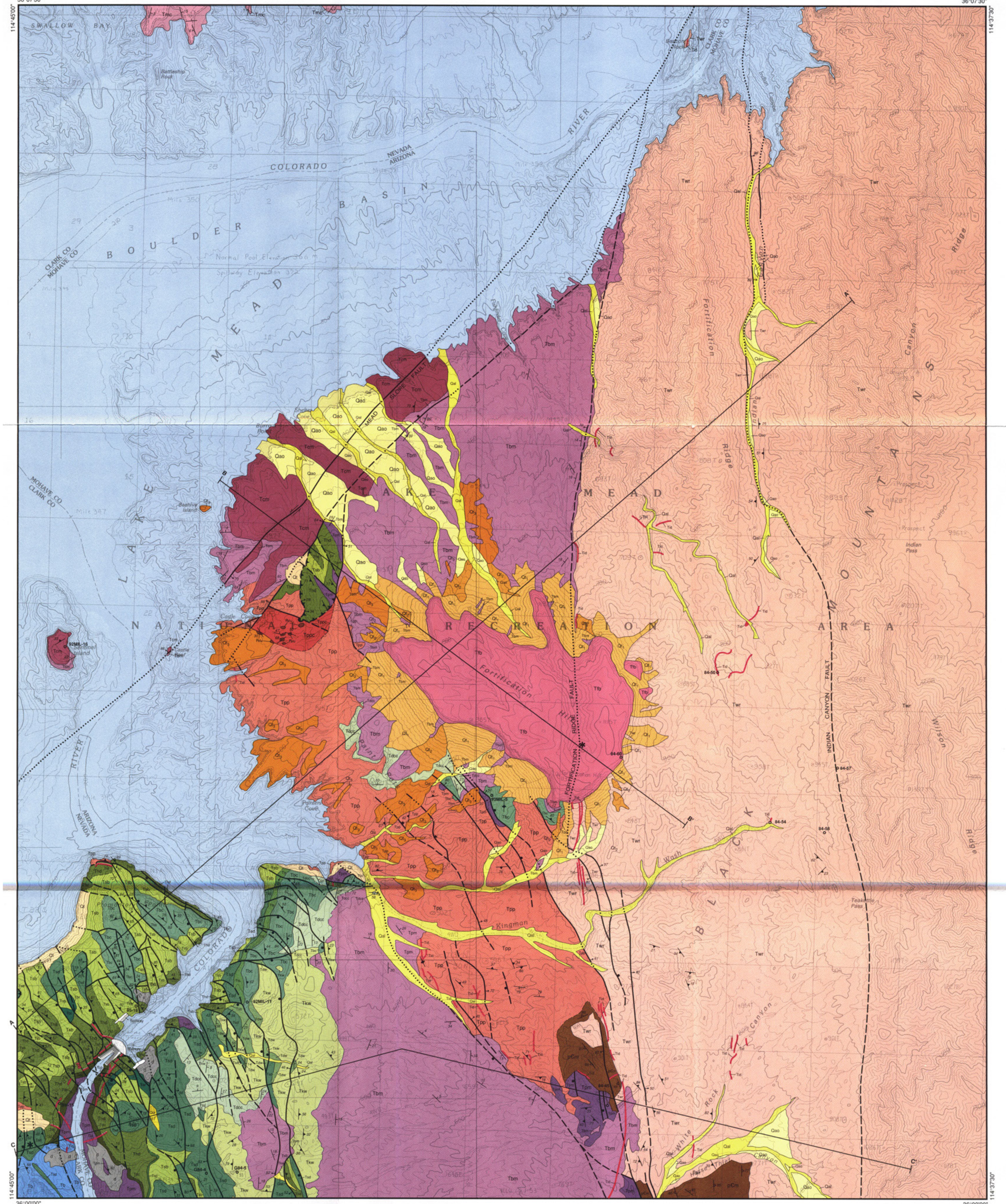
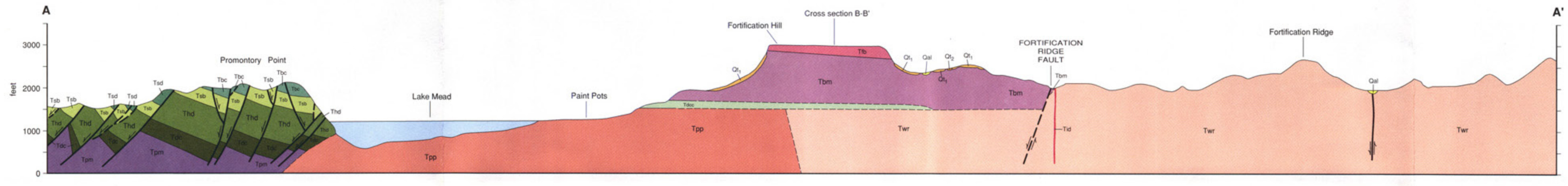
