NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A DIVISION OF NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY

Geologic Map of Mount Taylor, Cibola and McKinley Counties, New Mexico

June, 2015

by

Fraser Goff[1], Shari A. Kelley[2], Cathy J. Goff[3], David J. McCraw[2], G. Robert Osburn[4], John R. Lawrence[5], Paul G. Drakos[6], and Steven J. Skotnicki[7]

[1] Adjunct Faculty, Department of Earth and Environmental Science, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801
[2] New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM 87801
[3] Independent Consultant, 5515 Quemazon, Los Alamos, NM 87544
[4] Earth and Planetary Science, Washington University, St. Louis, MO, 63130
[5] Lawrence GeoServices, Ltd. Co., 2321 Elizabeth St. NE, Albuquerque, NM 87112
[6] Glorieta Geoscience Inc., P.O. Box 5727, Santa Fe, NM 87502
[7] Independent Consultant, 281 W. Amoroso Dr., Gilbert, AZ, 85233

New Mexico Bureau of Geology and Mineral Resources
Open-File Report 571

Mapping of these quadrangles was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act (Fund Number: G14AC00228), 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, *Assoc. Director for Mapping Programs*).

Figure 1 — Panorama of Mount Taylor viewed NE across Horace Mesa on a stormy day in July 2007. Summit is composed of stacked flows of hornblende trachyandesite (2.7 Ma). Ridge to right consists primarily of slightly older trachyandesite and trachydacite lavas. Low hill in middle ground is scoria cone of trachybasalt (about 2.6 Ma). Cliff exposes sequence of trachybasalt lava on Mount Taylor-derived debris flows that overlie Grants Ridge tuff (3.3 Ma) and Cretaceous Gibson Coal Member of Crevasse Canyon Formation (Photo by F. Goff).

Location Map

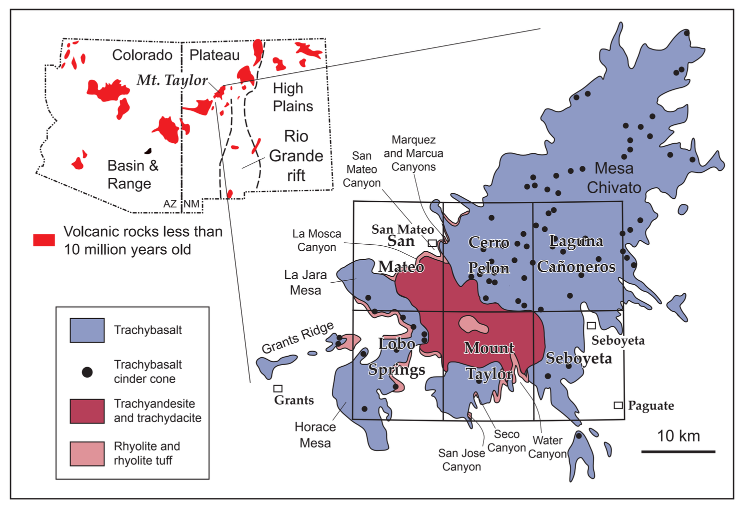


Figure 2 — The Geologic Map of Mount Taylor is the compilation of the revision and synthesis of six 1:24,000 Open-file geologic map (OF-GM) quadrangles previously produced by the New Mexico STATEMAP program of the New Mexico Bureau of Geology and Mineral Resources. These include:

Geologic Map of San Mateo 7.5-Minute Quadrangle, Cibola and McKinley Counties, New Mexico. OF-GM 194. McCraw et al. (2009)

Geologic Map of Cerro Pelon 7.5-Minute Quadrangle, Cibola and McKinley Counties, New Mexico. OF-GM 202. Goff et al. (2010)

Geologic Map of Laguna Cañoneros 7.5-Minute Quadrangle, Cibola and McKinley Counties, New Mexico. OF-GM 244. Goff et al. (2014)

Geologic Map of Lobo Springs 7.5-Minute Quadrangle, Cibola County, New Mexico. OF-GM 181. Goff et al. (2008)

Geologic Map of Mount Taylor 7.5-Minute Quadrangle, Cibola County, New Mexico. OF-GM 186. Osburn et al. (2009)

Geologic Map of Seboyeta 7.5-Minute Quadrangle, Cibola County, New Mexico. OF-GM 126. Skotnicki et al. (2012)

Explanation of Map Symbols

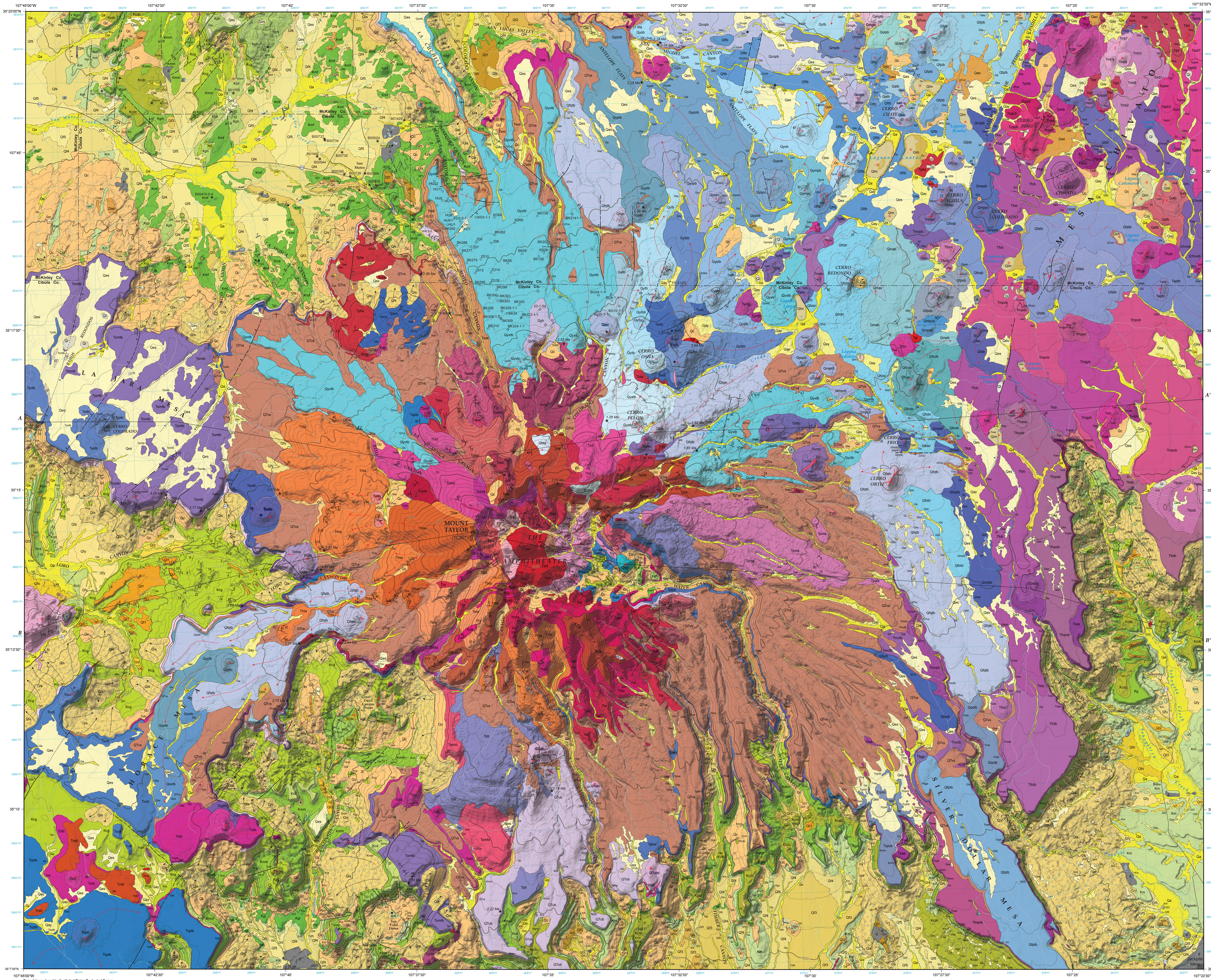
- A — A′: Location of geologic cross section.
- Contact—Identity and existence certain; location accurate where solid, approximate where dashed, concealed where dotted. Identity and existence uncertain where queried.
- Inclined contact of dike.
- Volcanic contacts: Rim of volcanic crater, hachures point into crater. Contact separating individual lava flows within the same map unit; location accurate where solid, approximate where dashed.
- Intrusive dike; unrelated to specific vents or cones.
- Fault—Identity and existence certain; location accurate where solid, approximate where dashed; and concealed where dotted. Uncertain sense of slip.
- Normal fault—Identity and existence certain, location approximate. Sense of slip suggested: U = upthrown block; D = downthrown block.
- Normal fault—Identity and existence certain; location accurate where solid, approximate where dashed, and concealed where dotted. Bar-and-ball on downthrown block. Tic shows dip of the fault plane.
- Anticline. Location approximate.
- Monocline. Location approximate.
- Direction of downslope movement of landslide.
- Direction of lava flow.
- Horizontal bedding.
- Strike and dip of inclined bedding.
- Strike of vertical, or near-vertical joint.
- Strike and dip of inclined joint.
- Strike and dip of inclined volcanic foliation.
- Strike of vertical volcanic foliation.
- Spring.
- Small volcanic cone or vent.
- Large volcanic cone or vent.
- 2.77 Ma: Locality of $^{40}Ar/^{39}Ar$ geochronologic sample with resultant date.
- N, R: Locality of geophysical magnetic polarity sample. N = normal polarity, R = reverse polarity.
- Prospect (pit or small cut).
- Open pit, quarry, or glory hole.
- BK277: Uranium exploration well.
- DH61-1: Dry hole.
- Oil and gas exploration well.
- B00039: Water well for industrial use.

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 may not be shown due to recent development.

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.

This map represents the compilation of the revision and synthesis of six The New Mexico Bureau of Geology and Mineral Resources (NMBGMR) Open-file Geologic Maps (OFGM). NMBGMR created the OFGM Series to as expedite dissemination of these geologic maps and map data to the public as rapidly as possible while allowing for map revision as geologists continued to work in map areas. Each map sheet carries the original date of publication below the map as well as the latest revision date in the upper right corner. In most cases, the original date of publication coincides with the date of the map product delivered to National Cooperative Geologic Mapping Program (NCGMP) as part of New Mexico's STATEMAP agreement. While maps are produced, maintained, and updated in an ArcGIS geodatabase, at the time of the STATEMAP deliverable, each map goes through cartographic production and internal review prior to uploading to the Internet. Even if additional updates are carried out on the ArcGIS map data files, citations to these maps should reflect this original publication date and the original authors listed. The views and conclusions contained in these map documents are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government.



Base data produced by the United States Geological Survey.
North American Datum of 1983 (NAD83).
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 13 S.
10 000-foot ticks: New Mexico Coordinate System of 1983 (west zone).
Imagery: NAIP, May 2011. Roads: ©2006-2013 TomTom Roads within US;
on Forest Sevice Lands: FSTopo data with limited Forest Service updates, 2013.
Names: GNIS, 2013. Hydrography: National Hydrography Dataset, 2011.
Contours: National Elevation Dataset, 2000. Boundaries: Census, IBWC, IBC, USGS, 1972 - 2012.

