GEOLOGIC MAP OF THE HENDERSON QUADRANGLE, NEVADA

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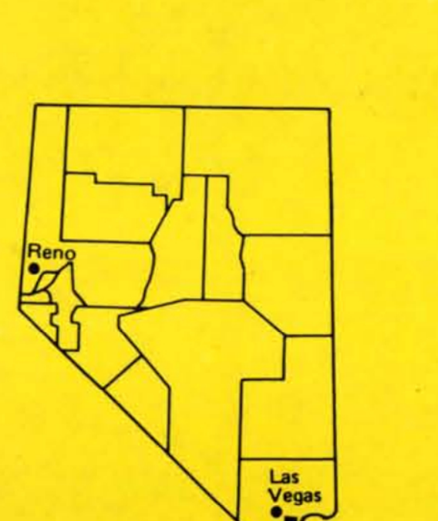
NEVADA BUREAU OF MINES AND GEOLOGY

MAP 67



A 1:24,000-scale geologic map of the Henderson 7½′ quadrangle; cross section; and text describing 45 geologic units, and structures.

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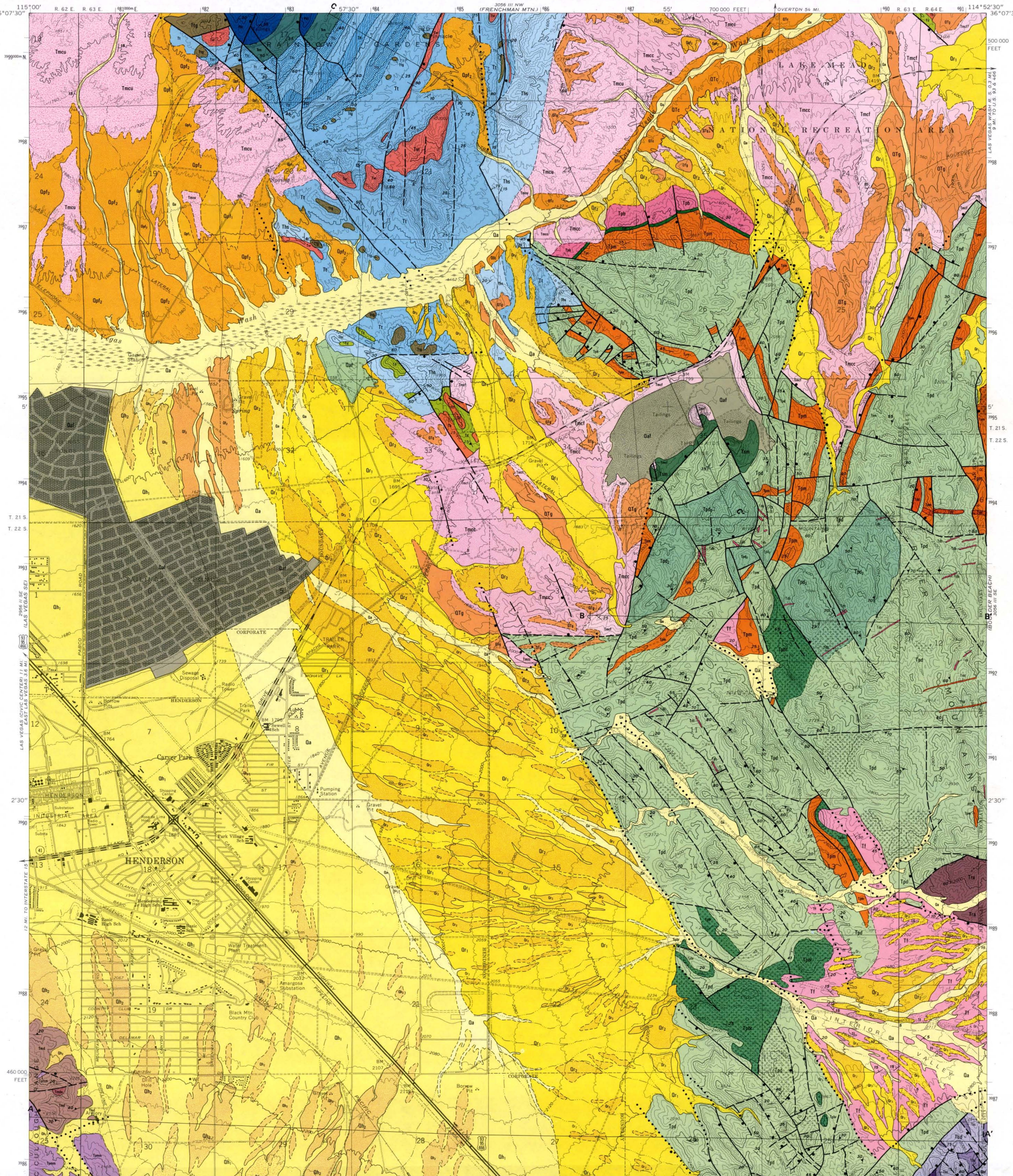
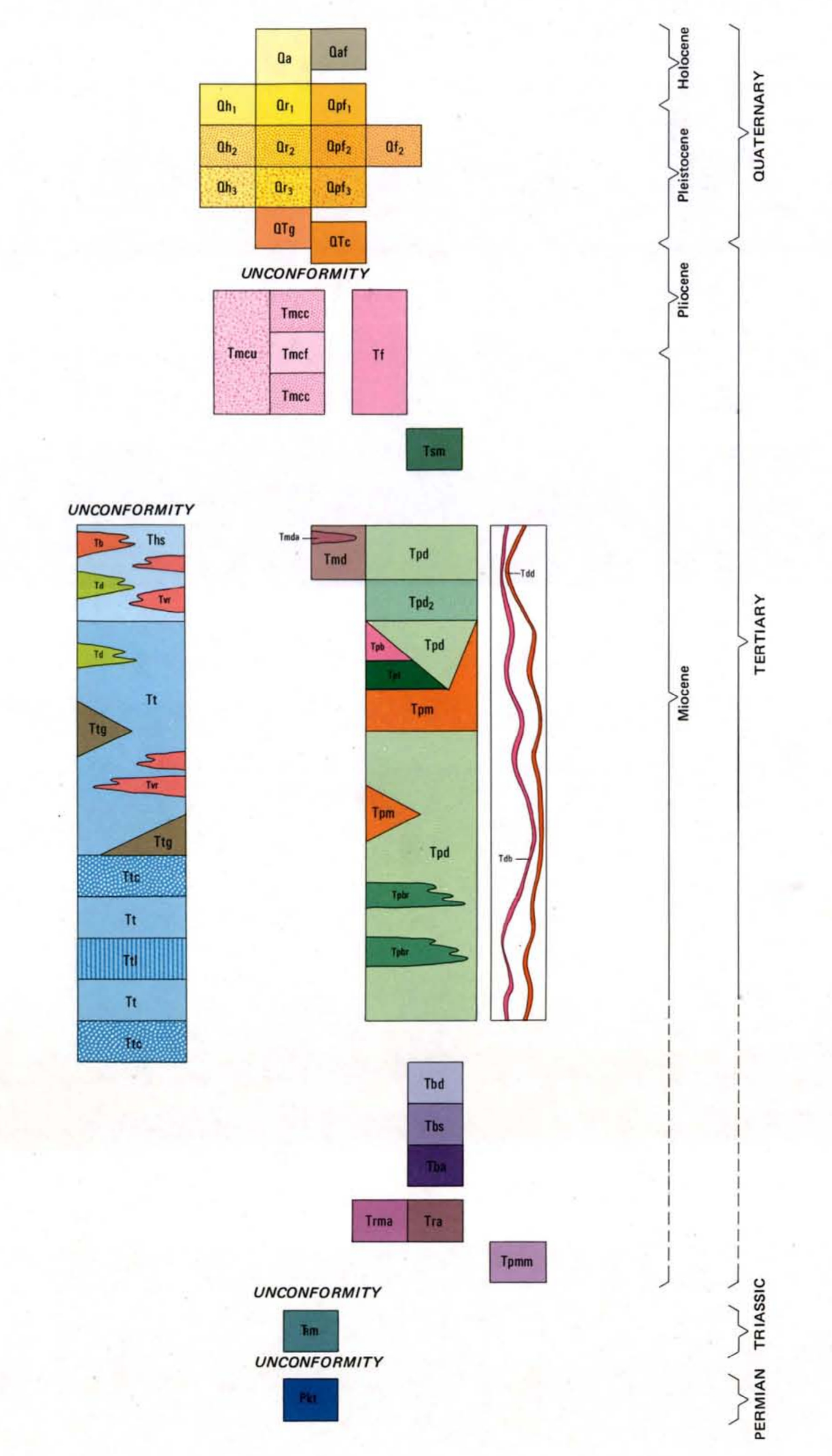




