

# Preliminary Geologic Map of the Milan Quadrangle, Cibola County, New Mexico (Year 1 of 1-Year)

By

**Geoffrey Rawling**

**June 2012**

**New Mexico Bureau of Geology and Mineral Resources**  
*Open-file Digital Geologic Map OF-GM 231*

**Scale 1:24,000**

This work was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP) under USGS Cooperative Agreement 10HQPA0003 and the New Mexico Bureau of Geology and Mineral Resources.



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

*The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government or the State of New Mexico.*

# Preliminary Geologic Map of the Milan Quadrangle

OF-GM-231

by Geoffrey Rawling

## EXPLANATION OF MAP UNITS

### Anthropogenic Deposits

**af** Artificial fill for stock tanks and road embankments

**daf** disturbed land in urbanized areas and surface excavations such as gravel pits etc.

### Quaternary and Tertiary Surficial Deposits

**Qa – Active alluvium (Holocene to Historic)** – Unlithified gravel and poorly to moderately sorted clay, silt, and sand in the active channel of the Rio San Jose. Incised into **Qvf** and basalt lava flows. Only mapped where extensive and obvious on air photos along the lower Rio San Jose; occurrences in other drainages are lumped with **Qvf**. Thickness: 0 to 4 (?) meters.

**Qvf - Valley fill (upper Pleistocene to Holocene)** – Unconsolidated, moderately sorted sand, silt, and clay in shades of brown and reddish-brown. Unit grades into minor alluvial fans and hillslope toe deposits and locally includes small gravelly terrace deposits adjacent to drainages, composed of sandy pebbles through boulders. Unit is

widespread north of Milan in the broad Rio San Jose valley where it locally includes sand sheets. Anthropogenic disturbance is common due to agriculture, grazing, and suburban development. Incised by active drainages, floored by sand and cobble to boulder gravel of **Qa**. Thickness: 3 to 12 meters in the valley north of Milan, 0 to 5 meters (?) in drainages.

**Qc – Colluvium (upper Pleistocene to Holocene)** - Poorly sorted boulder to cobble gravel with a matrix of sand, silt and clay. Boulders may be up to several meters in diameter. Unit was deposited by mass-wasting process and mantles the base of slopes. Unit includes small alluvial fans and interfingers with alluvial deposits on valley bottoms. Thickness: 0 to 15 (?) meters.

**Qsd – Sandsheets and small dunes (upper Pleistocene to Holocene)** – Aeolian sand deposits in swales and locally mantling low-relief topography on **Qls** deposits around Black Mesa. Identified on aerial photographs. Thickness: 0 to 10 (?) meters.

**Qht – Hillslope toe deposits (upper Pleistocene to Holocene)** – Poorly sorted gravel with a matrix of sand, silt and clay. Unit was deposited by mass-wasting, alluvial, and aeolian processes, and mantles the base of slopes. Unit includes small alluvial fans and interfingers with valley bottom deposits. Thickness: 0 to 10 (?) meters.

**Qls – Landslide deposits (middle Pleistocene to Holocene)** – Areas of hummocky topography with abundant small closed depressions and swales around Black Mesa.

Deposit is a mixture of Toreva blocks, slumps, and earthflows, and is composed of blocks of basalt, and chaotic mixtures of angular basalt boulders, underlying Triassic mudstones, and aeolian sand. Surface is usually mantled by basalt boulders.

Thickness: 0 to several 10s of meters.

**Tg - Pediment gravel deposits (Miocene (?) to Pliocene)** – Unconsolidated and heavily eroded terrace remnants composed dominantly of poorly sorted subangular to angular clasts of red Proterozoic granite and white bull quartz. Clasts are generally 20-30 cm and occasionally up to 80 cm in diameter. Subrounded clasts of grey limestone comprise less than 5% of the deposit. Deposits cap hills and mesas and are 90 – 100 m above present canyon bottoms. Similar Proterozoic clasts are common as scattered lag gravels on upland surfaces in the southwest part of the quadrangle. Clasts are sourced from Proterozoic exposures to the west of the quadrangle. Thickness: 0 to 6 meters.

