Geologic Map of the San Mateo Quadrangle, McKinley and Cibola Counties, New Mexico.

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Scale 1:24,000

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Figure 1. Panorama east-southeast across La Jara Mesa from the lacustrine beds within the Bajios Redondos graben, to the cinder cone of Cerro Colorado and the associated fault scarp to the northeast (right) in the middle distance, and 3,345 m (11,301 ft) Mount Taylor in the far distance. Photo by J. R. Lawrence.

Figure 2. San Mateo Main Street. Mount Taylor Mine tailings seen in distance behind sign. Cretaceous Menefee Formation rocks in mid distance beveled by the Upper San Mateo geomorphic surface. Beyond that are San Mateo Creek gravels atop lower ridge in photo left, as well as landslide deposits and the volcanics of La Jara Mesa. Mount Taylor is on the skyline. Photo by D. J. McCraw.

OVERVIEW

The San Mateo 7.5-minute quadrangle lies in northwest New Mexico north of the city of Grants. The area covered by the quadrangle, which extends from 35°15'N to 35°22'30"N and 107°37'30"W to 107°45'W, is approximately 158 km^2 (61 mi^2). Relief is significant as elevations range from approximately 2,094 m (6,870 ft) where San Mateo Creek flows out of the quadrangle to the west to the highest point in the southeastern corner of the map on the northwestern flank of Mount Taylor (MT), 2,957 m (9,700 ft). The southern half of the quad is a volcanic plateau, La Jara Mesa (LJM), comprised of numerous cinder and scoria cones and multiple trachybasalt lava flows atop an extensive pyroclastic deposit, the Rhyolite tuff of Grants Ridge (*Tgrt*), and has a well developed paleosol at its top. The center of the quad contains primarily Cretaceous Menefee Formation deposits which are largely covered by large landslide and talus deposits sliding off the plateau escarpment. Across the alluvial valley of San Mateo Creek and tributaries to the north, location of the Lee Ranch headquarters, a series of homoclinal marine and terrestrial Cretaceous beds gently dip to the east-southeast (see Figure 3).

Figure 3. Homoclinal Cretaceous beds in the northern part of the quad. Photo by A. S. Read.

The majority of the quadrangle is made up of National Forest lands, in the south and in the north. With the exception of the small village of San Mateo, and a few smaller ranches on the western edge of the quad, the remaining lands make up only a small part of the vast private Lee Ranch. Access is divided as LJM and MT are only accessible from Grants to the south via NM 547 and primarily FS 544. Below the mesa, the main access is from NM 609, the highway from Milan to San Mateo. Additional Forest Service and private Lee Ranch roads provide good access to the northern half of the quad if permission is obtained from Lee Ranch.

The San Mateo quadrangle lies within the Grants Uranium Belt, and uranium mining, by in large from the subsurface Jurassic Westwater Canyon Formation has been active here for over a half a century. Three large mines are located on the quad: the Mount Taylor Mine to the east, just to the northeast of San Mateo, The San Mateo Mine to the south at the base of the La Jara Mesa escarpment, and the Johnny M Mine in the northern part of the quad. In addition to these mines, with renewed interests in nuclear power, numerous prospects and renewed claims riddle the area. The presence of highly permeable gravel to boulder beds within the alluvium, which can channel contaminates from mine dewatering sites south towards the regional population centers of Milan and Grants is of special geohydrological concern to the state.

Comments to Map Users

This quadrangle map has been Open-filed in order to make it available to the public. The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards, and due to the ongoing nature of work in the area, revision of this map is likely. As such, dates of revision are listed in the upper right corner of the map and on the accompanying report. ***The contents of the report and map should not be considered final and complete until published by the New Mexico Bureau of Geology and Mineral Resources.***

A geologic map graphically displays information on the distribution, nature, orientation, and age relationships of rock and surficial units and the occurrence of structural features such as faults and folds. Geologic contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic map are based on 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. Significant portions of the study area may have been mapped at scales smaller than the final map; therefore, the user should be aware of potentially significant variations in map detail. 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 everywhere.

The cross sections are constructed based on exposed geology, and where available, subsurface and geophysical data. Cross sections are interpretive and should be used as an aid to understand the geologic framework and not used as the sole source of data in locating or designing wells, buildings, roads, or other structures. Finally, 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 either the State of New Mexico or the U.S. Government.

STRATIGRAPHY

Neogene Sediments

Much of the surficial deposits of the quadrangle are thin and have a strong eolian component. The extensive landslide, talus, and colluvial deposits on the flanks of LJM, Jesus Mesa, and smaller Cretaceous formation mesas and cuestas would be the major exception, followed by the alluvial valley fill and terraces of San Mateo Creek and its tributaries. Where these streams flow out of the uplands, alluvial thicknesses are <1 to 2 m thick, but water well records show that San Mateo Creek alluvium quickly reaches up to 20 m thick with a large basal gravel/boulder deposit beneath sandy clay at the surface. Brod (1979) reports additional gravel beds within the alluvium which is 30+ m thick at the far western edge of the quad. Two additional gravel/boulder deposits (see Figures 4 and 5) of Plio-Pleistocene age cap Cretaceous Kmf ridges, thus recording 3-4 significant cut and fill cycles along San Mateo Creek, in response to massive meltwater events off of MT and base level changes of the Rio San Jose, a tributary of the Rio Grande (Drake, et al., 1991; Love, 1989). The last 2 of these cycles can be seen in entrenched tributaries coming off of Jesus Mesa and the San Mateo Mountains to the north. (see Figure 6).

Neogene Volcanic Stratigraphy

Tertiary volcanic rocks associated with La Jara Mesa include an upper sequence of mafic units (i.e., tuffs, lava, tuffs and pyroclastic cinder deposits) and older rhyolite

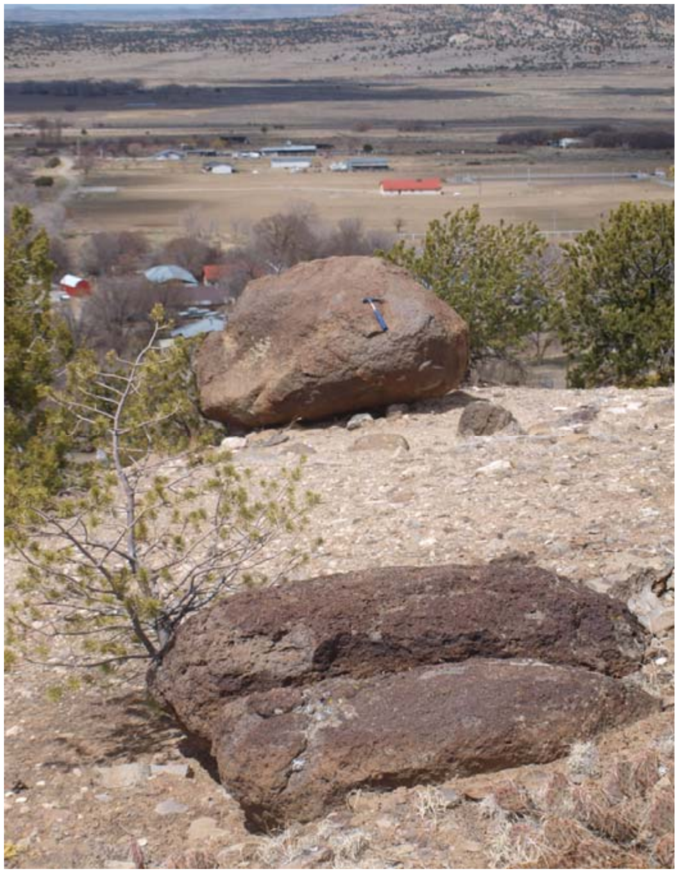

Figure 4. Rounded trachybasalt boulders of QTg_1 deposit atop of ridge above San Mateo water tank, 260091E 3912704N. Photo by D. J. McCraw.

Figure 5. Boulders within QTg_2 deposit south of San Mateo Creek. The dimensions of this boulder at 260165E 3911558N is 374 cm long (axis of tape) x 172 cm tall x 253 cm wide. Photo by D. J. McCraw.

Figure 6. Arroyos have cut and backfilled at least twice in northern tributaries. Photo by A. S. Read.

tuffs. The mafic volcanics, mapped elsewhere on Sam Mateo quadrangle and described by Goff and other (2008) to be of trachybasalt composition, originated from two prominent eruptive centers occurring near the southern mesa margin. Collectively they make up the resistant volcanic layer capping LJM. Three trachybasalt units are recognized. These overlie the Rhyolite Tuff of Grants Ridge which crops out sporadically on the mesa flanks.

Youngest of the mafic units, designated younger olivine trachybasalt (*Tyotb*) (Goff and others, 2008), forms the mesa-rimming cliff in the extreme southwest corner of the quadrangle (see Figure 7). The term “younger” indicates that the lava overlies, and is

Figure 7. View looking east of LJM cliff-forming younger olivine trachybasalt unit *Tyotb*, overlying rhyolite tuff of Grants Ridge (*Tgrt*), 251894E 3904908N. Photo by D. J. McCraw.

relatively younger than, a specific trachydacite tuff (*Ttdt*), dated at 2.51 Ma to 2.73 Ma (Lipman and Mehnert, 1979). *Ttdt* was used as a regional marker horizon by Goff and others for mapping the volcanics of Lobo Springs (Goff, *et al.*, 2008) and San Mateo quadrangles. *Tyotb* occurs as a flow that erupted from Cerro Colorado, a large cinder cone rising approximately 130 m above the mesa surface forming its most prominent topographic feature and landmark. The cone is composed of stratified ferruginous pyroclastic cinders (*Tyotbc*), scoriaceous lapilli and bombs with several thin intercalated lava beds dipping inward toward an eroded crater. Cerro Colorado was breached on its southwestern margin by a major flow that issued from its base and flowed to the south and west. Extensive erosion south of LJM has apparently reduced much of the original aerial extent of this flow. The estimated *Tyotb* flow thickness ranges from 13 m to 33 m as observed along the southwest mesa margin.

