: dikes are <1 to 5 meters wide.

Tcd – Diorite of Champ Hill (Oligocene) - Dark-gray to grayish-brown, fine-grained phaneritic diorite with 10–15% phenocrysts of augite. Forms an irregular pluton underlying Champ Hill and much of the surrounding area east of NM-48 in the northeast corner of the quadrangle. Subcrop and float of this rock and similar rocks with more or fewer phenocrysts of augite and plagioclase and variable phenocryst size cover a large area with inliers or xenoliths of Mesaverde sandstone. Probably a stock (forming Champ Hill) and associated dikes and sills. Float of similar rocks from dikes and sills is common in the northern half of the quadrangle. Thickness: Base and top not exposed; sill shown in cross section A–A' ≥190 meters.

Tsv – Sierra Blanca volcanic rocks, undivided (upper Eocene to Oligocene) – Walker andesite breccia of Thompson (1972). Interbedded dark-purple, purplish- red, red, and light- to dark-gray and gray-green volcanic flow breccias, volcanic debris flows, shallow intrusive sills, lahars, and volcaniclastic sedimentary rocks from the Sierra Blanca volcanic center to the west of the quadrangle. Rocks are generally alkalic and range from mafic (tephrite, phonotephrite, trachybasalt) to intermediate (andesite and latite) to felsic (rhyolite, trachyte, phonolite) in composition. Flow breccias are dominant and consist of varicolored, angular to subrounded clasts of volcanic and lesser intrusive rocks in a purple or purplish-gray, fine-grained matrix. Matrix is often propylitically altered. Clast population may be monolithologic or varied. Outcrops are massive to crudely bedded and individual flow units are generally 2 to 3 meters thick. Shallow intrusive sills are light to dark gray and aphanitic. Lahar deposits and volcaniclastic sedimentary rocks are red to purple muddy sandstones to conglomerates with variably developed bedding and sorting. Sandstones are well bedded, often with fining-upward graded beds less than 0.5 centimeters thick. Natural exposures of all units are poor and individual units are not laterally traceable. Not subdivided except in areas compiled from Moore et al. (1988b, see below). Good exposures are in road cuts on NM-532 and display interbedded volcanic and volcaniclastic units folded into 50 to 100 meter wavelength synclines and anticlines, probably due to faulting and forcible intrusion of numerous dikes and sills. Thickness: ≥250 meters.

Tsv-tp – Trachyphonolite porphyry flows - Fine- to medium-grained, medium- to dark-gray-green flows with plagioclase phenocrysts. Unit from Moore et al. (1988b). Thickness: ≥25 meters.

Tsv-tf – Trachybasalt flows - Fine- to very fine-grained, dark- gray aphyric flows. Unit from Moore et al. (1988b). Thickness: ≈60 meters.

Td – Diorite (upper Eocene or Oligocene) – Shallow subvolcanic sill or non-vesicular flow concordant with over and underlying **Tsv** flow breccias. Medium- to dark-gray, aphanitic to very fine-grained phaneritic matrix with 10–45% plagioclase phenocrysts from <1 to 4 centimeters in length and 5–7% augite phenocrysts generally less than 1 centimeter in length. Plagioclase phenocrysts are often aligned horizontally or grouped in radial rosettes. Thickness: ≈90 meters.

Tdsc – Dike and sill complex (upper Eocene to Oligocene) – Area northeast of the Bonito Lake stock characterized by float of a wide variety of intermediate and felsic igneous rocks including andesite, diorite, monzonite, and latite, but very sparse outcrop. Appears to be >90% igneous rocks. No outcrop or float of Bonito Lake stock or textures indicative of flow breccias, lava flows, or tuffs. Field relations suggest that felsic rocks such as monzonite are more common as irregular, discordant masses, whereas intermediate rocks such as diorite are more common as dikes and sills. Isolated subcrop on hilltop west of Mills Canyon of white to tan quartz sandstone is either Mesaverde Group sandstone or contact metamorphosed Cub Mountain Formation sandstone and is the only sedimentary rock observed in this unit. Unit is probably a dike and sill complex. Roadcut at Bonito Store exhibits several vertical andesite dikes intruded into gray aphanitic andesite sills or nonvesicular flows(?). Contact with **Tsv** is gradational between Mills and Vickers Canyons. Thickness: Base and top not exposed; ≥600? meters.

Cenozoic Sedimentary Rocks

Tcm – Cub Mountain Formation (Eocene) – White to tan sandstones, dark-red sandy mudstones, and purplish-red silty mudstones. Sandstones are medium- to thick-bedded, cross-bedded, medium-grained, and arkosic to volcaniclastic. Pebble conglomerate lenses, mudballs, and rip-up clasts of red mudstone, and olive, black, and gray siltstone and shale are locally common. Sandstones are generally more friable than underlying Cretaceous sandstones. Sandy and silty mudstones are thick bedded to massive and micaceous. Several outcrops are volcaniclastic in nature, and the unit thus includes the Sanders Canyon Formation of Cather (1991), but the two formations are not mappable separately in the quadrangle. Unit is ubiquitously intruded by igneous dikes, sills and irregular masses. Thickness: ≥450 meters.

Mesozoic Sedimentary Rocks

Kmv – Cretaceous Mesa Verde Group, undivided (upper Cretaceous) – Lavender to tan sandstone and conglomerate, olive to gray sandy siltstone and siltstone, and dark-gray, grayish-purple, and black shale. Sandstones are fine- to medium-grained, medium- to very thick-bedded, trough cross-bedded, and composed of subrounded to subangular grains. Dominantly quartzose and resistant, but locally arkosic and friable. Conglomerate is present as lenses within sandstone beds. Iron concretions and plant fossils are common. Shales are carbonaceous and fissile and usually interbedded with blocky weathering, thin- to medium-bedded, occasionally micaceous, siltstone and sandy siltstone layers with rip-up clasts of black shale. Subdivisions of the unit (e.g., Gallup Sandstone, Crevasse Canyon Formation) are not mappable in the quadrangle. Unit is ubiquitously intruded by igneous dikes, sills and irregular masses. Adjacent to these bodies shales are often contact metamorphosed to low grade hornfels and weather into gray angular chips rather than black flakes. Thickness: ≈240 meters.