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

1:36,000

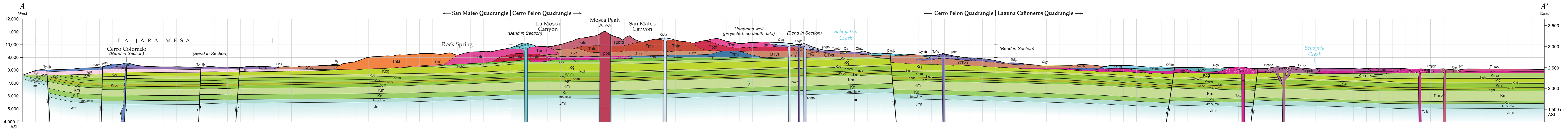
Scale bars: 1 0.5 0 1 2 3 4 Miles; 1 0.5 0 1 2 3 4 5 6 Kilometers; 2000 0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000 Feet

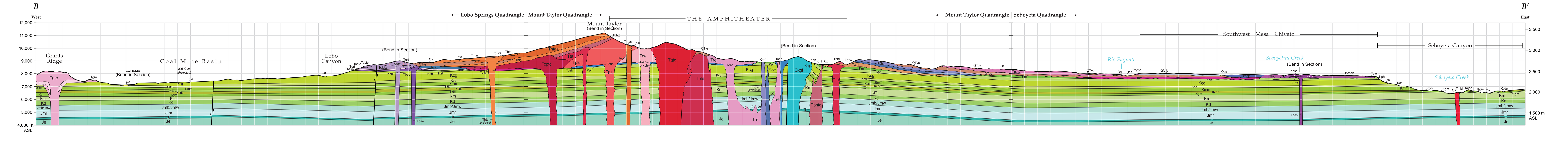
Contour Interval 100 Feet

North American Vertical Datum of 1988

Magnetic Declination June, 2015 9° 0' East At Map Center

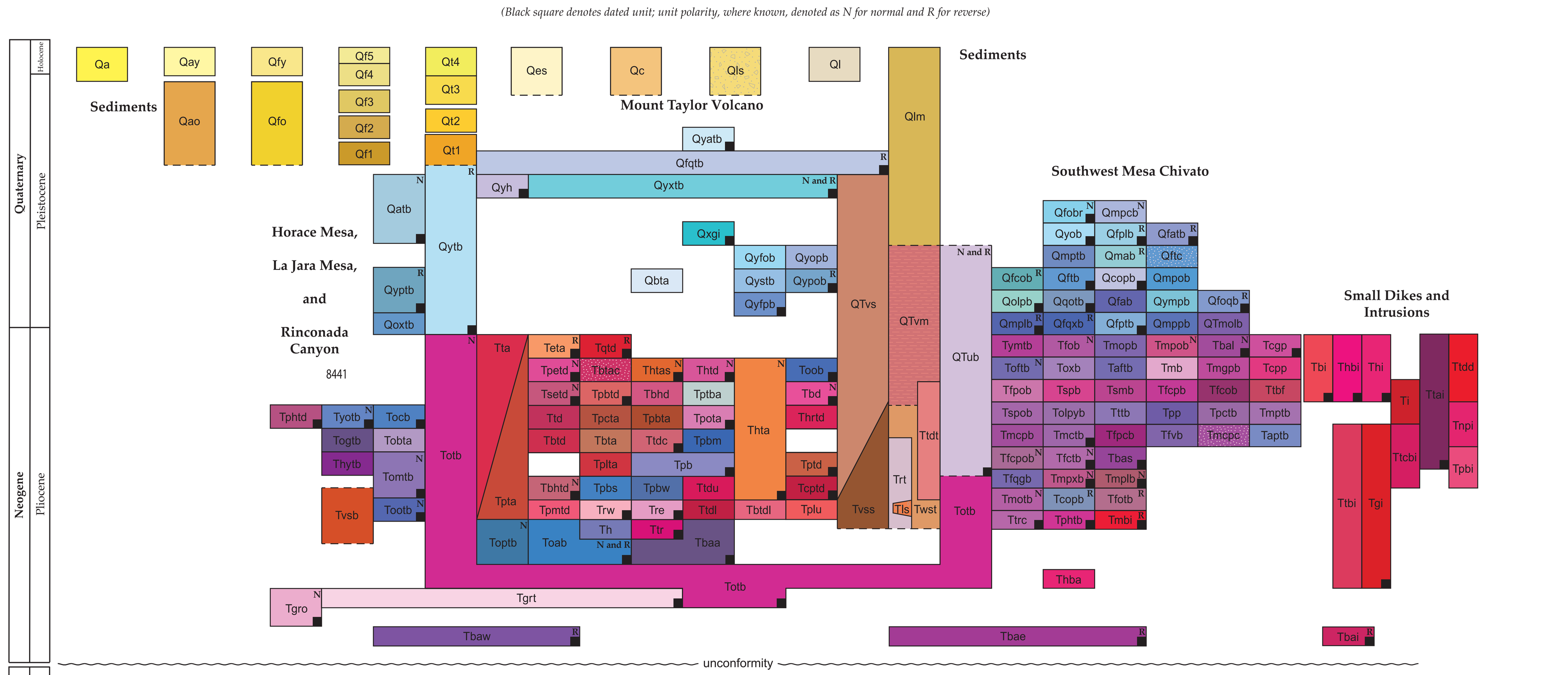
Geologic Cross Sections

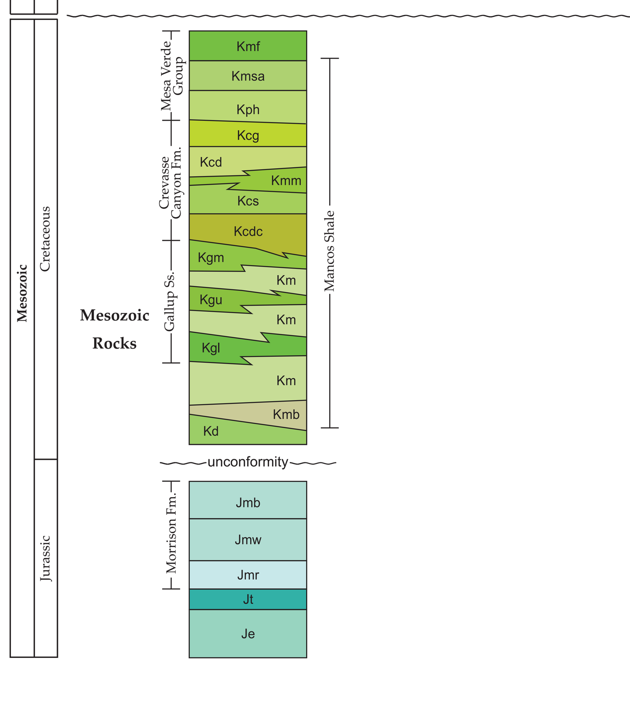




Correlation Of Map Units

(Black squares denote dated unit; unit polarity, where known, denoted as N for normal and R for reverse)





Description Of Map Units

Note: Descriptions of map units are listed in approximate order of increasing age. Volcanic units are primarily subdivided into two geographic groups: Mount Taylor and southwestern Mesa Chivato. Formal stratigraphic names of Cretaceous units are described by Sears et al. (1941), Lipman et al. (1979), Dillinger (1990), and Skotnicki et al. (2012). Field identification of volcanic rocks is based on hand specimens, petrography and chemical data published by Hunt (1938), Baker and Ridley (1970), Lipman and Mehnert (1979), Crumpler (1980a, 1980b, 1982), Perry et al. (1990), and this report. Names of volcanic units are based on the above chemical data and the alkali-silica diagram of Le Bas et al. (1986). We use the term "hawaiite" interchangeably with trachybasalt. See Goff et al. (2008) for a contemporary description of the rocks and geology in the Mount Taylor area. A "C" in rock description means at least one chemical analysis is available for the unit in question. Radiometric 40Ar/39Ar dates are from the NMBMT laboratory (Socorro) unless otherwise stated. We measured magnetic polarities of some fossil specimens by Brunton compass (MPB); all other polarities were obtained with a portable fluxgate magnetometer (MPF). Correlations of magnetic polarities with age follow chart in Gee and Kent (2007): N = normal polarity and R = reverse polarity; MT = Mount Taylor; AM = Mount Taylor amphitheater.

Quaternary

Surficial sediments

Disturbed land and/or artificial fill — Areas of modern excavation and associated deposits of compacted, very fine to very coarse sand (often with minor pebbles), silt, and clay around open-pit mines, mine adits, and dams and reservoirs. Numerous, small check dams were not included.

Modern Stream alluvium — Deposits of gravel, sand, silt and minor clay in swales associated with modern streams; mostly Holocene in age; maximum thickness of various alluvium deposits is uncertain but may exceed 15 m.

Younger alluvium — Alluvium that lies above modern drainages, underlying surfaces adjacent to modern drainages that are located approximately 5 to 15 m above local base level; maximum observed thickness about 15 m.

Younger alluvial fan deposits — Undifferentiated deposits of poorly sorted, gravel, sand, and silt debouching from some type of hillslope channel, usually in upland settings. Thickness usually increases downslope from <1 to up to 15(?) m.

Alluvial fan deposits in basins flanking Mount Taylor — Poorly sorted fan lobe deposits of gravel, sand, and silt debouching from streams draining mountain uplands filling basin margins. Often intermixed with colluvium in mountain front settings. Youngest fan deposits are inset into older deposits, ranging in age from middle(?) Pleistocene (Qf1) (only found capping isolated Cretaceous / colluvial mesas) to upper Pleistocene to lower Holocene (Qf2–Qf4) to Holocene to modern (Qf4–Qf5). Thicknesses generally decrease with distance from mountain front from ≥ 20 m to <1 m.

Alluvial stream terrace deposits — Generally strath terraces comprised of moderately- to well-sorted alluvial gravel, sand, and silt found flanking above stream alluvial bottoms. Strath elevations increase in height with age, ranging from ~30 to 50 m (~100-165 ft) above streams for middle(?) Pleistocene terraces (Qt1); to ~12 to 25 m (~40–80 ft) for upper Pleistocene terraces (Qt2–3); to ~2.1 to 4.5 m (~6.9–15 ft) for uppermost Pleistocene to lower Holocene terraces (Qt4). Thicknesses range from 2 to ~15 m.

Eolian and/or alluvial sheetwash deposits — Windblown deposits of silt and fine sand, often reworked by sheetwash into often fining-upwards, alluvially pebbly sand to silt on various surfaces, but most commonly basaltic-capped plateau flanks surrounding the main volcanic edifice. ≤3 m thick.

Shallow lake deposits — Fine-grained, poorly exposed deposits of medium- to fine-grained sand, silt and clay filling shallow, small diameter basins on lava flow surfaces and sag ponds along fault traces; thickness ≤5 m. Generally contain water only during rainy seasons.

Colluvium — Poorly sorted slopewash and mass wasting deposits from local sources; mapped only where extensive or where covering critical relations; thickness can locally exceed 15 m.

Older alluvium — Alluvium that often lies well above modern drainages and usually not associated with them. They are comprised of poorly to moderately sorted gravel, sand, and silt derived from the weathering of surrounding rocks, including volcanics, volcaniclastics, and Cretaceous sediments. They usually occur on broad uplands and ridges; maximum observed thickness about 10 m.

Older alluvial fan deposits — Undifferentiated fan deposits of poorly sorted, gravel, sand, and silt found flanking volcanic uplands. Thickness usually increases downslope from 1 m to up to 15(?) m.

Landslides — Poorly sorted debris that has moved chaotically down steep slopes; slumps or block slides that have moved down slope; ages vary from Holocene to middle to upper Pleistocene; thicknesses vary considerably.

Maar crater-fill deposits — Poorly exposed, organic-rich, eolian-derived clay and silt filling eroded tuff rings and circular vents; may contain shallow, ephemeral lakes. Margins may contain larger blocks of eroded basalt and exotic pebbles of probable Cretaceous age; probable thickness is ≤50 m.

Volcanic Rocks Of Mount Taylor And Vicinity

Very aphyric trachybasalt of Cerro Pelón — Very fine-grained hawaiite (C) and scoria deposits (Qyatc) having very tiny sparse olivine phenocrysts and sparse quartz xenocrysts in glassy groundmass. Cone contains two dikes (Qyatd). Flow west of cone dated at 1.26±0.19 Ma; flows ≤30 m thick.

Quartz-bearing trachybasalt — Several cone and flow complexes of similar age surrounding Mount Taylor (MT). All consist of fine-grained hawaiite (C) and scoria deposits (Qfqtc) containing sparse olivine phenocrysts and sparse to rare quartz xenocrysts. Cerro Ortiz cone contains several dikes (Qfqtd). Three flows are dated 1.53±0.07 to 1.64±0.04 Ma; MPB and MPF of five sites all R; maximum thickness of flows is ≤35 m.

Medium-grained trachybasalt — Cone and flow complex north of MT; consists of flows and scoria deposits (Qyhc) of hawaiite containing sparse phenocrysts of plagioclase and augite, and sparse xenocrysts of quartz in dense, medium-grained trachytic groundmass; several short, north-trending dikes (Qyhd) are exposed in cone and canyon wall; dated at 1.73±0.02 Ma; MPF variable (lightning?); maximum thickness about 80 m.

