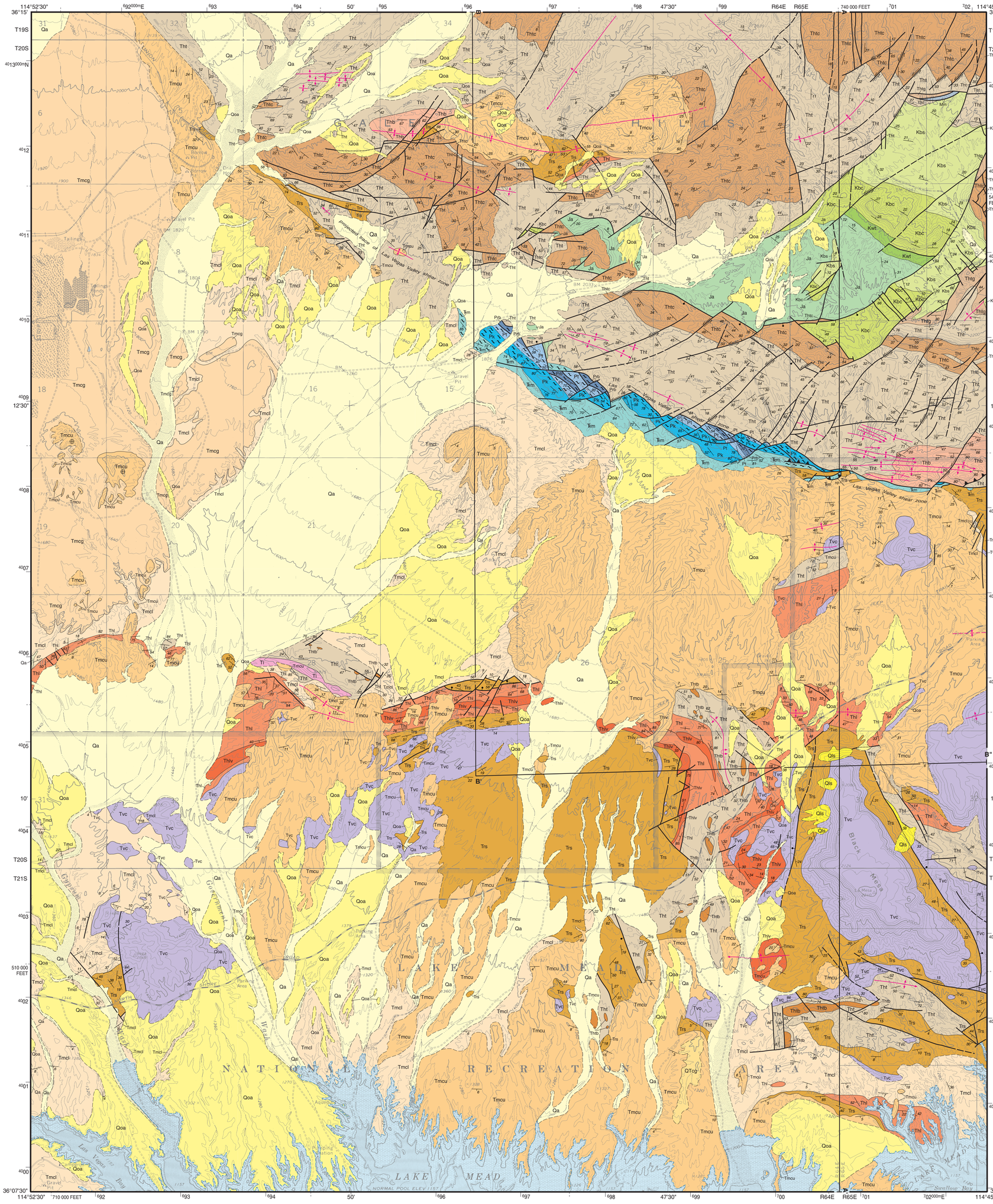


GEOLOGIC MAP OF THE GOVERNMENT WASH QUADRANGLE, CLARK COUNTY, NEVADA

Ernest M. Duebendorfer

2003

Qls **Landslide and talus deposits (Holocene)** Unconsolidated, angular cobble- to boulder-sized deposits consisting of basaltic andesite of the volcanic rocks of Callville Mesa. Locally derived. Mapped deposits are restricted to Black Mesa.

