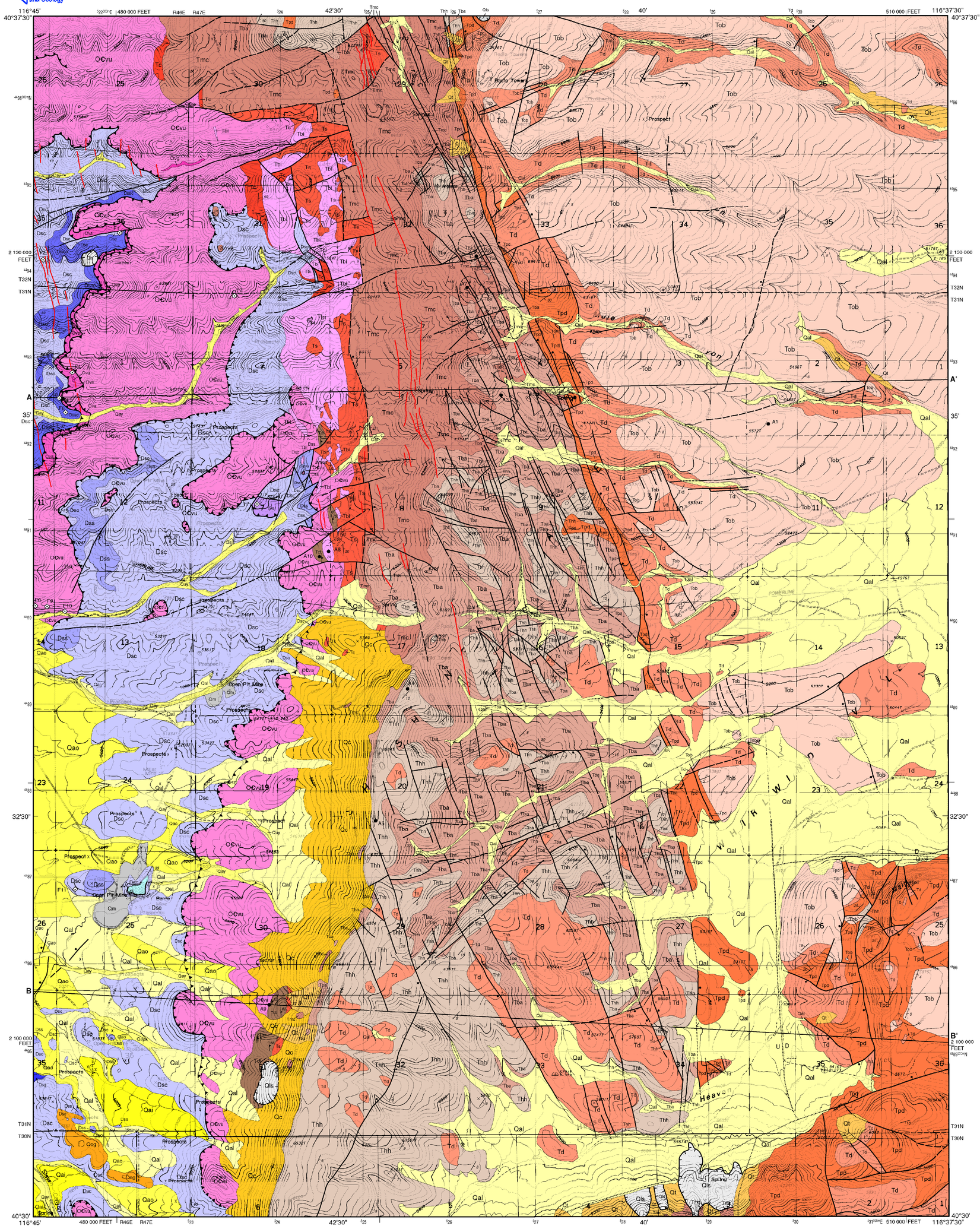
Nevada Bureau of Mines and Geology

USGS Prepared in cooperation with the U.S. Geological Survey

MAP 144 GEOLOGIC MAP OF THE MULE CANYON QUADRANGLE, LANDER COUNTY, NEVADA



SURFICIAL DEPOSITS

Qm **Mine dumps (late Holocene)** Broken waste rock from mining operations at barite mines in west-central part of quadrangle.

