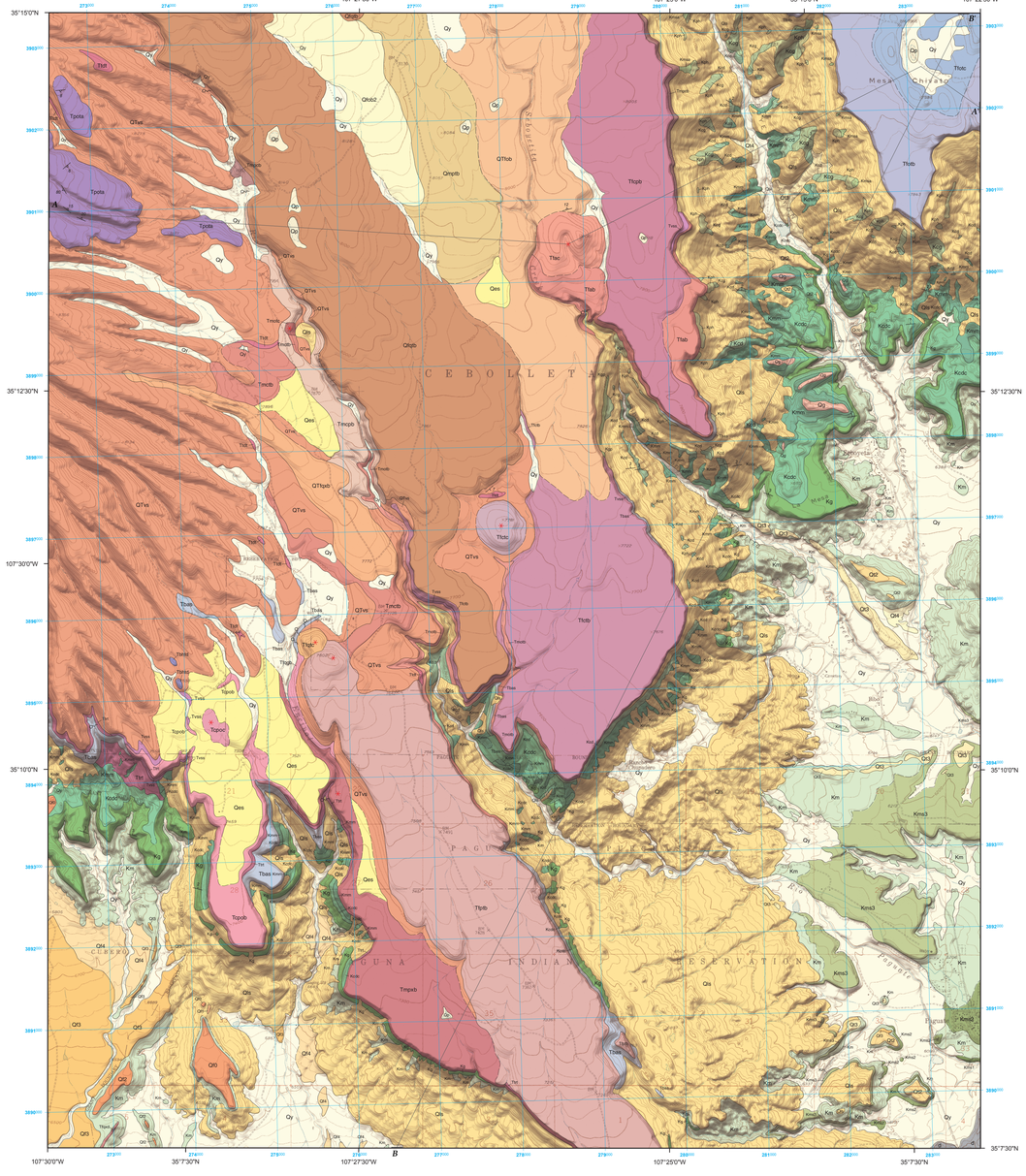

Base map from U.S. Geological Survey 1970, from photographs taken 1965, field checked in 1970, edited in 1993.
1927 North American datum, UTM projection — zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in blue

QUADRANGLE LOCATION

1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 226

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, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

Geologic map of the Seboyeta quadrangle, Cibola County, New Mexico.