Xenocrystal trachybasalt — Five cone and flow complexes of similar age peripheral to northern MT; consist of medium- to fine-grained hawaiite (C) and scoria deposits (Qxtc) having very sparse phenocrysts of olivine, plagioclase and very rare xenoliths of peridotite and norite (e.g., Goff and Goff, 2013). Some specimens contain rare quartz xenocrysts (Baldridge et al., 1996); some cones contain additional fragments of trachyandesite, trachydacite, and Cretaceous sandstone; one cone contains a dike (Qyxtd); three flows dated at 1.74±0.03 to 1.85±0.06 Ma; MPF of youngest flow R; three others N; maximum thickness about 50 m.

Younger trachybasalt — Several cone and flow complexes peripheral to northern MT including Cerro Osha; consist of relatively aphyric lavas and scoria deposits (Qytc) of hawaiite with rare, very tiny phenocrysts of plagioclase ± olivine; two cones contain NE-trending dikes (Qytd); southern dike dated at 2.35±0.03 Ma; MPF is R; unit Qytb also includes a sequence of flows along NE edge of map that may be ≤2 Ma; flows ≤60 m thick.

Aphyric trachybasalt — Three cone and flow complexes peripheral to MT; consist of flows and scoria deposits (Qatc) of hawaiite (C) with rare tiny phenocrysts of plagioclase, tiny olivine, and rare quartz xenocrysts; eroded cone on Horace Mesa fed by impressive dike (Qatd, Goff et al., 2013a, fig. 5) dated at 1.80±0.01 Ma; MPF of three flows dated at 1.76±0.05 to 2.18±0.02 Ma; maximum thickness about 60 m.

Xenocrystal gabbro intrusive — Circular intrusive plug of fine-grained olivine gabbro (C) within east sector of Mount Taylor AM (Goff et al., 2013b, fig. 3); grades into vesicular basalt toward top of intrusion (Hunt, 1938); contains 2% plagioclase phenocrysts in equigranular groundmass; also contains sparse xenoliths of gabbro and quartz; recent drilling by country rocks display weak hydrothermal alteration within 20 m of contact; age is 1.97±0.05 Ma; thickness about 150 m.

Fine-grained olivine trachybasalt — Single cone and flow north of MT; consists of fine-grained hawaiite and scoria deposits (Qyfoc) with abundant tiny phenocrysts of olivine; unit not dated; maximum thickness ≤50 m.

Olivine plagioclase trachybasalt — Two cone and flow complexes north of MT consisting of slightly porphyritic hawaiite and scoria deposits (Qyopc); both cones contain NE-trending dikes (Qyopd). Specimens are relatively aphyric containing tiny rare phenocrysts of olivine ± augite and sparse small phenocrysts of plagioclase; northerly cone contains rare fragments of gabbro and Cretaceous sandstone; unit not dated; maximum thickness about 50 m.

Basaltic trachyandesite — Eroded cone and short flow of basaltic trachyandesite (C) on north flank of MT. Phenocrysts consist of plagioclase, augite, hypersthene ± rare olivine; unit not dated; thickness ≤100 m.

Spotted trachybasalt — Lava flows and scoria deposit (Qystc) of distinctive, spotted hawaiite containing rare phenocrysts of plagioclase, and tiny phenocrysts of augite and olivine; unit not dated; maximum thickness about 120 m.

Plagioclase olivine trachybasalt — Cone and flow complex NE of MT; consists of flows and scoria deposit (Qypoc) of distinctive, medium-grained hawaiite (C) containing abundant plagioclase, olivine and augite phenocrysts; cone contains NNE-trending dikes (Qypod); flow dated at 2.29±0.06 Ma; MPF is R; maximum thickness about 100 m.

Porphyritic gabbro-bearing trachybasalt — Two cone and flow complexes on north and SW flanks of MT; consist of medium- to fine-grained hawaiite (C) and scoria deposits (Qyptc) containing sparse small phenocrysts of plagioclase, olivine and augite; locally contains gabbroic xenoliths (Goff et al., 2013b); two complexes dated at 2.30±0.13 Ma; MPF is R; maximum thickness <25 m.

Fine-grained plagioclase trachybasalt — Cone and flow complex NE of MT; consists of fine- to medium-grained, trachytic hawaiite (C) and scoria deposits (Qyfpc) having tiny-plagioclase and olivine phenocrysts; dike (Qyfpd) cuts flow south of cone; unit dated at 2.37±0.14 Ma; thickness of cone about 150 m.

Older xenolith-bearing trachybasalt — Medium-grained porphyritic hawaiite in central Horace Mesa having phenocrysts of olivine, plagioclase, and augite and very rare xenoliths of gneiss and peridotite; unit not dated; thickness <40 m.

Tertiary - Pliocene

Basalt and trachybasalt, undivided — Lumped unit of mafic rocks south of MT loosely equivalent to the "upper basalt" of Lipman and Moench (1972). Consists of many flows and several scoria cones of variable composition and texture; most are hawaiite (C); at least three flows and one cone complex contain peridotite and gabbro xenoliths; two flows dated at 2.22±0.06 and 2.75±0.03 Ma, respectively but most flows are probably Pliocene; MPF of two flows N; one is R; thickness highly variable.

Volcaniclastic sedimentary rocks — Debris flows, hyperconcentrated flows, and fluvial deposits shed from MT stratovolcano during growth; underlie and interlayer with a multitude of flows, domes and cones peripheral to MT; interlayered with many tuffs (Twst, Trt, Ttdt); gradational with older fluvial deposits (Tvss); most deposits Pliocene; maximum thickness >200 m.

Porphyritic enclave and quartz-bearing trachydacite — Trachyandesite to trachydacite flows (C) on SW margin of MT amphitheater having abundant volcanic enclaves up to 50 cm in diameter in devitrified matrix; contain 10–15% phenocrysts of large Kspar, plagioclase, augite, biotite and resorbed quartz; dated at 2.48±0.07 Ma; MPF is R; maximum thickness >200 m.

Porphyritic quartz-bearing trachydacite of Amphitheater — Irregular-shaped intrusion of porphyritic trachydacite to alkali rhyolite (C) in western amphitheater containing phenocrysts of Kspar, plagioclase, augite, hornblende, biotite and minor quartz in a devitrified groundmass; contains dikes (Tqtd) of similar composition and texture; contains sparse enclaves of mafic volcanic rocks; dated at 2.54±0.02 to 2.58±0.02 Ma; MPF of two sites both R; thickness exceeds 200 m.

Hornblende trachyandesite — Thick massive flow of porphyritic trachyandesite (C) satellite vents (Thtav) and various flows SW of, and on south margin of MT; display rare-to-sparse megacrysts of resorbed hornblende (≤5 cm) in devitrified groundmass; phenocrysts consist of plagioclase, augite, magnetite, olivine, hypersthene, and hornblende; may contain plagioclase-pyroxene clots; satellite eruption dated at 2.60±0.10 Ma; flow beneath summit dated at 2.70±0.02; MPF of both sites is N; other flows are older; thickness ≤275 m.

Summit hornblende trachyandesite — Several flows comprising the summit and west margin of MT; phenocrysts consist of plagioclase, augite, hypersthene, hornblende, sparse biotite, and minor Kspar in devitrified groundmass; contains rare, small (≤10 mm) hornblende megacrysts; dated at 2.73±0.01 Ma; MPF is N; maximum thickness >215 m.

Trachyandesite, undivided — Multiple flows of porphyritic lavas found in flanks of Mount Taylor. Phenocrysts consist of plagioclase, clinopyroxene and magnetite ± hypersthene; various flows not dated; thickness ≤100 m.

Augite megacrystal basalt — Fine-grained basalt (C) and scoria deposits (Toac) located several km SW of MT; contains sparse resorbed megacrysts of augite (≤1 cm); phenocrysts consist of olivine, plagioclase, augite and magnetite; fissure and dike (Toad) extend from NE side of eroded scoria cone; dated at 2.62±0.01 Ma; maximum thickness about 100 m.

Porphyritic hornblende trachydacite of San José Canyon — Trachydacite satellite dome and flow complex roughly 13 km south of MT; equivalent to porphyry of San Jose Canyon (Lipman et al., 1979); flow-banded porphyritic lava with large phenocrysts of plagioclase and smaller phenocrysts of hornblende and augite; dated at 2.63±0.10 Ma; thickness about 55 m.

Trachybasalt of Cerro Colorado (La Jara Mesa) — Weakly porphyritic hawaiite and scoria deposits (Tytc) containing sparse small phenocrysts and cumulate clusters of plagioclase, olivine and trace augite; dated at 2.64±0.01 Ma; MPF is N; thickness ≤30 m.

Hornblende trachydacite — Satellite eruption NW of MT; composed of massive to sheeted porphyritic trachydacite (C) containing phenocrysts of plagioclase, augite, and minor hornblende; dated at 2.66±0.02 Ma; MPF is N; thickness nearly 200 m.

Porphyritic biotite trachydacite — Massive to sheeted, porphyritic trachydacite (C) on NE margin of AM containing phenocrysts of Kspar, augite, biotite, sparse hornblende, rare quartz, and opaque oxides in devitrified groundmass; dated at 2.66±0.01 Ma; MPF is N; thickness about 300 m.

Porphyritic basaltic trachyandesite — Massive stubby flow with broad dike on north margin of amphitheater; consists of porphyritic basaltic trachyandesite (C) containing phenocrysts of augite, plagioclase and rare olivine; unit not dated; maximum thickness about 110 m.

Olivine-rich basalt — Flows and scoria deposits (Tooc) of basalt (C) found NE of MT; contain conspicuous phenocrysts of olivine and augite phenocrysts; eroded cone cut by NNE-trending dike (Tood); dated at 2.67±0.12 Ma; maximum thickness about 50 m.

Porphyritic olivine trachyandesite—Satellite eruption NE of AM consisting of highly porphyritic trachyandesite to trachydacite (C) containing abundant large phenocrysts of plagioclase and tiny phenocrysts of olivine, augite, plagioclase and sparse biotite in very fine-grained, devitrified groundmass; contains sparse enclaves of plagioclase-augite ≤12 cm in diameter; flow near vent dated at 2.68±0.04 Ma; flow near toe is 2.67±0.01 Ma; thickness about 75 m.

Porphyritic enclave-bearing trachydacite — Thick flows of porphyritic trachydacite (C) on west margin of AM having conspicuous enclaves of volcanic rocks up to 50 cm in diameter, especially in the lower flows; contain Kspar, plagioclase, augite, hypersthene and biotite phenocrysts in devitrified groundmass; dated at 2.68±0.09 Ma; MPF is N; thickness about 250 m.

Porphyritic biotite-hornblende trachydacite, undivided — Satellite dome, small plug, and several flow complexes NW, SW, east, and west margin of MT and AM; consist of massive to sheeted trachydacite (C) containing phenocrysts of plagioclase, Kspar, hornblende, biotite and minor augite in fine-grained groundmass; dome dated at 2.66±0.01 to 2.69±0.04; MPF is N; plug is 2.68±0.03 Ma; MPF is N; upper Rinconada Canyon flow is 2.72±0.04; MPF is N; thickness ≤275 m.

Very porphyritic biotite-hornblende trachydacite — NNW-trending flow, dike and plug complex in north wall and margin of AM; consists of porphyritic trachydacite (C) containing large phenocrysts of plagioclase and smaller biotite, hornblende, rare Kspar, augite, and opaque oxides in a trachytic devitrified groundmass; unit not dated; maximum thickness about 150 m.

Coarse porphyritic trachydacite — Satellite dome and flow complex on two hills ESE of AM; consists of coarsely porphyritic trachydacite containing large Kspar, augite and sparse magnetite phenocrysts in devitrified groundmass; dated at 2.70±0.04 Ma; thickness about 250 m.

Porphyritic trachydacite of Mosca Peak — Massive to sheeted, porphyritic trachydacite (C) containing phenocrysts of Kspar, plagioclase, augite, and biotite in granular to trachytic groundmass; contains rare plagioclase-augite-biotite clots; contains prominent, NNW-trending intrusion (Tpbtd) of similar composition; intrusion dated at 2.71±0.03 Ma; thickness about 500 m.