Qal **Alluvium, undivided (late Holocene to Pleistocene)** Unconsolidated and poorly to moderately sorted sand-to-boulder-sized debris. Locally includes or is transitional to colluvium and talus debris in mountain areas.

Qay **Young alluvium (late Holocene)** Unconsolidated and poorly to moderately sorted silt, sand and gravel in active or recently active stream channels. Minimal soil development.

Qai **Intermediate alluvium (late Pleistocene)** Weakly consolidated sand and gravel in upper part of fan in southwestern part of quadrangle and in fan remnants and terraces near southern border. Covered with eolian silt and fine-grained sand. Poorly exposed, but in artificial cut in eastern part of largest exposure consists of angular pebble to boulder clasts of chert in matrix of sand and silt. Surface fully smoothed and largely planar, about 6 m above major stream at southwest corner of quadrangle. Deposited largely on older alluvial deposits (Qao). Soils typically include eolian silt cap as much as 50 cm thick and a massively cemented calcium carbonate horizon as much as 100 cm thick.

Qao **Older alluvium (Pleistocene)** Poorly consolidated sand and gravel alluvial-fan deposits. Poorly exposed. Has eolian cover of silt and fine-grained sand. Surface fully smoothed, forming broadly rounded, locally planar, concordant surfaces about 12 m above major drainage channel in west-central part of quadrangle. Locally deposited on Paleozoic bedrock. Soils typically capped by eolian silt 50 cm to as much as 100 cm or more thick and a massively cemented calcium carbonate horizon a few meters thick. Upper soil horizons commonly stripped.

Qc **Colluvium (Holocene)** Unconsolidated fragments of bedrock on west-facing escarpment of Shoshone Range below Miocene volcanic rock cap. Consists mostly of clasts of mafic volcanic rocks ranging in size from sand to boulders. Locally contains fragments of Oligocene Caetano Tuff.

Qt **Talus deposits (Holocene)** Unconsolidated angular fragments derived from Miocene volcanic flow rocks on high parts of Shoshone Range escarpment to east and south.

Qls **Landslide deposits (Pleistocene)** Broken and rotated masses of Paleozoic rocks and of Miocene volcanic rocks. Deposits composed of Paleozoic rocks are near west border of quadrangle 1.8 km south of north border. Deposits composed of Miocene volcanic rocks are on steep, west-facing escarpment that is capped by Mule Canyon sequence and andesite of Horse Heaven in southwest part of quadrangle and on south side of Horse Heaven.

Qog **Older gravel (Pleistocene)** Weakly consolidated sand and gravel deposits that cap two small hills near southwest corner of quadrangle about 70 m above prominent drainage channel to the west. Surface smoothed and vaguely planar. Height above adjoining fan surfaces suggests Pleistocene age.

VOLCANIC AND SEDIMENTARY ROCKS

Tob **Olivine basalt (Miocene)** Dark-gray to black olivine basalt lava flows. Contains scattered, small (<2 mm) olivine phenocrysts in a fine-grained, subophitic groundmass of plagioclase, clinopyroxene, ilmenite, and minor olivine. Abundant, fine-grained cavities give the rocks a dikytaxitic texture. Small (1 cm) vesicles are common near tops of flows. Whole-rock $^{40}Ar/^{39}Ar$ dates of 14.7±0.8 in Mule Canyon Quadrangle and 14.7±0.2 Ma in southern Sheep Creek Range (table 1). Map unit locally includes thin (<10-m-thick) sequence of white to dark-orange, crystal-lithic rhyolite(?) air-fall tuff and reworked tuff, and tuffaceous sedimentary rocks discontinuously present between olivine basalt flows and underlying trachydacite flows (unit Td). Sanidine $^{40}Ar/^{39}Ar$ date of 14.84±0.04 Ma on an air-fall tuff bed in southwestern Sheep Creek Range (table 1).

Td **Trachydacite (Miocene)** Black and light-gray to light reddish-brown, aphyric to sparsely porphyritic trachydacite lava flows. Contains 1 to 2% fine- to medium-grained phenocrysts of plagioclase, clinopyroxene, ilmenite, and sparse sieve-textured sanidine in microcrystalline trachytic to pilotaxitic groundmass of plagioclase and Fe-Ti oxide minerals. Consists of several flows marked by glassy, highly vesicular flow tops and devitrified, massive flow interiors that commonly have platy joints. Vesicles commonly elongated into narrow tubes several centimeters long. Plagioclase $^{40}Ar/^{39}Ar$ date of 15.42±0.10 Ma on flow in southwestern Sheep Creek Range (table 1).