May 2009

by

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

http://geoinfo.nmt.edu

Map Symbols

- Gelogic contact– solid where exposed or known, dashed where approximately known, queried where uncertain.
- Spring
- Strike and dip of bedding.
- Strike and dip of volcanic foliation.
- Volcanic vent. Queried where uncertain.
- A — A' Location of geologic cross section.

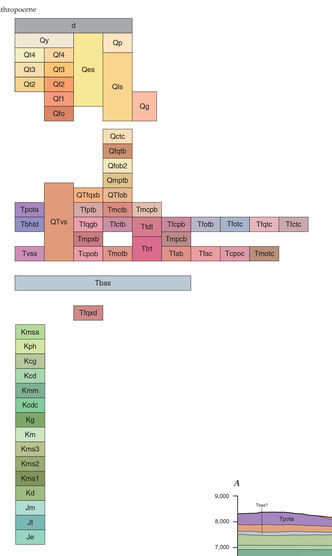
COMMENTS TO MAP USERS

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map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation.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. Govemment.

CORRELATION DIAGRAM



Map Unit Descriptions

Quaternary Deposits

Disturbed by human action (Anthropocene).

Younger alluvial deposits (Holocene)–Deposits of sand, gravel and silt in main valley bottoms; locally includes stream terraces, alluvial fans, and canyon wall colluvium; Late Holocene in age; maximum thickness of various alluvium deposits is uncertain but is at least 10 m. A well drilled in the NE ¼, SW ¼, SW ¼ of section 27, T 11 N, R 6 W (in Encinal Canyon) penetrated a total thickness of 11 meters of alluvium overlying Mancos shale. Alluvium in canyon bottoms and along major drainages is typically coarse-grained, cobble to boulder size sandy gravel of mixed volcanic lithologies and subordinate sandstone clasts. Alluvium in embayments adjacent to main drainages is typically finer-grained, silt and sand dominated deposits with pebble-gravel lenses and minor interbedded gravel beds. Valley floor alluvium and low terrace deposits are characterized by weakly-developed soils with 10YR-2.5Ycolor, none to minimal carbonate accumulation, and lack of Bt horizon development. As mapped, Qy also contains some units possibly equivalent to **Qy4**.

Playa deposits (Holocene and possibly also Pleistocene)—Mostly fine-grained deposits that fill small depressions in soil-covered basalt on the plateau and within the small volcanic maar in the northeast corner of the map.

Alluvial deposits underlying Qt4 terrace surfaces—Deposits of sandy pebble to boulder size gravel underlying terrace surfaces located approximately 3 to 5 m above local base level (Figure 1). The only **Qt4** deposits on the Seboyeta Quadrangle are located along Encinal Canyon, where deposits are in excess of 5 m thick (basal contact is not exposed). Soils developed in deposits underlying **Qt4** surfaces are weakly developed, with 10YR-2.5Y color, Bw horizon development, none to minimal carbonate accumulation, (Table 1). Late Holocene (?) in age.

Alluvial deposits underlying Qt3 terrace surfaces—Deposits of sandy pebble to boulder size gravel 1 to 3 m thick underlying strath terrace surfaces located approximately 6 to 24 m above local base level along Rio Paguate, Seboyeta Creek, and Seboyeta Creek drainages. Bt horizon is typically absent (stripped), with stage I to II carbonate horizon exposed at surface. Late Pleistocene (?).

Alluvial deposits underlying Qt2 terrace surfaces—Deposits of sandy pebble to boulder size gravel underlying terrace surfaces located approximately 11 to 30 m above local base level. Surfaces typically have a slope greater than the adjacent valley floors, so elevation above base level can vary significantly for one depositional unit. Deposit thickness ranges from 2 to 12 m or more. Where preserved, soils are well developed, exhibit Stage II to III carbonate morphology, Bt horizon with 5YR to 7.5YR color. Likely middle to late Pleistocene in age.

