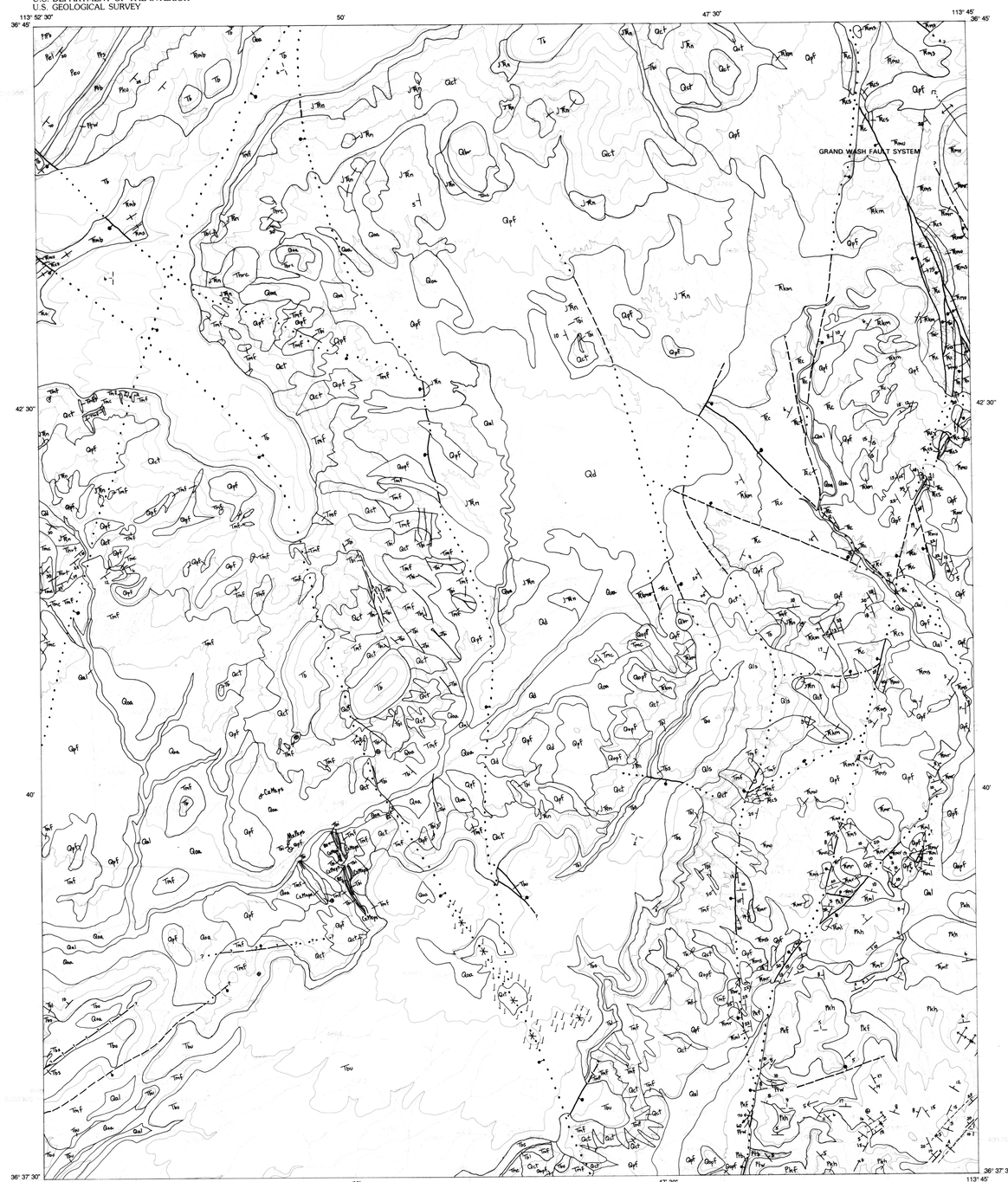
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT
MAP-95-86



Base from U.S. Geological Survey, Cane Springs, 1985
Transverse Mercator projection

SCALE 1:24 000
1 1/2 0 1 MILE
1 5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
SUPPLEMENTAL CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1995

ARIZONA
QUADRANGLE LOCATION

Geology mapped by I. Lucchitta, R.G. Bohannon, and H.J. Reick, 1981; I. Lucchitta and P.G. Basdekas, 1991 and 1993; and C. M. Dehler, 1994.