Tpd **Porphyritic dacite (Miocene)** Black, reddish-brown, and lavender-gray, porphyritic high-K dacite containing 5 to 20%, 0.1- to 4-mm phenocrysts of plagioclase, clinopyroxene, ilmenite, and minor olivine. Phenocrysts commonly form small glomeroporphyritic clots. Consists of two thick flows east of Muleshoe fault in eastern part of the quadrangle and along the Argenta and Malpais Rims, as well as several dikes, small plugs(?), and thin flows in the northwestern part of the quadrangle. Tops of flows commonly black vitrophyre. The upper few meters of the vitrophyre commonly is scoriaceous. Vitrophyre grades downward into irregular zones of devitrified spherulitic dacite characterized by abundant reddish-brown spherulites 0.5 to 5 cm in diameter. Spherulitic zones grade downward into massive, dark-red to lavender-gray, devitrified dacite that is subhorizontally layered. Plagioclase $^{40}Ar/^{39}Ar$ dates of 15.34±0.10 Ma and 15.33±0.09 Ma (table 1). As much as 200 m thick along the Malpais and Argenta Rims (John and others, 2000).

Thh **Andesite of Horse Heaven (Miocene)** Black, light-gray, and reddish-brown, aphyric to sparsely porphyritic basaltic andesite and andesite lava flows. Contains sparse, fine-grained plagioclase, olivine, and/or clinopyroxene phenocrysts in intergranular to intersertal groundmasses of plagioclase, clinopyroxene, olivine, and Fe-Ti oxide minerals. Consists of as many as eight thin flows marked by highly vesicular, glassy flow tops and devitrified, massive flow interiors. Interiors of flows commonly have spheroidal weathering. Whole-rock $^{40}Ar/^{39}Ar$ dates of 15.86±0.12 and 15.2±0.8 Ma on lava flows collected in the Mule Canyon Quadrangle (A4 and A5, table 1) and 15.76±0.80 Ma on basal flow in Corral Canyon about 20 km south of the quadrangle (fig. 2).

Tmc **Mule Canyon sequence, undivided (Miocene)** Sequence of green, red, dark-gray, and black basalt, basaltic andesite, and andesite lava flows, feeder dikes, and minor pyroclastic rocks. Rocks in the Mule Canyon sequence are mostly aphyric to sparsely porphyritic. Porphyritic rocks contain fine-grained phenocrysts of plagioclase, clinopyroxene, ilmenite, and, locally, olivine. Notable exceptions are coarse-grained olivine basalt porphyry flows present near base of sequence and porphyritic basalt flows with distinctive medium-grained plagioclase phenocrysts in middle of sequence. Rocks range in composition from basalt to andesite (about 49 to 60 weight percent SiO_2; table 3; John and others, 2000). Whole-rock $^{40}Ar/^{39}Ar$ date of 15.91±0.09 Ma on a basalt flow in the middle of the sequence (A7, table 1).

Tba **Basalt and andesite (Miocene)** Sequence of dark reddish-orange to olive-gray to black, aphyric to sparsely porphyritic andesite lava flows locally forming uppermost part of Mule Canyon sequence. Generally contains <1% fine-grained plagioclase phenocrysts in a devitrified aphanitic groundmass. Tops of flows typically are highly vesicular containing abundant small (<2 mm) spherical vesicles. Flow interiors are dense, flinty rocks. Many exposures contain thin (5 cm) vesicle-rich layers interlayered with dense non-vesiculated rock. Whole-rock $^{40}Ar/^{39}Ar$ date of 15.85±0.08 Ma (A6, table 1).

Tbi **Basalt and basaltic andesite intrusive rocks (Miocene)** Mostly dark-gray-weathering, reddish-brown, fine-grained basalt and basaltic andesite. Consists of fine-grained plagioclase, clinopyroxene, olivine, and Fe-Ti oxide minerals in a diabasic texture. Forms dikes from <2 to 30 m wide and large irregular masses intrusive into Paleozoic sedimentary rocks, middle Tertiary sedimentary rocks, and the Mule Canyon sequence in the northwest part of the quadrangle. Whole-rock $^{40}Ar/^{39}Ar$ dates of 16.4±0.4 and 16.13±0.09 Ma (table 1). Unit also consists of a few narrow (<5–10 m) dikes of porphyritic dacite and black, nearly aphyric andesite.