Platy trachyandesite, undivided — Platy to massive, slightly porphyritic trachyandesite (C) containing phenocrysts of plagioclase, augite and olivine in a trachytic devitrified groundmass; contains rare quartz xenocrysts; contains plagioclase-augite-olivine clots; eroded cone (Tbtac) lies on ridge to east and may be source of trachyandesite flows to west; unit not dated; thickness about 170 m.

Sugary enclave trachydacite — Porphyritic, glassy to devitrified trachydacite (C) NW of Mosca Peak composed of two map units; basal unit (Tsetdl) contains 15–20% phenocrysts of plagioclase, augite, hornblende and biotite; upper unit (Tsetdu) has similar phenocrysts set in a sugary matrix, both contain conspicuous, mafic enclaves; upper unit dated at 2.71±0.06 Ma; MPF of sugary unit N; thickness about 250 m.

Slightly porphyritic biotite trachydacite — Platy flows of slightly porphyritic trachydacite (C) on north margin of AM; contains 2–4% small plagioclase, biotite, and augite phenocrysts; unit not dated; thickness about 215 m.

Porphyritic trachyandesite, undivided — Lumped unit of massive to sheeted, porphyritic trachyandesite flows (C) from multiple vents having phenocrysts of plagioclase, augite, hornblende, rare olivine, and opaque oxides in devitrified groundmass; lava from north amphitheater rim dated at 2.63±0.07 Ma; other flows older; thickness about 300 m.

Trachydacite — Small exposure of porphyritic trachydacite ENE of AM; contains 15–20% crystals of biotite, plagioclase, hornblende, and sparse quartz; contains rare megacrysts of augite; unit not dated; thickness about 40 m.

Porphyritic augite trachyandesite — Massive to sheeted flows of trachyandesite in north margin of AM with conspicuous megacrysts of augite; phenocrysts are plagioclase, augite and rare olivine; unit not dated; thickness about 150 m.

Porphyritic biotite trachyandesite — Massive to sheeted flows of trachytic, devitrified trachyandesite in north AM containing large plagioclase, conspicuous biotite, augite and sparse olivine phenocrysts; unit not dated; thickness ≥160 m.

Porphyritic hornblende-biotite trachybasalt — Distinctive, massive porphyritic basaltic trachyandesite (C) on south rim of AM; contains abundant phenocrysts of hornblende, plagioclase, augite, magnetite, and sparse Kspar in devitrified groundmass; contains small plagioclase-magnetite-augite clots; unit not dated; thickness ≤200 m.

Older gabbro-bearing trachybasalt — Medium-grained porphyritic hawaiite (C) and scoria deposits (Togtc); phenocrysts consist of abundant small olivine, plagioclase, and augite; contains rare cumulate clots of plagioclase and olivine; unit not dated; thickness about 35 m.

Aphyric basaltic trachyandesite — Flows, scoria deposits (Tobtc) and dikes (Tobtd) of basaltic trachyandesite (C) at head of Lobo Canyon; contains tiny phenocrysts of plagioclase, augite and olivine in glassy, aphyric groundmass; contains rare-quartz xenocrysts; unit not dated; thickness about 75 m.

Older megacrystal trachybasalt — Several cone and flow complexes surrounding MT of similar age and mineralogy; consist of fine-grained hawaiite (C), scoria deposits (Tomtc) and dikes (Tomtd) containing conspicuous, large (≤1.5 cm), augite, plagioclase, and olivine megacrysts (e.g., Lipman et al., 1979); phenocrysts consist of plagioclase, olivine, augite ± hypersthene; some cones contain augite megacrysts; cones on La Jara Mesa contain hydromagmatic deposits (Tomth); eroded cone south of MT contains two dikes of trachyandesite with gabbro fragments (Goff et al., 2013b); flow near Cerro Pelón is 2.64±0.10; La Jara Mesa flow is 2.77±0.06 Ma; Rinconada flow (two dates) is 2.79±0.06 and 2.78±0.03; MPF all sites is N; maximum thickness about 80 m.

Porphyritic plagioclase trachybasalt — Massive thick flow of trachydacite (C) south of AM; contains 15–20% large phenocrysts (≤2.5 cm) of plagioclase and smaller phenocrysts of augite, biotite, magnetite and minor Kspar in devitrified groundmass; dated at 2.78±0.05 Ma; MPF is N; thickness about 120 m.

Plagioclase basalt — Classic "plagioclase basalt" of Baker and Ridley (1970), Lipman et al. (1979) and Perry et al. (1990); consists of massive to vesicular hawaiite (C) flows on north and south flanks of AM containing 10–20% tabular phenocrysts of plagioclase (≤2.5 cm) and smaller phenocrysts of olivine and augite in a glassy matrix; flows to south dated at 2.76±0.06 Ma; north flows dated at 2.79±0.04 Ma; thickness about 60 m.

Plagioclase basalt of Seco Canyon — One of several highly porphyritic, plagioclase phyric mafic lavas previously called "plagioclase basalt;" massive to vesicular flow of basaltic trachyandesite (C) found in Seco Canyon area south of AM; contains abundant large phenocrysts of plagioclase and smaller phenocrysts of olivine and augite; unit not dated; maximum thickness about 100 m.

Plagioclase basalt of Water Canyon — Massive, highly porphyritic plagioclase-phyric lava exposed in NE wall of AM, in walls of Water Canyon, and adjacent areas to west; consists of trachyandesite (C) containing abundant phenocrysts of large plagioclase but smaller phenocrysts of augite and sparse olivine in medium-grained groundmass; unit not dated; thickness about 150 m.

Plagioclase basalt south of San Mateo—Massive to vesicular basaltic trachyandesite (C) and scoria deposits (Tpbmc) having abundant large phenocrysts of plagioclase and much smaller phenocrysts of olivine and augite; unit not dated; thickness about 75 m.

Porphyritic plagioclase-rich trachyandesite — Massive flows on mesa south of San Mateo and poorly exposed flow north of Cerro Aguila; consist of highly porphyritic trachyandesite containing large phenocrysts of plagioclase and smaller phenocrysts of augite, olivine and magnetite; flow south of San Mateo dated at 2.86±0.04 Ma; maximum thickness about 50 m.

Upper biotite trachydacite — Massive flow SE of AM of slightly porphyritic trachydacite with 2–4% phenocrysts of small plagioclase, augite, and biotite in devitrified trachytic matrix; unit not dated; maximum thickness about 100 m.

Lower biotite trachydacite — Massive flow beneath and resembling **Ttdu**; two units separated by volcaniclastic gravel (**QTvs**); lower flow contains conspicuous enclaves of volcanic rocks; unit not dated; thickness about 150 m.

Porphyritic biotite trachydacite — Thick massive flow exposed in lower NE wall of AM; contains abundant phenocrysts of plagioclase, augite, biotite and hornblende (?) in devitrified groundmass; unit not dated; thickness about 120 m.

Porphyritic intermediate composition volcanic rocks, undivided — Poorly exposed flows in walls of AM; float generally contains phenocrysts of plagioclase, augite, hornblende and/or biotite; thickness ≤300 m.

Porphyritic mixed lava — Unit several km south of MT described as "distinctive bulbous flow or intrusion" (Lipman et al., 1979); consists of porphyritic trachydacite mixed with variable amounts of fine-grained, slightly porphyritic, basaltic enclaves; trachydacite phenocrysts are Kspar, plagioclase, augite, hornblende and rare quartz; mafic component contains plagioclase, augite, hypersthene, and olivine phenocrysts; unit not dated; thickness about 280 m.

Basaltic-rich volcaniclastic gravels — Fluvial deposits containing primarily subrounded- to rounded-clasts of basalt, trachybasalt and subordinate intermediate composition volcanic rocks; contain minor cobbles of rhyolite, chert, and Precambrian crystalline rocks; unique to SW Horace Mesa; thickness ≤25 m.

Volcaniclastic sandstone — Fine- to course-grained fluvial sandstone containing small clasts and grains of quartz, plagioclase, olivine, augite, chert, pumice, and various types of mafic and intermediate composition volcanics; may contain thin-beds of trachydacite or rhyolite tuffs too thin to map; occupies shallow channels cut into earliest lava flows; underlies and interlayers with **QTvs**; thickness ≤35 m.

Older olivine trachybasalt—Flows and scoria deposits (**Tootc**) of borderline basalt/hawaiite (C) with conspicuous-olivine and sparse-plagioclase and augite phenocrysts; dated at 2.89±0.07 Ma (Perry et al., 1990); MPF is N; thickness >50 m.

Trachydacite tuffs—Beds of trachydacite (C) pumice fall, pyroclastic flow and reworked pumice scattered all around MT; phenocrysts consist of plagioclase, augite, biotite ± hornblende ± Kspar in eutaxitic groundmass; four dates range from 2.700±0.002 to 2.79±0.09 Ma; maximum thickness ≤ 15 m.

Tuffs of Water and San Mateo Canyons, undivided — Bedded tuffs and tephras of rhyolite to trachydacite composition with interlayered volcaniclastic sands and gravels; consist of pyroclastic fall and flow deposits ≤4 m thick; rhyolitic tuffs most common toward base of unit; five dates range from 2.74±0.03 to 3.04±0.12 Ma; maximum thickness about 200 m.

Landslide deposit — Unsorted debris forming discontinuous layer in upper Marquez Canyon; consists of angular trachydacite blocks 3–4 m in diameter on top of boulder- to cobble-sized volcaniclastic debris; intercalated within **Twst**; thickness between 6 to 12 m.

Rhyolitic tuffs — Beds of rhyolitic (C) pumice fall and reworked pumice from isolated sites all round MT; continuous beds exposed in cliffs above San Mateo; may include thin-beds of Grants Ridge Tuff in cliff exposures (see below); contain phenocrysts of quartz, Kspar, biotite, and augite; bed south of San Mateo dated at 3.08±0.20 Ma; thickness of individual beds usually <3m.

Older fine-grained trachybasalt — Small plug-like body of massive olivine hawaiite in lower NE wall of AM; contains small phenocrysts of olivine and augite, and fragments of altered rhyolite; unit not dated; thickness about 35 m.

East Amphitheater biotite rhyolite — Massive to flow-banded, fine- to medium-grained biotite rhyolite (C); probably consists of multiple intrusions; porphyritic varieties contain quartz, Kspar, biotite, augite and plagioclase; some types contain only sparse quartz, Kspar, and biotite; locally displays intense silicification; dated at 2.91±0.04 Ma; thickness about 200 m.

West Amphitheater biotite rhyolite — Flow-banded to spherulitic to massive rhyolite (C) containing small phenocrysts of quartz, Kspar, biotite, augite, plagioclase, and minor hornblende; may show hydrothermal alteration from later intrusions; dated at 3.03±0.11 Ma (Perry et al., 1990); thickness about 200 m.

Fine-grained trachyte — Eroded, dissected plug of fine-grained trachyte (C) in east AM; contains scant-small phenocrysts of plagioclase in trachytic groundmass; dated at 3.14±0.01 Ma; thickness about 120m.

Amphitheater basanite — Two flows of fine-grained to aphyric basanite (C) exposed in eastern AM and Water Canyon; contain extremely-tiny phenocrysts of iddingsitized olivine in glassy to devitrified groundmass; dated at 3.22±0.04 Ma; thickness about 65 m.

Older alkali basalt — Fine- to medium-grained olivine basalt (C; Lipman and Moench, 1972); contains small phenocrysts of olivine and very scant phenocrysts of plagioclase and augite; most common in eastern AM and Water Canyon; small plug and flow also found in upper Rincoñada Canyon; two dates span 3.14±0.03 to 3.21±0.12 Ma; MPF (2 sites) are N and R; thickness ≤35 m.

Older porphyritic trachybasalt — Flows and scoria deposits (**Toptc**) of medium-grained porphyritic basalt/hawaiite (C); contain conspicuous olivine and plagioclase phenocrysts; unit not dated; MPF is N; thickness about 35 m.

Older trachybasalt, undivided — Lumped unit consisting of older, primarily fine-grained to aphyric hawaiite and scoria deposits (**Totc**) surrounding MT and underlying most of southern Mesa Chivato; most flows contain some olivine phenocrysts; flow in upper Seboyeta Canyon is 2.83±0.02; MPF is N; two flows NW of MT are 3.20±0.05 to 3.31±0.08; flow in SW Horace Mesa is 3.24±0.09 Ma; maximum thickness about 45 m.