Scale 1:24,000

0 0.5 1 KILOMETER
1000 METERS

0 0.5 1 MILE
0 2000 4000 FEET

CONTOUR INTERVAL 40 FEET
DOTTED LINES ARE 20–FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

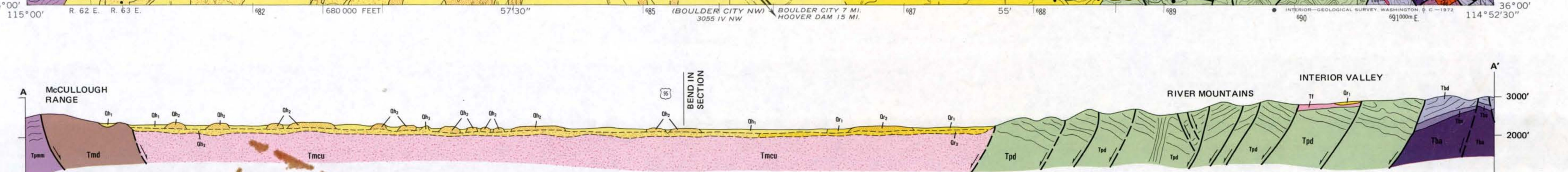
Contact. Dashed where approximately located, dotted where concealed.

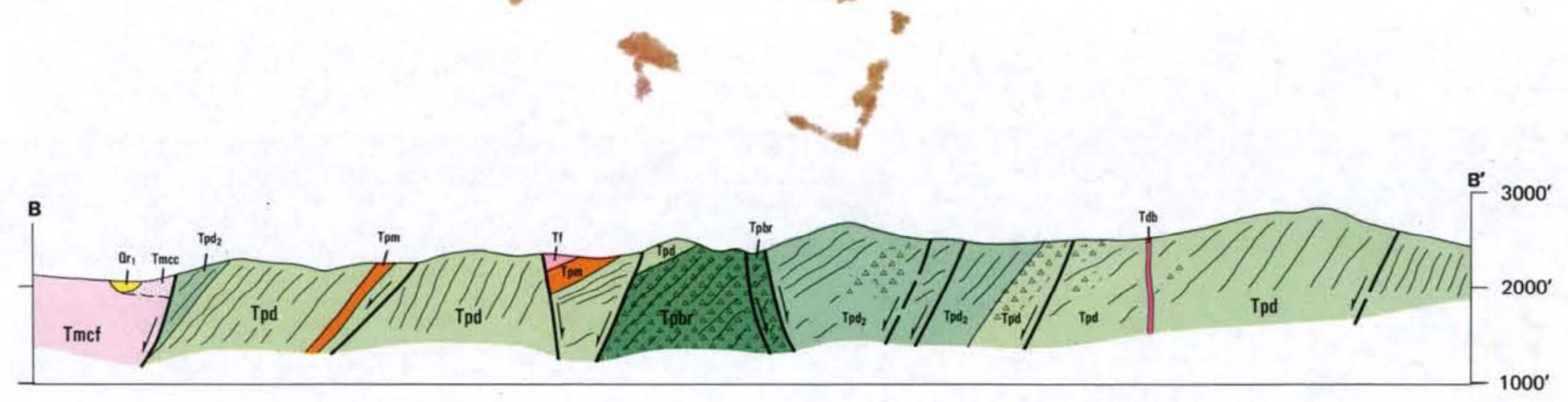
Fault. Dashed where approximately located, dotted where concealed, ball on downthrown side, arrow indicates fault plane attitude.