Ts **Sedimentary rocks (Miocene and/or Oligocene)** White, beige, and dark gray, fine- to medium-grained clastic sedimentary rocks and less abundant limestone. Includes pebble conglomerate, sandstone, siltstone, finely laminated mudstone, and minor ostracode-bearing limestone. Conglomerate beds locally mapped as separate unit (Tc) where they form the dominant rock type. Small folds and faults common in fine-grained mudstone and probably are the result of soft-sediment deformation. Mudstone and siltstone locally silicified. Probably mostly fluvial and lacustrine deposits. Unit ranges in thickness from >250 m near north end of quadrangle to <90 m at south end where colluvium (Qc) and talus (Qt) masks unit. Age between 34 and 16.4 Ma on the basis of stratigraphic position between isotopically dated rocks.

Tc **Conglomerate (Miocene and/or Oligocene)** Tan, white, and blue-gray, locally rusty weathering conglomeratic and sedimentary breccia. Pebbles, cobbles, and boulders supported in matrix of sand and grit. Medium to large pebbles are dominantly black chert, mostly angular but a small percentage are rounded. About 20% of clasts are subrounded to well-rounded light-gray quartzite cobbles. Sparse cobbles of the Caetano Tuff and sparsely porphyritic rhyolite tuff that may correlate with the units B and D of the Bates Mountain Tuff present locally. Matrix, at least locally, has abundant small pebbles, grit, and large sand grains of smoky quartz, welded vitric tuff, and spherulitic glass from Oligocene Caetano Tuff, as well as silty argillite, sandstone, and chert from Paleozoic rocks. Crude bedding. North end of northeastermost body has lens about 200 m long and as much as 2 m thick resembling layer of tuff but consists of abundant closely packed boulders of Caetano Tuff, many tabular and as large as 0.4 m by 1.5 m. Unit is lenticular and as much as 50 m thick. Age between about 34 and 16.4 Ma on the basis of stratigraphic position between isotopically dated rocks.

Tct **Caetano Tuff (Oligocene)** Medium-gray to grayish-red to black, generally densely welded rhyolite ash-flow tuff containing about 30% phenocrysts of smoky quartz, sanidine, plagioclase, and biotite in vitroclastic groundmass of shards and flattened pumice fragments. Devitrified except lower few meters of exposures in southwest part of quadrangle. Exposed in probable paleochannels at base of Tertiary section at three localities in northwestern part of quadrangle and two in southwestern part. Sanidine $^{40}Ar/^{39}Ar$ dates of 33.87±0.08 Ma for basal vitrophyre in southwest part of quadrangle (A5, table 1) and 34.01±0.04 Ma for devitrified tuff in the west-central part of quadrangle (A10, table 1).

Slaven Chert in this area consists of:

Dsc **Chert (Early, Middle, and Late? Devonian)** Medium-gray to black chert, black to medium-gray sandstone and quartzite, subordinate amounts of dark-gray to dark-greenish-gray argillite, and minor amounts of medium-gray calcareous sandstone and bedded barite. Exposed at numerous localities along length of western part of quadrangle in two major thrust sheets separated by a thrust sheet of Ordovician Valmy Formation. Chert commonly (1) in in beds 1 to 5 cm thick, forming ribbon chert, and (2), in some sequences, contains interlayered argillite 0.5 to 3 cm thick. Bold outcrops of unit in lower thrust sheet contains numerous conspicuous sandstone and quartzite sequences that commonly are 3–7 m thick, interlayered with chert sequences that commonly are 5 m or more thick. Sandstone and quartzite consist of rounded, mostly fine- to medium-grained quartz grains and sparse angular grains of black chert. Bedding commonly not evident. Less prominent sequences of thin-bedded brown-weathering sandstone a few meters to possibly as much as 10 m thick present locally. Unit locally contains lenses 1–5 m long of black, medium-gray-weathering, laminated limestone and calcareous sandstone. Chert bedding planes and much of argillite altered to a medium-light-gray to light grayish-green color and locally stained brown and yellow brown from Fe-oxide minerals. Structurally high thrust sheets of unit contain medium- to dark-gray barite in beds 1 to 30 cm thick, locally in sections as thick as about 5 m with interlayered chert, as exposed at barite mines and prospects. Chert in both thrust sheets commonly highly contorted; structurally high thrust sheet locally contains boudins of barite and chert. Where exposed, upper and lower unit contacts are thrust faults. Thickness of exposed sections of formation difficult to determine but likely in range of 100 to as much as 600 m in each thrust sheet. Date in lower thrust sheet Early Devonian as determined from fossils at fossil localities F1, F2, and F5 (table 2). Date in upper thrust sheet possibly Early to Late Devonian assumed from lithologic correlation with Slaven Chert widely exposed elsewhere in Shoshone Range (Gilluly and Gates, 1965); Middle Devonian age determined from conodonts at fossil locality F11 (table 2).