Qa **Alluvium (Holocene to Pleistocene)** Boulders, cobbles, pebbles, sand, and silt in active drainages and as alluvial fan deposits. Clasts are locally derived. Generally poorly sorted, variably rounded, and unconsolidated. Thickness is generally less than 3 m in southern and eastern parts of the map, but may be considerably thicker in the west-central part of the map.

Qoa **Older alluvium (Pleistocene?)** Boulders, cobbles, pebbles, sand, and silt present on elevated terraces and on inactive alluvial fans. Generally distinguished from modern alluvium by well-developed desert pavement and darker color on aerial photographs due to rock varnish. Generally poorly sorted, variably rounded, and unconsolidated to well cemented by caliche. Thickness ranges from 3 m to probably more than 20 m.

QTcg **Colorado River gravels(?) (Pliocene-Pleistocene?)** Conglomerate, weakly consolidated to unconsolidated and clast supported. Clasts range in size from 1 to 10 cm, are very well rounded, and include Paleozoic sandstone (Tapeats Sandstone or Supai Formation?), chert, Proterozoic gneiss, and Tertiary biotite-hornblende granite with abundant sphene (Wilson Ridge pluton), gray porphyritic dacite, and purple andesite. May contain some locally derived clasts of basaltic andesite of Callville Mesa. These latter clasts are somewhat larger and more angular than the other clasts. There is a conspicuous absence of Paleozoic carbonate clasts. Crops out only in the southeastern part of the quadrangle.

Muddy Creek Formation (late Miocene) Conglomerate, sandstone, siltstone, gypsum, and gypsiferous siltstone. Divided here into two members separated by prominent gypsum layer 3-10 m thick. The unit overlies youngest basaltic andesite flows of Callville Mesa (8.49±0.20 Ma, K/Ar plagioclase; Feuerbach and others, 1991) and is overlain by the lowest basalt flow at Fortification Hill (5.89±0.08 Ma, K/Ar plagioclase, Feuerbach and others, 1991) and is therefore bracketed between 8.5 and 5.9 Ma.

Tmcu **Upper member** Boulder-cobble conglomerate with minor sandstone and siltstone; tan to light brown, very poorly sorted, moderately to well indurated. Both clast- and matrix-supported conglomerates present. Resistant to weathering where well indurated. Heterogeneous clast suite dominated by Paleozoic and Mesozoic rocks, but also contains clasts of the Miocene Horse Spring Formation, dacite of Lava Butte, Proterozoic crystalline clasts that have been reworked from megabreccias in the Thumb Member of the Horse Spring Formation, intermediate and mafic volcanic rocks of the Hamblin-Cleopatra volcano and basaltic andesites that comprise the volcanic rocks of Callville Mesa. The latter clasts are generally locally derived. The unit locally exhibits fanning dips, particularly near the Las Vegas Valley shear zone. North of the Las Vegas Valley shear zone and in the eastern half of the quadrangle south of the Las Vegas Valley shear zone, the upper member overlies older Tertiary rocks with no intervening lower member. South of Black Mesa, unit mapped as upper Muddy Creek Formation is dominated by sandstone and gypsiferous siltstone. There appears to be a regional southeastward fining of the upper member. However, the possibility that this unit is actually the lower Muddy Creek Formation cannot be ruled out. Thickness uncertain but may locally exceed 50 m.