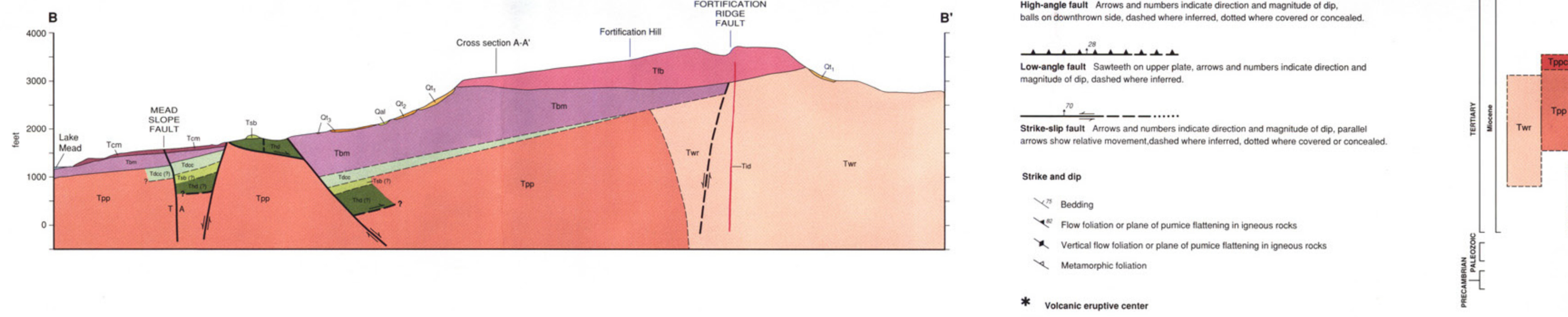
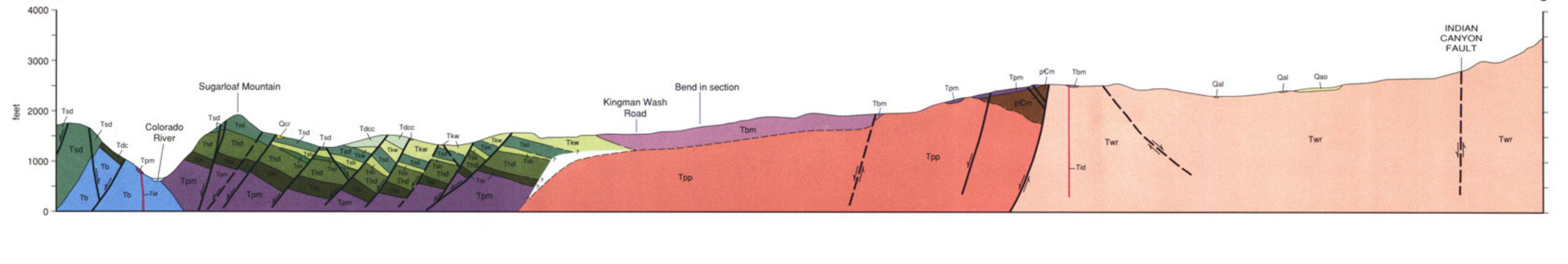