Deposits underlying Qf4 fan surfaces—description is from Mt. Taylor quad. Qf4 surfaces form part of the modern piedmont. Deposits of fine sand to coarse gravel; typically interbedded fine to medium sand and imbricated cobble-to-boulder-size gravel with individual gravel beds 1-3m thick. Qf4 deposits often bury Qf3 deposits and include buried soils (Figure 2, from Mt Taylor Quad). Total thickness 3 to 10 m or more. Where present, **Qf3** buried soils are 1 to 5 m below the Qf4 surface. Qf4 soils are characterized by A-Bw-C or A-Bk-C profiles with maximum Stage I carbonate morphology (Table 1), locally includes buried A horizons. Middle to late Holocene. The large deposit in Seboyeta is covered locally by younger (**Qy?**) deposits.

Deposits underlying Qf3 fan surfaces—Qf3 surfaces form part of the modern piedmont. Deposits of sandy pebble to boulder gravel of mixed volcanic lithologies and subordinate sandstone clasts. Total thickness is from 4.5 m to more than 7 m. Soils are partially eroded, but exhibit Stage III carbonate morphology, Bt horizon with 5YR to 7.5YR color where preserved (Figures 3 and 4, Table 1). Likely middle Pleistocene.

Deposits underlying Qf2 fan surfaces—Deposits of subrounded to subangular sandy pebble to boulder gravel underlying remnant fan surfaces. Deposits range from isolated remnants that are less than 1 m thick to continuous surfaces where deposits are up to 19 m thick. **Qf2** fan surfaces in the Seboyeta Quadrangle are approximately 12 m above local base level. Soils are typically stripped although stage I-II carbonate morphology is locally preserved. Early to middle Pleistocene?

Deposits of subrounded to subangular sandy pebble to boulder gravel—Forms one small terrace remnant in the southwestern part of the map, just below the level of **Qf0** deposits.

Deposits underlying Qf0 fan surfaces—Deposits of subrounded to subangular sandy pebble to boulder gravel underlying remnant fan surfaces. Deposits are approximately 18 m thick (Figure 5). Qf0 fan surfaces on the Seboyeta Quadrangle are approximately 60 m above local base level. Multiple buried soils are present within the deposits including, Bt soil with 5YR color, Bw soil with 10YR color, and multiple Bk soils with Stage II carbonate morphology (Figure). The surficial soil exhibits Stage III carbonate morphology, Bk horizons with 7.5YR to 10YR color. Early Pleistocene?

Landslide deposits—Poorly sorted debris that has moved chaotically down steep slopes; slumps or block slides (toreva blocks) partially to completely intact, that have moved down slope; slumps and block slides usually display some rotation relative to their failure plane; thickness varies considerably depending on the size and nature of the landslide. As mapped includes colluvium and talus deposits that contains material deposited on slopes that originated as avalanches, debris flows, and reworked deposits of each. There are typically deposited on a variety of different ages, some with well developed laminar caliche horizons.

Old alluvial deposits along Seboyeta Canyon—These remnants are composed of very poorly sorted subrounded to angular debris composed mostly of basalt clasts. The deposits reside more than 400 feet above the modern drainage and most do not appear to be continuous with the more extensive landslide deposits. They appear to be remnants of deposits that are older than the landslide deposits. Locally, this unit may include **Qls** deposits.

Eolian deposits—Typically 0.3 to 0.8 m thick deposit of silt and very fine sand forming sand sheet on Encinal Mesa. Characterized by thin (approximately 10 cm thick) late Holocene deposit overlying buried middle Pleistocene eolian deposit approximately 20 to 70 m thick. Surficial soil is weakly developed with 7.5YR color, absence of carbonate morphology, and lack of Bt horizon development. Buried soil is well developed, exhibits Bt horizon with 5YR color (Table 1). Underlying volcanic rubble has continuous carbonate coatings.

