Base from U.S. Geological Survey Monkeys Head, 1959; modified by author using U.S. Geological Survey Monkeys Head orthophoto, 1972, to show Bill Williams River road and Arizona Highway 95

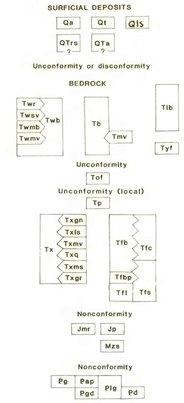
Geology mapped by D.R. Sherrod, February, 1987.
Mesozoic rocks south of Bill Williams River generalized from Spencer and others, 1986

Alluvium and pediment gravels not shown

Alluvium, talus deposits, and pediment gravels not shown
Megabreccia and breccia (unit Tx) not subdivided on cross-section

Talus deposits not shown

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qa **Younger alluvium (Holocene and Pleistocene)**—Gravel, sand, and silt of streams and washes at grade with Colorado River. Along Bill Williams River, unit comprises channel and flood-plain deposits containing moderately well-sorted sub-rounded to well-rounded clasts; in the intermittently active desert washes, unit generally contains poorly sorted subangular clasts. Locally includes broad low terraces standing less than 1 m higher than adjacent active wash channels and lacking varnished desert pavement

Qt **Talus (Holocene and Pleistocene)**—Slope-mantling deposits comprising chiefly blocks of basalt or basaltic andesite eroded from lava flows (in units Twb and Tb), and sand and cobbles eroded from underlying sedimentary rocks (in units Tof, Tfc, and Tfs)

Qls **Landslides (Pleistocene)**—Small, local slide blocks comprising mainly unit Twb

QTrs **Old river sediment (Pleistocene and Pliocene?)**—Unconsolidated to weakly indurated, yellowish-gray- to light-brownish-gray-weathering, planar-bedded to festoon cross-bedded sand, pebbly sand, and gravel that form low hills and blanket benches adjacent to Bill Williams River. Unit represents an older episode of aggradation; the bench floors sit about 30 m above present river floor and the low hills are as much as 35 m higher than river floor

QTa **Older alluvium (Pleistocene and Pliocene?)**—Pediment-forming veneer and terrace deposits of poorly to moderately indurated, poorly to very poorly bedded subangular sand, gravel, and blocks. Forms beds 0.3-2 m thick. Terrace surfaces are commonly 1-3 m above active wash floors. Unit characteristically has well developed desert pavement on upper surface. Undeformed; unconformably or disconformably overlies older units. Age chiefly Pleistocene, but some high-standing deposits could be of Pliocene age

BEDROCK

Volcanic and volcaniclastic rocks of Bill Williams Mountains (Miocene)—Interfingering sequence of lava flows, domes, and pyroclastic and epiclastic volcanic rocks. Age is middle and late Miocene, on basis of K-Ar ages ranging from 13.7 to 6.8 Ma east of quadrangle (Suneson and Lucchitta, 1979, 1983). Divided into:

Twr **Rhyolite.** Aphyric to slightly porphyritic lava flows and domes containing phenocrysts of plagioclase, sanidine, and quartz. Ferromagnesian minerals are virtually lacking. Silica ranges from 71 percent to 76 percent in samples of similar rocks from adjacent quadrangle to east (Castaneda Hills quadrangle; Suneson and Lucchitta, 1983)

Twsv **Silicic volcaniclastic rocks.** Thinly bedded to moderately thick-bedded air-fall tuff and tuffaceous sandstone. Locally grades up into unwelded ash-flow tuff near east edge of map. The distribution and variation in thickness suggest the pyroclastic rocks were erupted from vents for rhyolite of the Bill Williams Mountains (unit Twr) in the map area and to the east. The epiclastic rocks result from the reworking of air-fall and ash-flow deposits

Twmb **Megacryst-bearing basalt.** Similar to unit Twb (described below) but contains conspicuous phenocrysts as much as 2 cm across of plagioclase, clinopyroxene, and olivine

