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

Geologic map of the Poverty Spring quadrangle, northern Mohave County, Arizona

by
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INTRODUCTION

The Poverty Spring 7.5' quadrangle (96 sq km; 63 sq mi) is located in northern Mohave County, Arizona, about 67 km (42 mi) south of St. George, Utah, the nearest settlement, and about 16 km (10 mi) west of the abandoned settlement of Mt. Trumbull (Bundyville), Arizona (fig. 1). Altitudes range from about 1,573 m (5,160 ft) in Hidden Canyon, northwest corner of the quadrangle, to 2,048 m (6,720 ft) on Poverty Mountain, southeast edge of the quadrangle. Vehicle access to the quadrangle is by an improved dirt road locally referred to as the Dellenbaugh Road (fig. 1). Several unimproved dirt roads lead from the Dellenbaugh Road to various locations within the quadrangle area.

The area is managed by the U.S. Bureau of Land Management including one section belonging to the state of Arizona. The area supports a moderate growth of sagebrush, cactus, cliffrose bush, and scattered pinyon pine and juniper trees.

PREVIOUS WORK

The area was mapped photogeologically and included on two Arizona state geologic maps, one by Wilson and others (1969), and the other by Reynolds (1988). A geologic map of the Sullivan Draw and vicinity borders the north edge of this quadrangle (Billingsley, 1994), a geologic map of the upper Hurricane Wash and vicinity adjoins the northeast corner of this map (Billingsley, in press a), and a geologic map of the upper Parashant Canyon and vicinity borders the east edge of this map (Billingsley, in press b).

MAPPING METHODS

A preliminary geologic map was made from aerial photographs at a scale of 1:24,000. In particular, many of the Quaternary alluvial units having similar lithologies were mapped using photogeologic methods based on regional geomorphic characteristics. Detailed field investigations were then conducted to insure accuracy and consistency of all map units.