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

CENOZOIC SURFICIAL DEPOSITS

Qal **Alluvium (Holocene and Pleistocene?)**—Silt, sand, pebbles, cobbles, and boulders in bottoms of largest and most active drainages. Poorly sorted, angular to subround constituents as large as several meters in diameter. High albedo, little or no soil development, and sparse vegetation. Maximum thickness about 3 m

Qd **Dune deposits (Holocene and Pleistocene?)**—Medium- to fine-grained, orange-red sand in active dunes covered by sparse vegetation. Little or no soil development. Thickness as much as 20 m

Qpf **Pediment and alluvial fan deposits (Holocene and Pleistocene?)**—Silt, sand, pebbles, cobbles, and boulders in widespread, mostly, sheet-like deposits on surfaces that connect to sediment source. Poorly to moderately sorted, subround to angular constituents as large as several meters in diameter. Soil zones incipient to moderately developed; vegetation common. Dissected 5 m or less. Maximum thickness about 5 m

Qct **Colluvium and talus (Holocene and Pleistocene)**—Silt, sand, pebbles, cobbles, and boulders in thin deposits on steep slopes, commonly beneath cliffs. Poorly to moderately sorted, angular to subround constituents as large as several meters in diameter. Dissected 40 m or less. Maximum thickness about 5 m

Qopf **Older pediment and alluvial fan deposits (Pleistocene)**—Silt, sand, pebbles, cobbles, and boulders in sheet-like deposits on gently- to moderately sloping surfaces. Topographically higher than pediment deposits (Qpf) and disconnected from sediment source. Poorly sorted, angular to subround, constituents as large as several meters in diameter. Soil zones incipient to well developed; vegetation common. Typically dissected 20 m or less. Maximum thickness about 5 m

Qoa **Older alluvium: (Pleistocene)**—Silt, sand, pebbles, cobbles, and boulders on dissected terraces as much as 15 m above modern stream level; exclusive of most active channel bottoms filled by alluvium (Qal). Consists of poorly sorted, angular to subround constituents as large as several meters in diameter. Includes isolated deposits on gently sloping surfaces of basalts flows (Tb, Tbu) as much as 140 m above modern stream level. Incipient to well developed soil zones; advanced calcrete in remnants above basalt; vegetation common. Alluvium (Qal) is included in older alluvium (Qoa) where too small to map separately. Maximum thickness about 10 m

Qls **Landslide deposits (Pleistocene)**—Landslide blocks consist of chaotic masses of basalt (Tbu, Tbl) and Tertiary sediments (Tbs, Trs) on north and east side of Mud Mountain. Thickness unknown

Qbr **Breccia (Pleistocene?)**—Rubble composed predominantly of basalt; probably as landslide masses. About 70 m thick

CENOZOIC VOLCANIC AND SEDIMENTARY ROCKS

Volcanic rocks, dikes and associated sediments (Pliocene and Upper Miocene)—Basalts (Tb) in northwest and north-central parts of quadrangle are derived from local feeder dikes and from Black Rock Mountain to the northeast (3.7±0.6 Ma, Billingsley, 1993). Basalts in southern part of quadrangle are derived from local vents and feeder dikes from Mud Mountain area. K/Ar ages of Mud Mountain flows from adjacent quadrangles are 5.45±1.11 Ma, (south), and 6.87 ±0.20 and 4.73±0.18 Ma (west; Reynolds, et al, 1986). Two basalt flows (Tbu, Tbl) are present in southern part of the quadrangle and above and below intrabasaltic sediments (Tbs)