Pleistocene

Volcanic Rocks of Southeastern Mount Taylor and Southern Mesa Chivato

Young basalt in the bottom of Seboyeta Canyon–The vent consists primarily of three cycles of alternating massive basaltic hydromagmatic beds overlain by layers of coarse pyroclastic breccia and welded basaltic scoria. The hydromagmatic beds consist of fragments of quenched basalt of varying sizes mixed with abundant fragments of Cretaceous sandstone and rounded chert. Pale brownish yellow palagonite, a clay typical of mafic hydromagmatic eruptions, is common in these beds. The pyroclastic breccia layers also contain fragments of Cretaceous sandstone and chert. An infill of lava cuts across the beds and layers of cycle 2 and forms a thin lava flow dipping south on the southwest side of the vent. The lava is covered by cycle 3 (uppermost) hydromagmatic and scoria layers. Two thin vertical dikes trending S30W cut cycle 1 deposits on the northeast side of the vent, visible along an abandoned trail. The lava, dikes, scoria and hydromagmatic fragments all consist of trachybasalt containing conspicuous phenocrysts and/or megacrysts of black clinopyroxene.

Fine-grained quartz-bearing olivine trachybasalt—Flows of dark gray, fine-grained trachybasalt containing sparse, but easily recognizable, small xenocrysts of quartz, and small sparse phenocrysts of olivine and black augite in groundmass of tiny plagioclase, olivine, augite, opaque oxides, and glass; many of the xenocrysts have pale green clinopyroxene reaction rims with host lava; olivine shows minor high-temperature iddingsite alteration; flows originate from Cerro Ortiz just north of quad boundary; flows overlie **QTvs** and **Qfob2**, and abut **Qmptb**; maximum observed thickness about 55 m; K-Ar date is 1.56 ± 0.17 Ma (whole rock; Lipman and Mehnert, 1979).

Fine-grained olivine basalt—Flows of dark gray to black, fine-grained basalt with sparse small phenocrysts of olivine in groundmass of plagioclase, olivine, augite, opaque oxides and glass; contains rare small quartz xenocrysts; olivine displays minor high-temperature iddingsite alteration; flows originate from the north; overlie **Qmptb** but underlie **Qfqtb**; maximum observed thickness is about 10 m.

Medium-grained plagioclase-phyric olivine trachybasalt—Gray, medium-grained, sparsely porphyritic trachybasalt flows containing plagioclase phenocrysts ≤3 cm long in groundmass of plagioclase, olivine, augite, opaque oxides and glass; olivine shows very minor high-temperature iddingsite alteration; flows originate from Cerro Frio north of quad boundary; underlies **Qfob2** but overlies Tlob; maximum observed thickness is about 15 m.

Quaternary- Tertiary (?)io-Pleistocene)

Fine-grained olivine basalt—Dark gray to black, fine-grained basalt flows with rare megacrysts of 0.25 cm rounded plagioclase and sparse phenocrysts of small olivine in groundmass of plagioclase, olivine, augite, opaque oxides and glass; superficially resembles flows of unit **Qfob2**; flows apparently originate from the northeast; underlies **Qmptb**, **Tfcpb**, and **Tfab**; maximum observed thickness is about 35 m.

Fine-grained, quartz- and xenolith-bearing olivine trachybasalt—Dark gray to black, fine-grained, occasionally flow-banded, nearly aphyric trachybasalt flows contain sparse small quartz xenocrysts with green clinopyroxene reaction rims; contains very rare, resorbed dunite xenoliths ≤4 cm in diameter and rare resorbed black augite megacrysts; groundmass consists of tiny plagioclase, olivine, augite, opaque oxides and glass; olivine displays minor high-temperature iddingsite alteration; one of younger flows in Seboyeta quad but is submerged in upper part of debris flows of **QTvs**; overlies **Tmctb**, and **Tmcpb**; maximum observed thickness about 20 m.

Volcaniclastic sedimentary rocks—Gray to tan to white debris flows, fluvial deposits and interbedded tuffs (Tdt and **Ttrt**) shed from the Mount Taylor stratovolcano during growth. Debris flow component is most abundant near source (northeast part of quadrangle) and consists primarily of boulders and cobbles of angular to subangular trachydacite and trachyandesite in a volcanic sand matrix. Boulders form a lag deposit on surface of debris flows. Fluvial component contains rounded to subrounded cobbles including a higher proportion of basaltic clasts, especially to south. Tuffs are described below. Underlies a multitude of mafic flows and cones east of Mt. Taylor; interbedded with two intermediate composition flows along northeast margin of quad (**Tpota** and **Tbhld**). Overlies a few older trachybasalts and basalts throughout much of the quadrangle. Maximum exposed thickness is >200 m.