Tmcg **Gypsum** White to gray or pale yellow-orange gypsum. Locally contains variable amounts of silt and clay. More resistant than the lower Muddy Creek Formation and forms a weakly resistant ledge in the western part of the quadrangle. Unit is currently being mined by PABCO Gypsum. Thickness ranges from 3 to 10 m.

Tmcl **Lower member** Claystone, siltstone, gypsum, and gypsiferous siltstone, with minor sandstone and conglomerate. Claystone, siltstone, and gypsiferous siltstone are tan to light red or red-brown; sandstone and conglomerate are light tan. Unit tends to be more conglomeratic at base grading upward into gypsiferous sandstone and siltstone. In the western part of the quadrangle, the boundary between upper and lower Muddy Creek Formation (informal designations) is defined as the top of the extensive 3- to 10-m-thick white gypsum layer. There is a local angular discordance between the upper and lower members of the Muddy Creek Formation. The lower Muddy Creek Formation is present only in the western part of the quadrangle and south of the Las Vegas Valley shear zone. Thickness may locally be greater than 900 m (Bohannon, 1984).

Tvc **Volcanic rocks of Callville Mesa (Miocene)** Basaltic andesite flows, breccias, and rare plugs. Aphyric to porphyritic with variable phenocrysts of olivine (typically iddingsitized), clinopyroxene, and plagioclase. Generally, dark gray to black or purple-gray. Locally, flows and plugs contain xenocrysts of quartz and alkali feldspar (Feuerbach and others, 1991). Flows and breccias are locally interbedded with red sandstone and siltstone of the upper parts of the red sandstone unit. Basaltic andesite is locally vesicular, amygdaloidal, flow banded, and autobrecciated. Scoria is abundant in exposures in the southwestern part of the quadrangle. Distribution of the unit may in part reflect paleotopography. Ages range from 11.41±0.14 ($^{40}Ar/^{39}Ar$ whole rock, Harlan and others, 1998) to 8.49±0.20 (K/Ar plagioclase, Feuerbach and others, 1991).

Trs **Red sandstone unit of Boulder Basin (Miocene)** Conglomerate, sandstone, siltstone, gypsiferous siltstone, and megabreccia. Interbedded with lower flows and breccias of the volcanic rocks of Callville Mesa in stratigraphically higher parts of the section. Conglomerate is most abundant directly south of the Las Vegas Valley shear zone. Distinguished near the Las Vegas Valley shear zone from the Muddy Creek Formation by its position beneath a major angular discordance and the presence of abundant, generally subrounded volcanic clasts of both the Hamblin-Cleopatra volcano and Callville Mesa in conglomerate of the upper Muddy Creek Formation directly above the unconformity. Conglomerate is light tan to light brown, well indurated, poorly sorted with subrounded to angular clasts of Paleozoic and Mesozoic sedimentary rocks, Bitter Ridge Limestone Member, and white tuffaceous siltstone probably derived from the Lovell Wash Member. In upper parts of section, the red sandstone unit locally contains sparse, angular clasts of basaltic andesite of the volcanic rocks of Callville Mesa. Sandstone is typically fine to medium grained, tan, friable, weakly indurated, with conspicuous wavy laminae, ripples, and disturbed bedding. Siltstone and gypsiferous siltstone are tan to red, friable, and weakly indurated. In the vicinity of Black Mesa, the red sandstone unit consists of light tan sandstone and red gypsiferous siltstone with minor granules of basaltic andesite and is overlain by the volcanic rocks of Callville Mesa. Unit contains at least two prominent white ash beds (to 2 m). Due to lithologic similarity with other Tertiary units, lack of contiguous outcrop, and absence of age data on physically isolated exposures, the following stratigraphic criteria were employed to establish age equivalence to the red sandstone unit of Bohannon (1984). To be designated as red sandstone unit, the rock must be overlain unconformably by demonstrable Muddy Creek Formation and (1) overlie the Horse Spring Formation with angular discordance, (2) contain clasts of youngest Horse Spring Formation, or (3) contain angular clasts of the volcanic rocks of Callville Mesa (Duebendorfer and Wallin, 1991).