Tb **Basalt of Black Rock Mountain**—Light-gray to black, aphanitic, vesicular to non-vesicular, porphyritic basalt, with as much as 10% mostly iddingsitized olivine 1-3 mm in diameter. Scarce plagioclase and pyroxene phenocrysts as much as 1 mm in length. Basalt conformably overlies sediments of Muddy Creek Formation (Tmc, Tmf). Contact with Muddy Creek Formation planar to undulating; some flows fill paleochannels. Forms caprock of local plateaus in northwestern part of quadrangle. As many as 5 flows with little or no sediment between flows. Minimum thickness of individual flows about 1.5 m. As much as 150 m thick

Tbu **Upper basalt of Mud Mountain**—Medium-gray aphanitic basalt; abundant vesicles less than 1 mm in diameter. Contains 10% or less olivine crystals as much as 3 mm in diameter. Defined by stratigraphic position above intrabasaltic sediments (Tbs) in southern part of quadrangle. Conformable contact with underlying intrabasaltic sediments (Tbs). Forms caprock of local plateaus in southern part of quadrangle. As much as 150 m thick

Tbs **Intrabasaltic sediments**—Light-brown to moderate orange-brown, medium to fine, poorly sorted, subround quartz sandstone and siltstone; weak calcite cement. Contains scattered pebbles of basalt as much as 30 cm in diameter, typically 1 to 3 cm in diameter, and pebbles and granules of black chert, white chert, metavolcanic rocks, and sandstone. Bedding is indistinct, horizontal, and locally trough cross stratified. Caliche common as root casts, nodules, and fracture fill. In absence of lower basalt flows (Tbl), intrabasaltic sediments (Tbs) cannot be distinguished from fine-grained sediments of Muddy Creek Formation (Tmf) and are included in Tmf. As much as 90 m thick

Tbl **Lower basalt of Mud Mountain**—Medium- to dark-gray aphanitic basalt. Contains moderate amount of vesicles less than 1 mm in diameter. As much as 15% partially iddingsitized olivine crystals less than 1 mm in diameter. Includes scarce plagioclase crystals as much as 1 mm in diameter. Defined by stratigraphic position below intrabasaltic sediments (Tsb) in southern part of quadrangle. Conformable contact with overlying intrabasaltic sediments (Tsb) and underlying Muddy Creek Formation (Tmc and Tmf) conformable. Contacts planar to undulating; some flows fill paleochannels. Thickness as much as 60 m

Tbi **Intrusive basalt**—Medium- to dark-gray aphanitic basalt. Vesicles as much as 5 mm. in diameter common. Approximately 5% to 10% moderately iddingsitized olivine crystals as much as 4 mm in diameter. Felty plagioclase laths as long as 1 mm; diktytaxitic texture. Dike swarm in west-central quadrangle probably represents core of a volcano. Dikes in northeast corner of quadrangle associated with north-trending faults. Most dikes intrude the Muddy Creek Formation (Tmf). A few dikes intrude the Navajo Sandstone (J*n) and the pebbly sandstone (**GaMs**ps). Thickness unknown

Muddy Creek Formation (Miocene)—Clastic sediments composed of silt, sand, conglomerate, and breccia believed correlative with Muddy Creek Formation, specifically red siltstone and sandstone facies present west of quadrangle and as far south as Lake Mead (Lucchitta, 1966). Divided into the fine-grained and conglomerate facies

Tmf **Fine-grained sediments**—Orange-red to pink silt and fine- to medium-grained, moderately well sorted, well rounded, quartz sandstone. Weakly consolidated; locally well consolidated by caliche. Bedding indistinct to horizontal, as much as 1 m thick, locally undulating, trough cross stratification common. Includes local lenses of pebbles and cobbles. Clast lithologies include chert, quartzite, sandstone, and metavolcanic rocks. Caliche present as nodules and root casts. Unconformable lower contact with Navajo Sandstone (J*n) and Petrified Forest Member of the Chinle Formation (Trc). Where lower basalt (Tbl) is absent, intrabasaltic sediments (Tbs) are included in this unit. Forms slope. Exposed thickness as much as 320 m