Tertiary

Pliocene

Fine-grained plagioclase-phyric olivine trachybasalt—Flows of gray, fine- to medium-grained, slightly porphyritic trachybasalt containing 0.5 to 1.5 cm plagioclase phenocrysts in a groundmass of plagioclase, olivine, augite and opaque oxides; contain virtually no glass; flows originate from eroded vent within Seboyeta quad; overlie **QTvs**, **Tfqgb**, and **Tbas**; maximum exposed thickness about 35 m.

Medium-grained clinopyroxene-phyric olivine trachybasalt—Dark gray, medium-grained, slightly porphyritic trachybasalt flows with abundant small phenocrysts of black augite, plagioclase and olivine in a groundmass of plagioclase, olivine, augite, opaque oxides and glass; olivine shows high-temperature iddingsite alteration; occasionally displays spotted appearance; underlies **QTfqxb** and **Tfptb**; interbedded within **QTvs**; maximum exposed thickness about 35 m; K-Ar age is 2.65 ± 0.15 Ma (Lipman and Mehnert, 1979).

Medium-grained clinopyroxene plagioclase-phyric olivine trachybasalt—Flows of gray, medium-grained sparsely porphyritic trachybasalt having phenocrysts of plagioclase and black augite in a groundmass of plagioclase, olivine, augite, opaque oxides and glass. Flows are exposed along most of the upper Rio Paguate; underlies **Qfqtb** and **QTfqxb**; interbedded in **QTvs** abuts **Tmctb**; overlies **Tmotb**; maximum exposed thickness is about 25 m.

Porphyritic olivine trachyandesite—Light gray, highly porphyritic lava flow with abundant 0.5 to 2.0 cm phenocrysts of complexly zoned plagioclase, and tiny phenocrysts of olivine, augite, plagioclase and sparse biotite in a very fine-grained, devitrified groundmass of plagioclase and opaque oxides; olivine shows extensive iddingsite alteration; minor Fe-oxide staining in cracks; contains sparse enclaves of plagioclase-augite ≤12 cm in diameter; flow is massive to sheeted; unit forms thick viscous flow in NW corner of quad; interbedded in **QTvs**; maximum exposed thickness is about 75 m.

Porphyritic biotite-hornblende trachydacite—Light gray to pale pink, highly porphyritic lava flow containing conspicuous phenocrysts of plagioclase, biotite and hornblende in a fine-grained devitrified groundmass of plagioclase, sanidine, biotite, augite and opaque oxides. Flow is massive and is exposed as two low knobs interbedded in **QTvs** on unnamed ridge in western part of quad. Maximum exposed thickness is about 7 m.

Porphyritic trachydacite tuffs—White to light gray beds of pumice and pumice-rich sediments interbedded in middle-to lower-parts of unit **QTvs**; pumice is highly vesicular containing sparse, small phenocrysts of plagioclase, augite ± sanidine, biotite, hornblende and quartz; tuffs originate from sources within Mount Taylor; beds are up to 5 m thick; 40Ar/39Ar dates on similar deposits to west and northwest range from 2.71 to 2.76 Ma (n=4; Goff et al., 2008, 2010).

Fine-grained clinopyroxene-phyric olivine trachybasalt—Flows of gray, fine- to medium-grained slightly porphyritic trachybasalt containing sparse plagioclase phenocryst ≤1.5 cm long and very sparse phenocrysts of equant, black augite in a groundmass of plagioclase, olivine, augite, opaque oxides and minor glass. Olivine displays high-temperature iddingsite alteration. Flows originate from eroded cinder cone (**Tfctc**) and cover all of southern Chupadero Mesa. Flows underlie **Qfqtb**, **QTvs** and **QTfotb**; flows overlie **Tmotb** and **Tbas**. Maximum exposed thickness is about 20 m.

Eroded cinder cone for lava flows of Tfctb–Scoria and cinder deposits.

Fine-grained, clinopyroxene porphyritic olivine basalt—Flows of dark gray to black, fine-grained, porphyritic basalt with conspicuous black megacrysts of resorbed augite and small phenocrysts of plagioclase, olivine and magnetite in a groundmass of plagioclase, olivine, augite, opaque oxides and glass; olivine is extensively altered to high-temperature iddingsite; flows cover most of Seboyatita Mesa and apparently originate from the east; unit underlies **QTfob** and overlies **QTvs**, **Tmpcb** and **Tfab**; maximum exposed thickness is about 20 m.