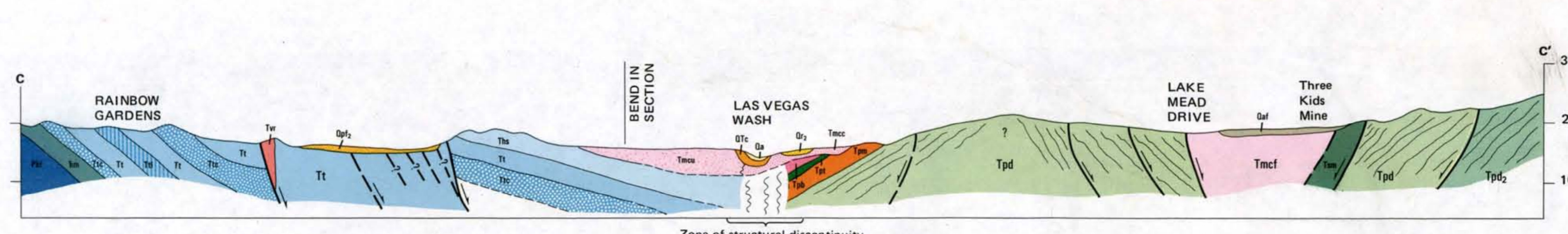
Strike and dip of beds.

Strike and dip of foliation.

Breccia zone.







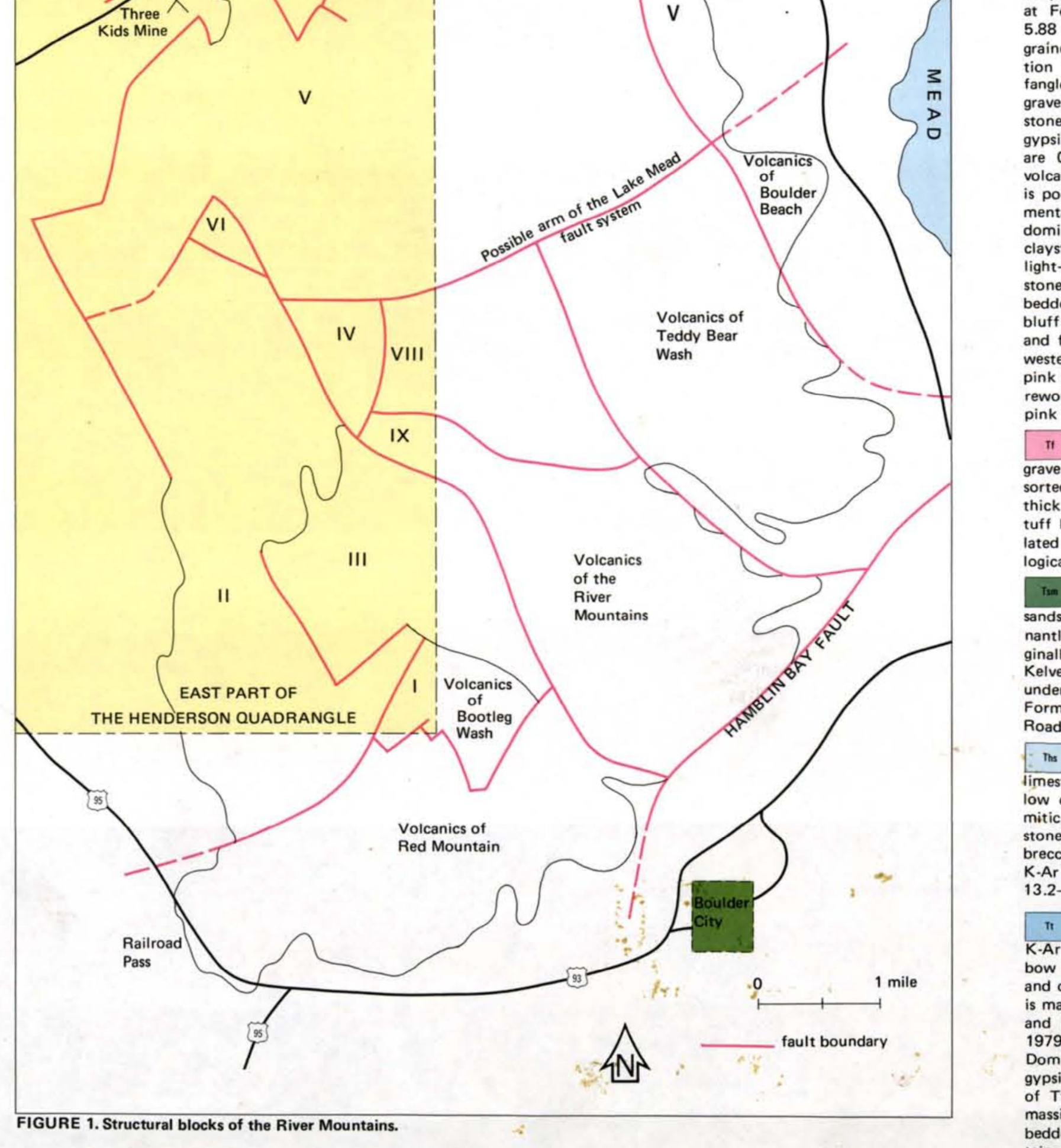


FIGURE 1. Structural blocks of the River Mountains.

Mapping in the northern part of the River Mountains based in part on Weskamp and Pavlovich (1968). Mapping in the Frenchman Mountain-Rainbow Gardens-Las Vegas Wash area based in part on Brenner-Tourtelot (1979) and Longwell (unpublished mapping).

LITHOLOGY

Sedimentary Rocks

QUATERNARY DEPOSITS

Qaf **Artificial fill.** Settling ponds of Basic Management, Inc. cover areas of Qh_1, Qr_2, Qf_2, and Qa; sanitary land fill covers Qr_1, Qr_2, and Ths; tailings from Three Kids Mine cover Qr_1, Qr_2, QTg, Tmcf, and Tsm.

Qa **Modern wash deposits.** Dominantly sandy pebble to cobble gravel; anastomosing bar and channel network; poorly to very poorly sorted, poorly to moderately stratified, non-indurated. Las Vegas Wash area contains mostly salt-rich silty sand, and has a deep knickpoint that is rapidly migrating upwash. No soil development. Deposits generally <3 m (10 ft) thick.