A slightly older trachybasalt flow, was named younger megacrystic trachybasalt (*Tymtb*) by Goff *et al.* (2008) for conspicuously large black clinopyroxene (augite) mega-phenocrysts. The *Tymtb* lava erupted from a prominent eroded cinder cone complex (informally named La Jara Cone) at the south edge of LJM (see Lobo Springs quadrangle, Goff *et al*., 2008), and flowed voluminously to the north and northwest. *Tymtb* cliffs, 15 m to 30 m thick, rim the mesa along most of its northen margin (see Figure 8). The eastern *Tymtb* lava terminus can be seen in the ravine on the west side of State Highway 547 where it overlies older trachybasalt (*Totb*) and rhyolite of Grant's Ridge (*Tgrt*) at the south-central edge of San Mateo quadrangle. *Tymtb* underlies *Tyotbc* at Cerro Colorado and overlies *Toob* west of El Rito Springs. An outlying pile of scoriaceous lapilli and small bombs (*Tymtbc*), occurring some 1,500 m northeast of La Jara Cone, is interpreted to be a portion of the cone wall torn away during effusive Tymtb eruption and rafted to its present location aboard flowing lava.

The oldest trachybasalt atop LJM is a prominent cliff-forming unit on the northern mesa rim in vicinity of El Rito Spring. This olivine-phyric lava was named older olivine trachybasalt (*Toob*) reflecting its occurrence stratigraphically below the 2.73-Ma trachydacite tuff (*Ttdt*) marker bed. *Ttdt* containing biotite-phyric pumice lapilli overlies *Toob* and appears to be incorporated near the base of volcaniclastic sediments (*Tvs*) at the cliff edge above El Rito Spring. The eruptive source for *Toob* is unknown but likely existed to the northeast of LJM on the flank of MT.

Figure 8. View of LJM cliff-forming younger megacrystic trachybasalt unit *Tymtb*, showing basal surge deposition. Rock hammer in lower right for scale, 253019E 3909873N. Photo by D. J. McCraw.
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Rhyolite tuff of Grants Ridge (*Tgrt*) crops out conspicuously on the southern flank of LJM and is partially exposed at El Rito Spring. Float evidence suggests that *Tgrt* is present below colluvial cover, overlying undifferentiated Cretaceous sediments, along the northern mesa edge to the west quadrangle margin and thus is inferred to be everywhere present beneath the capping basalts across the mesa. A nearly complete *Tgrt* section was measured (Appendix A) along a decrepit jeep trail below the southwest mesa rim where it underlies a 12-m-thick *Tyobt* cliff. Tgrt can be subdivided into three subunits: (1) an upper ash-flow tuff (ignimbrite), (2) a middle sequence of bedded tuff comprised of air-fall pumice beds, reworked tuff and surge deposits, and (3) a basal sequence of ignimbrite tuff(s). As mapped across La Jara Mesa, *Tgrt* includes a 90 cm –

1.5 m thick paleosol horizon occurring between the tuff and various trachybasaltic lavas (Appendix C).

Mesozoic Rocks

The oldest rocks in the map area are members of the Jurassic Morrison formation and outcrop only in a small area in the extreme southwest corner of the map below La Jara Mesa. Most of the northern third of the map area exposes Cretaceous sedimentary rocks. Overall, these Cretaceous rocks are a regressive sequence from open marine deposition (Mancos Shale) to marginal marine and finally deltaic conditions (coal beds). Superimposed on the overall regressive sequence were a number of smaller transgressions and regressions. Depending on the extent of these events, some units may or may not be present in any particular area (see correlation chart).

Previous mapping of Mesozoic rocks in the region by Elmer S. Santos (1966a; 1966b) and Thaden, *et al.* (1967) was found to be generally very good and little change was made to previously mapped contacts or stratigraphic interpretations of Santos (1966b) on the San Mateo quadrangle. Most improvements to previous mapping consist of additional attitude measurements, minor adjustments of contact locations, and newly mapped minor structures.

STRUCTURE

Most of the stratified units on the quadrangle are relatively flat lying or are shallowly east-dipping. The east-dipping Cretaceous rocks form the west limb of a regional-scale northeast plunging syncline beneath Mount Taylor (see Dillinger, 1990). Most of the faults in the area appear to be normal faults, with generally very steep dips.

There are two general fault trends: an earlier population of North-South striking faults that are usually cross-cut by Northeast-striking faults. The earlier population of North-striking faults appears to be related to Laramide compression and offset a monoclinal fold in the vicinity of Jesus Mesa. Many of these faults were probably reactivated as normal faults during Tertiary extension and associated volcanism. At least one of these faults east of Jesus Mesa appears to be a reverse fault (see cross section A-A'). The later population of Northeast-striking faults appear to be entirely extensional and are probably related to both extension associated with Tertiary rifting and deformation associated with Mount Taylor volcanism. Several faults that offset volcanic rocks on La Jara Mesa have significantly more displacement in older rocks.

Volcanic rocks underlying La Jara Mesa are essentially flat-lying and appear but weakly deformed. However, a series of sub-parallel NNE- to NE-trending, high-angle normal faults imparts a prominent and consistent structural grain across the mesa. Four faults were observed to displace rim-forming trachybasalt flows on the south and/or north edges of the mesa. A fifth fault beneath Cerro Colorado, is inferred. Faults are informally labeled here from west to east as LJM 1-5.

***Faults LJM-1 and LJM-2*.**

This pair of normal faults forms a NNE-trending structural graben associated with Bajios Redondos (hence, Bajios Redondos graben) on the west side of Cerro Colorado. LJM-1 forms the western graben margin. This structure was observed to displace trachybasalt lavas with downthrown vertical movement to the east, by an estimated 10 m and 20 m on the south and north mesa rim, respectively. LJM-2 completes the graben on its east side, displacing *Tyotb* by an estimated 10 m of throw, downward on the west side.

On the south mesa rim, LJM-2 has a strike of about N50E and an inferred vertical dip. This same structure is inferred to intersect the west flank of Cerro Colorado and to have cut both lava (*Tyotb*) and cinder (*Tyotbc*) deposits of the volcanic cone. The fault trace projects to the north mesa rim; however, no definite displacement of trachybasalt lava was confirmed here.

Figure 9. Fault scarp associated with fault LJM-2 seen in middle distance below Mount Taylor on the skyline, 250909N 3908343E N Photo by D. J. McCraw.

LJM-3.

NE-trending fault LJM-3 has a prominent topographic expression, forming a lineament along the base of a NNE-trending Tymtb ridge that cuts diagonally across the SE corner of LJM. Down-to-the-west vertical displacement, on the order of 12 to 18 m, is strongly implied where it cuts across the west flank of La Jara Cone, displacing *Tymtbc* scoria deposits. The northern extension of LJM-3 is traceable to the cliff edge NE of El Rito spring where it displaces *Toob* with down-to-the-east movement that suggests a reversal of movement, or scissors action (Goff,, pers, commun., 2008) to the east.

LJM-4.

NNE-trending fault LJM-4 cuts trachybasalt flow (*Toob*) with down-to-the-northwest vertical displacement in the cliff immediately above El Rito Spring. This structure likely forms the conduit that produces considerable groundwater flow at the cliff base. It exhibits an apparent throw of up to 12 m. LJM-4 has an apparent strike at the cliff edge of N30E─N45E. The fault is lost to the south of El Rito spring but its projected trace, parallel to that of LJM-3, is likely.

LJM-5.

A post-*Tytmb* fault that probably acted as a magmatic conduit controlling the locus of volcanism beneath the vent and pile of cinders at Cerro Colorado is strongly inferred. The fault strike likely conforms to the regional NE trend. Such a fault may have down-to-the-west movement similar to the neighboring structure, LJM-2, as shown in Cross section B-B'. No field evidence was observed to support this claim.

Figure 10. Fault scarp associated with fault LJM-5 seen through the trees. Surficial displacement is 22 m, 255261N 3906173E. Photo by D. J. McCraw.

MAP UNIT DESCRIPTIONS

Descriptions of map units are listed in approximate order of increasing age. Formal stratigraphic names of Cretaceous units are described by Sears, et al. (1941), Lipman, et al., (1979), and Dillinger (1990). Field identification of volcanic rocks is based on hand specimens, petrography and chemical data published by Hunt (1938), Baker and Ridley (1970), Lipman and Moench (1972), Lipman and Mehnert (1979), Crumpler (1980a, 1980b, 1982), and Perry, et al. (1990). The names of volcanic units are based on the above chemical data and the alkali-silica diagram of Le Bas, et al. (1986). See Goff, et al. (2008) for a contemporary description of the rocks and geology in the Mount Taylor area.

NEOGENE

daf **Disturbed and/or artificial fill** — Dumped fill and areas affected by human disturbances, mapped where deposits or extractions are areally extensive. Includes mine pads and settling ponds associated with the uranium mining industry, as well as check dams.

Qa **Stream alluvium (Quaternary)** — Brown (7.5YR4/2) to light reddish-brown (5YR 6/4), unconsolidated, moderately sorted, silty sand to sandy clay at the surface with buried gravel/boulder beds subsurface. Varies considerably in thickness from <1 to 3 m in tributaries and up to 30+ m.

Qae **Stream and valley slope alluvium subjected to eolian processes (Quaternary)** — Unconsolidated to partly consolidated, well-sorted, fine-grained sand, silty sand, and clay. Thickness 1 to 3 m.

Qaf **Alluvial fan deposits (Quaternary) –** Typically fan-shaped deposits of coarse to fine gravel and sand, silt, and clay within and at the base of steep relief; grades into alluvial deposits along main channels; probably Holocene to middle Pleistocene in age; maximum thickness about 15 m.

Qes **Eolian silt and sand subjected to sheetwash (Quaternary) –** Windblown and sheet wash deposits of loose, silt and fine sand 0.2 to greater than 2 m thick.