STRATIFIED ROCKS

d — Disturbed ground Talus piles formed from the dumping of excavated gravel during the construction of Hoover Dam.

Qal — Alluvium (Holocene) Modern unconsolidated wash deposits; angular to subrounded gravel and sand. Poorly sorted silt, sand, and gravel locally derived and deposited in active alluvial fans and washes. Deposits generally less than 3 m thick.

Qt — Talus Angular to subangular cobble to boulder deposits derived from local sources that may be covered with a thin (<10 cm) calcareous soil. Barren rock surfaces are usually coated with rock varnish.

Qt_1 — Talus Angular to subangular basaltic cobble to boulder deposits located on steep slopes adjacent to Fortification Hill. All talus deposits have a thin to thick coating of rock varnish.

Qao — Alluvium, older Moderately stratified, poorly to moderately sorted, unconsolidated deposits of angular to subrounded gravel and sand. Gravel beds may be imbricated and cross-stratified. Sand beds may be cross-stratified. Deposits up to 15 m thick.

Qt_2 — Talus, older Inactive talus slopes surrounding Fortification Hill composed of angular to subangular basaltic cobble- to boulder-sized rock.

Qt_3 — Pediment surfaces Typically represented by 1- to 3-m-thick deposits of cobble- to boulder-sized basalt of Fortification Hill and Wilson Ridge plutonic rock. These deposits are usually cemented by caliche.

Qcr — Paleo-Colorado River gravels Poorly to moderately lithified gravel beds up to 2 m thick. Clasts are subrounded to well rounded and range in size from coarse sand to 15-cm cobbles. Lithologies are representative of the Grand Canyon section (Precambrian granite, schist, and gneiss to Paleozoic carbonate and quartzite). The deposits are found only on the Arizona side of the dam along the eastern base of Sugarloaf Mountain in unconformable contact with Sugarloaf dacite.

Tfb — Basalt of Fortification Hill Over 55 flows up to 10 m thick of dark-gray to light-gray vesicular to massive basalt. The basalt commonly contains phenocrysts of olivine (3 to 4%, 1 to 3 mm, usually altered to iddingsite and/or serpentine), augite (1 to 2%, <1 to 1 mm, usually altered to hematite), and plagioclase (3%, 1 to 2 mm, usually altered to sericite). Amygdules of zeolite and/or calcite are common. These flows originated from cinder cone and fissure eruptions along the Fortification Ridge fault zone (D. Feuerbach, 1993, personal commun.) filling a northeast-trending paleo-channel eroded into the Black Mountains conglomerate and the Paint Pots and Wilson Ridge plutons. This unit was originally designated the Fortification Basalt Member of the Muddy Creek Formation by Longwell (1963) and Anderson and others (1972) but is here informally renamed the basalt of Fortification Hill due to the renaming of the Muddy Creek Formation by Mills (this map; see Tbm below). (K-Ar ages, 5.88 to 4.73 ± 0.2 Ma; Damon and others, 1978; Feuerbach and others, 1991.)

Tcm — Basalt of Callville Mesa Gray to black flows of olivine augite basalt lying in conformable contact with the Black Mountains conglomerate. Phenocrysts of olivine and pyroxene have been extensively altered to iddingsite and serpentine. Although similar in appearance and mineralogy to the basalt of Fortification Hill, the basalt of Callville Mesa is geochemically distinct. These flows were most likely erupted from vents at Callville Mesa, the local name for a volcanic field about 2 km northwest of Callville Bay on Lake Mead. Flow foliation attitudes were measured using the plane of flattening of vesicles within the basalt flows. K/Ar ages of plagioclase separates from the flows at Callville Mesa range from 10.46 ± 0.23 Ma (basal flows) to 8.49 ± 0.20 Ma (upper flows) (Feuerbach and others, 1991).

Tmc — Muddy Creek Formation (Longwell, 1936) Moderately to thickly bedded cross-stratified silt, sand, and gravel beds. Orange to red silt and sand beds are interbedded with, or separate from, thick beds of gravel. Gravel beds are clast supported. Clasts are <1- to 40-cm and are composed of variable proportions of gneiss, quartzite, chert, andesite, dacite, and basalt. Volcanic clasts are subangular to subrounded; other clasts are subrounded to well rounded. Near Callville Bay, tuffaceous(?) sand and basaltic gravels predominate. Bedding in the Muddy Creek Formation may be horizontal to moderately tilted (15°).