Qh_1 Qh_2 Qh_3 **Pediment and fan deposits of Henderson.** Silty, sandy pebble gravel; composed dominantly of dacite clasts derived from the volcanic rocks of the McCullough Range. Poorly to very poorly sorted, poorly to moderately stratified. Qh_1: Anastomosing network of undifferentiated Holocene alluvium, occurring in low wash terraces, and modern wash deposits (Qa); deposits are non-indurated; low terraces are characterized by bar and channel topography with incipient desert varnish and desert pavement. Soils under terraces have A–C profiles with incipient calcic horizons as much as 50 cm (20 in.) thick. Deposits generally 1–2 m (3–6 ft) thick. Qh_2: Slightly indurated deposits underlying broad, flat interfluvial surfaces; moderately to well-developed desert varnish and desert pavement with basaltic lag boulders commonly 30 cm (12 in.) in diameter. Soils have dark-brown to yellowish-brown cambic and argillic B horizons 30–45 cm (12–18 in.) thick and moderately to well-developed calcium carbonate (Cca) horizons about 1 m (3 ft) thick. Deposits generally 1–2 m (3–6 ft) thick. Qh_3: Deposits underlying moderately to well-dissected fan surfaces and underlying most Qh_1 and Qh_2 deposits. Surfaces are generally rounded with moderately to well-developed desert varnish and desert pavement; basaltic lag boulders are commonly 0.3–1.0 m (1–3 ft) in diameter. Deposits are moderately indurated by seams and stringers of calcium carbonate. Remnants of soil have petrocalcic horizons up to 2 m (6 ft) thick. Total thickness uncertain; maximum exposed thickness about 5 m (16 ft).

Qr_1 Qr_2 Qr_3 **Pediment and fan deposits of the River Mountains.** Silty, sandy pebble to cobble gravel; composed dominantly of dacite clasts with locally high concentrations of basalt, tuff, and sedimentary clasts, all derived from the River Mountains area; locally rich in reworked and pedogenic gypsum. Poorly to very poorly sorted, poorly to moderately stratified. Qr_1: Anastomosing network of undifferentiated Holocene alluvium, occurring in low wash terraces, and modern wash deposits (Qa); deposits are non-indurated; low terraces are characterized by bar and channel topography with incipient desert varnish and desert pavement. Soils under terraces have A–C profiles with incipient calcic horizons as much as 50 cm (20 in.) thick. Deposits generally 1–3 m (3–10 ft) thick. Qr_2: Slightly indurated deposits underlying broad, flat interfluvial surfaces; moderately to well-developed desert varnish and desert pavement. Soils have dark-brown to yellowish-brown cambic and argillic B horizons 30–45 cm (12–18 in.) thick and moderately to well-developed Cca horizons about 1 m (3 ft) thick; soils locally have gypsic horizons. Deposits generally 1–3 m (3–10 ft) thick. Qr_3: Deposits underlying well-dissected fan surfaces in the Interior Valley and probably underlying most Qr_1 and Qr_2 deposits. Surfaces are generally rounded linear ridges with moderately to well-developed desert varnish and desert pavement. Remnants of soil have hard, well-cemented petrocalcic horizons 1–2 m (3–6 ft) thick. Total thickness uncertain; exposed thickness in the Interior Valley is about 6 m (20 ft).

Qpf_1 Qpf_2 Qpf_3 **Pediment and fan deposits of Frenchman Mountain.** Silty, sandy pebble to cobble gravel; composed of limestone, sandstone, siltstone, and quartzite clasts with locally high concentrations of clasts of granite and gneiss, all derived from Frenchman Mountain area; locally gypsiferous. Poorly to very poorly sorted, poorly to moderately stratified. Qpf_1: Anastomosing network of undifferentiated Holocene alluvium, occurring in low wash terraces, and modern wash deposits (Qa); deposits are non-indurated; low terraces are characterized by bar and channel topography with incipient desert varnish and desert pavement. Soils under terraces have A–C profiles with incipient calcic horizons as much as 50 cm (20 in.) thick. Deposits generally 1–2 m (3–6 ft) thick. Qpf_2: Slightly indurated deposits underlying broad, flat interfluvial surfaces; moderately to well-developed desert varnish and desert pavement; few to no surface boulders; surface limestone clasts typically etched. Soils have dark-brown to yellowish-brown cambic and argillic B horizons 30–45 cm (12–18 in.) thick and moderately to well-developed Cca horizons about 1 m (3 ft) thick; soils locally have gypsic horizons. Deposits generally 1–3 m (3–10 ft) thick. Qpf_3: Deposits underlying well-dissected fan surfaces; surfaces are generally rounded linear ridges with moderately to well-developed desert varnish and desert pavement. No diagnostic soils, but deposits are locally highly gypsiferous. Unit may in part be equivalent to QTg. Deposits generally 1–10 m (3–33 ft) thick.

Qf_2 **Pediment and fan deposits, undifferentiated.** Deposits near Las Vegas Wash derived from interfingering of Qh_2 and Qr_2 sediments.

QUATERNARY-TERTIARY DEPOSITS

QTg **Older alluvial-fan deposits.** Sandy pebble to boulder gravel; in the River Mountains area, composed dominantly of dacite clasts and typically gypsiferous; in the Frenchman Mountain area, composed of granitic and gneissic clasts. Fan surfaces are well dissected and characteristically consist of rounded linear ridges; soils are preserved only as isolated petrocalcic remnants. Poorly to very poorly sorted; poorly to moderately stratified; moderately indurated. Deposits typically seen unconformably ovelying Tmcc and Tmcf. Deposits generally 1–10 m (3–33 ft) thick.

QTc **Conglomerate of Las Vegas Wash.** Sandy pebble to cobble conglomerate; composed of rounded and subrounded sedimentary, volcanic, granitic, and gneissic clasts cemented in sandy, calcareous matrix. Moderately to well sorted, generally well stratified with large-scale, fluvial crossbedding; well indurated. Deposits are restricted to a channel 0.5 km (0.3 mi) wide along Las Vegas Wash; deposits unconformably overlie (cut and fill) Tmcc and Tmcf, and are unconformably overlain by (or in part equivalent to) QTg. Prominent ledge former along wash. Estimated thickness 15–30 m (50–100 ft).