Qe **Eolian sand (Quaternary) –** Fine- to medium-grained sand capping low mesas at the foot of La Jara Mesa. Up to 15 m thick.

Qls **Landslide deposits (Quaternary) –** Poorly sorted debris that has moved chaotically down steep slopes; slumps or block slides partially to completely intact, that have moved down slope; slumps and block slides usually display some rotation relative to their failure plane; ages vary from Holocene to mid- to late-Pleistocene; thicknesses vary considerably depending on the size and nature of the landslide.

Qt **Talus (Quaternary) –** Poorly sorted debris and mass wasting deposits primarily from trachybasalt-covered mesa tops; thickness can locally exceed 15 m.

Qc **Colluvium (Quaternary) –** Poorly sorted slope wash and mass wasting deposits from local sources; thickness can locally exceed 15 m.

Ql_2 **Younger lacustrine deposits (Quaternary) –** fine-grained sand to silty clay located in small closed basins within the Bajios Redondos graben. Holocene in age. Water still ponds after heavy rains. Thickness about 2 m.

Ql_1 **Older lacustrine deposits (Quaternary) –** fine-grained sand to silty clay located in small closed basins within the Bajios Redondos graben, often surrounding Ql_2. Late Pleistocene in age. Thickness 2-3 m.

Qat **Stream terrace alluvium (Quaternary) –** Brown (7.5YR4/2) to light reddish-brown (5YR 6/4), unconsolidated, moderately sorted, silty sand to sandy clay at the surface. Two distinct tributary valley fill deposits record 3 cut and fill cycles since the mid to late Pleistocene. Thickness 1-4 m.

Qoae **Fan pediment alluvial and eolian deposits (Quaternary)** — Unconsolidated to partially indurated fine- to medium-grained sand and gravel. Often associated with either the Upper or Lower San Mateo geomorphic surfaces. Soils exhibit Stage III pedogenic carbonate. Thickness approximately 2 m.

QTg_2 **Terrace gravel (Pliocene-Early Pleistocene)** — Unconsolidated fine- to medium-grained sand, gravel, and rounded trachybasalt boulders up to >3 m in size. Deposits were shed off of Mount Taylor down both San Mateo and La Mosca Canyons out onto the valley floor. Thickness varies from 10-20 m at heads of canyons to 3-5 m at distal margins.

QTg_1 **San Mateo Creek terrace gravel (Pliocene-Early Pleistocene)** — Unconsolidated fine- to medium-grained sand, gravel, and rounded trachybasalt boulders up to >2 m in size capping Kmf in San Mateo Canyon. Thickness 5-8 m.

Pliocene Volcanic and Volcaniclastic Deposits

Tyotb **Younger olivine trachybasalt**—Black to gray, fine- to medium-grained very weakly porphyritic trachybasalt flow and red ferruginous cinder deposits (Tyotbc). Sparce phenocrysts (<<1% by volume) of small (≤ 2 mm in diameter) subherdal plagioclase, euhdral fresh green olivine and trace clinopyroxene that locally occur in cumulophyric clusters. Extensive flow originated from cinder cone forming Cerro Colorado near the south edge of LJM. Overlies *Tgrt* along south and southwest mesa margin. Unit not dated. Thickness of flow(s) is ≤30 m.

Tyxtb **Younger xenocrystal trachybasalt**—Two distinct flows of black to gray, medium- to fine-grained basalt having very sparse phenocrysts of olivine, plagioclase, and augite and very rare xenoliths mantle peridotite. Flows occur in east-central and northeast portions of quadrangle from vents on adjacent Cerro Pelon quadrangle. Flows overlie unit *Tvs*. Flows not dated. Maximum thickness is <40 m.

Tymtb **Younger megacrystal trachybasalt**—Black to gray, medium-grained porphyritic hawaiite and red to black cinder deposits (*Tymtc*) having abundant megacrysts of augite and olivine and phenocrysts of olivine and plagioclase. Unit consists of cinder cone complex with exposed conduit and multiple flows on southern edge of La Jara Mesa. Unit also contains thin hydromagmatic beds (*Tymth*) exposed beneath flows to north and east of cone, partly north of quadrangle boundary. Texture is intersertal to slightly trachytic. Microphenocrysts consist of olivine, (titan) augite, plagioclase, and opaque oxides in glass. Olivine shows considerable iddingsite alteration. Overlies thin bed of trachydacite tuff (*Ttdt*) and older trachybasalt (*Totb*) along highway NM 457. Overlies tuff of Grant's Ridge (*Tgrt*) along all of southern La Jara Mesa. Unit not dated. Thickness of flows is <60 m.

Tta **Trachyandesite, undivided**—Multiple flows of gray to blue-gray, porphyritic lavas. Phenocrysts consist of resorbed plagioclase, oxidized clinopyroxene, hypersthene, sparse biotite, sparse oxidized hornblende, and magnetite in a pilotaxitic groundmass containing microphenocrysts of plagioclase, clinopyroxene, apatite, opaque oxides, and devitrified glass. May contain rare, small (≤5 mm) hornblende megacrysts. Some specimens show minor Fe-oxide alteration. Overlies older plagioclase phyric basalt (*Toptb*) near SE corner of map. Interbedded with volcaniclastic sedimentary deposits (*Tvs*). Flows not dated. Exposed thickness is ≤100 m.

Thta **Hornblende trachyandesite**—Multiple flows of gray to yellow-gray to pale pink, porphyritic lavas with conspicuous hornblende megacrysts (≤5 cm). Three probable vents are identified on the SW flank of Mount Taylor but similar lavas occur elsewhere on Mount Taylor. Megacrysts consist of partly resorbed brown hornblende with partial jackets of magnetite. Phenocrysts consist of partly resorbed and complexly zoned plagioclase and plagioclase clots, clinopyroxene, magnetite, resorbed olivine, orthopyroxene, and oxidized hornblende in a trachytic to pilotaxitic groundmass having microphenocrysts of plagioclase, pyroxene, opaque oxides, apatite, and devitrified glass. Some specimens have plagioclase-pyroxene clots and clinopyroxene jackets over orthopyroxene. Interbedded with *Tvs*. Overlies older trachybasalt (*Totb*) and porphyritic enclave-bearing trachydacite (*Tpetd*). Long flow complex on southern edge of quadrangle is dated at 2.52 ± 0.07 Ma (Perry *et al*., 1990). Maximum exposed thickness at least 275 m.

Tvs **Volcaniclastic sedimentary rocks**—Gray to tan to white debris flows, fluvial deposits and interbedded tuffs shed from the Mount Taylor stratovolcano during growth. Debris flow component is most abundant near source (SE) 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 NW. Tuffs consist mostly of thin beds and lenses of fall deposits with vesiculated pumice having phenocrysts of plagioclase, clinopyroxene ± hornblende ± biotite. Unit is interbedded with practically all lavas on northwest side of Mount Taylor. Underlies two flow complexes of *Tyxtb*. Overlies older olivine basalt (*Toob*) and tuff of Grant's Ridge (*Tgrt*). Maximum exposed thickness is >200 m.

Ttdt **Trachydacite tuff**—Pyroclastic flow (ignimbrite), pyroclastic fall and reworked tuffs containing light gray to tan pumice with phenocrysts of plagioclase, potassium feldspar, clinopyroxene, orthopyroxene, biotite, and sparse hornblende. Texture is glassy, slightly porphyritic, and vesicular. Most outcrops consist of poorly exposed fall deposits in widely separated locations, generally <1 m but as much as 2 m thick. Pumice clasts are generally a few cm in size at most. Generally occurs within bottom half of *Tvs*. Overlies tuff of Grant's Ridge (*Tgrt*). Pyroclastic flow dated at 2.73 ± 0.16 (biotite) and 2.51 ± 0.25 (plagioclase) by K/Ar methods (Lipman and Mehnert, 1979).

Tpetd **Porphyritic enclave-bearing trachydacite**—Thick, multiple flows of dark gray to tan porphyritic lavas having conspicuous enclaves up to 50 cm in diameter, especially in the lower flows. Lava contains phenocrysts of large potassium feldspar, plagioclase, clinopyroxene, orthopyroxene and biotite in an intergranular to hyalopilitic groundmass of plagioclase, potassium feldspar, clinopyroxene and devitrified glass. Groundmass contains sparse phenocrysts (?) of quartz. Enclaves consist of potassium feldspar, plagioclase, clinopyroxene, orthopyroxene, magnetite, and vesiculated glass. Source of lavas is from obliterated vent in amphitheater of Mount Taylor. Underlies *Tyxtb*, *That*, and *Tvs*. Unit not dated. Maximum exposed thickness >200 m.

Tcptd **Coarse porphyritic trachydacite**—Pale pink to tan, very coarse porphyritic lava containing large (≤ 3 cm) phenocrysts of potassium feldspar. Unit superficially looks like granite and makes a distinctive fine gravelly soil. Smaller phenocrysts consist of magnetite, potassium feldspar, plagioclase, oxidized clinopyroxene, and apatite in a hyalopilitic groundmass of tiny felted plagioclase, potassium feldspar, clinopyroxene, opaque oxides and devitrified glass. Unit shows minor Fe-oxide alteration. Unit underlies *Thta* and *Tpetd* in extreme SE corner of quadrangle. Unit is not dated. Maximum observed thickness is about 80 m.

Tbta **Basaltic trachyandesite**—Dike, plug, and flow complex of black, sparsely porphyritic lava containing small phenocrysts of plagioclase and clinopyroxene, and tiny plagioclase-clinopyroxene-olivine clots. Groundmass is hyalopilitic containing microphenocrysts of plagioclase, iron oxides and devitrified glass. Contains very minor cinder deposits at highest elevations of unit. Intrudes and partially covers older plagioclase basaltic trachyandesite (*Topta*) in eastern portion of quadrangle. Unit is not dated. Maximum exposed thickness is 45 m.