Fine-grained olivine trachybasalt—Dark gray, fine-grained trachybasalt flows with sparse phenocrysts of olivine, plagioclase and augite in groundmass of plagioclase, olivine, augite, opaque oxides and glass; flows originate from eroded hills of cinders and scoria (**Tfotc**) on southern Mesa Chivato; overlie Cretaceous rocks; maximum exposed thickness of flows is about 15 m.

Eroded cinder cone for lava flows of Tfotb–Scoria and cinder deposits.

Medium-grained plagioclase-phyric trachybasalt—Flows of gray, medium-grained, porphyritic trachybasalt with phenocrysts of plagioclase and very small phenocrysts of olivine and augite in groundmass of plagioclase, olivine, augite, opaque oxides and glass; underlies **Tfcpb** and overlies Cretaceous rocks along northeast edge of Seboyatita Mesa; maximum exposed thickness about 15 m.

Aphyric basalt—Black, very fine-grained, aphyric basalt flows with tiny microphenocrysts of plagioclase, olivine, augite, opaque oxides and abundant glass; olivine displays extensive iddingsite alteration; flows originate from eroded cinder cone (**Tfac**); underlies **Tfob** and **Tfcpb**; overlies Cretaceous rocks; maximum exposed thickness of flows is about 40 m.

Fine-grained quartz- and xenolith-bearing trachybasalt—Flows of gray, fine-grained trachybasalt with rare quartz xenocrysts and very rare xenocrysts (0.5 to 2 cm) of pyroxene gabbro in a groundmass of plagioclase, olivine, augite, opaque oxides and glass; quartz may have pale green clinopyroxene reaction rims; gabbro is medium-grained and equigranular; highly eroded vent (**Tfqtc**) is mostly stripped of scoria and bombs; underlies **Tfptb**; interbedded in **QTvs**; overlies Tmpxb and Tbas; maximum exposed thickness of flow is about 15 m.

Eroded cinder cone for lava flows of Tfqgb—Scoria and cinder deposits.

Medium-grained clinopyroxene-phyric olivine trachybasalt—Gray, medium-grained, slightly porphyritic trachybasalt flows with sparse megacrysts of resorbed black augite in a groundmass of plagioclase, olivine, augite, opaque oxides and a little glass; olivine shows considerable iddingsite alteration; forms distinctive flows along southwest margin of Silver Dollar Mesa; probable source is low hill on east side of middle Encinal Creek; underlies **QTvs** and **Tfptb**; overlies **Tcpob**, **Ttrt**, **Tbas** and Cretaceous rocks; K-Ar date is 2.93 ± 0.12 Ma (whole rock; Laughlin et al., 1993).

Volcaniclastic sandstone—Gray to tan, fine- to course-grained fluvial sandstone containing small clasts and grains of quartz, plagioclase, olivine, augite, chert, pumice, and various types of basalt and intermediate composition volcanics; may contain thin beds of trachydacite or rhyolite tuffs too thin to map; occupies shallow channels cut into earliest lava flow surfaces in the region; underlies QTvs; interbedded with various older lava flows; overlies **Tbas**; maximum exposed thickness is about 35 m but usually is much less.

Medium-grained olivine trachybasalt—Flows of gray to black, medium-grained, trachybasalt containing about 3% of ≤1 mm olivine phenocrysts in a slightly trachytic groundmass of plagioclase, olivine, augite, opaque oxides and glass; olivine is extensively altered to iddingsite. Flows originate from small exhumed cinder cone (Tmotc) on west side of upper Paguate Creek; underlies Tvss and several lava units; overlies Tbas and Cretaceous rocks; maximum exposed thickness is about 35 m.

Eroded cinder cone for lava flows of Tmotb–Scoria and cinder deposits.