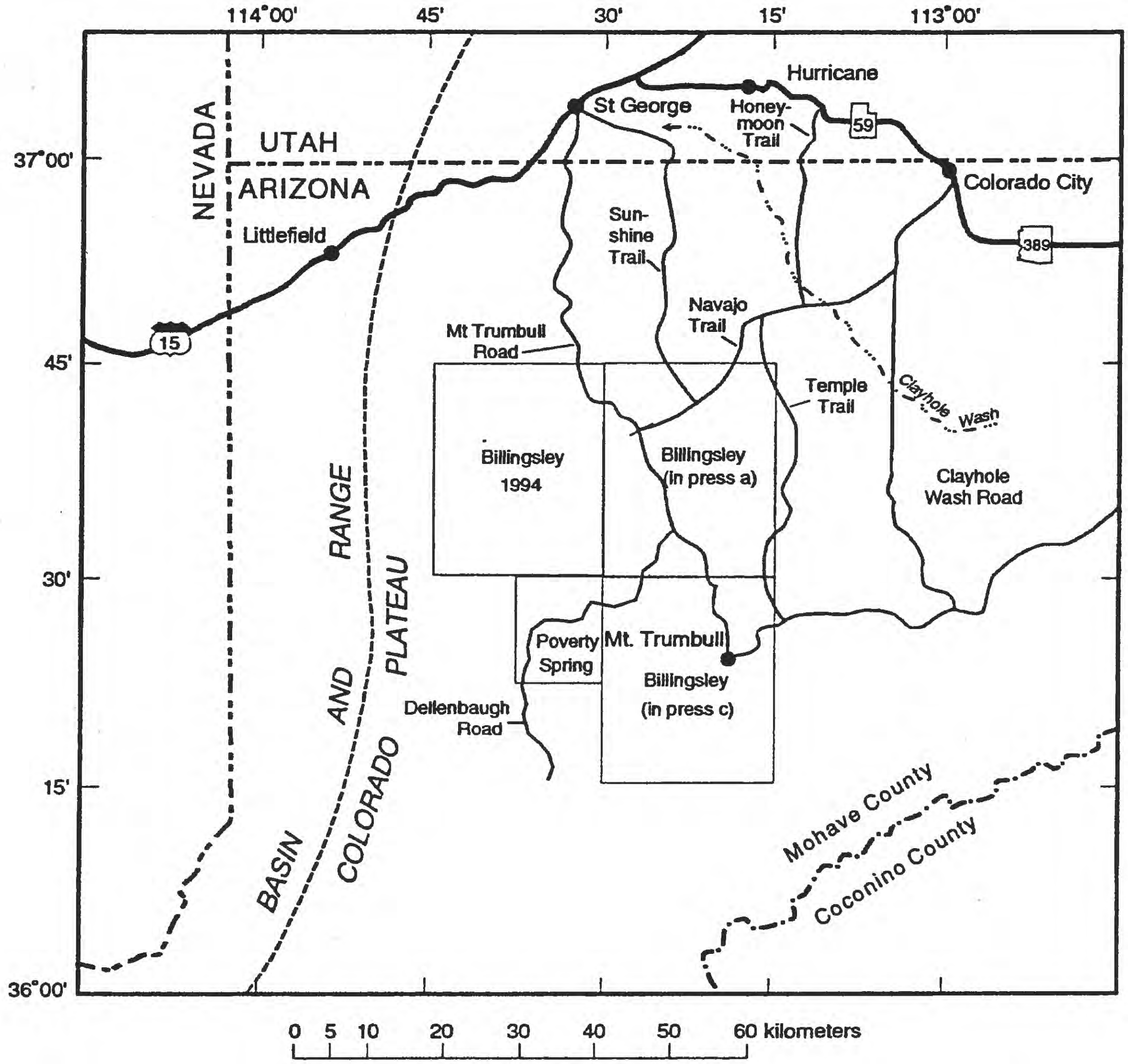


Figure 1. Index map for the Poverty Spring quadrangle and vicinity, northern Mohave County, northwestern Arizona.

GEOLOGIC SETTING

The quadrangle area lies within the Shivwits Plateau, a subplateau of the southwestern part of the Colorado Plateaus physiographic province. The Shivwits Plateau in this quadrangle is characterized by relatively flat lying bedrock strata having an average regional dip of less than 2° east. About 290 m of Triassic strata and about 260 m of Permian strata are exposed in the quadrangle.

Cenozoic surficial deposits are widely distributed in the quadrangle area consisting of igneous, alluvium, and landslide deposits. The volcanic rocks include basaltic dikes, flows, and pyroclastic deposits. The alluvial deposits are identified by photogeologic techniques based on their geomorphic relationships to structural features and eroded landscape features.

STRATIGRAPHY

The sedimentary bedrock strata of this quadrangle include, in ascending order, the Toroweap and Kaibab Formations (Lower Permian), and the Moenkopi Formation (Lower Triassic). About three-quarters of the surface bedrock exposed in this quadrangle is gray cherty limestone, sandy limestone, and gray to white siltstone and gypsum of the Kaibab Formation. The other one quarter consists of gray and red conglomerate, sandstone, siltstone, and gray gypsum and dolomite of the Moenkopi Formation which is mostly covered by Tertiary basalt flows. The Moenkopi is partly exposed on the north and south slopes of Poverty Mountain in the south-east part of the quadrangle, but minor outcrops are found in paleovalleys at various locations in the quadrangle.

A major regional unconformity separates the Permian and Triassic strata of this region of Arizona. After deposition of the Harrisburg Member of the Kaibab Formation, erosion of the Harrisburg was mainly confined to paleoriver valleys and associated tributaries. In this map area, north of Poverty Mountain, three paleovalleys were eroded into the Harrisburg during Early Triassic time and filled with gray conglomerate of the Timpoweap Member of the Moenkopi Formation. Imbrication of pebbles in the conglomerate indicate deposition was from streams that flowed eastward. The conglomerate and some coarse-grained sandstone material is locally derived from the Kaibab Formation.