Topta **Older plagioclase basaltic trachyandesite**—Flows of splotchy white and black porphyritic lavas and minor cinder deposits (*Toptac*) containing abundant large (2 cm), often aligned plagioclase phenocrysts. Other phenocrysts consist of clinopyroxene and minor iddingsitized olivine. Groundmass is intersertal and slightly vesicular containing micorphenocrysts of plagioclase, iron oxides and devitrified glass. Forms circular hill in east central margin of quadrangle. Intruded by *Tbta*. Interbedded in *Tvs*. Overlies *Trt* and *Tgrt*. Unit is not dated. Maximum exposed thickness is over 200 m.

Totb **Older trachybasalt**—Black to dark gray, fine-grained basalt having sparse olivine and plagioclase phenocrysts in intersertal groundmass containing microphenocrysts of plagioclase, augite, olivine, opaque oxides and glass. May have rare quartz xenocrysts. Underlies *Tyxtb*, *Tvs*, and *Thta*. Unit not dated. Maximum observed thickness is about 20 m.

Toptb **Older porphyritic trachybasalt**—Black to gray basalt with sparse plagioclase and olivine phenocrysts. Texture is intersertal and slightly vesicular. Groundmass contains plagioclase, augite, minor olivine, opaque oxides, and glass. Olivine shows iddingsite alteration. Overlain by *Tta* and *Tvs*. Unit not dated. Maximum exposed thickness is about 130 m.

Trt **Rhyolite and trachydacite tuffs, undivided**—White to gray, bedded tuffs with interbedded sands and gravels. Tuffs consist primarily of fall deposits no more than 4 m thick. Phenocrysts in rhyolitic pumice consist of potassium feldspar, plagioclase, minor clinopyroxene, quartz, and biotite in eutaxitic groundmass. Trachydacite pumice contains phenocrysts of plagioclase, clinopyroxene, biotite ± hornblende in eutaxitic groundmass. Unit may contain a few meters of Grant's Ridge tuff (*Tgr*t) at very bottom. Unit not dated. Maximum exposed thickness is about 75 m (Appendix A).

Tootb **Older olivine trachybasalt**—Black to gray basalt with conspicuous olivine and sparse plagioclase phenocrysts. Texture is intersertal. Groundmass contains plagioclase, olivine, augite, opaque oxides, and glass. Olivine shows iddingsite alteration. Overlies *Tgrt*, and *Kmf*. Underlies *Tvs*. Maximum exposed thickness is >50 m.

Tgrt **Rhyolite Tuff of Grants Ridge**—White to pale pink, bedded pyroclastic fall, flow and surge deposits; some beds have abundant aphyric obsidian clasts. Most lithics consist of pink to gray Precambrian granite and gneiss, chert, sandstone, limestone and rare basanite. Pumice clasts are glassy to slightly devitrified with very rare phenocrysts of potassium feldspar. Underlies a wide variety of units, particularly *Toob*, *Totb*, *Tymtb*, and *Tyotb* on La Jara Mesa. Overlies *Kmf*. Unit is not dated. Maximum observed thickness is about 110 m. Measured tuff section on south flank La Jara Mesa (Appendix B) is a minimum of 67 m.

MESOZOIC

Cretaceous

Menefee Formation

Kmf **Menefee Formation, Cleary Coal Member** — Interbedded shales, siltstones, fine to medium grained sandstones, mudstones, and thin coals. Generally forms low-relief topography or forms landslides around the margins of the basalt-capped La Jara Mesa. The contact with the underlying Point Lookout Sandstone is sharp and the top of the unit is not exposed. This unit is the regressive equivalent of the Gibson Coal Member of the Crevasse Canyon Formation but within the map area is everywhere separated from it by the transgressive sands of the Point Lookout sandstone. The top of the unit is not exposed, but a minimum thickness is at least 90 m.

Point Lookout Sandstone

Kpl **Point Lookout Sandstone** — Light gray and reddish brown to buff medium to fine-grained cross bedded sandstone. This cliff-forming sandstone caps Jesus Mesa. Nodular concretions (approximately 1 cm diameter) and larger (50 cm diameter) hematite concretions are common at the top of the unit. Outside of the map area, this unit is divided into a lower and upper part by the presence of the Satan Tongue of the Mancos Shale, which isn't present locally. The exposed thickness is between 25 and 50 m.

Crevasse Canyon Formation

Kcg **Gibson Coal Member** — Interbedded black to brown siltstone, thin to medium bedded tan, golden-yellow, brown, and greenish gray sandstone, and black coal. The sandstones are composed of well to moderately sorted, very fine- to medium-grained angular to subrounded quartz grains with < 10% mafic minerals and <1% clay (litharenite). The sandstone beds are cross-bedded, ranging from trough cross-beds to large-scale, low amplitude planar cross-beds. Ripple marks are locally preserved. Mud clast conglomerates frequently occur at the base of the sandy intervals. Bioturbation is rare. Petrified wood fragments are common; logs up to 10 cm in diameter and 0.5 m long are locally preserved. Elliptical to spherical fractured siderite to goethite concretions with calcite (or more rarely, barite) filling the fractures, are present throughout the unit. The coal beds are generally < 0.5 m thick. The lower contact is gradational with the underlying Dalton Sandstone Member; the top unconformably overlain by the Point Lookout Sandstone. The exposed thickness is between 55 and 75 m.

Kcd **Dalton Sandstone Member**—Forms two prominent cliffs, a lower yellowish-orange cliff and an upper white cliff with an intervening short slope (doublet). The basal sandstone near the contact with the underlying Mulatto Tongue of the Mancos Shale often has thin beds containing abundant pelecypod casts and molds.

The carbonate-cemented basal sandstone is composed of well-sorted, very fine-grained angular quartz grains with < 5% mafic minerals and <1% clay. The weakly cemented upper sandstone consists of well sorted, fine-grained, angular to subrounded quartz grains with <1% lithics and 7 to 10% feldspar. The upper and lower contacts are gradational with the overlying Gibson Coal Member of the Crevasse Canyon Formation and the underlying Mulatto Tongue of the Mancos Shale. Maximum exposed thickness is ≤25 m.

Kcs **Stray Sandstone Member** — Forms two prominent reddish-orange cliffs with an intervening short slope (doublet). On a fresh surface, this medium-bedded, planar cross- bedded sandstone is white to yellowish gray. This sandstone is composed of well to moderately sorted, very fine- to medium-grained angular quartz grains with < 1% mafic minerals and <1% clay. The top of the Stray Sandstone is a thin (<1 m) conglomerate with pebbles to cobbles of quartzite, chert, and quartz. The upper and lower contacts are gradational with the overlying Mulatto Tongue of the Mancos Shale and the underlying Dilco Coal Member of the Crevasse Canyon Formation. Very limited exposure in the extreme SW corner of the map area. Maximum exposed thickness is ≤ 25 m.

Kcdc **Dilco Coal Member** — Interbedded black to brown siltstone, thin to medium bedded tan, brown, and olive-green sandstone, and black coal. The sandstones are composed of well to moderately sorted, very fine- to fine-grained angular quartz grains with < 5% mafic minerals, 1 to 5% muscovite, and 1-5 % potassium feldspar altered to clay. The sandstones are cross-bedded to ripple laminated. Elliptical to spherical fractured siderite to goethite concretions, with calcite (or more rarely, barite) filling the fractures, are present throughout the unit. The coal beds are < 0.5 m thick and are usually in the lower part of the unit. The upper and lower contacts are gradational with the overlying Stray Sandstone of the Crevasse Canyon Formation and the underlying main body of the Gallup Sandstone. The exposed thickness is between 25 and 40 m.

Gallup Sandstone

Kgm **Main body** — Yellowish gray, white, or golden yellow, medium to thick-bedded, cross-bedded sandstone. The sandstone consists of moderately sorted, fine to very fine-grained angular to subrounded quartz grains with < 5% mafic minerals, 1 to 2% muscovite, plant debris, and potassium feldspar altered to clay (10 to 30%). Often the sandstone beds are bioturbated with ~1.0 cm diameter cylindrical, vertically oriented burrows. Carbonaceous shale is intercalated with the sandstone. Locally contains fossiliferous (*Innocermid*) beds near the top. Faint, very low angle trough cross beds occur locally in sets less than 0.25 m thick, with azimuth of 010 ° (northerly flow). Beds are primarily planar-tabular or laminated. The lower contact is gradational with Mancos Shale and the upper contact is gradational with the Dilco Coal Member of the Crevasse Canyon Formation. Maximum exposed thickness is ≤ 30 m. Note: on the cross sections, all Gallup sands and intervening Mancos shales are shown lumped as Kg.

Kgu **Upper tongue** — White medium-bedded, cross-bedded to tabular sandstone that is locally capped by well-cemented, fractured, brown-weathering, planar crossbedded sandstone. The brown sandstone is carbonate cemented; the weakly cemented white sandstone does not react to hydrochloric acid. The sandstone consists of well-sorted, fine-grained angular quartz grains with < 5% mafic minerals and potassium feldspar altered to clay (15 to 25%). The white arkosic sandstone has no muscovite, but the brown capping sandstone has trace amounts of muscovite and biotite. Hematitic concretions and stained surfaces occur throughout unit. The upper and lower contacts are gradational with Mancos Shale. Maximum exposed thickness is ≤ 7 m. The lower tongue (Kgl) is not exposed in the map area.

Mancos Shale

Kmm **Mulatto Tongue** — Golden yellow, thin-bedded, tabular to ripple-laminated sandstone and black shale. Moderately to well sorted, very fine-grained angular to very well-rounded quartz grains with < 1% mafic minerals, ~1% muscovite, and abundant clay (~30%). Coarse to very coarse sandstone beds near the basal contact with the Stray Sandstone and lenses of conglomerate with well-rounded pebbles of black and white chert and black quartzite are locally present. Upper and lower contacts are gradational with the Dalton and Dilco Coal (or Stray Sandstone where present) members of the Crevasse Canyon Formation. Maximum exposed thickness is ≤120 m.