Tbm — Black Mountains conglomerate Poorly to moderately stratified conglomerate and sandstone composed primarily of clasts from the Wilson Ridge pluton. Locally, the unit contains a minor amount of clasts derived from the Patsy Mine and Hoover Dam volcanic sections and the Paint Pots pluton. Deposits range from well-sorted, medium-grained sand to poorly sorted subangular cobbles and uncommon boulders. This unit probably represents braided stream fanglomerate deposits. To the south of the map area, the basal conglomerate is composed predominately of Precambrian metamorphic and igneous clasts. The Muddy Creek Formation in the southern Lake Mead region (Longwell, 1936, 1963; Bohannon, 1984) is here renamed the Black Mountains conglomerate due to the distinct lithologic difference between these two units. In the southern map area, bedding dips gently (6° to 30°) to the east and northeast and in the northern map area bedding dips gently (11° to 21°) to the west.

Black Canyon assemblage

Tdcc — Dry Camp conglomerate (U.S. Bureau of Reclamation, 1950; Mills, 1985) Well-stratified conglomerate composed predominately of volcanic clasts from the Hoover Dam volcanic section and the Patsy Mine Volcanics. Igneous rock from the Wilson Ridge pluton forms the remainder of the clasts. The matrix is typically deep orange to red. Alternating coarse sand and gravel beds are typical of the unit. Uncommon horizons in the sandy beds reveal infilled mud cracks and low amplitude (1 cm) asymmetric ripple marks. Repeating beds of normally graded coarse sand and clay are common near the southwestern base of Fortification Hill. The upper contact of the Dry Camp conglomerate is unconformable with the Black Mountains conglomerate due to the steeper dip of the Dry Camp conglomerate. The Dry Camp conglomerate is distinguished from the Black Mountains conglomerate by its low percentage of plutonic clasts and abundance of Black Canyon assemblage volcanic clasts. This unit was originally named the Dry Camp Breccia by Ransome (U.S. Bureau of Reclamation, 1950).

Tkw — Kingman Wash Road basaltic andesite (Mills, 1985) Dark-gray, olivine-bearing basalt to basaltic andesite flows that crop out along Kingman Wash Road. Olivine phenocrysts are usually highly weathered and comprise 2% to 3% of the rock. Flows are massive to platy and locally exhibit rubbly bases and tops. Flow attitudes were taken on the plane of flattening of vesicles within the flows. Occasional partially assimilated xenoliths of Paleozoic carbonate up to 1 m in diameter may be found in flows along the southern boundary of the quadrangle. The source of the basalt flows is unknown. The basal contact of the Kingman Wash Road basaltic andesite is unconformable with the Sugarloaf dacite and conformable with the Dry Wash conglomerate. A whole-rock $^{40}Ar/^{39}Ar$ plateau age of 12.66 ± 0.1 Ma has been determined for the Kingman Wash Road basaltic andesite by Gans and Faulds (written commun., 1994). Flows of the Kingman Wash Road basaltic andesite were originally mapped by Ransome as flows of basalt and/or trachydolerite (U.S. Bureau of Reclamation, 1950).

Tdw — Dry Wash conglomerate Well-stratified coarse-grained sandstone and conglomerate typical of braided stream deposits. The sandstone and matrix sand in the conglomerate beds is typically red to reddish brown. The conglomerate beds are predominately clast supported with angular to subangular clasts composed of rock from the Wilson Ridge pluton and stratigraphically lower Black Canyon assemblage. Occasional horizons of scoriaceous basalt inferred to be from the initial eruption of the Kingman Wash Road basaltic andesite may be found in upper beds of the unit. The lower and upper contacts are conformable with the Sugarloaf dacite and the basaltic andesite of Kingman Wash Road respectively.