Twmv **Mafic volcaniclastic rocks.** Sandstone and lapilli tuff. Clasts are chiefly glassy and altered scoria and cinders of basalt or basaltic andesite. Unit probably represents penecontemporaneous reworking of tephra erupted from vents for mafic lavas in Bill Williams Mountains (chiefly unit Twb)

Twb **Basalt and basaltic andesite.** Forms medium-gray-weathering lava flows 1-5 m thick, and reddish brown breccia 1-3 m thick. The rocks commonly contain 1-2 percent extensively idingsitized olivine phenocrysts 1-3 mm across, less than 1 percent quartz xenocrysts 1-2 mm across, and about 5 percent plagioclase as much as 1 mm across. Silica ranges from 45 percent to 55 percent in samples of similar rocks from adjacent quadrangle to east (Castenedo Hills quadrangle; Suneson and Lucchitta, 1983)

Tb **Basalt, basaltic andesite, and andesite of The Mesa (Miocene)**—Lava flows and minor breccia. Basalt and basaltic andesite are nearly aphyric with less than 1 percent of olivine phenocrysts now altered to hematite and iddingsite. Flows commonly 2-10 m thick. Andesite commonly occurs as cliff-forming flows greater than 40 m thick that weather grayish-orange-brown. Fresh andesite is pale greenish gray and contains less than 1 percent of acgerine-augite needles and plagioclase laths 1 mm long

Tmv **Mafic volcaniclastic rocks (Miocene)**—Sandstone and lapilli tuff of mafic scoria and tephra. Unit is similar to mafic volcaniclastic rocks of Bill Williams Mountains (unit Twmv) but is associated with lava at west end of The Mesa

Tib **Basalt intrusions (Miocene)**—Sills and laccoliths in Bill Williams Mountains. Also includes dikes shown in cross sections of Buckskin and Bill Williams Mountains

Tyf **Younger fanglomerate (Miocene)**—Poorly bedded, poorly sorted sedimentary breccia and sandstone. Unit is lithologically similar to the older fanglomerate (unit Tof) but can be separated from it on the basis of a locally developed angular unconformity. Where the unconformity is absent, rocks equivalent to the younger fanglomerate probably form the upper, flat-lying part of the older fanglomerate

Tof **Older fanglomerate (Miocene)**—Poorly to moderately bedded, poorly to moderately sorted sedimentary breccia and sandstone. Locally contains well-bedded sandstone and siltstone probably resulting from deposition in a distal fan or flood plain environment. Includes well-sorted eolian sandstone in Glory Wash (southwest corner of quadrangle). Calcite cement forms nearly 50 percent of deposit exposed 200 m east of Monkeys Head promontory. Older fanglomerate is synorogenic; it was deposited before, during, and after the episode of extensional faulting 18-13.7 Ma that tilted all older rocks. Age is middle and late Miocene on basis of stratigraphic relations; unit concordantly overlies middle Miocene Peach Springs Tuff (unit Tp) and conformably underlies middle and upper Miocene volcanic and volcaniclastic rocks in Bill Williams and Buckskin Mountains

Tp **Peach Springs Tuff (Miocene)**—Moderately to densely welded ash flow. Thickness ranges from 20 to 60 m in map area. Unit is continuously exposed along dip slope of ridge in northwestern part of map area but is limited to four small isolated exposures south of Fox Wash. Mean K-Ar age (standard deviation) of 18.3±1.2 Ma reported by Glazner and others (1986) from 17 sanidine and 4 biotite separates

Tx **Megabreccia and breccia (Miocene)**—Very large brecciated bedrock blocks and very thickly bedded monolithologic to heterolithologic coarse breccia. Classs are pre-Tertiary sedimentary and crystalline rock. Unit is interbedded with sedimentary and volcanic rocks of Fox Wash. Probably formed as small to large gravity-slide blocks and catastrophic debris avalanches emplaced into the Fox Wash sedimentary basin during middle Miocene extensional faulting (Spencer and others, 1986; this map). Locally divided into:

Txgn **Gneiss-clast deposits.** Breccia containing clasts of dioritic or monzodioritic orthogneiss. Foliation remains fairly consistent over distances of 10 m where clasts are still tightly fitted together. Uncommon; found only in the central part of the quadrangle along Fox Wash. Source unknown; clasts do not resemble Proterozoic gneiss exposed in quadrangle