TERTIARY ROCKS

Tmcc Tmcf Tmcu **Muddy Creek Formation.** Extensive basin-fill sediments of lacustrine and subaerial origin (Longwell and others, 1965); mapped as unnamed formation by Brenner-Tourtelot (1979) and as QTcs by Bingler (1977). Formation unconformably overlies Ths and is generally gently dipping except where disrupted by faulting. Total thickness in quadrangle >100 m (325 ft). Formation is overlain by a basalt at Fortification Hill in the Lake Mead area, K-Ar dated at 5.88 ± 0.18 m.y. (Damon and others, 1978). **Tmcc**: Coarse-grained facies comprises upper and lower portions of the formation in this area and consists of yellowish- to reddish-brown fanglomerate; well-cemented coarse sandy, pebble to cobble gravel. Deposits locally contain interbedded gypsiferous siltstone, and in the area near North Shore Road, they consist of gypsiferous pebbly sand. Upper portion is well bedded (beds are 0.3–0.6 m [1–2 ft] thick) and consists dominantly of volcanic pebbles 1–2 cm (½–1 in.) in diameter. Lower portion is poorly to moderately bedded and consists of volcanic, sedimentary, gneissic and granitic clasts. **Tmcf**: Fine-grained facies; dominantly gypsiferous pink to red siltstone, sandy siltstone and claystone; upper portions contain massive beds of white to light-pink gypsum; locally manganese-rich; beds of whitish siltstone and claystone locally occur throughout. Deposits are thin bedded (shaly) to massive; the unit is a prominent badland and bluff former in Las Vegas Wash-Lake Mead area. **Tmcu**: Coarse- and fine-grained facies, undifferentiated. In the area along the western flank of Frenchman Mountain area, unit consists of pink gypsiferous pebbly sand and sandy gravel, containing clasts reworked from older sedimentary rocks, interbedded with pink to white siltstone.

Tf **Fanglomerate of the Interior Valley.** Yellowish-brown to reddish-brown fanglomerate; sandy pebble to cobble gravel composed of volcanic clasts in a calcareous matrix. Poorly sorted; moderately to well bedded with 1.2–15 cm (½–6 in.) thick beds common; well indurated. Contains one or more tuff layers 15 cm (6 in.) thick. Deposits contained within isolated basins and pockets in the River Mountains; sedimentologically similar, and probably equivalent, to Tmcc.

Tsm **Manganiferous sedimentary rocks of the Three Kids Mine.** Gray to black manganese-rich tuff, tuffaceous sandstone and siltstone; moderately to well bedded. Dominantly of pyroclastic origin; variably reworked by water. Originally mapped as part of the Muddy Creek Formation (McKelvey and others, 1949; Longwell and others, 1965). Deposits underlie Tmcf; they are probably older than the Muddy Creek Formation and may be part of the volcanic rocks of Powerline Road.

Ths **Horse Spring Formation.** Carbonate rocks; dominantly light to pinkish gray; finely to medium crystalline limestone and siliceous limestone with interbedded white to yellow calcareous siltstone and shale. Deposits locally are dolomitic and lithium bearing (Brenner-Tourtelot, 1979). Limestones are generally thick bedded to massive, and commonly brecciated. Intruded by and interbedded with Tb, Td, and Tvr. K-Ar ages in the Muddy Mountain-Gale Hills area range from 13.2–21.3 m.y. (Anderson and others, 1972).

Tt Ttc Ttl Ttg **Thumb Formation.** Continental red-bed and limestone deposits. K-Ar ages on intrusive and interbedded volcanic rocks in Rainbow Gardens (Tvr) range from about 11–17 m.y. (Anderson and others, 1972). In the Muddy Mountains area the formation is mapped as the lower member of the Horse Spring Formation and is fission-track dated at about 13–17 m.y. (Bohannon, 1979a). **Tt**: Comprises major portion of Thumb Formation. Dominantly red to pink calcareous siltstone and sandstone, gypsiferous shale and claystone; contains undifferentiated beds of Ttc conglomerate, Ttl limestone and Tvr; locally contains massive beds of gypsum. Siltstone and sandstone are well bedded with beds commonly 2.5–15 cm (1–6 in.) thick. Contains several Tvr flow interbeds and dikes. **Ttc**: Gray to red calcareous pebble to cobble conglomerate; occurs as a basal facies and as interbeds throughout the lower half of the formation. Characteristically contains subrounded to well-rounded clasts of pre-Tertiary limestone, sandstone and quartzite in a well-cemented sandy matrix; contains no Ttg-type granitic or gneissic clasts. Beds are very resistant and are prominent ridge formers. **Ttl**: Dominantly pink to light-brown finely crystalline to clastic limestone (calcarenite to calcirudite); contains intercalated red siltstone and sandstone; may be locally conglomeratic. Unit occurs in lower half of formation. **Ttg**: Masses and beds of brecciated basement rock and breccia occurring within Tt; believed to be of massive landslide origin (Longwell, 1974). Basement rocks are presumed to be of Precambrian age and derived from the Gold Butte Granite, now exposed in the Gold Butte area, south of the Virgin Mountains (Anderson, 1973; Longwell, 1974). Rock types include: rapakivi granite, porphyritic microcline granite, gneissic garnetiferous granite, quartz monzonite, gneiss, and quartzo-feldspathic schist. Deposits form prominent resistant knobs and pinnacles within Tt.

TRIASSIC ROCKS

Trm **Moenkopi Formation.** In this quadrangle, formation consists of interbedded gray limestone, light-gray to green shale, yellow to yellow-green calcareous sandstone, red gypsiferous siltstone, and massive gypsum (site of White Eagle Mine).

PERMIAN ROCKS

Pkt **Kaibab and Toroweap Formations.** In this quadrangle, formations consist dominantly of medium-gray, finely to medium-crystalline limestone and siliceous limestone, and clastic limestone (calcarenite to calcirudite). Beds of siliceous limestone have dark coatings of desert varnish, giving outcrops a characteristic striped appearance.