Tmc **Conglomerate**—Medium-orange, matrix-supported conglomerate composed of poorly-sorted, angular to well-rounded fine sand to cobbles. Weakly calcite cemented to unconsolidated. Clasts as much as 20 cm in diameter. Lithologies include Proterozoic gneiss and schist and Paleozoic carbonate rocks. Beds horizontal to lenticular and as much as 50 cm thick, some defined by fining-upward sequences. Conformable contact with underlying fine-grained sediments (Tmf). Unconformable contact with tuffaceous facies of the Horse Springs Formation (Thrt) and Navajo Sandstone (J*n). Forms slope. As much as 110 m in exposed thickness

Rainbow Gardens Member of the Horse Springs Formation (Miocene)

Thrt **Tuffaceous facies**—White, fine- to medium-grained, sub-angular to round quartz sand with minor biotite crystals. Lag deposit of coarse sand at base of beds. Horizontal, planar tabular and trough cross-stratification with internal laminations or graded beds. Cut-and-fill structures with rip-up lag deposits at base. Friable. Forms ledges. Intercalated with green laminated mudstone as much as 3 meters in thickness and green to white tuffaceous limestone and crystalline limestone in 2 to 50 cm thick tabular beds. Unconformable lower contact with Navajo Sandstone (J*n) and upper contact with Muddy Creek Formation (Tmf). As much as 210 m in thickness

Thrc **Conglomerate facies**—Brown to red-brown, coarse-grained sand to cobbles (as much as 4 cm. in diameter) in minor clay matrix. Clasts poorly sorted and sub-angular to round; some flattened. Clast compositions include chert, quartzite and carbonate rocks. Irregular, crudely horizontal and laterally discontinuous thick beds. Unconformable lower contact with Navajo Sandstone (J*n) and upper contact with Muddy Creek Formation (Tmf) are unconformable. As much as 250 m in thickness

SEDIMENTS OF UNKNOWN STRATIGRAPHIC POSITION

GaMs ps **pebbly sandstone (Cenozoic? or Mesozoic?)**—Light gray sandstone and pebbly sandstone; weathers dark buff to brown. Composed of well sorted, subangular to well-rounded, fine to very fine, frosted quartz sand grains in silica cement and clay matrix. Contains angular pebbles of white and gray chert as much as 2 cm in diameter and rounded clasts of brick- red, poorly indurated sandstone as much as 2 cm in diameter that weather to form vugs. Planar and trough cross-stratification with counter laminations common in sandstone. Pebbly sandstone massively bedded. Porosity ranges from low to high. Unit contains wavy bands of silica cement less than 1 cm thick. Forms rounded-weathering, resistant outcrop. Complex relationship with dikes (Tbi) in the south-central part of quadrangle; sandstone commonly has basaltic matrix and dikes bear imprint of sedimentary structures suggesting fluidization of pebbly sandstone by basalt. May be correlative with Muddy Creek sediments (Tmf, Tmc), the Rainbow Garden member of the Horse Springs Formation (Thrc, Thrt, Thrs), or the Willow Tank Formation (Kwt). Thickness as much as 5 m

MESOZOIC SEDIMENTARY ROCKS

J*n **Navajo Sandstone (Jurassic and Upper Triassic?)**—Cliff-forming, red-orange and pale-yellow to white, medium-grained, well rounded, well sorted aeolian quartz sandstone composed of frosted grains. As much as 2 m thick sets of large-scale trough-cross stratification. Heavy-mineral concentrations along trough laminae. Inverse grading on slip faces common. Moderately indurated. Contact with overlying units unconformable. As much as 520 m in exposed thickness

TrJkm **Kayenta and Moenave Formations, undivided (Upper Triassic?)**—Orange-brown interbedded sandstone and mudstone. Bedding planar to wavy, with small-scale trough cross beds. Contains uncommon purple, trough-crossbedded sandstone with rounded iron concretions 1-2 cm. in diameter. Large-scale (aeolian) trough crossbeds more common at the top, near disconformable contact with the Navajo Sandstone (J*n). As much as 200 m in exposed thickness

Chinle Formation (Upper Triassic)—Variegated and interbedded mudstone, siltstone, sandstone and basal conglomerate. Medium- to massively-bedded. Two members present in quadrangle; the Petrified Forest and Shinarump Members