Medium-grained augite- and plagioclase-phyric olivine trachybasalt—Gray, medium-grained, porphyritic trachybasalt flows with phenocrysts of plagioclase, olivine, sparse augite and magnetite in a groundmass of plagioclase, olivine, augite, opaque oxides and glass; olivine displays extensive high-temperature iddingsite alteration; augite phenocrysts are very sparse in some locations but porphyritic texture is quite distinctive; covers most of Encinal Mesa; flows originate from low hill of cinders (**Tcpoc**); underlies **QTvs** and **Tmpxb**; interbedded with Tvss and Ttrt; overlies Tgrt and Tbas; maximum exposed thickness about 20 m.

Eroded cinder cone for lava flows of Tcpob–Scoria and cinder deposits.

Porphyritic rhyolite tuffs—White to pale pink beds of pumice, pumice-rich sediments and thin ignimbrites; pumice is highly vesicular containing sparse, small phenocrysts of sanidine and biotite ± hornblende, clinopyroxene and quartz; tuffs originate from sources within Mount Taylor; underlies QTvs and Tvss; interbedded with Tcpob; overlies Tbas; beds are up to 25 m thick near western margin of quadrangle; $^{40}Ar/^{39}Ar$ dates on similar deposits to west and northwest range from 3.08 to 2.79 Ma (n=3; Goff et al., 2008, 2010).

Spotted aphyric analcite basanite—Dark gray to bluish gray, fine-grained, nearly aphyric basanite flows with rare tiny phenocrysts of plagioclase and olivine in a groundmass of plagioclase, abundant olivine, augite, analcite, opaque oxides and glass; the analcite displays ocellar texture (Lipman and Moench, 1972); olivine shows intense, high-temperature iddingsite alteration; vugs, vesicles and cracks are commonly filled with opal±chalcedony, calcite and Fe-oxides; weathered surfaces are distinctly to vaguely spotted in outcrop; upper part of unit is massive to rubbly; lower part is columnar jointed; underlies all other Mount Taylor volcanic rocks except Tmaob; source is apparently within Mount Taylor; flows fill shallow paleo-valleys developed on top of Cretaceous rocks; maximum exposed thickness is about 45 m. K-Ar date is 3.26 ± 0.31 Ma (whole rock, Perry et al., 1990).

Fine-grained quartz- and xenolith-bearing olivine basalt dike—Dark gray, fine-grained, slightly porphyritic basaltic dike containing sparse small phenocrysts of olivine in a groundmass of plagioclase, olivine, augite, opaque oxides and glass; contains sparse small quartz xenocrysts with pale green clinopyroxene reaction rims and sparse xenoliths of dunite; olivine shows iddingsite alteration; dike extends northeast from Picacho Peak plug, which is just south of quad; intrudes Cretaceous (?) rocks; $Ar^{40}/^{39}$ date on plug is 4.49 ± 0.08 Ma (groundmass; Hallett et al., 1997).

Cretaceous and Jurassic Rocks

Mancos Shale, Satan tongue–Intgerbedded dark shale and less abundant very fine-grained quartz sandstone. Only exposed in the far northeast part of the map. See measured sections 1 and 20 for a more detailed description. About 65 meters thick but top is covered.

Point Lookout Sandstone, Hasta tongue–Fine-grained quartz sandstone with rare darker lithic grains. Uppermost 5 meters shows planar cross-bedding in sets up to 1 m. Below about 5 meters bedding is mostly horizontal with low-angle cross-beds, especially in the lowermost 2-3 meters. Forms prominent light gray cliff. Thickness 45 m.

Gibson Coal member, Crevasse Canyon Formation–Interbedded light orange very fine-grained quartz sandstone in massive to thinly bedded layers up to 4 metres thick and dark shale. The shale commonly contains dark brown to black lignite coal in seams up to 2 meters thick. Locally contains light gray fragments of fossilized wood. Thickness 95 m.

Dalton Sandstone member, Crevasse Canyon Formation–Light tan-colored very fine-grained quartz sandstone. Grains are mostly subrounded quartz and light gray grains that appear to be either altered feldspar or argillite grains. Some beds appear massive to very weakly bedded. Other beds show planar cross-bedding in sets up to about 30 cm thick. Forms a prominent light gray cliff. See measured sections 2 and 20 for a more detailed description. Thickness 24 m.