Volcanic Rocks

MID-TERTIARY ROCKS

Tpd Tpd_2 Tpm Tpb Tpbr Tpt **Volcanic Rocks of Powerline Road. Tpd**: Numerous flows of texturally variable, plagioclase-, biotite-, and hornblende-bearing dacite. Interbedded with epiclastic sandstone, conglomerate and breccia, and thin pyroclastic units. Dacite lavas are commonly flow banded and display large amplitude flow folds. In the SE/4,S11,T22S,R63E flow banding is highly contorted; plunging flow folds have wavelengths of 30–60 m (100–200 ft) and amplitudes of about 60 m (200 ft). Flows vary in color from grayish red to grayish yellow green. Zeolitized flows are white. The upper and lower parts of many flows are brecciated, and basal (and less commonly upper) vitrophyre zones are present. Spherulitic dacite is the dominant rock type in the NE/4,S36,T21S,R63E to the east of the Three Kids Mine. Spherulites vary in size from <0.5 cm (0.2 in.) to >5 cm (2 in.). The resistant spherulites are easily plucked from a soft perlitic matrix and become a locally important component of wash deposits. Just to the south of the Three Kids Mine, dacite is very fine grained and contains xenoliths of porphyritic dacite and andesite. Tpd forms a broad lava shield. Flow direction studies indicate the source of most of the flows lies to the east of the quadrangle, however a probable source is in the NW/4,S25,T22S,R63E. Here the roots of a northwest-trending, fan-structured dome are exposed. A yellow-green pyroclastic unit containing abundant fragments of pumice up to 15 cm (6 in.) in size crops out to the north of Lake Mead Drive in S27,T21S,R63E. Tpd is equivalent to the rhyodacite unit (Trr) of Anderson (1977). **Tpd_2**: Grayish-red to red dacite flows with plagioclase, biotite and hornblende as phenocrysts. The unit varies in thickness from 45–60 m (150–200 ft), and contains numerous xenoliths of dark-gray andesite. Tpd_2 is an important marker horizon in the northern River Mountains. **Tpm**: Basalt and andesite flows. K-Ar dated at 11.8 ± 0.5 m.y. by Anderson and others (1972). Three varieties crop out in the map area: 1) Basalt with phenocrysts of augite (up to 1 cm [0.4 in.]) in size, and plagioclase set in a grayish-red-purple matrix. Many flows have vesicular and fine-grained tops, and coarsely porphyritic interiors. The basal parts of several flows have been enriched in augite phenocrysts due to gravitational settling. 2) Aphyric platy basalt containing microscopic crystals of plagioclase, augite and olivine. 3) Andesite with plagioclase, hornblende, and augite phenocrysts. Varieties 1 and 2 are interbedded with agglomerate and breccia. A thick agglomerate unit overlies Tpm along the eastern margin of the quadrangle in S6,T22S,R64E. This area probably is close to the source of the flows. **Tpb**: Dark-gray porphyritic olivine basalt flows crop out to the north of Lake Mead Drive. Olivine is subhedral to euhedral (up to 0.5 cm [0.2 in.] in size) and is set in a glassy matrix containing small plagioclase laths and subhedral augite crystals. The flows are interbedded with agglomerate and breccia. **Tpbr**: Thick section of poorly bedded, unsorted, monomictic breccia interstratified with Tpd. Clasts range in size from <1 cm (0.5 in.) to >2 m (6.5 ft). Fragments are completely surrounded by fine-grained matrix. Probably deposited by mud flows. **Tpt**: Volcaniclastic unit containing well-bedded white to very light-gray ash and pumice lapilli, and red to orange sandstone and conglomerate. The pumice is locally interbedded with two thin (>1 m [3.3 ft] thick) flows of basalt. The pyroclastic beds may be air-fall deposits; the sandstones and conglomerates are water deposited. Tpt crops out only to the north of Lake Mead Drive where it separates Tpm from Tpb.

Tbd Tbs Tba **Volcanic Rocks of Bootleg Wash. Tbd**: Flows of gray to grayish-red well flow-banded dacite with plagioclase, biotite, hornblende and quartz phenocrysts. The unit is at least 60 m (200 ft) thick. The total thickness of Tbd is unknown since its upper parts are eliminated by faulting. Brecciation is common at the base of the unit. Basal vitrophyre is rare. Partly equivalent to the trachyandesite unit Trt of Anderson (1977). **Tbs**: Gray to red epiclastic sedimentary rock containing well-bedded and well-sorted sandstone, conglomerate and breccia. Some beds are rich in pumice lapilli, others contain abundant clasts of volcanic and plutonic rock. Mainly a water-deposited unit, but some of the breccia may have been deposited by mud flows. The unit is locally interbedded with a plagioclase, biotite-bearing dacite. In the extreme southeast corner of the map, Tbs is 35 m (115 ft) thick; however, the apparent thickness of this unit varies from <5 m (15 ft) to >60 m (200 ft). **Tba**: Dark-gray flows of andesite and andesite breccia. The unit has a minimum thickness of 25 m (80 ft). Plagioclase is the dominant phenocryst. Some units are weakly flow banded.

Trma **Volcanic Rocks of Red Mountain.** Highly altered and oxidized gray to light-red porphyritic intermediate lavas. The unit is cut by numerous dark-colored, plagioclase and biotite-bearing intrusions. Trma is sheared by several low-angle faults on Red Mountain just to the southeast of the Henderson quadrangle. Mapped as volcanic rocks (Trv) by Anderson (1977).

Tra **Volcanic Rocks of the River Mountains.** Numerous flows of dark-gray to black porphyritic andesite, 1–5 m (3–15 ft) thick. Vesiculation is common in the upper and lower parts of each flow. The interiors of some flows are coarsely porphyritic. Flows are cut by numerous sills and dikes of dark-gray plagioclase and biotite-bearing dacite, 3–15 m (10–50 ft) thick. Plagioclase phenocrysts in the intrusions characteristically have a greenish tint. The unit is part of a large stratovolcano centered on the River Mountain stock in the Boulder Beach quadrangle.

Tdd Tdb **Dikes. Tdd**: Dikes of dacite that vary in width from 1–150 m (3.3–490 ft), and in length from 200 m (650 ft) to over 2 km (1.25 mi). The rock is aphyric to porphyritic with plagioclase and biotite as dominant phenocrysts. **Tdb**: Dikes of basalt and andesite usually >3 m (10 ft) in width. Several dikes contain large augite phenocrysts and may be related to Tpm; others are fine grained. Dark-gray andesite dikes contain phenocrysts of plagioclase and hornblende. The density of Tdb dikes is greater than depicted on the map.

Tb Td **Volcanic Rocks North of Lake Mead Drive. Tb**: Basalt flows containing phenocrysts of plagioclase and augite. Commonly brecciated. Tb may be equivalent to Tpm to the south of Lake Mead Drive. **Td**: Dacite flows and breccia. Flows contain phenocrysts of plagioclase, biotite and hornblende and are commonly flow banded. Td may be equivalent to Tpd to the south of Lake Mead Drive.

Tvr **Volcanic Rocks of Rainbow Gardens.** Flows of aphyric to porphyritic lavas ranging in composition from basalt to dacite. Rock types are not differentiated on the map.