Trc **Petrified Forest Member**—Forms slopes. Variegated purple, pink, red, green, yellow, brown and tan mudstone, siltstone, sandstone, and conglomerate. Lower part variegated, upper part mainly red to red-brown. Sandstone and conglomerate horizontally bedded and trough- and planar crossbedded, most commonly in the upper part of the member. Mudstone and siltstone commonly massive, as much as several tens of meters in thickness. Fossil wood common as float on and within outcrops. Disconformable contact with overlying Kayenta and Moenave Formation (**Trcs**). Thickness as much as 450 m

Trcs **Shinarump Member**—Weathers into rounded outcrops. Tan to buff sandstone, pebbly sandstone and conglomerate. Sand medium- to coarse-grained, poorly sorted, subangular to rounded. Conglomerate is matrix- to clast-supported with poorly to moderately sorted clasts as much as 6 cm. in diameter. Clasts lithologies include black chert, red chert, yellow chert, quartzite, and bull quartz. Horizontal stratification and planar-tabular and trough crossbedding common. Sandstone beds as much as 20 cm thick. Laterally discontinuous conglomerate beds as much as 2 m in thickness. Fossil wood common as float on and within outcrops. Conformable contact with overlying Petrified Forest Member (**Trc**). Thickness as much as 20 m

Moenkopi Formation (Middle (?) and Lower Triassic)—Heterogeneously-bedded mudstone, siltstone, sandstone, gypsum, dolomite, and basal conglomerate. Six members present in quadrangle. In descending order: Upper red, Schnabkaib, Middle red, Virgin Limestone, Lower red, and the Timpoweap members

Trmu **Upper red member**—Forms ledges and slopes. Red interbedded mudstone, siltstone, sandstone and minor gypsum. Disconformable contact with overlying Chinle Formation (**Trcs**). As much as 30 m. thick

Trms **Schnabkaib Member**—Forms steep slopes with ledges. White aphanitic, laminated dolomite, and gypsum with subordinate red and white siltstone, mudstone, and sandstone. Gypsum, dolomite and siltstone are interbedded in thin (2-5 cm.) beds. Bedding is parallel, even, and continuous. Gradational contact with Upper red member (**Trmu**) placed arbitrarily at highest thick white siltstone bed. Thickness as much as 160 m

Trmr **Middle red member**—Forms slope. Interbedded red-brown siltstone and sandstone, white and gray gypsum, platy dolomite, green siltstone and gray-green gypsiferous mudstone. Siltstone and sandstone laminated. Abundant veins of gypsum in siltstone. Gradational upper contact arbitrarily placed at base of lowest bed of light gray dolomitic siltstone. Thickness averages about 50 m

Trmv **Virgin Limestone Member**—Consists of three, light-gray, ledge-forming limestone beds 1.5 to 6 m. thick, separated by white to pale-yellow, slope-forming thin-bedded gypsum and gypsiferous siltstone. Includes thin beds of brown, red, and green siltstone, gray limestone, and brown, platy calcarenite. Upper contact placed at top of highest bed of gray gypsum. Lower limestone contains abundant star-shaped echinoderm plates and *Composita* brachiopods. Thickness about 40 m

Trml **Lower red member**—Interbedded red, thin-bedded sandy siltstone and gray, white, and pale-yellow laminated gypsum and minor sandstone. Lower beds in part consist of reworked siltstone and gypsum of the Harrisburg Member of the Kaibab Formation (**Pkh**). Upper contact placed at base of lowest bed of gray limestone of Virgin Limestone Member (**Trmv**). Averages about 9 m. in thickness, locally as much as 50 m. thick in the southeast corner of quadrangle where it fills shallow paleovalleys cut into the underlying Kaibab Formation (**Pkh**)