The northernmost Triassic paleovalley of this map is a western extension of a paleovalley called Poverty valley (Billingsley, in press b). Poverty valley can be traced about 16 km (10 mi) northwest of this map area (Billingsley, 1994), and about 24 km (15 mi) east (Billingsley, in press a). Poverty valley is about 0.7 km (0.4 mi) wide and about 40 to 50 m (130 to 165 ft) deep.

Two tributary paleovalleys are south of and parallel to Poverty valley. These paleovalleys are currently being re-eroded by Holocene erosion. The conglomerate is unconsolidated and because it consists of gray Kaibab material, it is difficult to determine the extent of these minor paleovalleys.

The basalt flows on Poverty Mountain were first described informally as the Shivwits basalt by Best and others (1980) and Reynolds and others (1986) in conjunction with other basalt flows south of this map area. But this basalt is widely separated from others south of this map forming a mappable unit. The basalt was formally renamed the Poverty Mountain Basalt by Billingsley (in press b). The Poverty

Mountain Basalt yielded a whole-rock a K-Ar age of 4.75±0.26 Ma (Reynolds and others, 1986). The basalt overlies east-dipping (2°) lower and middle strata of the Moenkopi Formation and upper Kaibab Formation. The basalt flowed west about 7 km (4.5 mi) and downslope across the east-dipping strata towards and down the ancestral "Hidden Canyon" drainage. The Poverty Mountain Basalt forms a protective caprock helping to preserve the soft strata of the Moenkopi Formation, which is the westernmost outcrop in the southern Shivwits Plateau.

The Quaternary age assigned to all alluvial deposits of the quadrangle is based on field relations to Quaternary and Pliocene basalts of this quadrangle and to those east and north of the quadrangle (Billingsley, 1994, in press a and b). Many of the alluvial deposits contain Pliocene and Pleistocene basalt clasts downslope from the outcrops east of this map area. The surficial units are useful in the study of local geomorphology and have intertonguing and gradational contacts.

STRUCTURAL GEOLOGY

The structural features in the quadrangle area show up particularly well on X-Band, side-looking radar imagery of the Grand Canyon quadrangle, Arizona (scale 1:250,000). This imagery provides an overall perspective of the structural fabric of this part of Arizona, especially in flatland areas (S.A.R. System, 1988).

The SAR imagery of this area suggests a few small faults present in the map area just east of Hidden Canyon drainage. These small faults are not readily seen on the ground, but offsets of local stratigraphy indicate that they are present, but mostly covered by alluvium. These small structures are probably Pleistocene age because Pleistocene basalts and underlying pre-Cenozoic strata are equally offset by faults north and east of this quadrangle (Billingsley, 1994; in press a and b).

The small anticline and syncline (southwest quarter of the quadrangle) are probably related to early Laramide compressional stresses (Huntoon, 1990). Warped and bent strata too small to show at map scale result from deformed solution of gypsum in the Harrisburg Member of the Kaibab Formation. These bent strata are commonly associated with solution of gypsum along drainages.

Small shallow sinkholes and karst caves are associated with the solution of gypsum in the Harrisburg Member of the Kaibab Formation. Based on their appearance, these sinkholes are relatively young features of Holocene and probable Pleistocene age. Hundreds of sinkhole depressions are breached by drainages on the Shivwits Plateau surface, but these are not plotted on the map. Sinkholes that form an enclosed basin or depression are shown by a triangle symbol.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Surficial deposits (Holocene and Pleistocene)--Surficial deposits are differentiated from one another chiefly by photogeologic techniques on the basis of difference in morphologic character and physiographic position. Older alluvial fans and terrace-gravel deposits generally exhibit extensive erosion whereas younger deposits either are actively accumulating material, or are lightly eroded as observed on 1976 aerial photographs. Surficial units on the map may have slightly different names and descriptions than units with the same map symbols on adjoining maps

Qaf **Artificial fill and quarries (Holocene)**--Alluvial and bedrock material removed from pits and trenches to build stock tanks and drainage diversion dams