Tbc — Black Canyon dacite Biotite, hornblende, and plagioclase dacite. The dacite flow has a rubbly to massive dark-gray perlitic base where preserved and a pink devitrified flow interior. Aphyric mafic magmatic enclaves ranging in size from 1 to 10 cm are common. The enclaves typically have crenulate margins, are vesiculated and may contain sparse plagioclase phenocrysts. Rare granitic and mantled ultramafic (plagioclase, pyroxene, and phlogopite) xenoliths are present. The presence of enclaves distinguishes the Black Canyon dacite from the stratigraphically lower Sugarloaf dacite. The source of the Black Canyon dacite is unknown. The basal contact of the Black Canyon dacite is conformable with the lower tuffaceous sandstone and conglomerate. Flow attitudes were taken from both planes of flow banding and phenocryst alignment. This unit was originally mapped by Ransome as the part of Biotite Latite flow that crops out in the southern map area (U.S. Bureau of Reclamation, 1950).

Tts — Tuffaceous sandstone and conglomerate Thin- to thick-bedded, coarse-grained sandstone and conglomerate exposed only along the eastern wall of Black Canyon. The tuffaceous sandstone is green to greenish yellow and has common grains of plagioclase, biotite, and hornblende. The conglomerate is matrix to clast supported with a red to reddish-brown sandy matrix. Clasts in the conglomerate are typically composed of stratigraphically lower units within the Black Canyon assemblage. The basal contact is conformable with the Sugarloaf dacite.

Tsd — Sugarloaf dacite (Mills, 1985) Pink to pinkish-gray dacite flow. The dacite is porphyritic with plagioclase, biotite, hornblende, magnetite, and ilmenite forming the main phenocryst phases. The flow commonly has a porphyritic dark-gray, perlitic base up to 4 m thick and a white rubbly flow top up to 10 m thick where preserved. The source of the flow is a dome complex approximately 2 km southwest of Hoover Dam. The dome intrudes the lower Dam conglomerate and tuff of Hoover Dam as evidenced by vertical bedding in these units at the contact with the dome along the southern dome margin. The dacite flow may be underlain by green, dacitic reworked tuffaceous sedimentary rocks and dacitic flow breccia. The lower sedimentary unit thickens southward from the Hoover Dam area. The basal contact of the Sugarloaf dacite is conformable with the Switchyard basaltic andesite. The perlitic base of the dacite flow yielded an $^{40}Ar/^{39}Ar$ biotite plateau age of 13.11 ± 0.02 Ma (Gans and Faulds, written commun., 1994). Flow attitudes were taken from planes of flow banding and phenocryst alignment. Bedding contacts were used for strike and dip measurements in the lower tuffaceous sedimentary rocks. Ransome mapped the basal tuffaceous sedimentary rocks in this unit as Tuff and he named the upper dacite flow Biotite Latite (U.S. Bureau of Reclamation, 1950).

Tsb — Switchyard basaltic andesite (Mills, 1985) Platy to massive, dark- to light-gray flows and flow breccias of olivine to olivine- and augite-bearing basaltic andesite. The 1- to 2-mm olivine and augite phenocrysts are usually highly weathered. The flows and flow breccias are thickest on Promontory Point and were probably fed through a series of dikes and sills, some of which are exposed along the walls of Black Canyon directly below Hoover Dam. The Switchyard basaltic andesite is in unconformable contact with the tuff of Hoover Dam and in conformable contact with the Spillway conglomerate. Flow attitudes were taken from the plane of flattening of gas vesicles and from flow banding. This unit and several other basalt flows in the area were originally named Basic Latite and trachydolerite by Ransome (U.S. Bureau of Reclamation, 1950).

Tsc — Spillway conglomerate (U.S. Bureau of Reclamation, 1950; Mills, 1985) Well-stratified conglomerate and coarse-grained sandstone composed of angular to subangular Boulder City(?) plutonic and Patsy Mine volcanic clasts. The unit is very similar in composition and appearance to older and younger conglomerates exposed in the region and probably represents a braided stream deposit. The sandstone beds and sandy conglomerate matrix is red to reddish brown. This unit is exposed only in the Spillway Wash area and to the west of Hoover Dam near the Bureau of Reclamation warehouse. The basal contact is unconformable with the tuff of Hoover Dam. This unit was originally named the Spillway Breccia by Ransome (U.S. Bureau of Reclamation, 1950).