Trmb **Basal member**—Forms resistant cliffs. In northwest corner of quadrangle, the lower red member, the Virgin Limestone Member, and the middle red member are combined in this unit (Bohannon, 1991; Bohannon and Lucchitta, 1991) where they cannot easily be distinguished from one another or one or more of these members is absent. Unit consists chiefly of white, light-brown and light-gray limestone. Bedding parallel, even and continuous; beds range from a few centimeters to more than 1 m in thickness. Unconformity between this unit and upper part of Kaibab Formation (**Pku**) in northwest part of map difficult to locate because units are similar. Contact approximately located above the uppermost gypsiferous beds in the Kaibab Formation. About 70 m thick

Trmt **Timpoweap Member**—Forms ledge. Gray, clast-supported conglomerate. Clasts subangular to subround, lithologies include limestone and white chert derived from the Kaibab Formation. Matrix of coarse sand present locally. Pebble imbrication indicates eastward paleocurrent. Upper contact with Lower red member (**Trml**) gradational and arbitrarily placed at lithologic change from predominantly gray conglomerate and coarse-grained sandstone to predominantly red siltstone and gypsum. Fills paleovalleys eroded into underlying Kaibab Formation. Average thickness 25 m

PALEOZOIC SEDIMENTARY ROCKS

Kaibab Formation (Lower Permian)—Thinly-bedded, fossiliferous, cherty and sandy limestone. Subdivided into Harrisburg and Fossil Mountain Members in southeast part of quadrangle. In northwest part of quadrangle, these members are combined into the Kaibab Formation undivided.

Pku **Kaibab Formation undivided**—Forms cliffs and ledges. Fossiliferous limestone in lower part (Fossil Mountain Member) is medium-gray and contains abundant brown chert nodules and stringers. The chert stringers define parallel and discontinuous bedding. Forms cliffs. The upper part (Harrisburg Member) consists of limestone, gypsum and siltstone. Bedding is irregular, wavy, uneven and discontinuous. Where Harrisburg Member has been removed by post-Kaibab erosion, the Triassic Moenkopi rests directly on Fossil Mountain Member. Because of the difficulty in locating the unconformity between the Kaibab and Moenkopi Formations, the mapped contact is only approximately located in the northwestern part of map. About 90 m thick

Pkh **Harrisburg Member**—Forms slope with ledges. Light-gray, fossiliferous, cherty, sandy, fine- to medium-crystalline limestone with interbedded red and gray gypsiferous siltstone and gray gypsum beds several meters thick. Bedding locally distorted by solution of gypsum. Upper contact disconformable with lower members of the Moenkopi Formation (**Trml, Trmt**). As much as 90 m thick

Pkf **Fossil Mountain Member**—Cliff-forming, yellow-gray to gray, fossiliferous, sandy, cherty, finely- to medium-crystalline, thin-bedded limestone. Chert in nodules and stringers weathers black in cliff outcrops. Gradational contact with overlying Harrisburg Member (**Pkh**) placed at top of cherty limestone cliff of Fossil Mountain Member (**Pkf**). As much as 90 m thick

Toroweap Formation (Lower Permian)—Heterogeneously-bedded shale, siltstone, sandstone, gypsum, and fossiliferous dolomitic limestone. Subdivided into the Woods Ranch, Brady Canyon, and Seligman Members

Pmv **Woods Ranch Member**—Slope-forming gray siltstone and pale-red shale with thick interbeds of massive, white to gray gypsum. Commonly covered by talus. Much subsidence and distortion of beds in drainages owing to solution of gypsum. Contact with Fossil Mountain Member of Kaibab Formation (**Pkf**) unconformable, caused by channel and solution erosion with local relief as much as 5 m. Marked by topographic break between cliff of Kaibab Formation and slope of Toroweap Formation. Map contact commonly generalized because of talus cover. Gradational contact with underlying Brady Canyon Member (**Pmb**). Approximately 55 m thick

Pmb **Brady Canyon Member**—Cliff-forming, gray to dark-gray, fossiliferous, fetid, medium- to coarsely-crystalline, medium-bedded limestone. Includes thin-bedded dolomite in upper and lower part. Parallel, discontinuous, and even bedding defined by elongated chert bodies; beds are several centimeters to tens of centimeters thick. Individual chert masses about .3 m long on average. Gradational contact with underlying Seligman Member (**Pms**), placed at bottom of limestone cliff. Approximately 85 m thick