Dsg **Greenstone (Middle or Late? Devonian)** Dark-greenish-gray to brownish-gray altered basalt flows, exposed at one small locality at west border of quadrangle 1.5 km north of the southwest corner. Poorly exposed. Part of subhorizontal body that extends into, and better exposed in, adjacent Bateman Spring Quadrangle. Internal structure of original flow or flows not evident. Locally silicified in dull dark-greenish-black masses as large as 0.5 m wide. Maximum thickness probably about 5 m but thickens to the west to 18 m in adjacent Bateman Spring Quadrangle. Similar greenstone interlayered with Slaven Chert to south in Tenabo Quadrangle originated as submarine basalt flows (C.T. Wrucke, unpub. data, 2002). Devonian age in Mule Canyon Quadrangle on the basis of interlayering with chert of Slaven Chert.

Dss **Sandstone (Devonian)** Light- to dark-gray and yellowish-brown fine-grained feldspathic sandstone and siltstone that commonly weathers light to medium gray and red brown. Locally laminated. Exposed in west-central part of quadrangle and within a few kilometers of southwest corner of quadrangle. Consists of variable amounts of fine- to medium-grained, rounded quartz grains in matrix of silt and very fine-grained angular quartz, plus 20–30% angular plagioclase, <1% K-feldspar, accessory white mica, and rare collophane. Contains about 20% calcite grains in west-central area. Unit near southwest corner identified from abundant float similar to exposed rock elsewhere. Float fragments suggestive of beds a few centimeters thick. Weathers mostly red brown. Sandstone in west-central area mostly well indurated and medium- to light-gray weathering; small percentage weathers red brown. Thickness uncertain but probably about 15 m near southwest corner and 100 m in west-central area. Date uncertain. Overlies chert of early Middle Devonian age at fossil locality F11 in southwestern part of quadrangle, but some may be Early Devonian in age as suggested by similarities with dated sandstone and siltstone in Tenabo and Battle Mountain Quadrangles (C.T. Wrucke, unpub. data, 2002; Hesse and others, 2001).

Dssc **Sandstone and chert breccia (Early Devonian)** Medium-gray medium-grained sandstone commonly containing a few percent of sand and grit-size fragments of black chert. Sandstone locally dominant but commonly interlayered with abundant chert breccia consisting of pebble-size, commonly angular, black to medium-gray fragments of chert. Chert clasts in breccia beds dominantly angular but a small percent rounded to subrounded; many contain petrographically distinct radiolarians and sponge spicules. Abundance of chert clasts highly variable from a few percent to about 80%; matrix supported. Locally contains thin lenses of dark gray limestone that weather medium gray. Thickness as much as 125 m. Early Devonian age on the basis of stratigraphic position between fossil localities F1 and F2 (table 2).

Se **Elder Sandstone (Silurian)** Dark-gray to black shale, siltstone, and laminated silty limestone present only in one small area in west-central part of quadrangle. Structurally overlies Slaven Chert and underlies quartzite of Valmy Formation. Poorly exposed. Weathers pale brown to medium dark gray. Graptolites in shale at locality F7 are upper Early Silurian (upper Wenlockian) in age (table 2).