Qs **Stream-channel alluvium (Holocene)**--Alluvium in active wash or large arroyo. Includes unconsolidated and poorly sorted, light gray to medium-brown, interlensing silt, sand, and pebble gravel. Intertongues with or inset against alluvial-fan (Qa_1 and Qa_2), and terrace-gravel (Qg_1 and Qg_2) deposits. Stream channels subject to high-energy flows and flash floods and support little or no vegetation. Contacts approximate. Estimated thickness 1 to 2 m (3 to 6 ft)

Qf **Flood-plain deposits (Holocene)**--Unconsolidated light-gray or brown silt, sand, and lenses of pebble gravel in flat-valley area. Deposits intertongue, merge with, inset against, or locally overlie valley-fill (Qv), and alluvial fan (Qa_1) deposits. Forms flat valley floor as opposed to concave valley profiles of valley-fill (Qv) deposits. Deposits are sparsely vegetated by sagebrush, cactus, and grass. Subject to flooding and local temporary ponding. As much as 2 m (6 ft) thick

Qg_1 **Young terrace-gravel deposits (Holocene)**--Unconsolidated, light-brown to gray, pebble to boulder gravel composed about equally of well-rounded limestone and sandstone, and angular and subrounded chert. Includes lenses of silt and sand and locally well-rounded to rounded basalt clasts. Includes reworked materials from alluvial-fans (Qa_1 and Qa_2), terrace-gravel (Qg_2), valley-fill (Qv), and talus (Qt) deposits. Forms alluvial benches about 1 to 3 m (3 to 6 ft) above local stream beds and supports moderate growth of cactus and grass. Averages about 1 to 4 m (3 to 14 ft) thick

Qa_1 **Young alluvial-fan deposits (Holocene)**--Unconsolidated gray silt and sand, partly cemented by gypsum and calcite. Includes lenses of coarse gravel composed of subangular to rounded pebbles and cobbles of limestone, chert, sandstone derived from the Kaibab and Moenkopi Formations. Locally includes basalt clasts in east half of quadrangle. Overlaps or intertongues with stream-channel alluvium (Qs), upper part of valley-fill deposits (Qv), floodplain (Qf), young terrace-gravel (Qg_1) deposits, and talus (Qt) deposits. Overlaps and partly includes reworked materials from low terrace-gravel (Qg_1) and older alluvial-fan

(Qa_2 and Qa_3) deposits near their downslope ends. Alluvial-fan subject to erosion by sheet wash and flash floods. Supports sparse to moderate growth of sagebrush, cactus, and grass. Up to as much as 6 m (20 ft) thick

Qc **Colluvial deposits (Holocene and Pleistocene?)**--White, gray, and red silt and fine-grained sand. Locally includes black, fine-grained and larger fragments of basalt; locally consolidated by gypsum and calcite cement that forms a calcrete on basalt flows. Common in enclosed basins or depressions in landslide areas. Similar to floodplain (Qf) deposits, but limited to local accumulations generally not associated with stream drainages. Subject to temporary ponding. Supports sparse growth of grass, About 1 to 3 m (3 to 10 ft) thick

Qv **Valley-fill deposits (Holocene and Pleistocene)**--Partly consolidated silt, sand, and interbedded lenses of pebble to small-boulder gravel. Intertongues or overlaps talus (Qt), flood-plain (Qf), young terrace-gravel (Qg_1), and alluvial-fan (Qa_1 and Qa_2) deposits. Subject to sheetwash flooding and temporary ponding; cut by arroyos in larger valleys. Supports moderate growth of sagebrush, grass, and cactus. As much as 5 m (15 ft) thick

Qt **Talus deposits (Holocene and Pleistocene)**--Unsorted debris consisting of breccia composed of angular blocks of local bedrock as much as 2 m (6 ft) in diameter. Includes silt, sand, and gravel; partly cemented by calcite and gypsum. Intertongues with alluvial-fan (Qa_1, Qa_2, and Qa_3) deposits, and upper part of valley-fill (Qv), and terrace-gravel (Qg_1 and Qg_2) deposits. Supports sparse to moderate growth of sagebrush, cactus, grass, and occasionally a pinion pine or juniper tree. Only relatively extensive deposits mapped. Up to as much as 5 m (15 ft) thick