Km **Main body —** Black to dark brown shale and silty shale intercalated with finely laminated to cross-bedded thinly bedded sandstone. The sandstones are wellsorted, 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.

Kd **Dakota Formation, undivided** —Alternating sandstones and shales of Dakota Formation and Mancos Shale. Very limited exposure in the extreme SW corner of the map forms a thin sandstone doublet and is probably the Twowells Member. Maximum exposed thickness locally is about 13 m (see Owen and Owen, Jr., 2003 for further regional detail).

Jurassic

Morrison Formation

J **Jurassic (and older) rocks, undifferentiated** — Jurassic rocks including those of the Morrison Formation, Todilto Formation, and Entrada Sandstone and underlying Paleozoic or Proterozoic rocks – thickness not known and depth to basement not known. (cross sections only)

Jmb **Morrison Formation, Brushy Basin Member** — Grayish green mudstone interbedded with thin lenticular beds of light gray to yellowish gray fine to medium grained sandstone. Very limited exposure in the extreme SW corner of the map. Maximum exposed thickness locally is about 10 m.

Jmw **Morrison Formation, Westwater Canyon Member —** Light gray and yellowish gray and light red fine to medium grained sandstones interbedded with thin greenish gray mudstones. Very limited exposure in the extreme SW corner of the map. Maximum exposed thickness locally is about 30 m.

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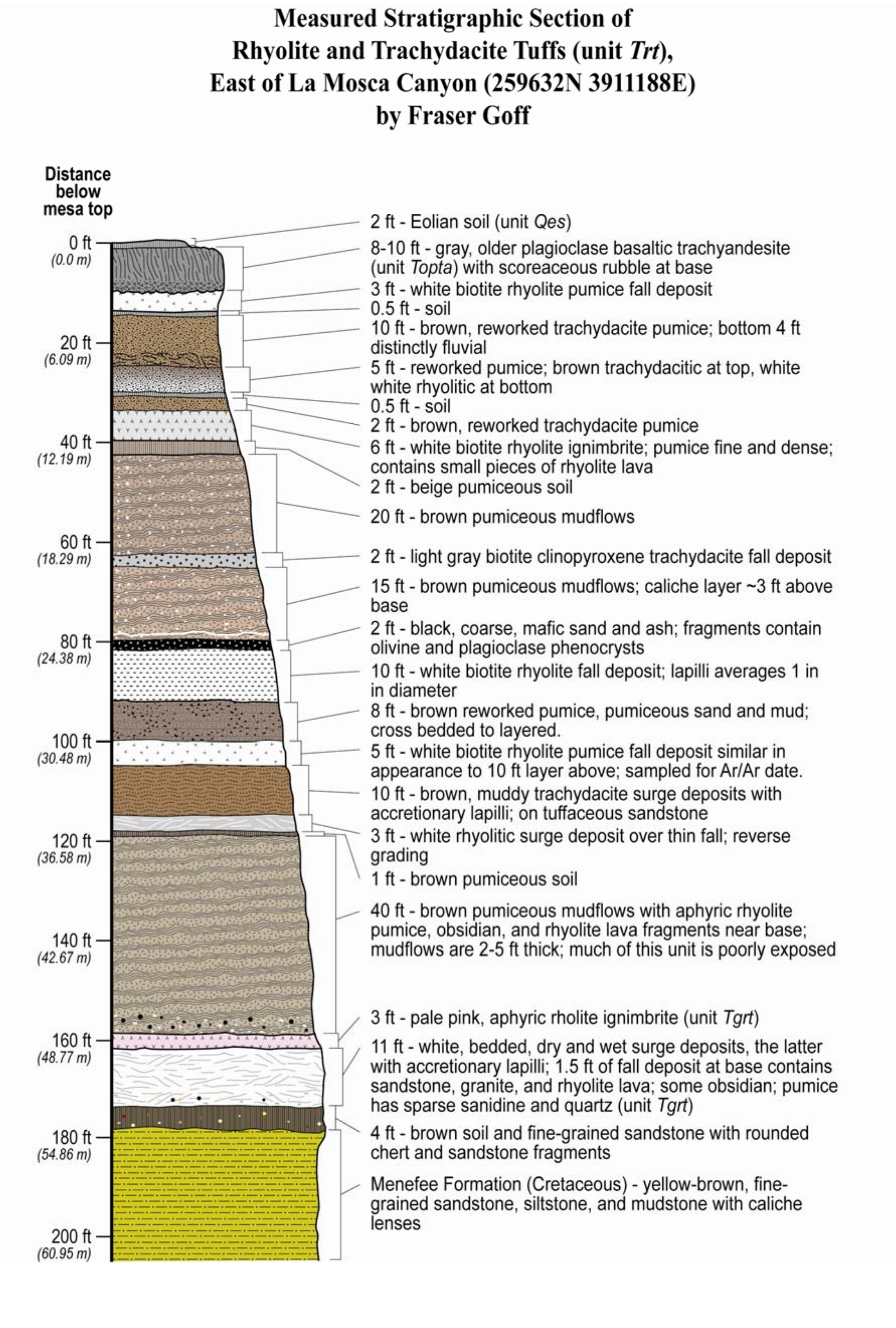
APPENDIX A
Figure A1.



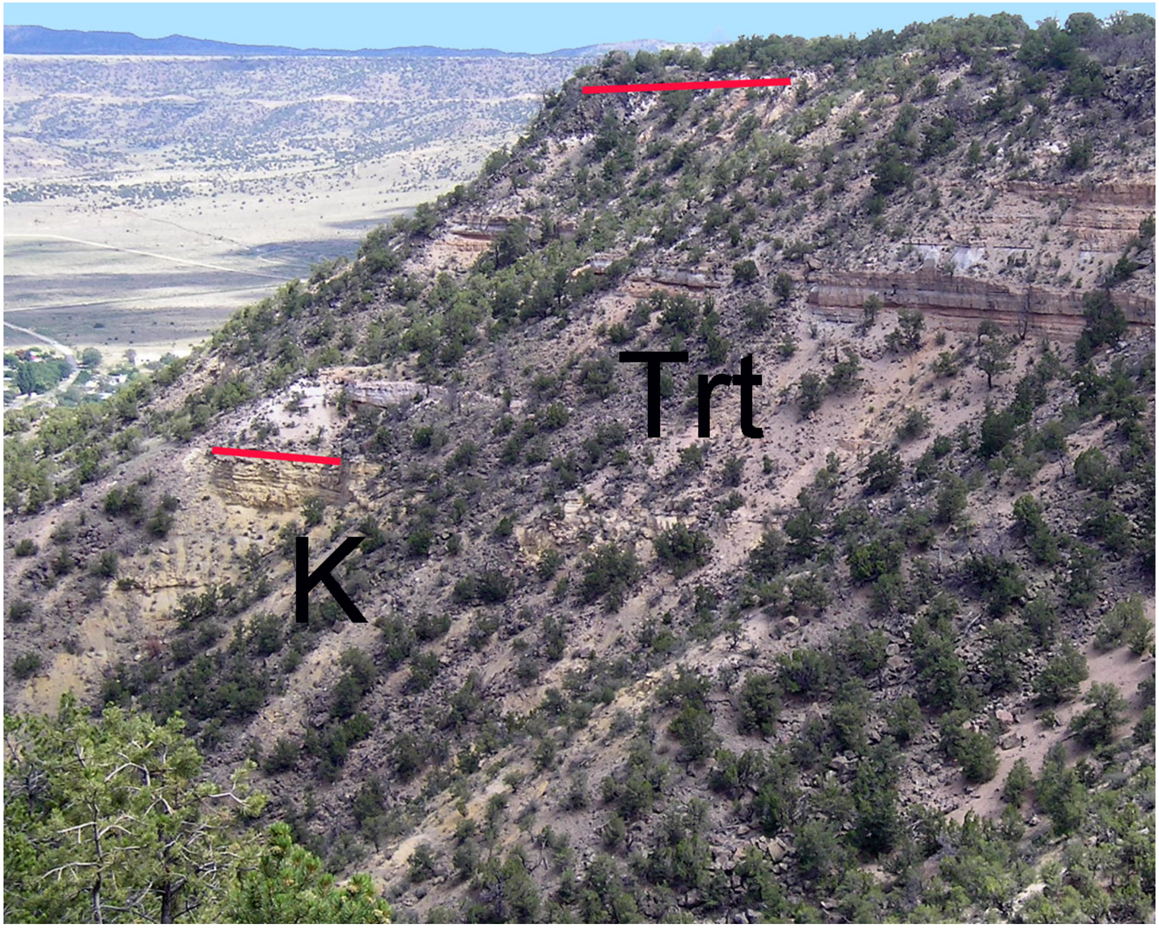


Figure A2. Photo of measured section looking NE, showing a sequence of tuffs and tuffaceous sediments (unit *Trt*) at 259632N 3911188E, east of La Mosca Canyon. The tuffs overlie Cretaceous rocks (K) but underlie a thin layer of plagioclase basaltic trachyandesite (*Topta*) and eolian deposits capping the mesa Photo by F. Goff.

Figure A3. Photo looking north of 5-foot-thick layer of white, biotite rhyolite fall deposit, at depth of about 100 to 105 feet in La Mosca Canyon Section described in measured section (above). Pumice from this deposit has been submitted for $^{39}Ar/^{40}Ar$ date. Photo by F. Goff.