Grants Ridge rhyolite tuff — Bedded rhyolitic pyroclastic fall, flow, and surge deposits; some beds have abundant aphyric obsidian clasts (C). Pumice clasts (C) are glassy to slightly devitrified with very rare phenocrysts of tiny Kspar. Lithics consist of Precambrian granite and gneiss, chert, sandstone, limestone and rare basanite; dated at 3.26±0.04 (obsidian) and 3.33±0.07 Ma (sanidine in pumice); maximum thickness about 110 m.

Grants Ridge rhyolite center — Multiple eruptions of sparsely porphyritic rhyolite (C) containing phenocrysts of Kspar, plagioclase, rare quartz, and very sparse biotite; texture: massive to flow banded; some zones spherulitic; locally contains mariolitic cavities with quartz, alkali feldspar, hematite, garnet, and topaz; north, lower flank of dome contains sparsely porphyritic obsidian; devitrified zone on SE dated at 3.18±0.01 Ma; MPF is N; obsidian dated at 3.498±0.003 Ma; maximum thickness >100 m.

West olivine basanite — Fine-grained, massive to sheeted basanite (C) with tiny microphenocrysts of iddingsitized olivine and sparse magnetite; commonly has spotted appearance; dated at 3.64±0.15 Ma; MPF is R; thickness about 40 m.

East olivine basanite — Fine-grained, nearly aphyric basanite (C) with tiny phenocrysts of plagioclase and iddingsitized olivine; weathered surfaces distinctly to vaguely spotted; upper part of unit massive to rubbly; lower part columnar; dated at 3.72±0.02 Ma; MPF is R; thickness about 45 m.

Volcanic Rocks Of Southwest Mesa Chivato

(*Note*: many units in this group are already described with Mount Taylor volcanic rocks above)

Quaternary

Porphyritic olivine basalt of Cerro Redondo — Massive to vesicular, fine-grained basalt (C) and scoria deposits (**Qfocr**); contain 15% phenocrysts of olivine, plagioclase, and augite near vent; contains 1-2% olivine phenocrysts near flow terminus; dated at 1.90±0.03 Ma; MPB is N (3 sites); thickness about 35 m.

Medium-grained plagioclase and augite phyric trachybasalt — Massive flows and scoria deposits (**Qmpcc**) of hawaiite with phenocrysts of plagioclase and augite; cone contains an eroded dike (**Qmpcd**) trending N40E; unit not dated; MPB is N suggesting an age between 1.77 and 1.95 Ma (Gee and Kent, 2007); thickness about 40 m.

Medium-grained aphyric trachybasalt — Flows and scoria deposits of hawaiite (**Qmac**) underlying east side of Cerro Redondo; flows have trachytic texture caused by aligned plagioclase microphenocrysts; contains tiny phenocrysts of augite and olivine; unit not dated; MPB is R suggesting an age >1.95 Ma (Gee and Kent, 2007); thickness is about 60 m.

Fine- to medium-grained, plagioclase-phyric trachybasalt — Fine- to medium-grained hawaiite (C) and scoria deposits (**Qfplc**) on NE edge of map with conspicuous trachytic texture; contains small phenocrysts of plagioclase, augite and olivine; cone contains NE-trending, poorly exposed dike (**Qfpld**); dated at 2.13±0.01 Ma; MPB is R; thickness about 75 m.

Fine-grained aphyric trachybasalt — Extremely fine-grained, aphyric hawaiite (C) and scoria deposits (**Qfatc**) containing no phenocrysts; contains NE-trending dikes (**Qfatd**); dated at 2.14±0.03 Ma; MPB is N; thickness about 100 m.

Younger olivine trachybasalt — Massive flows and scoria deposits (**Qyoc**) of fine-grained hawaiite containing 2-4% olivine phenocrysts; flows may have felty texture; three cones contain several NNE-trending dikes (**Qyod**); may contain plagioclase and augite megacrysts; dated at 2.18±0.06 Ma; thickness about 70 m.

Medium-grained plagioclase-phyric trachybasalt — Flows and small scoria cone (**Qmptc**) of medium-grained, plagioclase-phyric hawaiite with tiny-phenocrysts of augite and olivine; unit not dated; thickness about 40 m.

Fine-grained augite-bearing olivine basalt of Cerro Aguila — Flows and scoria deposits (Qfoqc) of fine-grained basalt/hawaiite (C) having small phenocrysts of olivine and sparse xenocrysts of quartz; scoria cone has several annular and linear dikes (Qfoqd); lava SE of cone dated at 2.25±0.01 Ma; MPB is R; dike in cone is 2.27±0.01 Ma; maximum thickness about 85 m.

Younger fine-grained plagioclase trachybasalt — Flows and scoria deposits from two cones (Qftc) of very similar, aphyric hawaiite having a felted groundmass of very fine-grained plagioclase, augite, and minor olivine; south cone has several dikes (Qftd); dated at 2.28±0.07 Ma; thickness about 50 m.

Porphyritic augite olivine basalt — Flows of very distinctive, speckled, medium- to coarse-grained porphyritic basalt and associated scoria cone (Qpoac) containing abundant phenocrysts (5-15%) of augite, olivine and plagioclase; may contain trace xenocrystic quartz; dated at 2.31±0.06 Ma; thickness about 30 m.

Medium-grained sparsely porphyritic olivine trachybasalt — Flows and scoria deposits (Qmpoc) of medium- to fine-grained hawaiite with sparse phenocrysts of olivine and very sparse-small phenocrysts of plagioclase and augite; cone contains NE-trending dike (Qmpod); unit not dated; thickness about 35 m.

Quartz-bearing olivine trachybasalt — Flows and scoria deposits of hawaiite (C) capping small mesa east of Bear Canyon, Rio Paguate; contains sparse olivine phenocrysts, possibly some disaggregated peridotite, and rare-quartz xenocrysts; dated at 2.32±0.01 Ma; thickness about 20 m.

Fine-grained augite-bearing olivine basalt — Flows and scoria deposits (Qfoac) of fine-grained olivine basalt (?), containing sparse, large phenocrysts of augite; cone contains pool of basalt on western summit and hydromagmatic deposits (Qfoad) on east summit; unit not dated; MPB is R suggesting an age >1.95 Ma (Gee and Kent, 2007); maximum observed thickness is about 80 m.

Olivine-rich plagioclase basalt — Flows and scoria deposits (Qolpc) of olivine-rich, porphyritic basalt (C) near north edge of map; contains scattered, large phenocrysts of augite; dated at 2.41±0.02 Ma; thickness about 100 m.

Younger medium-grained plagioclase trachybasalt — Flows and scoria deposits (Qympc) of medium-grained hawaiite (C) with small, platy, interlocking microphenocrysts of plagioclase and tiny microphenocrysts of olivine and augite; scoria contains rare fragments of Cretaceous sandstone; unit not dated; thickness about 60 m.

Fine-grained plagioclase and augite phyric olivine basalt — Flows and scoria deposits (Qfpoc) of basalt (C) containing conspicuous phenocrysts of plagioclase, augite and olivine in fine-grained groundmass; cone contains several dikes (Qfpod); unit not dated; MPB is R suggesting an age >2.15 but <2.58 Ma (Gee and Kent, 2007); maximum thickness about 60 m.

Plagioclase-phyric trachybasalt of Cerro Colorado (Mesa Chivato) — Flows and scoria deposits (Qmppc) of medium-grained hawaiite; flows contain imbricate phenocrysts of aligned plagioclase, cone contains phenocrysts of plagioclase; unit not dated; thickness about 45 m.

Medium-grained plagioclase-phyric trachybasalt of Cerro Frio — Medium-grained, sparsely plagioclase-phyric hawaiite (C) and scoria deposits (Qmpfc) containing plagioclase phenocrysts ≤3 cm long and smaller phenocrysts of olivine and augite; dated at 2.44±0.01 Ma; MPB (2 sites) both R; a similar looking, faulted flow lies just east of Laguna Bonita in NE part of map; age unknown but possibly younger than Cerro Frio; maximum thickness about 70 m.

Fine-grained aphyric trachybasalt — Flows and scoria deposits (Qfac) of very fine-grained, aphyric hawaiite containing visible microphenocrysts of plagioclase and olivine; cone contains a NE-trending dike (Qfad) and a sill-like body; unit not dated; maximum thickness about 35 m.

Fine-grained, quartz- and xenolith-bearing olivine trachybasalt — Fine-grained, occasionally flow-banded, nearly aphyric hawaiite (C); contains sparse quartz xenocrysts; contains very rare, 1-8 cm, dunite xenoliths and augite megacrysts; unit not dated; maximum thickness about 20 m.

Tertiary - Pliocene

Hydromagmatic deposits from maar eruptions — Consist of poorly exposed hydromagmatic deposits derived from explosive interaction of shallow groundwater with magma during eruption. Best exposures occur in the modified drainage on south end of Laguna Cañoneros maar where deposits consist primarily of plane-parallel base surge beds containing a mixture of quenched basaltic (hydroclastic) shards and fragments, sideromelane, yellow-brown palagonite, and rare accidental clasts. Most deposits primarily buried by colluvium and recognized by lag of pebble-sized lithic fragments. Overlies and containing Ttdt pumice (2.70 Ma?) at Laguna Cañoneros site above; ages of other vents and deposits not precisely known but seem to be late Pliocene to early Pleistocene (Goff et al., 2014); maximum observed thickness about 8 m.

Medium-grained olivine trachybasalt — Flows of medium-grained trachybasalt with abundant, small phenocrysts of olivine in trachytic groundmass; unit not dated; MPB (1 site) is R indicating an age ≤2.58 Ma (Gee and Kent, 2007); maximum thickness about 15 m.

Campo Grande volcanic center — Volcanic center at NE edge of map dominated by basaltic pyroclastic rocks and discontinuously exposed flows (Tcgt); NE-striking spine of agglomerate forms eastern ridge of cone; flows display variable texture and mineralogy but generally have phenocrysts of olivine, plagioclase and augite; dated at 2.52±0.01 Ma; maximum thickness about 120 m.

Medium-grained, gabbro bearing, plagioclase-phyric trachybasalt — Flows and scoria deposits (Tmgpc) of medium-grained hawaiite with small scattered phenocrysts of plagioclase and olivine; contains conspicuous 5 cm xenoliths of gabbro that become more obvious closer to source; cone contains two WNW-trending dikes (Tmgpd); unit not dated; MPB is R suggesting an age >2.58 Ma; maximum thickness about 25 m.

Fine-grained augite- and plagioclase-phyric olivine trachybasalt — Flow and scoria deposits (Tfpoc) of fine-grained hawaiite containing phenocrysts of olivine, augite and plagioclase; contains several NE-trending dikes (Tfpod); unit not dated; maximum thickness about 25 m.

Quartz basanite of Laguna Cañoneros — Flows of aphyric basanite (C) forming west-shore of Laguna Cañoneros maar; has distinctive hackly texture containing abundant, visible microlites of olivine and augite; contains sparse xenocrysts of quartz; dated at 2.58±0.01 Ma; MPB (1 site) is N; exactly at major magnetic polarity boundary (Gee and Kent, 2007); thickness about 15 m.

Cerro Pino volcanic center—Volcanic center located SW of Campo Grande dominated by basaltic pyroclastic rocks; six pyroclastic deposits identified (**Tcpp1**, oldest to **Tcpp6**, youngest); contain olivine, plagioclase and augite phenocrysts; NE-trending, steeply dipping flows or dike near summit (**Tcpl**) contain 1–2% olivine phenocrysts in aphanitic matrix; unit not dated; maximum thickness about 80 m.

Fine-grained olivine basalt — Fine-grained basalt (?) consisting of long, southerly, flows; contain rare megacrysts of 0.25 cm resorbed plagioclase and augite, and phenocrysts of olivine; megacrysts less abundant with distance from source; flows apparently originate from Cerro Pino complex; contains two thin hydromagmatic beds (**Tfoh**) on south flank of Cerro Pino; MPB (2 sites) both N suggesting an age >2.58 Ma (Gee and Kent, 2007); thickness about 25 m.