Tbr — Breccia Very localized clast-supported cobble- to boulder-sized breccia which underlies the Switchyard basaltic andesite. The breccias are composed of either basaltic andesite (Switchyard) on western exposures or dacitic clasts (compositionally similar to the Sugarloaf dacite) on eastern exposures. The unit only crops out 1 km to the east and west of Hoover Dam and appears to fill erosional channels in the top of the tuff of Hoover Dam. The source of the dacitic breccia has not been determined while the basaltic breccia most likely represents basal flow breccia of the Switchyard basaltic andesite. The breccia is in unconformable contact with the tuff of Hoover Dam.

Thd — Tuff of Hoover Dam (Smith, 1984) A dacitic, poorly to moderately welded, lithic ash-flow tuff. The tuff contains phenocrysts of plagioclase, biotite, hornblende, and ± clinopyroxene. Lithic fragments are representative of the Patsy Mine Volcanics and the Wilson Ridge pluton(?). The lithic content and size increases from about 15% (about 2 cm in size) south of Hoover Dam to over 75% (up to 1 m in size) on the north end of Promontory Point. The tuff thickens rapidly northward from Spillway Wash to the north end of Promontory Point. A basal surge deposit is present in the Spillway Wash area adjacent to the Hoover Dam spill pile (d). A 2-m-thick conglomerate interbedded between cooling units is exposed in several areas adjacent to Hoover Dam and in Spillway Wash. The lithology of the conglomerate is typical of other conglomerates in the area. The tuff is composed of numerous cooling units with poorly developed columnar jointing present in the uppermost cooling unit. Compositionally, the tuff is reversely zoned with respect to silica (59 to 66 wt% from base to top) (Mills, 1985). The basal contact of the tuff of Hoover Dam is conformable with the Dam conglomerate and may be sharp to gradational in nature. Bedding attitudes were taken from the plane of flattening of pumice fragments within the tuff. The base of the tuff of Hoover Dam yielded an $^{40}Ar/^{39}Ar$ biotite mean plateau/isochron age of 13.9 ± 0.1 Ma (Gans and Faulds, written commun., 1994). This unit was originally named the Latite Flow Breccia by Ransome (U.S. Bureau of Reclamation, 1950).

Tdc — Dam conglomerate (U.S. Bureau of Reclamation, 1950; Mills, 1985) Well-stratified conglomerate and sandstone composed of Boulder City(?) plutonic clasts, Patsy Mine volcanic clasts, and sparse Precambrian metamorphic clasts. The unit is distinguished by alternating beds of coarse sandstone and clast supported conglomerate. The sandstone beds contain weak to moderate crossbedding while the conglomeratic beds are composed of imbricated, angular to subangular, 1- to 15-cm clasts. The sandstone and sandy conglomerate matrix is deep red to reddish brown. The unit most likely represents deposition of detritus by braided streams which were infilling active fault basins in the area. The unit thickens rapidly from the Spillway Wash area (2 m thick) northward toward Hoover Dam (120 m thick). This unit is very similar in appearance and lithology to the conglomerates higher in the section. The contact between the Dam conglomerate and the Patsy Mine Volcanics is unconformable. This unit was originally named the Dam Breccia by Ransome (U.S. Bureau of Reclamation, 1950).

Tpm — Patsy Mine Volcanics, undifferentiated (Longwell, 1963; Anderson, 1971) Plagioclase-, augite-, and olivine(?)-bearing basalt and basaltic andesite flows and flow breccias. Flows may be interbedded with volcaniclastic sandstones. Local scoriaceous horizons are also present. The more steeply dipping Patsy Mine flows (about 35°) are unconformably overlain by less steeply dipping units (about 15°) of the Black Canyon assemblage. Flow attitudes were taken from flow banding and from the plane of flattening of gas vesicles. The lower contact of the Patsy Mine Volcanics is not exposed in the map area. The uppermost flows in the Hoover Dam area yielded an $^{40}Ar/^{39}Ar$ whole-rock modified plateau age of 14.19 ± 0.03 Ma (P. Gans and J. Faulds, written commun., 1994).