A 1- to 2-m-thick crystal vitric tuff about 50 m above the base of the red sandstone unit north of the Las Vegas Valley shear zone yielded a $^{40}Ar/^{39}Ar$ plateau date of 11.70±0.08 Ma on sanidine (Harlan and others, 1998). This unit may correlate with tuff dated by Bohannon (1984) at 11.2±1.2 Ma (zircon fission-track date).

South of Black Mesa are scattered exposures of megabreccia blocks including crackle and jigsaw breccia (cf. Yarnold and Lombard, 1989) up to several 100 m across. Host rock for the megabreccia is a gypsiferous siltstone. The megabreccias are composed of biotite quartz-feldspathic orthogneiss, weakly foliated diorite, and amphibolite. Megacrystic granite and garnet-biotite gneiss, which are abundant in the megabreccia blocks of the Thumb Member of the Horse Spring Formation, are conspicuously absent in these deposits. A hornblende-biotite dacite block from the megabreccia yielded a $^{40}Ar/^{39}Ar$ plateau date on biotite of 12.96±0.09 Ma (Harlan and others, 1998). Fracture surfaces on many blocks contain a blue amphibole of hydrothermal origin that has been identified as riebeckite and eudenite. This mineral is associated with fracture surfaces in the Wilson Ridge pluton south of Lake Mead. Both the 12.9-Ma age and the presence of blue amphibole, which must postdate the Wilson Ridge pluton, preclude these deposits being part of the Thumb Member of the Horse Spring Formation.

Ti **Intrusive rocks (Miocene)** Hypabyssal hornblende-plagioclase "diabase" that contains minor amounts of clinopyroxene and olivine. Sphene is an abundant accessory mineral. Occurs as a sill intruded into the Thumb Member of the Horse Spring Formation. Hornblende is distinctively needle-like in crystal form. Unit weathers into spheroids 1-5 cm in diameter. Present only in section 28, T20S,R64E in the central part of the quadrangle. Unit has been dated at 13.19±0.12 Ma ($^{40}Ar/^{39}Ar$ on hornblende, Harlan and others, 1998).

Horse Spring Formation (Miocene)

Thl **Thlv** **Lovell Wash Member** White to tan limestone, calcareous sandstone, tuffaceous sandstone and siltstone, and minor pebble conglomerate. Locally, white tuffaceous sandstone grades upward into white tuffaceous grit (clasts to 5 mm). Gritty unit also appears near the base of the Lovell Wash Member. With the exception of a small exposure in the north-central part of the map area, the Lovell Wash Member is restricted to the area south of the Las Vegas Valley shear zone. In the central part of the map area, the unit contains 50+ m-thick basalt flows and mafic volcanic breccias in the upper parts of the section (Thlv). Directly west of Black Mesa, the unit consists of yellow-orange limestone overlain by and interbedded with vesicular aphyric basaltic andesite, basalt agglomerate, white-tan tuffaceous sandstone, and calcareous-matrix-supported breccia that contains blocks of basalt. Some basalts are coarse grained, show diabasic texture, and could be sills. East of Black Mesa along the Callville Bay road the unit consists of white, red, brown, and yellow silty limestone and sandstone. In the Government Wash Quadrangle, unit thickness is highly variable and stratigraphic pinchouts, due to either nondeposition or subsequent erosion, are present. Three km east of the Government Wash Quadrangle, the thickness of unit is about 450 m.

An olivine phyric basalt flow interbedded with tuffaceous and calcareous sandstone and siltstone in the upper part of the of the Lovell Wash Member of the Horse Spring Formation yielded a whole-rock, $^{40}Ar/^{39}Ar$ plateau date of 13.17±0.10 Ma (Harlan and others, 1998). An aphanitic basalt yielded a whole-rock $^{40}Ar/^{39}Ar$ isochron date of 13.28±0.09Ma. These dates are consistent with the zircon fission-track date of 13.0±0.8 Ma reported from Lovell Wash by Bohannon (1984).