Megacrystal trachybasalt — Nearly buried cone and flow complex; consists of fine-grained hawaiite and scoria deposits (**Tymtc**) having rare megacrysts of augite and olivine; small phenocrysts consist of plagioclase, augite and minor olivine; unit not dated; maximum thickness about 25 m.

Medium-grained plagioclase-phyric olivine basalt — Flows and scoria deposits (**Tmopc**) of plagioclase-phyric hawaiite with pronounced trachytic texture; contains minor small olivine phenocrysts; eroded cone contains complexly fingered dike (**Tmopd**); unit not dated; MPB (1 site) is N suggesting an age >2.58 Ma (Gee and Kent, 2007); thickness about 45 m.

Sugary plagioclase-phyric olivine trachybasalt — Widespread flows and scoria deposits (**Tmpoc**) of medium-grained hawaiite with sparse phenocrysts of plagioclase and olivine in trachytic groundmass; texture occasionally sugary; eroded cone contains an arcuate dike (**Tmpod**); unit not dated; MPB (2 sites) both N suggesting an age >2.58 Ma; maximum thickness about 30 m.

Older plagioclase trachybasalt — Two flow and scoria cone complexes (**Toftc**) consisting of aphyric, fine-grained hawaiite (C); contain tiny interlocking plates of plagioclase and microphenocrysts of olivine and augite; unit not dated; MPB (1 site) is N suggesting an age >2.58 Ma; cones contain dikes (**Toftd**); maximum thickness ≤20 m.

Older xenocrystal olivine basalt — Single knob NE of Cerro Redondo consisting of fine-grained olivine basalt (C) and minor agglutinate; probably an eroded vent; contains abundant small (≤0.25 cm) xenocrysts of peridotite; phenocrysts are mostly olivine with minor augite and plagioclase; unit not dated; thickness about 25 m.

Medium-grained porphyritic trachybasalt — Flows and scoria deposits west of Cerro Redondo (**Tmptc**); consist of medium-grained hawaiite containing sparse but obvious phenocrysts of augite, olivine and plagioclase; also contain rare xenocrysts of quartz; unit not dated; thickness about 35 m.

Fine-grained aphyric trachybasalt — Poorly exposed, flow of very fine-grained hawaiite containing no obvious phenocrysts; originates from faulted scoria cone west of Cerro Redondo; unit not dated; thickness about 10 m.

Medium-grained augite and plagioclase-phyric trachybasalt cone — Nearly buried scoria cone west of Cerro Redondo containing bombs and cinders of medium-grained, vesicular hawaiite with sparse, conspicuous phenocrysts of augite and plagioclase; unit is not dated; thickness about 5 m.

Fine-grained megacrystal basalt and pyroclastic deposits — Multiple flows and scoria deposits (**Tmb1**, oldest to **Tmb9**, youngest) in NE corner of map; units 1–3 primarily flows; units 7–9 dominated by pyroclastic material; matrix is aphanitic to fine-grained; contains sparse plagioclase, augite, and olivine phenocrysts, 1–3% augite megacrysts ≤2 cm across, rare xenocrysts of quartz, and rare "crustal" xenoliths; unit not dated; maximum thickness about 60 m.

Fine-grained augite and plagioclase-phyric olivine trachybasalt — Two flow and cone complexes; consists of fine-grained hawaiite and scoria deposits (**Tfpoc**) with conspicuous phenocrysts of augite, plagioclase, and small olivine; northern cone highly eroded and contains great assortment of spindle bombs and agglutinate; southern complex overlies extensive hydromagmatic beds (**Tfpoh**); unit not dated; thickness about 20 m.

Medium-grained sparsely porphyritic olivine trachybasalt — Multiple flows (**Tspb1**, oldest to **Tspb7**, youngest) of medium-grained hawaiite in NE corner of map; contains <1% plagioclase, augite, and olivine phenocrysts 4–5 mm in diameter; unit not dated; thickness about 8 m.

Sparsely megacrystal trachybasalt — Flow in NE corner of map with <1% 5–7 mm megacrysts of augite in fine-grained matrix of plagioclase laths; unit not dated; thickness ≤10 m.

Fine-grained trachybasalt — Non-descript trachybasalt flows containing <<1% phenocrysts of olivine, plagioclase, and augite; some flows contain quartz xenocrysts; some flows have spotted texture; unit not dated; maximum thickness about 50 m.

Fine-grained augite and plagioclase-phyric trachybasalt — Stubby flows and scoria deposits (**Tfcpc**) of fine-grained hawaiite near NE margin of map; contains sparse phenocrysts of augite and plagioclase and rare megacrysts of ≤1 cm augite; flow SW of scoria cone has much agglutinate and seems to be part of NNE- trending fissure; unit not dated; thickness about 80 m.

Fine-grained augite megacrystal olivine basalt — Tiny flow remnant and scoria deposits (**Tfcoc**) of fine-grained basalt containing abundant black augite megacrysts; groundmass contains tiny-olivine phenocrysts; cone contains NW-trending dike (**Tfcod**); unit not dated; thickness about 25 m.

Sparsely porphyritic olivine basalt — Aphanitic flow SW of Campo Grande containing <1% olivine and augite phenocrysts ≤4 mm in diameter; unit not dated; thickness ≤15 m.

Porphyritic olivine augite basalt — Aphanitic to fine-grained flows with 1–3% phenocrysts of olivine, augite and plagioclase 3–7 mm in diameter; contain 1–2% augite xenocrysts 1 cm across; unit not dated; thickness ≤25 m.

Trachybasalt — Fine-grained flow of variable texture; contains small olivine and augite phenocrysts; unit not dated; maximum thickness about 10 m.

Porphyritic basalt with plagioclase phenocrysts — Porphyritic fine-grained basalt flows containing 5–12% plagioclase ≤5 mm phenocrysts with trace ≤3 mm augite and olivine phenocrysts; unit not dated; thickness ≤30 m.

Porphyritic augite-phyric trachybasalt — Distinctive flow with 15% augite phenocrysts 2–4 mm in diameter and lesser amounts of plagioclase in equigranular matrix; unit not dated; thickness about 3 m.

Fine-grained aphyric trachybasalt — Flows and scoria deposits (**Taptc**) on east edge of map; consists of fine-grained hawaiite with rare, small, phenocrysts of olivine and elongated plagioclase microlites; cone contains impressive assortment of bombs and N-trending dike (**Taptd**); unit not dated; thickness about 65 m.

Medium-grained augite-phyric olivine trachybasalt — Medium-grained, slightly-porphyritic hawaiite with abundant, small phenocrysts of augite, plagioclase, and olivine; occasionally displays spotted appearance; K-Ar age 2.65±0.15 Ma (Lipman and Mehnert, 1979); thickness about 35 m.

Medium-grained augite plagioclase-phyric olivine trachybasalt — Flows of medium-grained, sparsely-porphyritic hawaiite having phenocrysts of augite, plagioclase and olivine; exposed along upper Rio Paguate; unit not dated; thickness about 25 m.

Fine-grained vesicular trachybasalt — Vesicular, aphyric to fine-grained hawaiite with <1% of <2–4 mm olivine and trace augite and plagioclase <2 mm in diameter; unit not dated; thickness ≤13 m.

Fine-grained augite-phyric olivine trachybasalt — Massive to platy flows of fine- to medium-grained, slightly-porphyritic hawaiite (C) containing sparse, phenocrysts ≤1.5 cm long, and very sparse, phenocrysts of olivine; flows originate from eroded cone (**Tfctc**) and cover southern Chupadero Mesa; dated at 2.65±0.02 Ma; MPB is N; maximum thickness about 20 m.

Porphyritic trachydacite tuffs — Beds of trachydacite to rhyolitic pumice (C) and pumice-rich sediments scattered through the southern Mesa Chivato area; pumice: highly vesicular, containing small, sparse phenocrysts of plagioclase, augite ± biotite, hornblende, sanidine, and quartz; sources presumably from Mount Taylor; date on bed in Seboyeta Mesa 2.700±0.002 Ma; dates on similar deposits to west range from 2.71 to 2.76 Ma (n=4); individual beds ≤2m thick.

Fine-grained augite porphyritic olivine basalt — Distinctive flows of fine-grained, porphyritic basalt with conspicuous megacrysts of augite and small phenocrysts of plagioclase and olivine; flows originate from scoria cone (**Tfcpoc**) containing NE-trending dike (**Tfcpod**); unit not dated; MPB (1 site) is N suggesting an age >2.58 Ma; underlies **Ttdt**; maximum thickness about 20 m.

Aphyric olivine basanite of Seboyetita Creek — Very fine-grained, aphyric basanite (C) with tiny microphenocrysts of plagioclase, olivine and augite, flows originate from eroded scoria cone (**Tbasc**); dated at 2.68±0.04 Ma; underlies **Tfcpob**; thickness about 40 m.

Medium-grained plagioclase-phyric trachybasalt — Massive to sheeted flows and scoria deposits (**Tmplc**) of medium-grained, porphyritic hawaiite (C) with phenocrysts of plagioclase and very small phenocrysts of olivine and augite; cone contains NNW-trending dike (**Tmpld**); flow forms cliff in upper Seboyeta Canyon; dated at 2.70±0.02 Ma; MPB (2 sites) both N; thickness about 15 m.

Fine-grained quartz- and xenolith-bearing trachybasalt — Flow of fine-grained hawaiite with rare, quartz xenocrysts and very rare, xenocrysts (0.5 to 2 cm) of pyroxene gabbro; gabbro is medium-grained and equigranular; eroded vent (**Tfqgc**) mostly stripped of scoria; unit not dated; thickness about 15 m.

Medium-grained augite-phyric olivine trachybasalt — Medium-grained, slightly porphyritic hawaiite flows (C) with sparse megacrysts of augite and small phenocrysts of olivine; forms distinctive cliff along SW margin of Silver Dollar Mesa; K-Ar date is 2.93 ± 0.12 Ma (Laughlin et al., 1993); MPF is N; thickness about 20 m.

Medium-grained olivine trachybasalt — Flows of medium-grained hawaiite (C) containing about 3% of ≤1 mm olivine phenocrysts in a slightly trachytic groundmass; flows originate from small exhumed cinder cone (**Tmotc**) on west side of upper Paguate Creek; unit not dated; MPB is N; thickness about 35 m.

Medium-grained augite- and plagioclase-phyric olivine trachybasalt — Massive to sheeted flows and scoria deposits (**Tcpoc**) of medium-grained porphyritic hawaiite with phenocrysts of plagioclase, olivine and sparse augite; unit not dated; MPF is R suggesting an age between 3.04 and 3.11 Ma; maximum thickness about 20 m.

Fine-grained olivine trachybasalt — Massive flows of fine-grained trachybasalt with sparse, phenocrysts of olivine, plagioclase, and augite; forms cliff on mesa east of Seboyeta Creek; unit not dated; MPF is R; thickness about15 m.

Basalt diatreme of Seboyeta Canyon — Complex diatreme consisting primarily of three cycles of alternating massive hydromagmatic beds overlain by layers of coarse pyroclastic breccia and welded basaltic scoria (Goff et al., 2014); Two dikes trending S30W cut NE side of diatreme; hydromagmatic beds contain fragments of Cretaceous sandstone and rounded chert. The lava, dikes, scoria and hydromagmatic fragments all consist of fine-grained basalt (C) containing conspicuous complex megacrysts of augite and hornblende; dated at 3.07±0.09 Ma; MPF is R; thickness about 50 m.

Fine-grained trachyte of Cerro Chivato — Highly foliated trachyte dome (C) in NE map area; contains sparse, phenocrysts of plagioclase in fine trachytic groundmass of plagioclase, augite, and hornblende (?); intrusion breccia on south margin of dome; dated at 3.16±0.02 Ma; thickness about 120 m.

Porphyritic hornblende trachybasalt—Massive to vesicular flows of hawaiite (almost basanite, C) containing 1–3% hornblende phenocrysts in fine-grained matrix with phenocrysts of plagioclase, olivine, and augite; forms faulted slopes north of Cerro Pino; dated at 3.16±0.01 Ma; maximum thickness about 20 m.

Hackly olivine basanite — Aphanitic flow of basanite (?) with pronounced hackly and spotted textures; contains <<1% of very tiny, iddingsitized-olivine microphenocrysts; unit not dated; overlies **Totb** in NE area of map; thickness about 10 m.