Pzlu — Paleozoic limestone and shale, undifferentiated Small 5- to 10-m^2 outcrops of Paleozoic limestone, cherty limestone and shale (Cambrian?) west of Fortification Hill. The limestone ranges from very light gray to a deep grayish green. The shales are thinly laminated and green to gray. The limestone and shale outcrops have been surrounded, assimilated, and altered by the Paint Pots pluton. The limestone is commonly altered to epidote along intrusive contacts with the pluton. Sparse corals have been found within some of the limestone blocks. The Tppc area on the map surrounding the outcrops indicates the extent of epidote and limestone clasts on talus and pediment surfaces.

pЄm — Precambrian metamorphic and igneous rocks Biotite-chlorite gneiss, almandine(?)-biotite gneiss, hornblende-biotite schist, amphibolite, and medium- to coarse-grained granitic pegmatite are the dominant Precambrian rock types. Strike and dip data were taken from foliation planes within the schists. Outcrops of Precambrian rock are commonly intruded by various phases of the Wilson Ridge and Paint Pots plutons.

INTRUSIVE ROCKS

Tid — Dikes Mafic, commonly composed of olivine basalt to olivine- and augite-bearing basaltic andesite. At the northern end of Wilson Ridge, north-trending, 1- to 2-m-thick mafic dikes are numerous but were not mapped due to the dike density. Three minette dikes crop out northeast of Fortification Hill on Fortification Ridge at the south end of Indian Canyon.

Tppc — Paint Pots pluton, carbonate block terrane Roof pendants of Cambrian(?) limestone and shale (Pzlu) within the Paint Pots pluton west of Fortification Hill.

Tpp — Paint Pots pluton Medium-grained to hypabyssal monzonite forms the dominant intrusive phase. Highly altered 1- to 2-mm plagioclase phenocrysts are the only identifiable phenocryst phase in the monzonite. Foliation attitude symbols on the map indicate areas where flow alignment of feldspar phenocrysts occur in the pluton. The monzonite is highly fractured, sheared, and faulted with pervasive hematitic and gypsiferous alteration throughout the pluton. Ubiquitous veins and veinlets of gypsum crosscut hematite-filled fractures. The pluton has been intruded by slightly younger porphyritic mafic dikes up to 1 m thick. Plagioclase (1 to 2%, 1 to 3 mm, altered to sericite) and biotite (<<1%, 1 to 2 mm, slightly altered) form the phenocryst phases within the dikes. On the northern edge of Promontory Point along the lake, the tuff of Hoover Dam and Switchyard basaltic andesite have been altered and intruded by the Paint Pots pluton. The pluton at this locality shows unequivocal evidence for magma mingling of a mafic and felsic phase. Magma mingling textures are present in several other areas of the pluton. The age relationship between the Paint Pots pluton and Wilson Ridge pluton has not been determined.

Twr — Wilson Ridge pluton Compositionally variable intrusion of diorite, quartz diorite, monzonite, quartz monzonite, and granite. Intrusive phases to the west of Wilson Ridge are fine- to medium-grained, equigranular to subporphyritic monzonite and diorite. Xenoliths of Precambrian metamorphic rock are locally present along the western flanks of Wilson Ridge. The central portion of Wilson Ridge is composed of equigranular, medium- to coarse-grained monzonitic to granitic rock. The eastern margin of the Wilson Ridge pluton is similar in composition to the central portion of the pluton. Foliation attitude symbols on the map indicate flow alignment of feldspar, biotite, and hornblende phenocrysts in the pluton. Numerous basaltic and granitic dikes trend north-south along the eastern margin. Marginal rocks of the pluton are highly fractured with surfaces having up to 2-mm-thick coatings of riebeckite and less commonly actinolite. The northern end of the Wilson Ridge pluton is intruded by numerous basaltic dikes. (Horsethief Canyon diorite, 13.3 ± 0.4 Ma (K/Ar biotite); Teakettle Pass quartz monzonite, 13.5 ± 0.4 Ma (K/Ar biotite); Larsen and Smith, 1990).