Ql **Landslide deposits (Holocene and Pleistocene)**--Unconsolidated masses of unsorted rock debris, including blocks of detached segments of bedrock strata that have rotated backward and slid downslope as loose, incoherent masses of broken rock and deformed strata, often partly surrounded by talus. Occurs principally on north and south side of Poverty Mountain. Only large masses mapped. Supports sparse growth of sagebrush, cactus, grass, juniper and pinyon trees. Unstable when wet. As much as 40 m (130 ft) thick

Qg_2 **Low terrace-gravel deposits (Holocene and Pleistocene)**--Similar to young terrace-gravel deposits (Qg_1) but partly consolidated. Forms benches as abandoned stream deposits about 4 to 5 m (12 to 15 ft) above local stream beds. Intertongues or inset against, or locally overlain by talus (Qt) and young alluvial-fan (Qa_1 and Qa_2) deposits. Approximately 2 to 6 m 6 to 20 ft) thick

Qa_2 **Intermediate alluvial-fan deposits (Holocene? and Pleistocene)**--Similar to young alluvial-fan (Qa_1) deposits and partly cemented by calcite and gypsum. Locally overlapped or merges into flood-plain (Qf), valley-fill (Qv), young alluvial-fan (Qa_1), and talus (Qt) deposits. Locally includes basalt clasts near Poverty Mountain. Supports moderate growth of sagebrush, cactus, and grass. Ranges from 3 to 5 m (10 to 15 ft) thick

Qa_3 **Older alluvial-fan deposits (Pleistocene)**--Similar to young and intermediate alluvial-fan (Qa_1 and Qa_2) deposits. Composed of well-rounded limestone, sandstone, chert, and basalt clasts in sandy gravel matrix. Locally includes abundant, well-rounded clasts of basalt derived from Poverty Mountain. Often adjacent to or overlapped by younger alluvial fan (Qa_2), talus (Qt), and landslide (Ql) deposits. Partly consolidated by calcite and gypsum cement. As much as 6 m (20 ft) thick

IGNEOUS ROCKS

Poverty Mountain Basalt (Pliocene)--As described by Billingsley (in press b). K-Ar whole-rock age is 4.75±0.26 Ma (Reynolds and others, 1986). Divided into:

Tpi **Intrusive dikes**--Dark gray, massive, finely crystalline, alkali olivine basalt, aphanitic groundmass with olivine phenocrysts. Forms small dike

Tpp **Pyroclastic deposits**--Reddish-black and red fragments of scoria, cinders, and small ribbons deposited on basalt flows. Forms cinder cone that is mostly covered by subsequent basalt flows; unconsolidated. As much as 12 m (40 ft) thick

Tpb **Basalt flows**--Dark-gray to light-gray, finely crystalline, alkali olivine basalt. Includes black augite and red to green olivine phenocrysts, less than 1 mm in diameter in glassy groundmass. Basalt overlies gently east-dipping (2° average) upper red member (east of this map), Shnabkaib Member, middle red member, Virgin Limestone Member, lower red member of the Moenkopi Formation, and Harrisburg Member of the Kaibab Formation. Basalt flowed west about 7.2 km (4.5 mi) descending over 150 m (500 ft). Ranges from 30 to 92 m (100 to 300 ft) thick

SEDIMENTARY ROCKS

Moenkopi Formation (Lower Triassic)--Includes, in descending order, Shnabkaib Member, middle red member, Virgin Limestone Member, lower red member, and Timpoweap Member as used by Stewart and others (1972). The Middle-Lower Triassic boundary probably lies in the upper red member just east of this map (Morales, 1987)