East olivine basanite — Fine-grained, nearly aphyric basanite (C) with rare, tiny phenocrysts of plagioclase and iddingsitized-olivine; weathered surfaces distinctly to vaguely spotted; upper part of unit is massive to rubbly; lower part is columnar; dated at 3.72±0.02 Ma; MPF is R; thickness about 45 m.

Small Dikes And Intrusions Located Throughout Map

Biotite trachydacite dikes, undivided — Massive porphyritic to coarse-porphyritic, trachydacite dikes (C) found within and on flanks of Mount Taylor AM (Goff et al., 2013a); contain phenocrysts of plagioclase, biotite, augite ± Kspar; commonly form tall fins; one dike of this type dated at 2.69±0.03 Ma; maximum width roughly 30 m, height ≤50 m; exposed length ≤1 km.

Hornblende trachydacite dikes, undivided — Massive-porphyritic trachydacite dikes (C) found within and on flanks of Mount Taylor AM (Goff et al., 2013a); contain phenocrysts of plagioclase, augite, hornblende ± Kspar; one dike dated at 2.77±0.02 Ma; exposed length ≤0.7 km.

Hornblende-biotite trachydacite dikes, undivided — Massive-porphyritic to coarse-porphyritic, trachydacite dikes (C) found within and on flanks of Mount Taylor AM; contain phenocrysts of plagioclase, augite, hornblende, biotite ± Kspar; one dike of this type dated at 2.64±0.06 Ma; exposed length ≤0.8 km.

Trachyandesite dikes, undivided — Massive-porphyritic, trachyandesite dikes (C) found mostly on flanks of MT; contain phenocrysts of plagioclase, augite ± hypersthene ± olivine; most dikes of this type are ≤10 m wide, ≤15 m tall and ≤60 m long; exception is large dike and plug complex south of San Mateo; the latter dike dated at 2.79±0.03 Ma.

Trachydacite dike — Poorly exposed dike trending E-W on SW Horace Mesa; consists of fine-grained trachydacite with very sparse, small phenocrysts of plagioclase; unit not dated; width ≤30 m; length ≤200 m.

Mafic dikes, undivided — Linear spines and fins identified only on air photos, which cut rocks of basaltic composition in NE part of map; dikes not dated; width ≤15 m.

Porphyritic nephelinite dike — Splotchy, porphyritic, 1-m-wide nephelinite dike (C) with >20% olivine phenocrysts; also contains minor augite and sparse plagioclase phenocrysts; dike trends nearly E-W; located just west of San Fidel dome (Goff et al., 2013a); dike too altered to dated.

Augite-megacrystal trachybasalt dikes and plug — Fine-grained, hawaiite (C) dikes containing megacrysts of augite and small phenocrysts of augite and plagioclase; may contain small xenocrysts of quartz; dikes trend nearly E-W cutting prominent N-S-trending folded Cretaceous rocks in Lobo Canyon area (Goff et al., 2013a); too altered to date; dikes ≤2 m wide; plug about 30 m wide.

Plagioclase basalt dikes — About four dikes of porphyritic plagioclase basalt cutting AM floor and SE rim; contain large plagioclase, small olivine, and augite phenocrysts; dikes not dated; width ≤25 m; length ≤150 m.

Olivine trachybasalt dikes — Many dikes ≤3 m-wide identified mostly in the Rincoñada Basin area (Goff et al., 2013a); consist of hawaiite (C) with small-phenocrysts of olivine and rare plagioclase and augite; dikes too altered to date; length ≤350 m.

Olivine gabbro intrusives — Medium- to fine-grained, allotriomorphic-granular gabbro (C) consisting mostly of plagioclase, augite, olivine, and opaque oxides (Goff et al., 2013b); geochemically vary from gabbro to monzodiorite; forms circular intrusive 50 m in diameter on isolated hill west of Rincoñada Canyon; forms two, sill-like bodies exposed NE of MT; blocks ≤1 m long found in scoria cone deposits of unit **Tomtc** east of Rincoñada Canyon; one of sills dated at 2.68±0.07 Ma; gabbro block from above mentioned cone dated at 3.10±0.24 Ma.

Olivine basanite dike of Picacho Peak — Fine-grained, basanite (C) dike on south margin of map; contains small olivine, plagioclase, and augite microphenocrysts; contains rare quartz xenocrysts; dike trends NE away from Picacho Peak plug (Lipman and Moench, 1972); plug dated at 4.49±0.08 Ma; magnetic polarity (lab) is R (Hallett et al., 1997); length ≤350 m.

Mesozoic Sedimentary Rocks (adapted from Goff et al., 2012 and Skotnicki et al., 2012)

Cretaceous

Mesa Verde Group

Menefee Formation — Interbedded, golden to yellow orange, medium- to thin-bedded sandstone, black to gray to brown shale and siltstone with carbonized wood fragments, and minor coal; petrified-wood fragments common; maximum exposed thickness ≥45 m.

Point Lookout Sandstone, Hasta tongue — Fine-grained, cross-bedded, quartz sandstone with rare darker lithic grains; forms prominent light gray cliffs; maximum exposed about 45 m.

Crevasse Canyon Formation

Gibson Coal Member — Interbedded, light-orange, very fine-grained, quartz sandstone in massive to thinly bedded layers up to 4 m thick and dark shale. The shale commonly contains dark-brown to black, lignite coal in seams up to 2 m thick. Locally contains light-gray fragments of fossilized wood; maximum exposed thickness <50 m.

Dalton Sandstone Member — Consists of two prominent sandstone layers: a lower, yellowish-orange layer and an upper white layer with an intervening shale bed; basal sandstone often has thin beds containing abundant pelecypod casts and molds; maximum exposed thickness is ≤25 m.

Stray Sandstone Member — Consists of two prominent, reddish-orange, sandstone layers with an intervening shale bed; top of unit is a thin (<1 m) conglomerate with pebbles to cobbles of quartzite, chert, and quartz. The Stray pinches out to the southeast; maximum exposed thickness in Lobo Canyon area ≤40 m.

Dilco Coal Member — Interbedded, black to brown siltstone, thin- to medium-bedded, tan, brown, and olive-green sandstone, and black coal; sandstones: cross-bedded to ripple laminated; coal beds <0.5 m thick; usually in the upper part of the unit; maximum exposed thickness in Lobo Canyon area ≤150 m.

Gallup Sandstone

Main Body — Yellowish-gray, white, or golden-yellow, medium- to thick-bedded, cross-bedded sandstone; carbonaceous shale is interstratified with the sandstone. Locally contains fossiliferous (*Inoceramid*) beds near the top. Maximum exposed thickness to southwest in Lobo Springs quadrangle is ≤25 m (Goff et al., 2008).

Upper tongue (combined with Km in cross sections) — White, medium-bedded, cross-bedded to tabular sandstone that is locally capped by well-cemented, fractured, brown-weathering, planar-cross-bedded sandstone. The upper and lower contacts are gradational with Mancos Shale. Maximum exposed thickness in Lobo Springs quadrangle is ≤30 m (Goff et al., 2008).

Lower tongue (combined with Km in cross sections) — White, medium-bedded, cross-bedded to tabular sandstone that is locally capped by well-cemented, fractured, brown-weathering, planar-cross-bedded sandstone. The upper and lower contacts are gradational with Mancos Shale. Maximum exposed thickness in southwest part of map is ≤15 m (Goff et al., 2008).

Mancos Shale

Satan Tongue — Interbedded dark shale and less abundant very fine-grained quartz sandstone exposed in Seboyeta Canyon; pinches out and interlayers with the Point Lookout sandstone going northwest (Sears et al., 1941). Maximum observed thickness is about 65 m.

Mulatto Tongue — Golden-yellow, thin-bedded, tabular to ripple-laminated sandstone and black shale. Burrows and scattered pelecypod molds are common in the sandstone beds. Upper and lower contacts are gradational with the Dalton and Stray sandstones. Maximum exposed thickness in southwest part of map is ≤50 m (Goff et al., 2008).

Main Body — Black to dark-brown shale and silty shale, intercalated with finely laminated to cross-bedded, thinly bedded sandstone. The sandstones are well-sorted, fine-grained, quartz arenites. Upper and lower contacts are gradational. Small tongues of Main Mancos are interbedded within the Gallup Sandstone units. Maximum exposed thickness of Main Mancos beneath Gallup Sandstone is ≤50 m.

Bridge Creek Limestone (combined with Km in cross sections) — Finely laminated, fossiliferous, light-gray limestone, interbedded with thin, black shale below the Main Body of the Mancos Shale. Unit is correlative with the Greenhorn Limestone. Contains abundant invertebrate fossils. Maximum exposed thickness in southwest part of map is ≤25 m (Goff et al., 2008).

Dakota Formation

Dakota Formation, undivided — Alternating sandstones and shales of Dakota Formation and Mancos Shale; Dakota unit identified in uranium well logs near San Mateo (Reise, 1977, 1980) is inferred to be the lower Oak Canyon Sandstone Member (about 25 m thick). Aggregate thickness of Dakota is about 100 m in northwestern map area (Owen and Owen, 2003; see also cross sections in Goff et al., 2008 and McCraw et al., 2009).

Jurassic

Morrison Formation

Brushy Basin Member — Grayish-green mudstone, interbedded with thin-lenticular beds of light-gray to yellowish-gray, fine- to medium-grained sandstones; very limited exposure in the extreme west-central edge of map; maximum exposed thickness about 10 m; maximum thickness in drill holes about 40 m (Reise, 1977; Goff et al., 2012).

Westwater Canyon Member — Light-gray and yellow-brown and light-red, fine- to medium-grained sandstones, interbedded with thin, greenish-gray mudstones; very limited exposure in the extreme west-central edge of map; maximum exposed thickness about 30 m; maximum thickness in drill holes about 50 m (Reise, 1977; Goff et al., 2012).

Recapture Member — Dark-red, variegated (pink, brown-ash, and gray) shale, and white quartz, cemented by lime sandstone. Some of the shale beds are calcareous and slabby; contains imbricated, gypsiferous beds; maximum thickness about 100 m.

Todilto Formation, undivided (cross section only) — Bedded, massive anhydrite and limestone identified only in State 36-1 well near south edge of map (San Fidel Dome). As defined here, includes only the Slick Rock Member (Lucas and Zeigler, 2003). Because this is a widespread unit throughout west-central New Mexico, it is shown in the cross section; thickness is assumed to be uniform at ≤25 m.

Entrada Formation, undivided (cross section only) — Massive, bedded to cross-bedded sandstone identified in State 36-1 well near south edge of map (San Fidel Dome). As defined here, includes only the Slick Rock Member (Lucas and Zeigler, 2003). Because this is a widespread unit throughout west-central New Mexico, it is shown in the cross section; bottom of unit was not penetrated.

References And Suggested Reading

Baker, I., and Ridley, W. I., 1970, Field evidence and K, Rb, Sr data bearing on the origin of the Mt. Taylor volcanic field, New Mexico, USA: Earth and Planetary Science Letters, v. 10, p. 106-114.

Baldridge, W. S., Sharp, Z. D., and Reid, K. D., 1996, Quartz-bearing basalts: Oxygen isotopic evidence for crustal contamination of mafic rocks: Geochimica et Cosmochimica Acta, v. 60, p. 4765-4772.

Crumpler, L. S., 1980a, Alkali basalt through trachyte suite and volcanism, Mesa Chivato, Mount Taylor volcanic field, New Mexico, Part I: Geological Society of America Bulletin, v. 91, p. 253-255.

Crumpler, L. S., 1980b, Alkali basalt through trachyte suite and volcanism, Mesa Chivato, Mount Taylor volcanic field, New Mexico, Part II: Geological Society of America Bulletin, v. 91, p. 1293-1313.

Crumpler, L. S., 1982, Volcanism in the Mount Taylor region: in: Albuquerque Country II, New Mexico Geological Society, 33rd Field Conference Guidebook, p. 291-298.

Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' Quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigations Map C-118-A, 1 sheet, 1:100,000 scale.