Txls **Limestone-clast deposits.** Breccia containing angular clasts of limestone. This is the least common of the breccia members and is exposed only in the central part of the quadrangle along Fox Wash

Txmv **Metavolcanic-clast deposits.** Breccia containing angular clasts as much as 1 m across of dark gray to bluish gray quartzo-feldspathic schist and lesser phyllite interpreted to be metavolcanic rocks

Txq **Quartzite-clast deposits.** Breccia containing angular clasts as much as 1 m across of dark gray to white quartzite, commonly stained orange to yellow-brown by iron oxide minerals. Faint bedding in clasts defined by heavy-mineral layers

Txms **Metasedimentary-clast deposits.** Breccia containing blocks as much as 5 m across of quartzite-limestone conglomerate. Conglomerate clasts themselves comprise rounded pebbles as much as 10 cm across of pale gray to greenish gray quartzite, limestone, and minor metasiltstone in a metamorphosed silty matrix rich in epidote and chlorite. Clasts are similar to Mesozoic sedimentary rocks exposed in northwestern Buckskin Mountains mapped south of quadrangle by Spencer and others (1986)

Txgr **Granite-clast deposits.** Monolithologic breccia containing unfoliated equigranular, fine- to medium-grained granite. Weathers to form hills mantled with sub-angular granitic blocks as much as 80 cm across. Source unknown; clasts do not resemble granite exposed in quadrangle

Sedimentary and volcanic rocks of Fox Wash—Arkosic sedimentary rocks and basalt and basaltic andesite lava flows. Divided into:

Tfb **Basalt and basaltic andesite (Miocene).** Chiefly olivine-phyric lava flows and minor breccia, but some lava in northwest part of quad may intrude sandstone and conglomerate of unit Tfc. Lavas contain 5-7 percent plagioclase phenocrysts, seriate to 2 mm; as much as 1 percent clinopyroxene 1 mm across; and as much as 1 percent orange iddingsitized olivine 1 mm across. Basalt and basaltic andesite are most abundant in northwest corner of quadrangle, forming a series of flows as much as 300 m thick. The unit there includes some beds of conglomerate and sandstone and an unwelded biotite-bearing silicic ash flow, none of which are thick enough to map separately. Elsewhere in the quadrangle the unit comprises one to several lava flows interbedded with sedimentary rocks (units Tfc and Ts). Stipple indicates probable near-vent rocks of unit Tfb, consisting of coarse, poorly sorted, nearly monolithologic mafic breccias comprising angular blocks as much as 2 m long of basalt and basaltic andesite set in a matrix of comminuted mafic volcaniclastic debris. Unit is probably early Miocene in age. It conformably underlies Peach Springs Tuff, which has a mean K-Ar age of 18.3 Ma (Glazner and others, 1986). Isotopic ages from lava flows found in similar stratigraphic position north and west of the quadrangle range from about 19 to 21.5 Ma, as summarized by Nielsen (1986)

Tfbp **Basaltic andesite porphyry (Miocene).** One or locally two lava flows found interbedded near the base of the basalt and basaltic andesite (unit Tfb) of the Fox Wash sequence. The porphyry is distinguished texturally by 30-40 percent of plagioclase phenocrysts as much as 2 cm long. The resulting "jackstraw" or "turkey-track" texture is a characteristic shared by several lava flows foundlocally in the region (Carr and others, 1980; Dickey and others, 1980; Nielsen, 1986)

Tfc **Conglomerate and sandstone (Miocene).** Coarse pebble, cobble, and boulder conglomerate, and coarse-grained arkosic sandstone and grit. Unit contains about equal proportions of conglomerate and sandstone. Pebbles, cobbles, and boulders are well rounded and commonly as much as 80 cm across, though boulders 1 to 3 m occur locally. Clasts are chiefly mesaplutonic rocks (90 percent), with fewer clasts of Tertiary rhyolite (less than 5 percent), Tertiary basalt (1-2 percent), and rarely quartzite. Imbrication and channel orientations suggest transport was chiefly from northwest to southeast. Top of section poorly exposed, but locally appears to become finer-grained upwards. Interfingers with unit Ts, which forms lenses and large blocks within the conglomerate and sandstone in the southern part of the quadrangle