Thb **Bitter Ridge Limestone Member** White, yellow, and tan limestone and calcareous siltstone and fine-grained sandstone. Bedding thickness ranges from 1-30 cm. In the extreme eastern part of the map area, the Bitter Ridge Limestone forms a conspicuous, resistant, east-striking hogback. The Bitter Ridge Limestone Member is restricted to the area north of the Las Vegas Valley shear zone. In the north-central part of the map area, the Bitter Ridge Limestone contains a grit that is very similar to tuffaceous grit near the base of the Lovell Wash Member. Thickness is 375+ m (Bohannon, 1983). At Frenchman Mountain, approximately 8 km east of the Government Wash 7.5' Quadrangle, the Bitter Ridge Limestone Member contains clasts of the 13.50±0.16 Ma dacite of Lava Butte ($^{40}Ar/^{39}Ar$ on hornblende, C. Henry, personal commun. to Jim Faulds, 1997).

Tht **Thumb Member** Conglomerate, megabreccia, sandstone, siltstone, gypsum, gypsiferous siltstone, with minor limestone, tuff, and tuffaceous and calcareous sandstone. Conglomerate occurs as discontinuous, 1- to 3-m-thick layers in sandstone/siltstone sequence. Conglomerate is minor in the unit mapped as Tht in contrast to the conglomerate-dominated Thtc unit. Conglomerate and sandstone are brown, gray, red, and locally yellow. Clast types in the conglomerate include Paleozoic carbonates and sandstones(?) and Mesozoic sandstone, mostly Aztec Sandstone. North of the Las Vegas Valley shear zone, tan to red-brown sandstone and siltstone occur as parallel beds of uniform thickness that are locally graded, cross bedded, or parallel laminated. At least two pebble conglomerates that contain exclusively Proterozoic crystalline clasts occur low in the Thumb section north of the Las Vegas Valley shear zone; however, megabreccia blocks such as those present east of Frenchman Mountain and south of the Las Vegas Valley shear zone are not present. Light gray and green tuff beds to 8 m thick occur north of the Las Vegas Valley shear zone. In the extreme eastern part of the map area and north of the Las Vegas Valley shear zone, the Thumb Member fines upward into red and yellow calcareous sandstone and siltstone where it conformably underlies the Bitter Ridge Limestone Member. South of the Las Vegas Valley shear zone, the Thumb Member is dominated by gypsiferous siltstone, and gypsum, with subordinate sandstone and minor conglomerate. Megabreccia blocks (>tens of meters) are present south of the Las Vegas Valley shear zone. The Thumb Member is cut by a hornblende-clinopyroxene-plagioclase diorite sill that yielded a $^{40}Ar/^{39}Ar$ plateau age of 13.19±0.12 Ma on hornblende (Harlan and others, 1998). The most reliable lower age limit on the Thumb Member in the western Lake Mead area is 16.2±0.8 Ma (Bohannon, 1984, zircon fission-track date). This date is corroborated by a 16.2±0.5 Ma date from the Thumb Member in the Virgin Mountains (Beard, 1996, $^{40}Ar/^{39}Ar$ biotite date).

Thtc **Conglomerate facies** Well-indurated, moderately to poorly sorted, brown to gray-brown boulder-cobble conglomerate interbedded with minor sandstone. Maximum clast size locally exceeds 2 m, but averages 10-50 cm. Clasts types include Paleozoic and Mesozoic sedimentary rocks, chiefly carbonate and quartz sandstone, and vary from subrounded to subangular. Conglomerate varies from moderately well bedded to completely structureless over intervals in excess of 30 m thick. The conglomeratic facies of the Thumb Member is restricted to north of the Las Vegas Valley shear zone in the Government Wash Quadrangle. Thickness is less than 1,200 m (Bohannon, 1983).