APPENDIX B

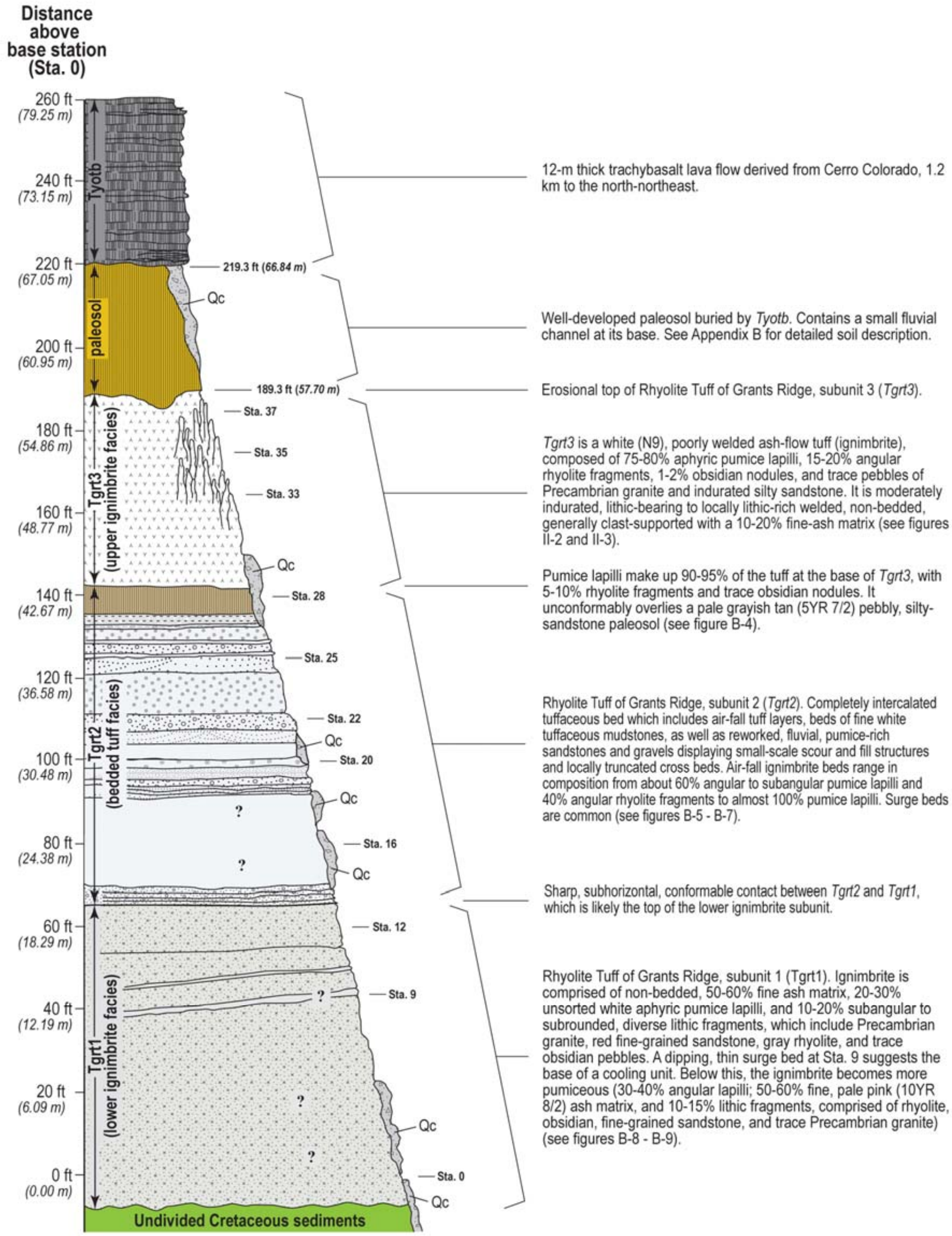
The partially exposed section of Rhyolite tuff off Grants Ridge (*Tgrt*) was measured using a decrepit jeep trail for access that switches back through the outcrop on the southwest flank of La Jara Mesa. The measured section is located near the south edge of the San Mateo quadrangle. A graphical representation of the descriptive data is presented in Figure A1.

The section was completed using the Jacob staff survey method with a level instrument height of 5.00 ft. For reference, the base datum (Sta. 0) at the lowest *Tgrt* exposure has UTM coordinates of 0251946 E, 3904745N. Sta. 36, near the top of the traverse, has a location of UTM 0251883E, 3904851N.

Rhyolite tuff of Grants Ridge has an exposed thickness at this locality of at least 67 meters. This thickness includes two soil layers as described below. The basal Tgrt contact with underlying Cretaceous rocks is concealed by colluvium. For descriptive purposes, Rhyolite Tuff of Grants Ridge is subdivided into three subunits: Tgrt 1, 2 and 3. Tgrt 1, having a minimum thickness of 19.90 m, represents a lower facies of ash-flow

Figure B1.

Measured Stratigraphic Section of Rhyolite Tuff of Grants Ridge (unit *Tgrt*), La Jara Mesa (3904851N, 0251883E) by John R. Lawrence



(ignimbrite) tuffs. This subunit is locally sporadically exposed and appears to represent more than one (possibly four) possible cooling unit or ash-flow eruption. Ignimbrites in the Tgrt 1 sequence are typically white, poorly welded, pumice-rich, lithic-bearing and ash matrix supported.

Subunit Tgrt 2, middle bedded tuff facies, is made up of complexly intercalated white to light gray tuffaceous layers. These include air-fall beds, fine-grained surge deposits with accretionary lapilli and reworked tuffaceous sandstones and gravels locally exhibiting truncated fluvial cross-bedding. Tgrt 2 is 23.29 m thick, including a 2-m-thick soil horizon forming the top of the bedded tuff sequence.

Subunit Tgrt 3, upper ignimbrite facies, is indicated to be a single ash-flow event. This ignimbrite is white, poorly welded, pumice-rich, lithic-bearing to locally lithic-rich, with predominantly clast-supported textures. Tgrt is up to 23.65 m thick. The thickness includes an 8- to 9-m-thick soil that unconformably overlies the ignimbite.

Sta. 37 Maximum elevation (i.e., measured vertical height above base Sta. No. 0) of contact between overlying soil horizon and Subunit Tgrt 3 is 57.70 m above base station (abs). Overlying pale orange tan (5YR 4/3) soil layer is up to 9 m thick. Elevation of the upper surface of the soil horizon in contact with overlying 3-m-thick trachybasalt flow (Tyotb), is 66.84 m abs (Figure1). Well-developed soil is composed of very fine grained sandy silt containing abundant tuffaceous grains and small pebbles (≤25 mm in diameter) within 30 cm of its base; becomes finer grained and more homogeneous upward. Soil is concealed by colluvium except in the lower 1 to 2 m. Contact with underlying Tgrt is unconformable, sharp to gradational, undulatory, exhibits distinct fluvial channel eroded into Tgrt. Maximum observed relief on contact about 2 m. See Photo No. 1.

Subunit 3 of Rhyolite Tuff of Grants Ridge, upper ignimbrite facies, Tgrt 3. White (N9), poorly welded ash-flow tuff (ignimbrite), pumice-rich, lithic-bearing to locally lithic-rich, non-bedded, generally clast-supported with 10─20% fine ash matrix, moderately indurated. Abundant (≤80% by volume) pumice lapilli (≤25 mm in diameter) are pristine (fresh) in appearance, aphyric, fibrous-textured. Tuff contains locally abundant lithic fragments (≤50 mm in diameter) of light gray (N6) flow-banded rhyolite; frequent (≤3% by volume) subangular to subrounded nodules of black obsidian commonly 5─10 mm (rarely as large as 75 mm) in diameter; also minor granitic pebbles. Tgrt 3 is locally eroded into pinnacles or spires, as shown in Photo No. 1.

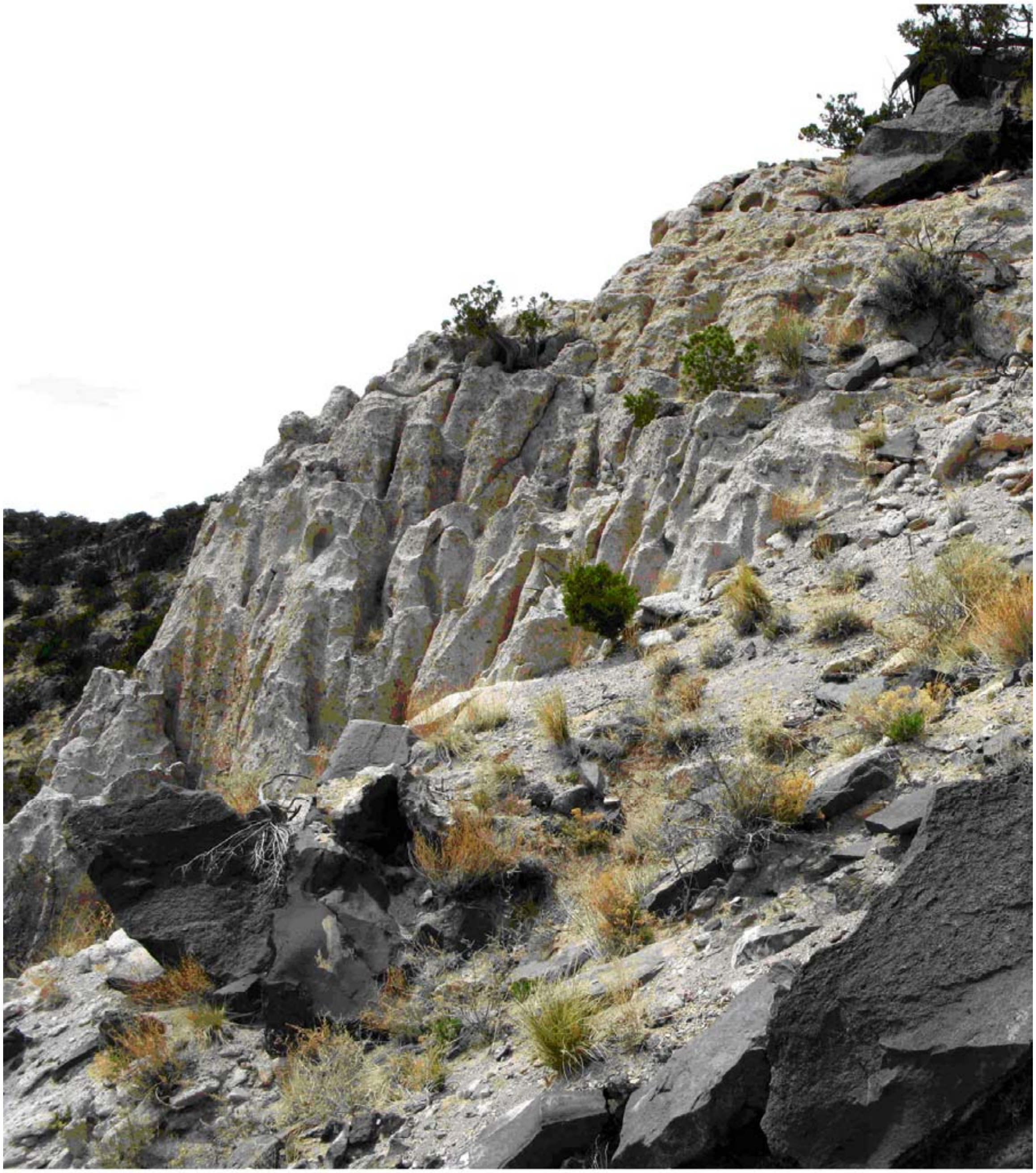


Figure B2. Westerly view from sta. 35 of eroded pinnacles in upper ignimbrite facies (Tgrt 3) of Rhyolite tuff of Grants Ridge. Unconformable contact with overlying pinkish tan soil seen in upper right of photo.