### **Quaternary and Tertiary Igneous Rocks**

**Qbz - Zuni Canyon Basalt flow (upper Pleistocene)** – Alkali-olivine basalt erupted from the Paxton Springs center to the southwest of the quadrangle. The basalt is holocrystalline, vesicular, and microporphyritic, with euhedral basalt phenocrysts up to 1.0 mm and rarer phenocrysts of clinopyroxene and plagioclase in a groundmass of plagioclase, pyroxene, and opaque minerals (Laughlin et al. 1972). Glassy surface rinds are eroded and ropy pahoehoe textures largely so. The age is  $20.7 \pm 2.2$  ka as determined by  $^{36}\text{Cl}$  cosmogenic exposure dating (Dunbar and Phillips 2004). It occurs

as scattered remnant outcrops along the walls of lower Zuni Canyon and a larger area of exposure south of Milan and east of the canyon mouth. Around the canyon mouth and within Milan it is covered by **Qvf** and/or obscured by development. The Rio San Jose has cut through the flow south of Milan. Thickness: 0 - 5 meters in Zuni canyon, 9 - 14 meters within and south of Milan.

**Qbf, Qvf/Qbf- Bluewater Basalt flow (upper Pleistocene)** – Tholeiitic basalt erupted from El Tintero cinder cone to the north of the quadrangle. The basalt is holocrystalline with olivine and plagioclase phenocrysts in a groundmass of plagioclase and clinopyroxene microphenocrysts with less common opaque oxides and olivine (Sims et al. 2007). Glassy rinds and ropy pahoehoe surface textures are completely eroded. The age is  $68 \pm 24/-20$  ka by  $^{238}\text{U} - ^{230}\text{Th}$  disequilibrium dating and 60 ka by  $^3\text{He}$  cosmogenic exposure dating (Sims et al. 2007). The flow occurs in the northeastern portion of the quadrangle and is mapped separately where exposed and/or with a thin sediment cover (**Qbf**), and where mantled by valley fill (**Qvf/Qbf**) but still identifiable on air photos. Based on water well logs, locally there are multiple buried flows with intervening sediments in the subsurface. Unit is more extensive to the south but is not identifiable on air photos. Thickness: 1 to 27 meters.

**Tbb – Basalt of Black Mesa (Pliocene)** – Hawaiite basalt (Perry et al. 1990) capping Black Mesa on the east side of the quadrangle. The age is  $2.573 \pm 0.130$  by  $^{40}\text{Ar}/^{39}\text{Ar}$  dating (Laughlin et al. 1993). Thickness: 15 to 20 meters.

## Mesozoic Sedimentary Rocks

### **Trps – Sonsela member of the Petrified Forest Formation (upper Triassic) –**

Probable identification of white to pale tan, thick-bedded cross-bedded sandstone.

Outcrop is surrounded by landslide deposits of **Qls** on private property in Milan and was observed from a distance. Sandstones in this member are described by Heckert and Lucas (2003) as trough cross-bedded, yellow to gray sublitharenites and subarkoses. Unit is part of the Chinle Group. Thickness: undetermined, base and top not exposed. Heckert and Lucas (2003) measured more than 20 meters at localities in the Zuni Mountains to the northwest.

### **Trcb – Bluewater Creek Formation (upper Triassic)– Purple, lavender, and grey**

mudstones exposed in roadcut in Milan at the eastern edge of the quadrangle.

Mudstones are slightly bentonitic and contain calcareous nodules. Bedding is poorly exposed and locally slumped. Rocks correspond to lithofacies assemblage I of Lucas and Heckert (2003). The formation is the lowest member of the Chinle Group and probably underlies much of the landslide deposits (**Qls**) surrounding Black Mesa.