Drake [Drakos], P. G., Harrington, C. D., Wells, S. G., Perry, F. V., and Laughlin, A. W., 1991, Late Cenozoic geomorphic and tectonic evolution of the Rio San Jose and tributary drainages within the Basin and Range/Colorado Plateau transition zone in west-central New Mexico: in: Julian, B. and Zidek, J., eds., Field guide to excursions in New Mexico and adjacent areas of Texas and Colorado, N. M. Bureau of Mines and Mineral Resources Bulletin 137, p. 149-157.

Fellah, K., 2011, Petrogenesis of the Mount Taylor volcanic field and the Jemez Mountains volcanic field: M.S. thesis, Washington State University, 89 p.

Gee, J. S., and Kent, D. V., 2007, Source of oceanic magnetic anomalies and the geomagnetic polarity timescale: Treatise on Geophysics, v. 5, Elsevier, London, p. 455-507.

Goff, F., Kelley, S. A., Zeigler, K., Drakos, P., and Goff, C. J., 2008, Geologic map of the Lobo Springs 7.5-minute quadrangle, Cibola County, New Mexico: New Mexico Bureau of Geology & Mineral Resources, Open-file Geologic Map 181, 1:24,000 scale.

Goff, F., Kelley, S. A., Lawrence, J. R., and Goff, C. J., 2010, Geologic map of the Cerro Pelon quadrangle, Cibola and McKinley counties, New Mexico: NM Bureau of Geology & Mineral Resources, Open-file Geologic Map 201, 1:24,000 scale.

Goff, F., and Goff, C. J., 2013, The Quarry lava flow, a peridotite-bearing trachybasalt at Mount Taylor volcano, New Mexico: NM Geological Society Guidebook, 64th Field Conference, p. 67-69.

Goff, F., Wolff, J. A., and Kelley, S. A., 2013, Mount Taylor dikes. NM Geological Society Guidebook, 64th Field Conference, p. 159-165.

Goff, F., Wolff, J. A., McIntosh, W., and Kelley, S. A., 2013, Gabbroic shallow intrusions and lava-hosted xenoliths in the Mount Taylor area, New Mexico: New Mexico Geological Society Guidebook, 64th Field Conference, p. 143-151.

Goff, F., Kelley, S. A., Lawrence, J. R., and Goff, C. J., 2014, Geologic map of the Laguna Cañoneros 7.5-minute quadrangle, Cibola and McKinley counties, New Mexico: NM Bureau of Geology and Mineral Resources, Open-file Geologic Map 244, 1:24,000 scale.

Goff, F., Lawrence, J. R., and Goff, C. J., 2014, Plio-Pleistocene maar-diatremes, Mesa Chivato, New Mexico, USA: in: Carrasco-Núñez, G., Aranda-Gómez, J. J., Ort, M. H., Silva-Corona, J. J., eds., 5th International Maar Conference, Abstracts Volume: Juriquilla, Qro. México, Universidad Nacional Autónoma de México, Centro de Geociencias, p. 20-21.

Hallett, R. B., 1994, Volcanic geology, paleomagnetism, geochronology and geochemistry of the Rio Puerco necks, west-central New Mexico: Ph.D. dissertation, New Mexico Institute of Mining and Technology, Socorro, 340 p.

Hallett, R. B., Kyle, P. R. and McIntosh, W. C., 1997, Paleomagnetic and 40Ar/39Ar age constraints on the chronologic evolution of the Rio Puerco volcanic necks and Mesa Prieta, west-central New Mexico: Implications for transition zone magmatism: Geological Society of America Bulletin, v. 109, p. 95-106.

Hunt, C. B., 1938, Igneous geology and structure of the Mount Taylor volcanic field, New Mexico: U.S. Geological Survey, Professional Paper 189-B, p. 51-80.

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

Le Bas, M. J., Le Maitre, R. W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745-750.

Lipman, P. W., and Moench, R. H., 1972, Basalts of the Mt. Taylor volcanic field, New Mexico: Geological Society of America Bulletin, v. 83, p. 1335-1344.

Lipman, P. W., and Mehnert, H. H., 1979, Potassium-argon ages from the Mount Taylor volcanic field, New Mexico: U.S. Geological Survey, Professional Paper 1124-B, 8 p.

Lipman, P. W., Pallister, J. S., and Sargent, K. A., 1979, Geologic map of the Mount Taylor quadrangle, Valencia [now Cibola] County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1523, 1:24,000 scale.

Lucas, S. G., and Zeigler, K. E., 2003. Stratigraphy of west-central New Mexico: in: Lucas, S. G., Semken, S. C., Berglof, W. R., and Ulmer-Scholle, D. S., eds., Geology of the Zuni Plateau, New Mexico Geological Society 54th Annual Field Conference, back inside cover plate.

McCraw, D. J., Read, A. S., Lawrence, J. R., Goff, F., and Goff, C. J., 2009, Preliminary geologic map of the San Mateo quadrangle, McKinley and Cibola counties, New Mexico: NM Bureau of Geology and Mineral Resources Open-file Map OF-GM-194, 1:24,000 scale.

Moench, R. H., 1963a, Geologic map of the Laguna quadrangle, Cibola County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-208, 1:24,000 scale.

Moench, R. H., 1963b, Geologic map of the Seboyeta quadrangle, Cibola County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-207, 1:24,000 scale.

Moench, R. H., and Schlee, J. S., 1967, Geology and uranium deposits of the Laguna district, New Mexico: U.S. Geological Survey, Professional Paper 519, 117 p.

Osburn, G. R., Kelley, S. A., Goff, F., Drakos, P. G. and Ferguson, C. A., 2009, Preliminary geologic map of the Mount Taylor quadrangle, Cibola County, New Mexico: NM Bureau of Geology and Mineral Resources Open-file Map 186, 1:24,000 scale.

Owen, D. E., and Owen, D. E., Jr., 2003, Stratigraphy of the Dakota Sandstone and intertongued Mancos Shale along the southern flank of the San Juan Basin, west-central New Mexico: in Lucas, S. G., Semken, S. C., Berglof, W. R., and Ulmer-Scholle, D. S., eds., Geology of the Zuni Plateau, New Mexico Geological Society 54th Annual Field Conference, p. 325-330.

Perry, F. V., Baldridge, 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.

Reise, W. C., 1977, Geology and geochemistry of the Mount Taylor uranium deposit, Valencia County, New Mexico: MS thesis, University of New Mexico, Albuquerque, 119 p.

Reise, W.C., 1980. The Mount Taylor uranium deposit, San Mateo, New Mexico: Ph.D. thesis, University of New Mexico, Albuquerque, 643 p.

Sears, J. D., Hunt, C. B., and Hendricks, T. A., 1941, Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U.S. Geological Survey, Professional Paper 193-F, p. 101-121.

Shackley, M. S., 1998, Geochemical differentiation and prehistoric procurement of obsidian in the Mount Taylor volcanic field, northwest New Mexico: Journal of Archaeological Science, v. 25, p. 1073-1082.

Skotnicki, S. J., Drakos, P. G., Goff, F., Goff, C. J., and Riesterer, J., 2012, Preliminary geologic map of the Seboyeta 7.5-minute quadrangle, Cibola County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-file Map 236, 1:24,000 scale.

Williams, H., Turner, F. J., and Gilbert, C. M., 1954, Petrography: W. H. Freeman & Co., San Francisco, 406 p.

Acknowledgements

The StateMap Program jointly supported by the US Geological Survey and the New Mexico Bureau of Geology and Mineral Resources funded this geologic map. J. Michael Timmons (NMBG&MR) provided logistical and technical support. We thank Kate Zeigler (Zeigler Geologic Consulting), Adam Read (NMBG&MR), Cal Ruleman, Pete Drakos (Glorieta Geoscience, Inc.) for mapping assistance during the 2007-2013 Mount Taylor field campaigns. Robert Andrews (Oak Ridge National Laboratory) helped with edge matching and magnetic polarity measurements during 2014. David McCraw, Mark Mansell, Shannon Williams, Kelsey Seals, Phil Miller, and Elizabeth Tyson (NMBG&MR) performed the cartography for various editions of the six quadrangles that this map is based on. David McCraw and Mark Mansell also did much of the cartography for this map. The following people and entities are graciously thanked for providing access to fenced private property: Harry Lee, Jr. (Lee Ranch and Fernandez Co.); Jed Elrod and Robert Alexander (Silver Dollar Ranch and Laguna Pueblo); Buddy Elkins (Elkins Ranch); Kelley D'Antonio (Lobo Ranch); Pete Del Mesa Wind Farm); Lee Maestas (Seboyeta Cattle Association). Darwin Vallo (US Forest Service, Grants) offered valuable advice on logistics on Forest Service and BLM lands. William Mcintosh and Lisa Peters (NMBG&MR) provided superb 40Ar/39Ar dates. Amy Trivett, Ginger McLemore (NMBG&MR) and Rusty Reise researched and provided well logs from various areas to improve our cross sections. Gordon Keating (Los Alamos National Laboratory, now deceased) worked with the first author on several reconnaissance surveys of Grant Ridge Tuff. Nelia Dunbar (NMBG&MR) assisted with chemical identification of rhyolite glasses by electron microprobe. Barry Kues (University of New Mexico) identified Cretaceous marine fossils in the Mancos Shale. David Mann (High Mesa Petrographics) crafted polished thin sections for petrographic analysis. John Wolff and Kamilla Fellah (Washington State University) provided chemical analyses of rocks. Additional chemical analyses were obtained from ALS, USA, Inc. (Reno). Frank Trumbell (US Geological Survey, HVO) suggested a vendor to obtain flux-gate magnetometers. Duane Champion (USGS, Alaska Branch) gave us magnetic polarity charts. Frank Perry (LANL) and Larry Crumpler (NM Natural History Museum) offered some petrologic insights.

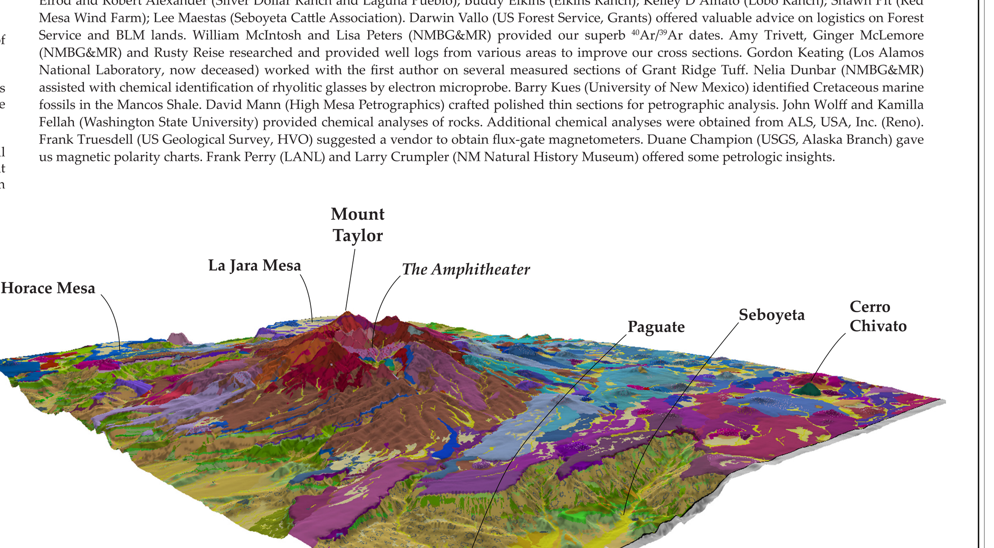


Figure 3 — Block diagram looking northwest to Mount Taylor (11,301 ft, 3,445 m) and southwest Mesa Chivato to the right, showing geology superimposed on elevation. North is parallel to right edge of diagram. Note clustering of intermediate to silicic domes and flows in the summit area (orange and maroons, 3.2 to 2.5 Ma) and the large coalesced fan of volcanic debris shed to east and southeast (brown, Plio-Pleistocene) formed by erosion of material from the summit amphitheater. Younger mafic rocks (mostly blues and purples, 2.5-1.26 Ma) drape the flanks of the volcano. Cerro Chivato (dark green dome in northeast part of diagram, 3.16 Ma) is part of an older volcanic center in southern Mesa Chivato now largely flooded by younger basaltic lavas, 1.9-2.5 Ma). Cretaceous rocks (green and yellow-green), which underlie the volcanic pile, are well exposed in canyons draining south.