Km – Mancos Shale (middle to upper Cretaceous) – Black to purplish-gray, laminated fissile shale. Ovoid calcareous concretions are locally abundant. Black to dark-gray to olive, thin-bedded, fine-grained sandstone and siltstone beds less than 0.5 meters thick and thin- to medium-bedded limestones 1 to 2 meters thick are minor constituents. The contact with the underlying Dakota Sandstone is transitional over at least a 50 foot interval, with thin medium-grained quartz sandstone beds within black fissile shale. Igneous intrusions are common. Thickness: ≈335 meters.

Kd – Dakota Sandstone (lower to middle Cretaceous) – Gray to tan to purple sandstone and minor black shale. Sandstone is medium- to thick-bedded, trough to tabular cross-bedded, ripple-marked, and composed of subangular to subrounded, vitreous quartz grains. Orange to rusty red liesegang bands are common on bedding planes and fracture surfaces. Sandstone is more resistant, forms more prominent outcrops, and weathers into more angular fragments than overlying Mesaverde sandstones. Matrix-supported sandy chert pebble conglomerate is present as a 1 meter thick layer at the base of unit and as sparse lenses throughout the unit. Thin, discontinuous beds of black shale similar to the overlying Mancos Shale are sparsely distributed throughout the upper portions of the unit. Thickness: ≈105 meters.

Ŧsr - Santa Rosa Formation (upper Triassic) - Dark-brownish-red, fine-grained sandstone, siltstone, and dark red mudstone. Reduction spots are common in the sandstone and siltstone. Base of the unit is marked by a gray to orange to red, medium- to thick-bedded quartzite and chert pebble conglomerate with a matrix of coarse chert-rich sand. Conglomerate is scoured into underlying Grayburg Formation. Very poorly exposed and usually mantled by colluvium from overlying Dakota Formation. Thickness: 33 to 45 meters.

Paleozoic Sedimentary Rocks

Pg – Grayburg Formation (upper Permian) - Gray, tan, and yellowish-brown, fine-grained sandstone and siltstone and minor gypsum. Sandstones and siltstones are very thin- to thick-bedded, parallel- to cross-bedded, and composed of quartz. Very poorly exposed. Thickness: ≈350 meters.

Psa - San Andres Formation (middle to upper Permian) - Light- to dark-gray and bluish-gray limestone and dolomite. Limestones and dolomites range from thin- to very thick-bedded, and are carbonate mudstones, wackestones, and grainstones. Freshly broken surfaces are darker gray than weathered surfaces and occasionally fetid. Beds are often silty or sandy. Dark-brown, irregular chert nodules are sparse. Fossils are sparse and are dominantly crinoid stem fragments. Intraformational solution breccias and paleokarst features are common along faults and as isolated occurrences, probably collapsed caves. They are characterized by red soil and red and yellow breccia fragments. Contact with the overlying Grayburg Formation is marked by development of reddish-yellow to buff solution breccia and abundant vugs filled with calcite crystals. The base of the unit is characterized by irregular bedding dips due to gypsum dissolution in the underlying Yeso Formation. Delineation of the San Andres into the lower thick-bedded Rio Bonito Member and upper thin-bedded

Bonney Canyon Member (Kelley, 1971) was attempted but was not possible due to steep topography, heavy vegetation, and sparse outcrop. The lowest portions of the unit do contain abundant thick beds, but in this area vertical changes in bedding thickness and bed color are not mappable distinctions. Thickness: ≈335 meters.

Py – Yeso Formation (middle Permian) - Cross-section only. Sandstone, siltstone, carbonates, and gypsum. Thickness: ≥240 meters based on exposures in Ruidoso Downs quadrangle to the southeast. Wasiolek (1991) reported a regional thickness range of 320 to 380 meters based on wells from the north central part of the Mescalero Reservation.

Pp€u - Permian to Proterozoic rocks – Cross-section only. Paleozoic sedimentary rocks and Proterozoic igneous and metamorphic rocks, undivided. Thickness of Sub-Yeso Paleozoic rocks unknown.

MAP AND CROSS SECTION SYMBOLS

Location of geologic cross section

Geologic contact, solid where exposed, dashed where approximately located, dotted where concealed, queried where inferred

Normal fault, arrow shows dip and dip direction of fault plane where measured, ball and bar on downthrown side, dashed where approximately located, dotted where concealed. Fault tip is queried where the termination of fault is unknown.

Fault, relative motion unknown, dashed where approximately located, dotted where concealed

Anticline, trace of axial plane showing plunge

Syncline, trace of axial plane showing plunge, dashed where approximately located

Dip and dip direction of bedding

Dip and dip direction of joints

Dip and dip direction of plane of small fault

Trend and plunge of slickenside striae

Paleocurrent direction, # i indicates number of imbricated gravel clasts measured. Tail of arrow is at measurement point

Outcrop and local trace of dike, with dip and dip direction where measured

Water well with NM State Engineer Office W.A.T.E.R.S. database reference number

Water well projected into cross section

NOTES AND ACKOWLEDGEMENTS

Geology within Mescalero Tribal lands in the southwestern corner of the quadrangle was compiled from Moore et al (1988b).

Doug Rappuhn of the New Mexico State Engineer's Office kindly provided lithologic logs of water wells in the Ruidoso area.

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