Thickness: undetermined, base and top not exposed. Heckert and Lucas (2003)

measured up to 60 meters in the Zuni Mountains to the northwest .

### **Trm – Moenkopi Formation (middle Triassic) – Sandstone, silty sandstone, and**

subordinate silty mudstone in shades of red and brownish-gray. Basal mudstones and silty mudstones are generally less than 5 meters thick, weak red to dark red, and weather into low, unvegetated slopes of shaley rubble. Overlying platy-weathering

silty sandstones are pale red lithic arenites and lithic wackes, thin- to very thin-bedded, and calcareous. They are moderately sorted, composed of 80% quartz and 20% chert, feldspar, and lithic fragments in medium- to fine-grained, subangular to subrounded grains. Outcrops are capped by weak red to pale red, resistant, massive to locally planar and trough cross-bedded, pebbly sandstones and sandy pebble conglomerates. They are medium- to less commonly fine-grained lithic arenites with up to 20 % chert, feldspar, and lithic fragments in subangular to subrounded grains with minor clay matrix. Varicolored chert and quartzite pebbles are common, either scattered throughout the rock or in discrete conglomeratic layers. In the northwest portion of the quadrangle the uppermost sandstones are light brownish-gray and distinctly lighter on air photos, and are more compositionally mature with more quartz and less lithic fragments, chert, and clay matrix. Thickness: up to 18 meters are exposed in the quadrangle; top is probably eroded. Heckert and Lucas (2003) measured ~ 25 meters in the Zuni Mountains to the northwest.

### **Paleozoic Sedimentary Rocks**

**Psa - San Andres Formation (middle to upper Permian)** – Medium to dark to very dark grey dolomitic limestone and calcareous dolomite interbedded with light tan to pink to pinkish-gray cross-bedded quartz sandstone. These rocks are locally overlain by very pale brown to light gray very fine-grained limestone. Sandstones are tongues or lenses of the underlying Glorieta Sandstone and the contact between the two is intertonguing. The contact is placed at the base of the lowest carbonate beds. Carbonate rocks range from medium- to very thick-bedded (up to 3 to 4 meters), are

usually internally massive, and grade into sandy dolomites and dolomitic sandstones adjacent to sandstone beds. Sandstones are composed of medium- to fine-grained, rounded to subrounded quartz grains, are non-calcareous, and usually have distinct tabular cross-beds. A prominent sandstone tongue 7 – 8 meters above the Glorieta sandstone visible in the walls of Zuni Canyon is mappable but pinches out repeatedly. At least three other variably discontinuous sandstone lenses are present higher in the section throughout the quadrangle. The top of the formation is a regional unconformity with development of paleokarst. Lenses, irregular masses, and erosional lag of varicolored chert are abundant at the top of the formation. Light gray limestones present in the southeast corner of the quadrangle and comprising the 7074 ft hill (VABM “Top”) in the central portion of the quadrangle are an upper member that was mostly removed by pre-Triassic erosion elsewhere. Thickness: highly variable due to pre-Triassic erosion and karst processes; up to 60 meters in cross-sections, ~ 150 meters on hill where upper member is present.

**Pg – Glorieta Sandstone** – White to pale orange to grayish-pink quartz sandstone.

Quartz grains are moderately well- to well-sorted, medium- to coarse-grained, rounded to subrounded, and occur in thick to very thick beds. Tabular cross beds are prominent. Unit intertongues with the overlying San Andres Formation and is gradational with the underlying Yeso Formation. Thickness: Approximately 30 meters in Zuni Canyon. Colpitts (1989) measured 60 meters at the western head of Zuni Canyon.