Tmd Tmda Tpmm **Volcanic Rocks of the McCullough Range. Tmd**: Numerous flows of gray to dark-gray dacite with plagioclase, biotite and hornblende phenocrysts. Vitrophyre is common at the base and top of each flow. Units are commonly flow banded. Flow breccia is present but uncommon. **Tmda**: Flows of plagioclase and augite-bearing andesite interbedded with Tmd. **Tpmm**: Numerous flows of andesite with plagioclase and augite as dominant phenocrysts. Rocks are gray, grayish purple and light brown; weathered surfaces are grayish yellow to light brown. Equivalent to andesite unit (Ta) of Anderson (1977).

STRUCTURE

GENERAL STRUCTURAL SETTING

Parts of the River Mountains, McCullough Range and Frenchman Mountain-Rainbow Gardens area lie within the Henderson quadrangle. The River Mountains are located to the northwest of Hoover Dam between Las Vegas Valley and Lake Mead. They are bounded to the south (and possibly to the north) by arms of a northeast-trending, left-lateral shear zone described by Anderson (1973) and named the Lake Mead fault system by Bohannon (1979b). The arm of the Lake Mead fault system that bounds the River Mountain to the south was named the Hamblin Bay fault by Anderson (1973). Within the range, slices of different mid-Tertiary volcanic edifices are juxtaposed along splays of the Hamblin Bay fault (fig. 1). In the Henderson quadrangle the bedrock consists of a thick pile of dacite flows, and mudflow breccia and pyroclastic deposits. In the north near Lake Mead Drive, this sequence is interbedded with basalt and andesite flows. Reconnaissance mapping in the River Mountains was done by Longwell (1963; and unpublished mapping). Parts of the River Mountains were previously mapped by McKelvey and others (1949), Weskamp and Pavlovich (1968), Anderson (1977), Brenner-Tourtelot (1979), and Smith (1979).

The Frenchman Mountain-Rainbow Gardens area is a northeast-trending group of peaks, linear ridges and valleys located just to the northwest of the River Mountains and to the east of the city of Las Vegas. Bedrock consists of a generally southeast-dipping, highly faulted section of Paleozoic through Tertiary sedimentary rocks lying on a basement of Precambrian gneiss, schist and granite. Previous mapping in the Frenchman Mountain area was done by Longwell (unpublished mapping), Longwell and others (1965), and Brenner-Tourtelot (1979).

The McCullough Range is a north-south-trending range that extends from the California-Nevada state line to just south of Henderson. The northern part of the range is predominantly Tertiary volcanic rock, but the southern part is composed almost entirely of Precambrian basement rock. Bingler (1977), Anderson (1977), and Bingler and Bonham (1973) previously mapped parts of the McCullough Range.

Las Vegas Valley is bounded on the east, southeast, and south by Frenchman Mountain, the River Mountains and the McCullough Range, respectively. The valley is a deep structural basin containing hundreds of meters of sediments of Muddy Creek age and younger. The Joe W. Brown, Wilson Federal No. 1 oil well (located about 13 km [8 mi]) northwest of the quadrangle penetrated more than 914 m (3000 ft) of basin fill before encountering the Horse Spring Formation. The valley floor is cut by a series of linear and curvilinear fault scarps of early- to mid-Quaternary age, and the Frenchman Mountain piedmont is cut by numerous fault scarps possibly as young as late Pleistocene. None of these young faults, however, extend into this quadrangle.

THE RIVER MOUNTAINS

Structural Blocks

The River Mountains in the Henderson quadrangle can be divided into nine fault-bounded, structurally different blocks (fig. 1).

I. Volcanic rocks of Bootleg Wash are broken by northwest- and northeast-trending faults. In general, the northeast-oriented faults are downthrown to the northwest and the northwest-trending faults are downthrown to the northeast. Slickensides on steeply dipping fault surfaces suggest dip-slip motion predominantly on both fault sets.

II. In this block, coplanar northwest-striking, southwest-dipping faults cut dacite flows and breccia units that dip to the northeast. The northern boundary of the block is a complex set of northeast-trending, southeast-dipping normal faults. The block's eastern boundary is formed by a northwest-striking fault that may be a continuation of a major splay of the Hamblin Bay fault.

III. The Interior Valley is a structurally controlled depression filled with fanglomerate deposits (Tf). The basin is bounded on three sides by faults. The fanglomerate deposits are presumably the protected remnants of a once extensive sedimentary layer. The thickness of sediments within the basin is unknown.

IV. Just to the north of the Interior Valley, dacite and breccia units strike east-west and dip steeply to the south. This block is bounded to the north by a major fault that may be part of the Lake Mead fault system. To the east, the same fault juxtaposes the volcanic rocks of Teddy Bear Wash and Powerline Road (fig. 1). The block is bounded to the west by a steeply dipping normal fault. To the south the same fault terminates the River Mountain stratovolcano (Tra) and may join the Hamblin Bay fault to the north of Boulder City. The interaction of these faults may have rotated the block in a counterclockwise manner, thus explaining its east-west orientation (almost perpendicular to the bedding and flow banding in adjacent blocks).

V. The structure of the northern part of the River Mountains is a broad anticline. In the Henderson quadrangle volcanic rocks of Powerline Road strike north-northwest and dip to the west. To the east in the Boulder Beach quadrangle, volcanic rocks of Powerline Road dip to the east. In block V volcanic rocks are cut by northwest-, east-west-, and northeast-trending fault sets. Displacements are greatest along the northwest set. Strike separation along the fault that bounds the Three Kids Mine (the Lowney Fault of McKelvey and others, 1949) is about 1.6 km (1 mi). Each northwest-trending normal fault is downthrown to the east, thus displacing northwest-dipping flows progressively to the southeast.

VI. A small triangular graben containing basalt, dacite and fanglomerate is wedged between blocks II and V. The units dip gently (about 25°) to the west.

VII. To the north of Lake Mead Drive, and separated from the other blocks by a major fault, is a highly faulted west-plunging anticline. The south limb is formed by steeply dipping basalts and dacites. The core of the structure is composed entirely of dacite flows and breccias. The north limb is formed by two basalt flows (Tpm and Tb) separated by waterlain and air-fall tuff (Tpt). The south limb of the structure is broken by northeast- and northwest-trending normal faults. This block originally may have formed the nose of the broad anticline of block V, but motion along the Lake Mead fault system may have transported it in a left-lateral sense to its present location.