Thtb **Megabreccia facies** Debris flow and rock avalanche deposits with individual clasts locally in excess of 10 m in length. Clast types include rapakivi and megacrystic granite, migmatitic garnet-biotite gneiss, coarse-grained leucogranite, amphibolite, medium-grained gabbro, pink megacrystic granite, hornblende schist and gneiss, fine-grained garnet-biotite schist. These rocks have been correlated to a source near Gold Butte, east of Overton Arm of Lake Mead (Parolini, 1986; Rowland and others, 1990).

Thtg **Gypsiferous facies** White to light gray gypsum and gray to pink-gray gypsiferous mudstone. Bedding indistinct to finely laminated.

Baseline Sandstone (Cretaceous)

Kbs **Baseline Sandstone** Well-sorted, well-rounded, medium-grained, moderately indurated, red, white, pale yellow and locally, pale green quartz arenite. Includes pebbly sandstone and minor pebble-conglomerate horizons. Clasts are well-rounded sandstone. Low-angle trough cross beds are common. Thickness is approximately 500 m in this quadrangle.

Kbc **Baseline Conglomerate** Conglomerate, sandstone, and siltstone. Yellow-gray and brown, well-indurated well-rounded boulder-cobble conglomerate, dominated by well-indurated quartz arenite (quartzite?) and Paleozoic(?) carbonate clasts. Minor interbeds of dull gray slabby calcareous sandstone, white to light-tan siltstone. Thickness is approximately 250 m in the quadrangle.

Kwt **Willow Tank Formation (Early Cretaceous)** Conglomerate, sandstone, siltstone, mudstone. Generally white to gray in color and nonresistant. Thickness is about 50 m in the quadrangle.

Ja **Aztec Sandstone (Jurassic)** Well-sorted, fine- to medium-grained, well-rounded red quartz arenite. Large-scale trough cross beds characterize the unit. Moderately indurated. Thickness is uncertain due to faulting but is at least 500 m.

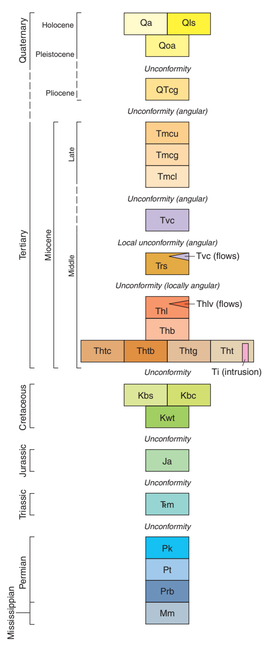
Ŧm **Moenkopi Formation (Early and Middle? Triassic)** Sandstone, siltstone, shale, gypsum, gypsiferous siltstone, and limestone. Sandstone is red to dark brown, and generally fine grained. Siltstone and shale are dark red to red-brown and contain conspicuously mottled blue-green beds and lenses. Ripple marks are commonly developed in finer grained units. The Virgin Limestone Member is a gray to light tan or yellow limestone that contains the distinctive fossil *Pentacrinus*. Thickness uncertain due to faulting and cover.

Pk **Kaibab Formation (Permian)** Gray to gray-brown, thickly bedded to structureless, cliff-forming limestone, sparse calcareous siltstone, and gypsum. Limestone contains abundant dark-brown chert nodules that are concentrated in bands imparting a striped appearance to the rock. Limestone is fossiliferous, with abundant crinoid stems, and ranges from fine- to medium-grained sparite to micrite. Gypsum is light gray to tan or pink and nonresistant. Present only as fault slivers within the Las Vegas Valley shear zone where it is locally very highly sheared.

Pt **Toroweap Formation (Permian)** Thickly bedded, gray to gray brown limestone with chert nodules and horizons. Similar in appearance to the Kaibab Formation, but bedding is somewhat better defined. Upper part of limestone is gray and crystalline and lacks chert. Gypsum is white to gray, yellow, or pink and nonresistant. Locally contains siltstone and mudstone horizons. Present only as fault slivers within the Las Vegas Valley shear zone where it is locally very highly sheared.