Pms **Seligman Member**—Slope-forming. Upper part: interbedded gray thin-bedded dolomite and gypsiferous sandstone; middle part: gray to red, thin-bedded, interbedded siltstone, sandstone and gray gypsum; lower part: brown and yellow, fine-grained, thin-bedded, low-angle crossbedded and flat-lying sandstone. Disconformable, sharp, planar contact with underlying Esplanade Sandstone (**Pes**). Forms slope with ledges in upper and lower part. Thickness approximately 55 m

Esplanade Sandstone (Lower Permian)—Fine-grained, well-sorted, heterogeneously crossbedded quartz sandstone. Divided into upper and lower members

Peu **Upper member**—Forms rounded ledges and cliffs. Red, light- buff and white, fine-grained, well-sorted, well-rounded quartz sandstone. Grain-supported. Moderately friable to well-indurated. Bedding wavy, discontinuous, non parallel and uneven; beds range from 0.5 to 2 m in thickness. Internal, low-angle trough and planar cross stratification common. About 280 m thick

Pel **Lower member**—Forms cliff. Light-buff to white, fine-grained, well-sorted, well-rounded quartz sandstone. Grain-supported. Bedding thick with large-scale trough- and planar cross beds. Contact with overlying Upper member (**Peu**) conformable. About 100 m thick

PPb **Bird Spring Formation (Lower Permian to Upper Pennsylvanian)**—Forms ledges and cliffs. Gray, light-gray and white limestone, brown-weathering arenaceous limestone and sandstone, and brown chert. Bedding generally parallel, even and continuous; crossbedding common in sandstone; beds 0.5 to 1 m thick. Cherty limestone comprises 10 to 30 % of formation. Arenaceous limestone interbedded with limestone and comprises about 10 to 20 % of formation. Highly fossiliferous. Lower part of formation probably correlates with Paloon Dolomite; upper part with Calville Limestone. Contact with overlying Esplanade Sandstone (**Pel**) disconformable. About 360 m thick.

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EXPLANATION

Contact

Fault—Dashed where approximately located; dotted where concealed; queried where inferred. Arrow indicates direction and amount of dip of fault plane. Diamond-head arrow indicates bearing and plunge of slip indicators such as slickensides, mullions and grooves. Bar and ball on downthrown side, where determined

Fold—Showing trace of axial plane. Dashed where approximately located, dotted where concealed

Syncline—Showing direction of plunge

Anticline—Showing direction of plunge

Monocline—Axial trace dashed where approximately located

—Trace of anticlinal axis

—Trace of synclinal axis

Strike and dip of beds—Leadered dots show location of measurement

Horizontal

Inclined—Number indicates dip angle

Approximate—Approximated dip or dip calculated from topographic expression

Implied dip from aerial photos—Not measured

Apparent dip—Shown in areas of low dip or poor exposure

Dike

Inclined—Number indicates dip angle

Vertical

Volcanic vent

Vent area

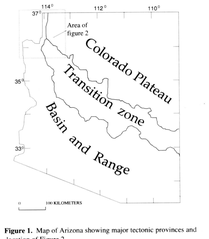

Figure 1. Map of Arizona showing major tectonic provinces and location of Figure 2.

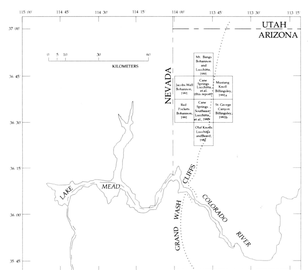

Figure 2. Index map showing published U.S. Geological Survey Open-Reports and Miscellaneous Investigations Series Maps relative to the Cane Springs 7½ quadrangle.

GEOLOGIC MAP OF THE CANE SPRINGS QUADRANGLE, NORTHERN MOHAVE COUNTY, AZ.

By

Ivo Lucchitta, Peggy G. Basdekas, Robert G. Bohannon, Hugh J. Reick, and Carol M. Dehler

1995