On a series of low hills to the southwest of block VII, dacite and basalt lie on thinly bedded carbonates of the Horse Spring Formation (Ths). The volcanic rocks are intensely brecciated along the contact; they may have slid (by gravity) along the irregular surface of the Horse Spring Formation to their present location.

VIII. This block is formed by north-striking, west-dipping ridges of dacite and basalt of the volcanic rocks of Powerline Road cut by sills and dikes of porphyritic basalt.

IX. Andesite flows and dacite dikes of this block are part of the River Mountain stratovolcano. Only the western margin and part of the core (the River Mountain stock) of the volcano are preserved in the River Mountains. The northern boundary of the block is a major west-northwest-trending fault zone. Because of brecciation and intrusive annealing, the map position of the fault is only approximately located.

Volcanic Source Areas

Few source areas for the volcanic flows were identified in the Henderson quadrangle. The source area for the volcanic rocks of the River Mountains is the vent of the River Mountain stratovolcano (now occupied by the River Mountain stock). The volcanic rocks of Powerline Road probably erupted from local centers, now occupied by dacite domes. One such dome in the NW/4,S25,T22S,R63E is elongated in a northwest direction parallel to the structural grain of block II.

Brenner and Glanzman (1979) suggest a caldera complex exists in the River Mountains. Their evidence includes: 1) "broken glass" fault patterns in the River Mountains and the Frenchman Mountain block; 2) volcanic agglomerate and faulting in the Three Kids Mine that may "represent resurgence of the central part of the caldera"; 3) the River Mountain stock, interpreted as the resurgent dome area of the caldera; and 4) ash within the Lovell Wash dolomite member (Horse Spring Formation) with a source in the River Mountains.

We find no structural or petrological evidence for a caldera in the River Mountains. The fault pattern within the River Mountains is systematic; it is not the random "broken glass" pattern described by Brenner and Glanzman, and it does not resemble fault patterns characteristic of resurgent domes within calderas (Smith and Bailey, 1968). The River Mountain stock occupies the neck of a mid-Tertiary stratovolcano, and is separated from neighboring volcanic rocks by major faults. It does not represent caldera resurgence. There are no major ash-flow sheets in the River Mountains. The nearest outcrops of ash-flow tuff (the Tuff of Bridge Spring) are in the El Dorado Mountains (Anderson, 1971). The source of this ash-flow tuff is unknown, but flow-direction studies (Brandon and Smith, unpublished) suggest a source to the southwest of the El Dorado Mountains. Therefore, the source of this ash-flow tuff is not in the River Mountains.

FRENCHMAN MOUNTAIN–RAINBOW GARDENS AREA

The part of Frenchman Mountain-Rainbow Gardens area that lies within the Henderson quadrangle is characterized by generally southeast-dipping Paleozoic through Tertiary sedimentary rocks that are cut by several prominent fault sets. Longwell (1974) describes the Frenchman Mountain block as being a sample of the foreland east of the Sevier orogenic belt, and Anderson (1973) further describes the block as a product of the intersection of multiple late Cenozoic normal and strike-slip faults.

In the vicinity of the White Eagle Mine (NW/4,S17,T21S, R63E) the Permian through Tertiary section is cut by northwest- to northeast-trending faults downthrown to the west and northwest with repetition of stratigraphic sections. Southeast of this area, near the four-corner intersection of S16,17,20, and 21, T21S,R63E, the Tertiary sedimentary section (Thumb and Horse Spring Formations) is displaced by a series of sub-parallel northeast-trending normal faults downthrown to the east. One major fault occurs within the siltstone and sandstone member of the Thumb Formation (Tt) and is prominently exposed at the Pinnacle. A second major fault, or series of faults, occurs in the Thumb Formation just below the contact with the overlying Horse Spring Formation. Exposures of the Horse Spring and Muddy Creek Formations immediately north of the Henderson quadrangle in S22,T21S,R63E also suggest that these units may be in normal-fault contact, but contact relationships are unclear.

Bounding the southwest flank of the Frenchman Mountain-Rainbow Gardens area is a major, northwest-trending, right-lateral shear zone. The zone is a possible splay of the Las Vegas shear zone that branches from the main fault to the northwest of the Frenchman Mountain block (Longwell, 1974). Evidence for right-lateral displacement in this quadrangle is the apparent westward bending of the Thumb Formation in S20 and 21, T21S,R63E. Along the shear zone to the northwest in the Frenchman Mountain quadrangle, a prominent linear resistant "spine" of deformed Thumb Formation conglomerate (Ttc) occurs to the northwest of "in situ" Ttc in the Frenchman Mountain block. This map pattern indicates horizontal transport of the Thumb Formation in a right-lateral sense. The southeast end of the zone appears to splay into several strands. There is no clear evidence this zone extends across Las Vegas Wash toward the Three Kids Mine and the River Mountains as suggested by Brenner-Tourtelot (1979).

Right-lateral movement along this zone ceased in late Cenozoic time, but was followed by normal faulting downthrown to the west. Strike-slip movement displaces sedimentary rocks as young as the Horse Spring Formation. Muddy Creek Formation deposits are not displaced by strike-slip faults; they are, however, down-faulted to the west along younger normal faults against the Thumb Formation. Mapping of Quaternary-age alluvial surfaces and fault scarps in the Las Vegas NE quadrangle (Bell, unpublished mapping) also shows multiple gravity-type faults as young as late Pleistocene age along this zone.

LAS VEGAS WASH

Several lines of evidence indicate a major fault zone may parallel Las Vegas Wash. The wash marks the boundary between volcanic rocks typical of the River Mountains, and sedimentary rocks and minor volcanics characteristic of the Frenchman Mountain-Rainbow Gardens area. Much of the volcanic rock and Tertiary sedimentary rock (Thumb and Horse Spring Formations) adjacent to the wash is highly brecciated and complexly faulted. Furthermore, a marked dip reversal occurs along the wash (see section C-C′). The nature of this faulting is speculative; however, it may be related to movement along the Lake Mead shear system. Movement on this zone predates Muddy Creek time, since the Muddy Creek Formation is in general flat-lying to gently dipping between Rainbow Gardens and the River Mountains. Where faulted, the Muddy Creek Formation is cut predominantly by north-northwest-trending normal faults. This fault zone is labelled on cross section C-C′ as a zone of structural discontinuity.

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Topographic base from U.S. Geological Survey Henderson 7½′ quadrangle, 1970
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