Prb **Permian red beds (Permian)** Pink-gray to pale yellow-orange sandstone and red siltstone. Sandstone is fine to medium grained and weakly to moderately indurated. Present only as fault slivers within the Las Vegas Valley shear zone where it is locally very highly sheared. Probably equivalent to the Hermit Formation.

Mm **Monte Cristo Formation (Mississippian)** Medium-grained dolostone with chert. Present only in northeast corner of map as fault slice or landslide block.



Lithologic contact Long dashes where approximately located, short dashes indicate structure form lines (cross section only), dotted where concealed.

Fault Showing dip; dashed where inferred or approximately located; dotted where concealed; bar and ball on downthrown side of normal-separation faults; arrows indicate relative motion along faults with known or inferred strike slip displacement; relative motion in cross section A, away from observer, T, toward observer.

Reverse fault Teeth on hanging wall.

Brittlely sheared and brecciated rock associated with the Las Vegas Valley shear zone.

Anticline Showing trace of axial plane and direction of plunge of axis; dotted where concealed.

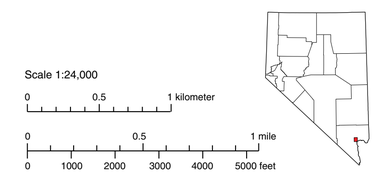
Syncline Showing trace of axial plane and direction of plunge of axis; dashed where inferred or approximately located.

Mesoscopic fold Showing direction of plunge and down plunge profile.

Strike and dip of bedding

Inclined · Overturned · Vertical · Horizontal

See accompanying text for figures, references, and a description and discussion of the geologic structure and stratigraphy of the Government Wash Quadrangle.



Scale 1:24,000

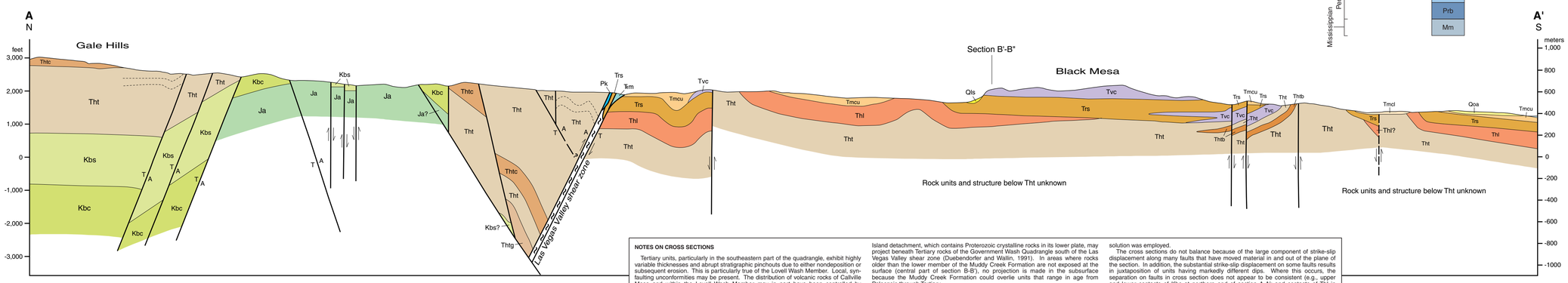
0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET

Base map: U.S. Geological Survey Government Wash 7.5' Quadrangle, 1970
Polyconic projection, 1927 North American Datum