Valmy Formation in this area consists of:

OCvu **Valmy Formation, undivided (Ordovician and Cambrian** Exposed rock consists of two thrust sequences separated by thrust bounded section of Slaven Chert. Lower exposed sequence composed of at least two thrust sheets exposed along and near west border of quadrangle near north corner. Upper thrust sequence crops out at top of Paleozoic section in west-central and southwest parts of quadrangle. Lower thrust sequence composed of interbedded, commonly poorly exposed, quartzite and argillite and minor amounts of limestone. Quartzite crops out locally as large, conspicuous high-standing outcrops 5 m or more high, but abundant quartzite also is present in thin, less conspicuous bodies interlayered with argillite. Base of lowest conspicuous quartzite shown as thrust fault. Ratio of quartzite to argillite is highly variable throughout unit. Upper thrust sequence dominantly quartzite. Quartzite in both thrust sequences commonly has bimodal grain size, consisting mostly of a light mosaic of very-fine to fine, angular to subrounded grains and 5–10% randomly distributed well-rounded fine- to medium-size grains; overall grain size from smallest to largest is sorted. Argillite is dark-gray to black and fissile and locally abundant in lower thrust sequence, mainly in northwest part of quadrangle. Colluvial chips of brownish-yellow siltstone and blaish-gray limestone present locally 2.5 km southeast of northwest corner of quadrangle resembles Ordovician siltstone and limestone in Tenabo Quadrangle to south (C.T. Wrucke, unpub. data, 2002). Thickness of unit not readily determined because of poor exposures and possible duplication of strata from thrust faulting, but probably at least 250 m in lower thrust sequence and 300 m in upper sequence. Graptolites from fossil localities F3, F8, F9, and F10 indicate Late Ordovician age (table 2). Cambrian age on the basis of determination by Anita G. Harris (written commun., 1998) of very late Late Cambrian conodont elements from limestone in Valmy Formation in Stony Point Quadrangle 1 km north-northwest of northwest corner of Mule Canyon Quadrangle. Probably some argillite in unit is same age as argillite unit (Ova).

Ova **Argillite (Early or Middle Ordovician)** Black to medium-gray argillite in thin thrust sheet near west border of quadrangle. Locally includes thrust lenses of quartzite a few meters long and one of greenstone (Ovg) about 12 m long. Thickness 5–40 m. Early or Middle Ordovician age from graptolite at fossil locality F4 (table 2).

Ovg **Greenstone (Ordovician)** Greenish-gray, brown-weathering altered basaltic rock in two exposures near west border of quadrangle, one in argillite (Ova) and one within Valmy Formation, undivided (OCvu). Thickness about 5 m. Ordovician age inferred from location within rocks typical of Valmy Formation.

See accompanying text for tables, references, and description of the geology of the Mule Canyon Quadrangle.

Contact Dashed where approximately located.

High-angle fault D Long dashed where approximately located, dotted where concealed; bar and ball on downthrown side; U, upthrown block, D, downthrown block.

Thrust fault Long dashed where approximately located, short dashed where inferred, dotted where concealed; sawteeth on upper plate; arrow shows inferred transport direction in cross section.

Landslide-related fault Dashed where approximately located, tick marks on landslide deposit.

Dike Part of basalt and basaltic andesite unit (Tbi).

Open-pit mines Approximate outline of open pits at Mule Canyon Mine in June 2000.

Bedding In cross sections for Caetano Tuff and sedimentary rock units.

Strike and dip of beds

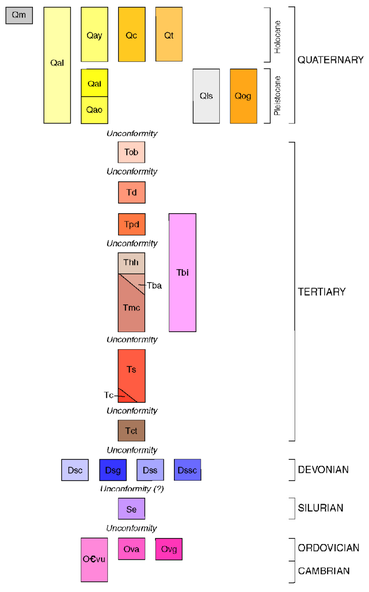
Strike and dip of compaction foliation in Caetano Tuff (Tct)

Direction and plunge of fold axis

● A5 **$^{40}Ar/^{39}Ar$ sample locality** See table 1.

◇ F6 **Fossil locality** See table 2.

CORRELATION OF MAP UNITS



GEOLOGIC MAP OF THE MULE CANYON QUADRANGLE, LANDER COUNTY, NEVADA

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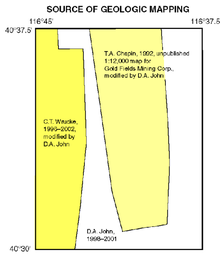
and
Chester T. Wrucke

2003

SOURCE OF GEOLOGIC MAPPING



Field work performed from 1996-2002.

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