Mancos Shale, Mulatto tongue–This unit is composed mostly of very thinly bedded siltstone, and minor shale and fine-grained sandstone. The unit typically forms a steep resistant slope which contains two intervals of medium-bedded fine-grained sandstone. These two intervals form light tan cliffs composed of thin planar beds. Thickness 80 m.

Dilco Coal member, Crevasse Canyon Formation–Interbedded very fine-grained, well sorted yellow quartz sandstone and dark carbonaceous shale. Thin- to medium-bedded sandstone beds are typically mottled in appearance, contain abundant horizontal burrows up to 1 cm in diameter, and are between 0.5 and 1 meter thick. Quartz grains are subrounded. Minor biotite flakes. Low-angle planar cross-beds are locally common in sets up to 20 cm thick. Ripple marks are common on the undersides of some sandstone beds. Shale horizons are characteristically dark gray, contain abundant dark carbonaceous matter and brown to black lignite coal beds up to several tens of centimeters thick, and are between 3 and 7 meters thick. Shale beds also contain perminearilized wood fragments and leaf and seed molds.

Gallup Sandstone–Very fine- to fine-grained quartz sandstone Light tan-colored, fine- to very fine-grained quartz sandstone. It contains subangular to subrounded quartz grains and sparse dark lithic grains. The unit is typically horizontally bedded to massive. Planar cross-beds are common in sets up to 1-2 meters. The unit is well exposed from the southwest corner of the map to the northeast corner. It is best exposed near the mouth of Seboyeta Canyon where it forms a prominent cliff. Here, the overlying Dilco Coal member has eroded recessively so that the Gallup sandstone forms a flay bench. Near Bear Canyon the formation splits into two distinct sandstone layers separated by dark shale. Unfortunately this split cannot be measured further south because the Gallup Sandstone has been completely removed farther south.

Mancos Shale–Thinly layered and laminated dark shale and quartz silstone. Weathered surfaces are typically medium gray to light tan, but fresh surfaces are characteristically dark gray to dark grayish green. Locally contains thin very fine-grained sandstone layers a few tens of centimeters thick, septarian concretions up to 1 meter across, and one thin light gray bentonite layer 15 cm thick within the lower 1/3rd of the mapped unit within the study area. Lower part also contains one layer 1 meter thick composed of very abundant oyster fossils. Translucent to clear platy crystals of gypsum up to 10 cm long are common weathering out of slopes. Sandstone layers contain sparse but ubiquitous very fine green-colored grains of unknown composition, the same size as the quartz grains.

Sandstone–Thin to medium bedded very fine grained quartz sandstone. Sparse darker lithic grains. Dark bivalve shell fragments up to 7 cm. Most beds appear massive. Low-angle planar cross-beds are visible in the upper 3 m. Darker lithics are locally mostly dark green in color common in dark laminae. Abundant bedding-parallel burrows above cross-beds. Forms cliff.

Sandstone–Upper part is thin to medium bedded very fine grained quartz sandstone. Sparse darker lithic grains. Dark bivalve shell fragments up to 7 cm. Most beds appear massive. Low-angle planar cross-beds are visible in the upper 3 m. Darker lithics are locally mostly dark green in color, common in dark laminae. Abundant bedding-parallel burrows above cross-beds. Forms cliff. Lower parties thin to medium bedded very fine grained quartz sandstone. Sparse darker lithic grains. Dark bivalve shell fragments up to 7 cm. Most beds appear massive. Low-angle planar cross-beds are visible in the upper 3 m of lower part. Darker lithics are locally mostly dark green in color, and are most common in dark laminae. Abundant bedding-parallel burrows above cross-beds. Forms cliff.

Sandstone–Very fine-grained to fine-grained quartz sandstone. Upper part is mostly massive. Abundant burrows on bed planes. Faintly to strongly laminated. Medium- to thick-bedded, with low-angle planar cross-bedding. Lower part is thin- to medium-bedded. Faint horizontal laminae. Flecks of dark organic matter. Crumbly. As mapped this unit contains beds of dark shale.

Dakota Sandstone (shown only in cross-section).

Morrison Formation (shown only in cross-section).

Todilto Formation (shown only in cross-section).

Entrada Sandstone (shown only in cross-section).