Tfs **Sandstone (Miocene and lower Tertiary?).** Chiefly arkosic sandstone, grit, and pebbly grit, commonly with Tertiary volcanic clasts in the upper part. Locally includes minor limestone, thin-bedded white gypsiferous sandstone, and siltstone. In many places the lowest 1-10 m of the unit is a moderately reddish brown to dark reddish brown grus derived from underlying Proterozoic granite and granodioritic gneiss (units Pg and Pgd). Pebbles are chiefly subrounded to well-rounded clasts of light-colored slightly foliated granitic gneisses not found in the area. Fewer pebbles (in decreasing order) are quartz porphyry (Mesozoic metavolcanic rocks), porphyritic granite, buil quartz, and rare quartzite(?). Cratonic sedimentary rocks characteristic of the Colorado Plateau are notably absent. Imbrication in lower part of unit suggests source to north or northwest. Upper part of unit contains clasts of unmetamorphosed Tertiary(?) biotite rhyolite, which appear abruptly about 15-40 m upsection from base in many places. West of Highway 95 and north of Lake Havasu, some beds are nearly entirely volcaniclastic, probably emplaced as the distal parts of lahars. In the Fox Wash area, the top of sandstone unit (Tfs) is drawn at the lowest bed of coarse pebble and boulder conglomerate in unit Tfc. Elsewhere the disinction is poorly defined, and the two units may overlap somewhat in both position and assignment. Age of unit is uncertain but probably early Tertiary(?). The lowest 15-40 m may represent a lengthy period of weathering, erosion, and deposition, from which a probable Oligocene(?) and Eocene(?) age is inferred (for example, Eberly and Stanley, 1978; Shafiqullah and others, 1980). The abrupt appearance of the biotite rhyolite clasts probably corresponds to a widespread eruptive episode sometime in Tertiary. Most isotopic ages for Tertiary volcanic rocks sampled elsewhere in the region are younger than about 22 Ma, so provisionally the upper part of the unit may be 22 Ma or younger

Tfl **Limestone (Miocene or lower Tertiary)**—Massive bed a few meters thick of hydrothermally altered limestone. Exposed for about 1 km in the northwest corner of the quadrangle, where it nonconformably overlies unit Pg. Underlies the Tertiary sedimentary and volcanic rocks of Fox Wash but in this area there is no grus-derived arkose that elsewhere characterizes the base of unit Tfs. Age uncertain but older than middle Miocene, based on stratigraphic position of limestone beneath lower Miocene volcanic rocks of the Fox Wash sequence. Contains reot casts(?) (J.G. Evans, written commun., 1988)

Jp **Planet volcanics of Spencer and others (1986) (Jurassic)**—Highly cleaved to schistose silicic and intermediate volcanic and metavolcanic rocks defined and mapped by Spencer and others (1986). Exposed south of Bill Williams River in southeast corner of quadrangle. Age is tentatively late Jurassic on basis of a U-Pb zoncordia intersection of about 155 Ma from two zircon fractions (Reynolds and others, 1987)

Mzs **Mesozoic metasedimentary rocks (Jurassic? and Triassic)**—Quartzite, phyllite, and calc-silicate rocks. Includes the Jurassic(?) Vampire Formation and Triassic or Jurassic Buckskin Formation as mapped by Spencer and others (1986). Exposed south of Bill Williams River in southeast corner of quadrangle

Metaplutonic rocks (Proterozoic)—Weakly to moderately foliated gneiss formed from granodiorite, granite, quartz monzonite, leucogranite, and diorite. Includes highly foliated and lineated gneiss in northwest-striking zones 100 to 800 m wide in the Bill Williams Mountains and Aubrey Hills. Metaplutonic rocks are moderately to dark reddish brown near unconformity with Tertiary sedimentary rocks (unit Tfs), owingto iron-oxides that coat fractures. The oxides come chiefly from clay-altered biotite and probably developed during early Tertiary weathering. The zone of abundant oxides roughly parallels the unconformable contact with unit Tfs and locally extends to an inferred paleodepth of 500 m (measured perpendicular to plane of unconformity). Divided into:

Pg **Granite and quartz monzonite.** Predominantly a coarsely porphyritic granite gneiss, with potassium feldspar phenocrysts as much as 3 cm across in equigranular 1-5 mm groundmass. Color index (C.I.) less than 10. Quartz monzonite is biotite-rich (C.I.=20) and lacks the large potassium feldspar phenocrysts. Areas underlain by coarsely porphyritic granite tend to have higher relief than where underlain by quartz monzonite. In many places the contact between granite and quartz monzonite is planar and the granite is clearly the younger of the two phases. Metamorphosed; slightly foliated and very weakly lineated

Pap **Aplite.** Pinkish-orange-weathering fine-grained (1 mm) granite. C.I. less than 1. Forms thin tabular bodies that cut unit Pg

Plg **Leucogranite.** Weakly to highly foliated pinkish-orange-gray-weathering granite and alaskite gneiss. C.I. generally less than 2. Where least deformed, rock is fine- to medium-grained and equigranular. Unit includes several masses. Leucogranitic mapped on the west and south flanks of the Bill Williams Mountains is younger than and probably magmatically related to unit Pg

Pd **Diorite.** Dark-weathering body of monzodioritic gneiss associated with leucogranite gneiss in northeast corner of quadrangle

Pgd **Granodiorite.** Weakly to moderately foliated medium-grained equigranular to slightly porphyritic granodiorite and quartz monzodioritic gneiss. Locally contains northwest-striking zones of highly foliated orthogneiss. In Aubrey Hills, unit is granodiorite that grades eastward into complexly layered granodioritic gneiss. Throughout the quadrangle the unit is cut by northwest-trending diabase dikes or sills on strike with similar sheets to the north, which were assigned a Middle Proterozoic age by Light and others (1983)

- **Contact**, approximately located and showing dip. Dotted where buried. o, y indicate relatively older and younger units within volcanic and volcaniclastic rocks of Bill Williams Mountains
- **Fault**, approximately located and showing dip. Dotted where buried. Ball and bar shows downthrown side for faults cutting units Twb, Tb, or other young deposits. Hachures indicate low-angle (less than 35°) normal fault mapped by Spencer and others (1986) south of Bill Williams River in southeast corner of map; hachures on upper plate
- **Gradational contact**, dotted where buried. Separates coarsely porphyritic granite gneiss (unit Pg) from granodioritic gneiss (unit Pgd) across a zone of high strain that affects both units
- **Anticline**, showing plunge. Dotted where buried
- **Monocline**. Arrows point to abrupt lessening of dip
- **Syncline.** Dotted where buried
- **Lowest bed in unit Tfs that contains numerous biotite rhyolite clasts.** V's, open stratigraphically upward. Dotted where buried
- **Conglomerate beds in unit Tfb**
- **Vent rocks in units Tfb and Twb**
- **Rhyolite domes in unit Twr.** Interpretation based mainly on geomorphic expression
- **Air-fall pumicite beds in units Tof and Tyf**
- **Lineament from aerial photographs**
- **Quartz veins**, showing dip
- **Strike and dip of beds.** Includes orientation of compositional layering in unit Mzs
  - Horizontal
  - Inclined
  - Overturned
- **Strike and dip of foliation.**
  - Inclined
  - Vertical
- **Plunge of mineral lineation.** Typically shown combined with foliation
- **Local small-scale fold in foliation**, showing plunge
- **Dikes**, showing dip. Number of tick marks indicates composition: basalt or basaltic andesite dikes, one tick; andesite or dacitic dikes, two ticks; rhyodacite or rhyolite dikes, three ticks
  - Inclined
  - Vertical

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PRELIMINARY GEOLOGIC MAP OF THE MONKEYS HEAD QUADRANGLE, MOHAVE AND LA PAZ COUNTIES, ARIZONA

By

David R. Sherrod

1988

Explanatory pamphlet accompanies map

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.