**Py – Yeso Formation (middle Permian)** – Moderate red to pale reddish-brown quartz sandstone. Quartz grains are very well-sorted, fine- to very fine-grained, and rounded to subrounded. Sandstones consist of thin-to thick planar tabular beds. White reduction spots and round concretions to 1 cm in size are locally common. Only the uppermost member is exposed and was correlated to the Joyita Member by Colpitts (1989). Unit is only exposed in Zuni Canyon and is mostly mantled by colluvium; the underlying Torres member is probably present in the canyon but obscured by colluvium. Unit is also probably present in western Limekiln Canyon along a NW-down fault, but it is again covered by colluvium. Thickness: Not completely exposed; Colpitts (1989) reports a total thickness of the formation in the Zuni Mountains of 379 meters.

**pYu – Pre-Yeso Formation rocks, undivided (middle Permian to Proterozoic)** – Rocks older than the Yeso formation, cross-section only.

### References

- Colpitts, R.M., 1989, Permian reference section of southeastern Zuni Mountains, Cibola County, New Mexico, *in* Anderson et al., eds., Southeastern Colorado Plateau: New Mexico Geological Society Guidebook 40, p. 177-180.
- Dunbar, N.W., and Phillips, F.M., 2004, Cosmogenic  $^{36}\text{Cl}$  ages of lava flows in the Zuni–Bandera volcanic field, north-central New Mexico, U.S.A., *in* Cather et al., eds., Tectonics, geochronology, and volcanism in the Southern Rocky Mountains and Rio

Grande rift: New Mexico Bureau of Geology and Mineral Resources Bulletin 160, p. 309 – 317.

Heckert, A.B., and Lucas, S.G., 2003, Triassic stratigraphy in the Zuni Mountains, west-central New Mexico, *in* Lucas et al., eds., *Geology of the Zuni Plateau: New Mexico Geological Society Guidebook 54*, p. 245-262.

Laughlin, A.W., Brookins, D.G., and Causey, J.D., 1972, Late Cenozoic basalts from the Bandera lava field, Valencia County, New Mexico: *Geological Society of America Bulletin*, v. 83, p. 1543-1552.

Laughlin, W.A., Perry, F.V., Damon, P. E., Shafiqullah, M., WoldeGabriel, G., McIntosh, W., Harrington, C.D., Wells, S.G., and Drakos, P.G., 1993, Geochronology of Mount Taylor, Cebollita Mesa, and Zuni-Bandera volcanic fields, Cibola County, New Mexico: *New Mexico Geology*, v. 15, p. 81-92.

Perry, F.V., Baldrige, W.S., DePaolo, D.J., and Shafiqullah, M., 1990, Evolution of a magmatic system during continental extension: The Mount Taylor Volcanic Field, New Mexico, *: Journal of Geophysical Research*, v. 95, p. 19,327-19,348.

Sims, K.W.W., Ackert Jr., R.P., Ramos, F.C., Sohn, R.A., Murrell, M.T., and DePaolo, D.J., 2007, Determining eruption ages and erosion rates of Quaternary basaltic volcanism from combined U-series disequilibria and cosmogenic exposure ages: *Geology*, v. 35, p. 471-474.

### **Photo Captions**

**milan\_9.4-2\_moenkopi\_ss\_beds.JPG** – Typical outcrop of cross-bedded Moenkopi pebbly sandstone. Hammer is 42 cm long.

**milan\_11.2-2\_Psa\_chert\_oc.JPG** – Outcrop of massive chert at top of San Andres Formation.

**milan\_13.5-2\_SE\_wall\_Zuni\_cnyn\_strat.JPG** – View of the southeast wall of Zuni canyon showing, in ascending order: 1. Yeso Formation, largely covered by colluvium; 2. Glorieta Sandstone forming a white to yellow cliff; 3. San Andres formation with multiple sandstone tongues (white to yellow) amongst grey carbonate beds.

**milan\_14.2-5\_Zuni\_Cnyn\_strat\_w\_basalt\_view\_dncnyn.JPG** - View down Zuni Canyon showing remnant outcrops of the Zuni Canyon basalt flow against cliffs of Glorieta Sandstone. The Glorieta is overlain by overlain by the San Andres Formation with a prominent lower sandstone lens.