Sta. 36 Elev. 180 ft (54.86 m) abs. Tgrt 3, upper ignimbrite of similar composition and texture to Sta. 37.

Figure B3. View of poorly welded, non-bedded pumice-rich, locally lithic rich ash-flow tuff, upper ignimbrite facies (Tgrt 3). Note abundant white pumice lapilli and locally clustered lithic clasts predominantly of gray flow-banded rhyolite with minor nodular black obsidian. Exceptionally large black obsidian nodule Lower center of photo) measures 75 mm across.

Sta. 35 Elevation 53.34 m abs. Tgrt 3, ignimbrite of similar composition and texture to Sta. 37. Collected sample for analysis of select pumice lapilli (Sample Tgrt-1) in the Tgrt 3 section at approximate elevation 53 m abs. See Photo No. 2, typical ash-flow tuff textures observed in upper ignimbrite facies, Tgrt 3.

Sta. 34 Elev. 170 ft (51.82 m) abs. Tgrt 3, upper ignimbrite of similar composition and texture to Sta. 37. Tuff poorly exposed.

Sta. 33 Elevation 50.29 m abs. Tgrt 3, upper ignimbrite facies, poorly welded, pumice-rich, lithicbearing, clast-supported, non-bedded, non-sorted, composed of aphyric pumice lapilli (typically 5─15 mm in diameter) making up 75-80% by volume; 15-20% angular rhyolite fragments (≤30 mm in diameter); 1-2% obsidian nodules (≤25 mm in diameter); trace pebble-size fragments (≤25 mm in diameter) of Precambrian granite and indurated silty sandstone.

Sta.32 and 31. Elev. 160 ft (48.77 m) to 155 ft (47.24 m) abs, respectively. Roadcuts at each station expose 1.5 m to 3 m of tuff section. Descending the jeep trail, one may observe a continuous section of Tgrt 3 ignimbrite that is generally homogeneous in texture and composition, similar to that described above.

Sta. 30 through 27. Elev. 150 ft (45.71 m) to 135 ft (41.15 m) abs, respectively. Bedrock poorly exposed along the jeep trail. Colluvial cover conceals the contact between upper ignimbrite facies and middle bedded tuff facies. . Contact well exposed near Sta. 26.

Sta. 26. Elev. 130 ft (39.62 m) abs. Slope outcrop exposes basal Tgrt 3 ignimbrite in contact with underlying pale grayish tan (5YR 7/2) pebbly silty sandstone/soil, assigned to Tgrt 2. Contact elevation at the top of soil layer is 43.19 m abs. Overlying igimbrite tuff here is poorly welded, typically unsorted and unbedded. Near its base, Tgrt 3 is composed predominantly of small pumice lapilli (5─10 mm in diameter) that make up 90─95% of the tuff with 5─10% of rhyolite fragments (≤20 mm in diameter) and trace abundance of nodular obsidian clasts (≤12 mm in diameter). Collected sample for analysis of pumice-rich ignimbrite (Sample Tgrt-2) near the Tgrt 3 base, at approximate elevation of 44 m abs. Photo No.3 also shows a 24-cm-thick surge layer at the ignimbrite base that exhibits textural fining from granular to very fine ash downward to the contact.

Figure B4. Upper ignimbrite and basal surge beds of subunit Tgrt 3 in conformable contact with underlying 2-m-thick soil layer that forms the top of middle bedded tuff sub unit Tgrt 2.

The gently subhorizontal Tgrt 3─silty sandstone contact is sharp, gently undulating and appears to be conformable. Underlying silty sandstone interbed, or soil layer, is approximately 2 m thick; lower soil contact with bedded tuff not well exposed.

Sta. 25 Elev. 125 ft (38.10 m) abs. Exposed Subunit 2 of Rhyolite Tuff of Grants Ridge, middle bedded tuff facies, Tgrt 2. Road cut and vertical slope exposes a 3-m-thick section of well-bedded tuff that includes complexly interlayed air-fall tuff, fine surge deposits and reworked granular fluvial tuffaceous sediments (Figure 1). These stratified tuffs and related sediments, informally assigned subunit Tgrt 2, are essentially flat-lying. Measured bedding strikes N55W and dips 3 degrees to the NE. Northeast viewing Photo No. 4 shows the outcropping bedded tuff section at Sta. 25. Beds include air-fall tuff layers (≤30 cm thick) composed of 60% angular to subangular pumice lapilli (≤50 mm in diameter) and 40% angular rhyolite fragments (see Photo No. 5). Some air-fall tuff layers are composed almost entirely of pumice lapilli. Beds of fine white tuffaceous mudstone

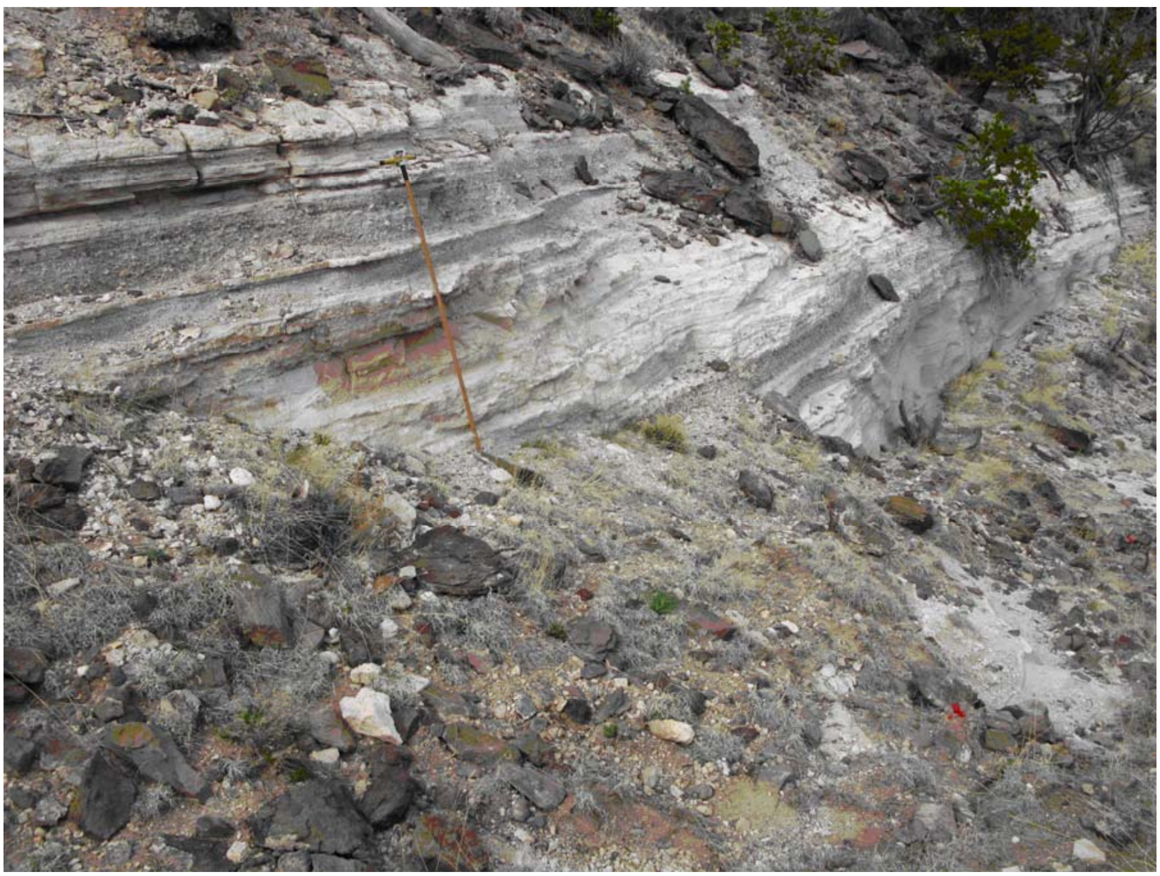


Figure B5. Northeast-viewing photo from Sta. 26 showing middle bedded tuff facies (Tgrt 2) made up of complexly intercalated tuff beds, including air-fall, surge deposits and reworked tuffaceous sandstone layers. Note 5-ft Jacobs staff for scale.

locally contain rounded accretionary lapilli (≤7 mm in diameter) as seen in Photo No. 6. Pumice-rich sandstones and gravel layers display small-scale scour and fill structures and locally truncated cross-beds, suggesting fluvial deposition of reworked tuffaceous granular materials.