Tb — Boulder City pluton A composite pluton of equigranular to porphyritic monzonite, quartz monzonite, and granite that crops out only in the extreme southwestern corner of the quadrangle. Foliation attitude symbols on the map indicate flow alignment of feldspar, biotite, and hornblende phenocrysts in the pluton. Ferromagnesian phenocryst phases are commonly weathered to hematite in the Hoover Dam area. Outcrops of the Boulder City pluton immediately to the west of the Hoover Dam area may be highly fractured and sheared (R.E. Anderson, written commun., 1994). The pluton is intruded by basaltic to dacitic dikes and the Sugarloaf dacite dome. A K/Ar biotite age of 13.8 ± 0.6 Ma for the pluton was determined by Anderson and others (1972).

See accompanying text for references and a discussion of geologic history.

MAP SYMBOLS

Contact Dashed where inferred.

High-angle fault Arrows and numbers indicate direction and magnitude of dip, balls on downthrown side, dashed where inferred, dotted where covered or concealed.

Low-angle fault Sawteeth on upper plate, arrows and numbers indicate direction and magnitude of dip, dashed where inferred.

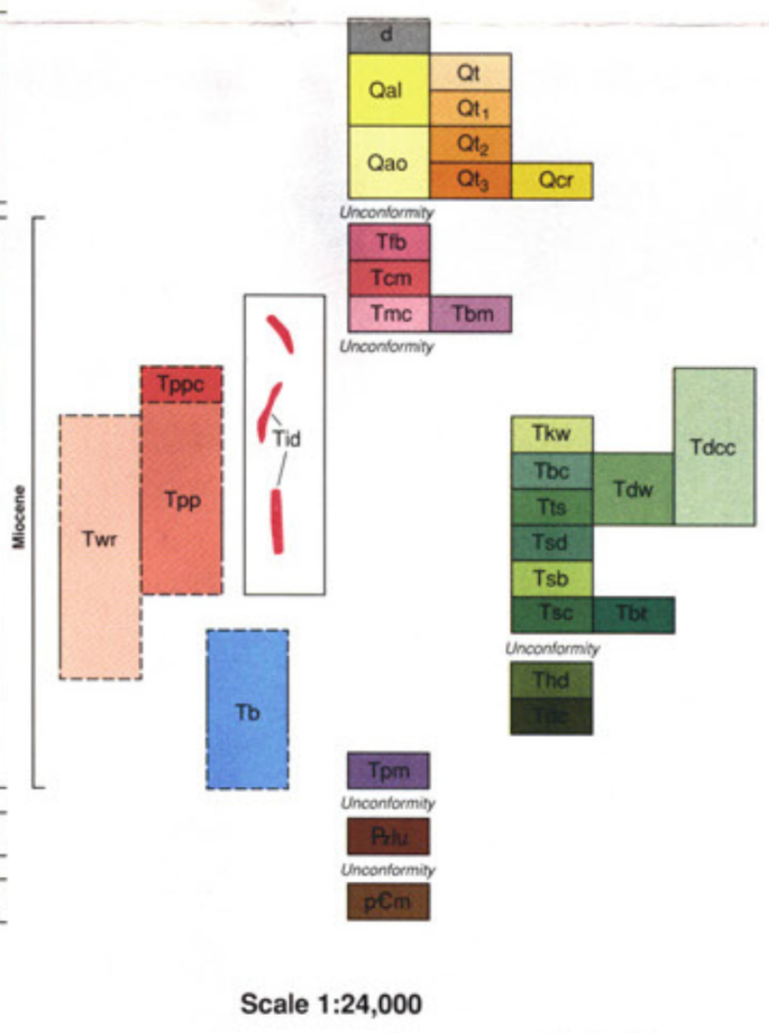
Strike-slip fault Arrows and numbers indicate direction and magnitude of dip, parallel arrows show relative movement,dashed where inferred, dotted where covered or concealed.

Strike and dip

- Bedding
- Flow foliation or plane of pumice flattening in igneous rocks
- Vertical flow foliation or plane of pumice flattening in igneous rocks
- Metamorphic foliation

***** **Volcanic eruptive center**

85-18 **Geochemical sample location and identification number**



Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 20 METERS

Base map: U.S. Geological Survey Hoover Dam 7.5' Quadrangle, 1983

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GEOLOGIC MAP OF THE HOOVER DAM QUADRANGLE, ARIZONA AND NEVADA

James G. Mills, Jr.

1994