NOTES ON CROSS SECTIONS

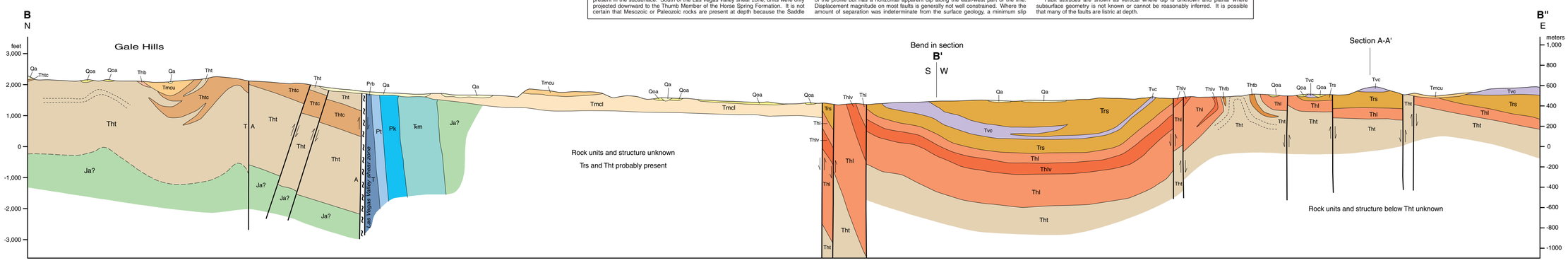
Tertiary units, particularly in the southeastern part of the quadrangle, exhibit highly variable thicknesses and abrupt stratigraphic pinchouts due to either nondeposition or subsequent erosion. This is particularly true of the Lovell Wash Member. Local, syn-faulting unconformities may be present. The distribution of volcanic rocks of Callville Mesa and within the Lovell Wash Member may in part have been controlled by paleotopography.

Projection of units in the subsurface was based on units exposed at the surface. In the region north of the Las Vegas Valley shear zone, units were projected downward to the Jurassic Aztec Sandstone although Triassic and Paleozoic rocks are probably present in the subsurface. South of the Las Vegas Valley shear zone, units were only projected downward to the Thumb Member of the Horse Spring Formation. It is not certain that Mesozoic or Paleozoic rocks are present at depth because the Saddle Island detachment, which contains Proterozoic crystalline rocks in its lower plate, may project beneath Tertiary rocks of the Government Wash Quadrangle south of the Las Vegas Valley shear zone (Duebendorfer and Wallin, 1991). In areas where rocks older than the lower member of the Muddy Creek Formation are not exposed at the surface (central part of section B-B'), no projection is made in the subsurface because the Muddy Creek Formation could overlie units that range in age from Paleozoic through Tertiary.

Due to highly variable dips throughout the area, it was not possible to construct cross sections that were everywhere normal to strike. Therefore, apparent dips locally result in a misleading portrayal of the structure. For example, near the bend in cross section B-B", the red sandstone has a southward dip along the north-south part of the profile but has a horizontal apparent dip along the east-west part of the line. Displacement magnitude on most faults is generally not well constrained. Where the amount of separation was indeterminate from the surface geology, a minimum slip solution was employed.

The cross sections do not balance because of the large component of strike-slip displacement along many faults that have moved material in and out of the plane of the section. In addition, the substantial strike-slip displacement on some faults results in juxtaposition of units having markedly different dips. Where this occurs, the separation on faults in cross section does not appear to be consistent (e.g., upper and lower contacts of Kbs at northern end of section A-A'; and contacts of Thl in central part of section B-B'). This is an artifact of honoring stratigraphic thickness constraints across faults that juxtapose units with significantly different dips. Finally, strike-slip displacement along faults results in juxtaposition of unlike sections in some cases.

Fault attitudes are shown as vertical where dip is unknown and planar where subsurface geometry is not known or cannot be reasonably inferred. It is possible that many of the faults are listric at depth.



Field work performed from 1990 to 1995.

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Field Review: R. Ernest Anderson, USGS, Denver; L. Sue Beard, USGS, Flagstaff; Stephen B. Castor, NBMG; James E. Faulds, NBMG; Stephen M. Rowland, UNLV; James Trexler, UNR.

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