Sta. 24 and 23. Elev. 120 ft (36.58 m) and 115 ft (35.05 m) abs, respectively. Exposure of 5- to 6-m-thick bedded tuff section, predominantly of fine, white mudstone surge deposits.

Sta. 22. Elev. 110 ft (33.53 m) abs. A 1.5-m-thick Tgrt 2 exposure of white very fine ash mudstone with accretionary lapilli, thin to medium bedded, grading downward to predominantly thin-bedded strata of intercalated coarse-grained tuffaceous sandstone and gravel layers with abundant pumice and rhyolite clasts; truncated cross beds common.

Sta. 21 Elev. 105 ft (32.00 m) abs. Colluvium (Qc) covering Tgrt 2 bedrock; no exposure.

Sta. 20 Elev. 100 ft (30.48 m) abs). A 1-m-thick Tgrt 2 exposure of white mudstone (upper 0.5 m) with accretiionary lapilli in contact with underlying pumice-rich reworked fluvial sandstone and pebble gravel. Note in Photo No. 7 rounded rhyolite cobble with sag structure in mudstone sediments.

Figure B6. Bedded tuff facies (Tgrt 2). Intercalated thick-bedded air-fall beds of pumice and rhyolite lthic fragments intercalated with thin white mudstone surge beds locally containing accretionary lapilli.

Sta. 19. Elev. 95 ft (28.96 m) abs. A 2.5-m-thick exposure of white Tgrt2 mudstone (upper 1.5 m) with accretionary lapilli (5–10 mm in diameter) in sharp conformable contact with underlying gray thin-bedded very fine to medium-grained rhyolite-rich sandstone (middle 0.5 m); all underlain by 1.0-m-thick interval of thin bedded very fine to medium-grained pumice-rich sandstone; base of exposure Qc covered. Strike and dip of bedding measured at N85W and 2 degrees N, respectively.

Sta. 18 Elev. 90 ft (27.43 m) abs. Extensive Qc cover; no bedrock exposure.

Sta. 17 Elev. 85 ft (25.91 m) abs. Minimal exposure; apparent pumice-rich ignimbrite indicated in slope at elevation 27.74 m abs. Possible Qc composed of Tgrt debris.

Sta. 16 Elev. 80 ft (24.38 m) abs. Qc covered; no bedrock exposure.

Sta. 15 Elev. 75 ft (22.86 m) abs. Minimal exposure of weathered, poorly welded ignimbrite composed of 70–80% small (≤10 mm in diameter) subangular pumice lapilli and 20–30% fine ash matrix with trace abundances of small pebble-size quartzite and fine-grained sandstone.

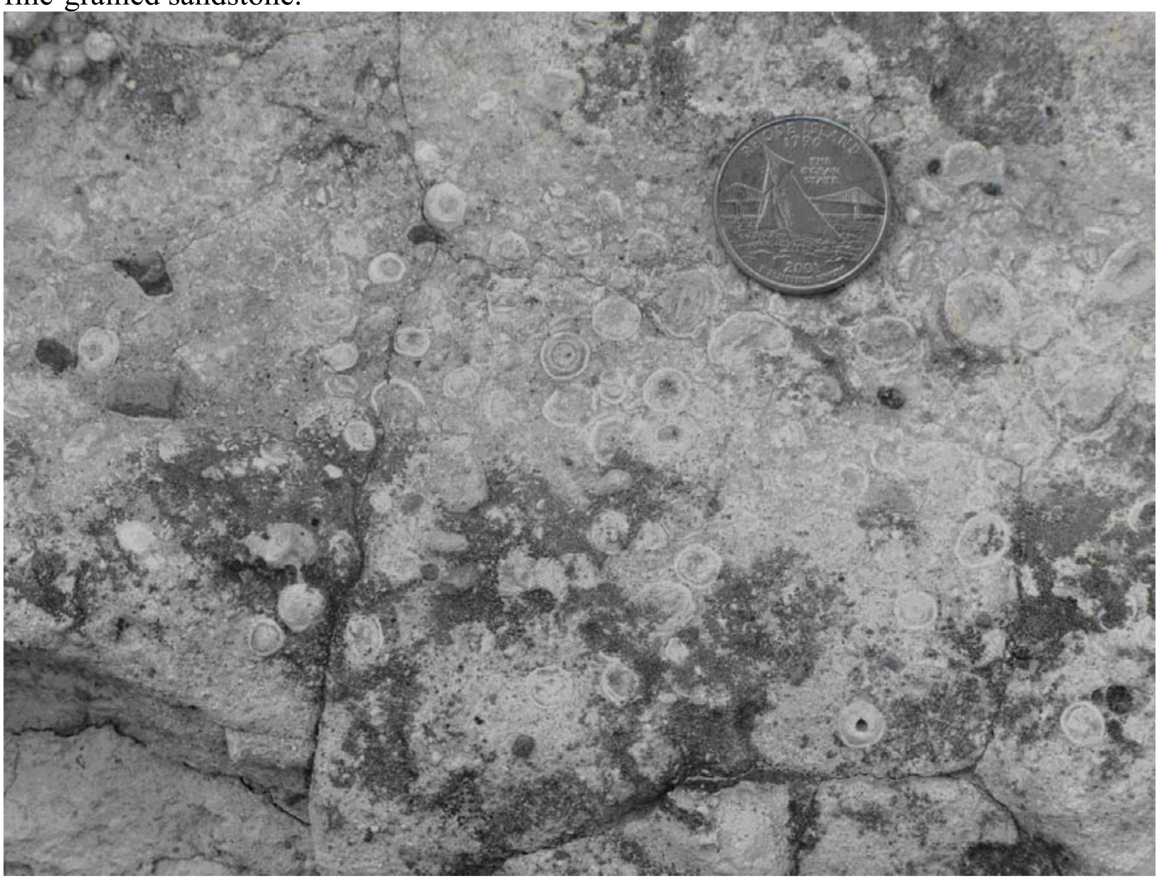


Figure B7. Bedded surge deposits in Subunit Tgrt 2. White to pale gray mudstone layers of fine volcanic ash containing local numerous spherical accretionary lapilli (≤7 mm in diameter).

Sta. 14 Elev. 70 ft (21.33 m) abs. Qc covered; no bedrock exposure.

Figure B8.. White Tgrt 2 accretionary lapilli-bearing mudstone surge beds (upper layer), with conspicuous rounded rhyolite pebble and associated sag structure, in contact with underlying thin-bedded pumice-rich sandstone; fluvial cross beds are truncated.

Figure B9.. Northeast-viewing photo from Sta. 8 showing horizontal contact between Tgrt 1 massive, ash-rich ignimbrite and underlying strongly pumiceous ignimbrite layer.

Sta. 13 Elev. 65 ft (19.81 m) abs. A 1.5-m-thick exposure of thick- to thin-bedded pumice-rich pebbly sandstone (95% pumice lapilli, 5% rhyolite grains and pebbles) with minor beds of finer tuffaceous sand and mudstone (i.e., surge beds). These bedded tuffaceous sedoments are preliminarily assigned as part of Tgrt 2.

Sta. 12 Elev. 60 ft (18.29 m) abs. Slope above Sta. 12 exposes basal Tgrt 2 contact with underlying Subunit 1 of Rhyolite Tuff of Grants Ridge, lower ignimbrite facies, Tgrt 1. The top of Tgrt 1 occurs at elevation 19.90 m abs. The Tgrt 2─Tgrt 1 contact is sharp, appears conformable, subhorizontal; likely top of lower ignimbrite facies . Ignimbrite contains 50─60% matrix of non-bedded fine ash,; 20─30% unsorted white aphyric pumice lapilli (typically 3─20 mm in diameter); 10─20% subangular to subrounded diverse lithic fragments (≤10 mm in diameter) including Precambrian granite and pink microcline, red fine-grained sandstone, gray rhyolite, trace black obsidian.

Sta. 11 and 10 Elevation 55 ft (16.67 m) and 50 ft (15.24 m) abs, respectively. Ignimbrite subunit Tgrt 1, as described above. At sta. 11, unit is cut by extensive subhorizontal joint or parting plane; no change in lithology above or below this thin boundary.

Sta. 9 Elev. 45 ft (13.71 m) abs. Continuously exposed subunit Tgrt 1 contains 0.4-m-thick tilted pumice-rich tuff interlayer composed of 60─70% pumice lapilli and less abundant lithic clasts (rhyolite, red sandstone, and Precambrian granite); 30─40% fine ash matrix. Interlayer is coarser than ignimbrite above or below; its base has a 5-cm-thick fine-grained surge bed suggesting the base of an eruptive interval or cooling unit. Top of interbed occurs at elevation 15.12 m abs. Strike and dip of bedding measured at N50W and 16 degrees NE, respectively.

Sta. 8 through 5. Elevation 40 ft (12.19 m) to 25 ft (7.62 m) abs. Continuously exposed ignimbrite, subunit Tgrt 1. At Sta. 8, exposed 1-m-thick layer of massive, lithic-poor, ash-rich, pumice-bearing ignimbrite with thin basal surge bed as shown in Photo No. 8. Below this layer (its basal contact at elev. 13.32 m abs), ignimbrite becomes more pumiceous and is composed of 30─40% by volume angular lapilli (≤35 mm in diameter), 50─60% fine pale pinkish tan (10YR 8/2) ash matrix (matrix-supported), and 10-15% lithic fragments (rhyolite, obsidian, fine-gtained sandstone, trace Precambrian granite). Sample of pumice (Sample Tgrt-4) collected for analysis from the lower ignimbrite horizon shown in the photo at approximate elevation of 13 m abs

Sta. 4 through 1. Elevation 20 ft (6.10 m) to 5 ft (1.52 m) abs. Qc covered interval; no exposure.

Sta. 0. Elev. 0.00 ft (0.00 m) abs. Base station selected on jeep trail as datum for traverse survey using Jacobs staff method. Lowermost known local Tgrt outcrop, poorly exposed, strongly weathered. Basal Tgrt contact covered by colluvium.