Ћms **Shnabkaib Member**--Interbedded, white, laminated, aphanitic, slope-and ledge-forming dolomite and silty gypsum. Includes red, thin-bedded mudstone, siltstone, and sandstone in lower part. Gradational and arbitrary contact placed at base of lowest bed of light-gray dolomitic limestone or siltstone of Shnabkaib Member. As much as 135 m (440 ft) thick

Ћmm **Middle red member**--Interbedded, red-brown, thin-bedded, laminated, slope-forming siltstone and sandstone, white and gray gypsum, minor white platy dolomite, green siltstone, and gray-green gypsifereous mudstone. Gradational contact with Virgin Limestone Member placed at top of gray limestone bed of Virgin Limestone. About 90 m (295 ft) thick

Ћmv **Virgin Limestone Member**--Consists of one, or in places, two light-gray, ledge-forming limestone beds 0.5 to 2 m (2 to 6 ft) thick, separated by white, yellowish-gray, and gray slope-forming, thin-bedded, gypsifereous siltstone. Erosional unconformity at base of lowest gray limestone bed truncates underlying red siltstone of lower red member as much as 1 m (3 ft) of relief east of this map area (Billingsley, in press a). About 6 to 8 m (20 to 25 ft) thick

Ћml **Lower red member**--Red, fine-grained, thin-bedded, gypsifereous, slope-forming sandy siltstone interbedded with gray, white, and pale-yellow laminated gypsum and minor sandstone. Lower beds contain reworked gypsum and siltstone of Harrisburg Member of Kaibab Formation. Interbedded or gradational contact with conglomerate of Timpoweap Member. Unconformable contact with Kaibab Formation. Locally fills paleovalleys eroded into underlying Kaibab Formation. About 10 m (30 ft) thick. Thickens locally in paleovalleys

Ћmt **Timpoweap Member**--Calcareous, light-gray, slope-forming conglomerate and light red to gray, coarse-grained, low-angle cross-bedded sandstone. Conglomerate composed of subangular to rounded pebbles and cobbles of gray and dark gray limestone, white and brown chert, and rounded quartzite in gray to light-brown, coarse-grained sandstone matrix derived from Kaibab Formation. Unconformable contact with Harrisburg Member of Kaibab Formation. Fills Triassic paleovalleys eroded into Kaibab Formation estimated as much as 50 m (165 ft) deep and about o.4 km (0.5 mi) wide. Rocks of Timpoweap occupy 3 paleovalleys, Poverty valley (Billingsley, in press b), and 2 smaller unnamed paleovalleys. Deposits mostly eroded by local streams. Pebble imbrication in lower conglomerate indicate an eastward paleoflow of depositing streams. Thickness 40 to 50 m (130 to 165 ft)

Kaibab Formation (Lower Permian)--Includes, in descending order, Harrisburg and Fossil Mountain Members as defined by Sorauf and Billingsley (1991). Divided into:

Pkh **Harrisburg Member**--Includes an upper, middle, and lower part. Upper part consists mainly of slope-forming, red and gray, interbedded gypsifereous siltstone, sandstone, gypsum, and thin-bedded gray limestone; mostly removed by erosion except at Poverty Mountain. Middle part consists mainly of two, thin cliff-forming marker beds. Top marker bed consists of gray, thin-bedded, cherty limestone; weathers dark brown or black and often forms bedrock surface of this quadrangle. Bottom marker bed consists of light-gray, thin-bedded, sandy limestone. Middle part unconformably truncates lower part. Lower part consists of slope-forming, light-gray and red, fine- to medium-grained, gypsifereous siltstone, sandstone, gray medium-grained, thin-bedded limestone, and gray massive gypsum beds. Solution of gypsum in lower part has locally caused limestone beds of middle part to slump or bend into local drainages. Gradational and arbitrary contact between siltstone slope of Harrisburg Member and limestone cliff of Fossil Mountain Member. Harrisburg, in general, forms slopes with middle limestone cliff. As much as 122 m (400 ft) thick

Pkf **Fossil Mountain Member**--Light-gray, fine- to medium-grained, thin-bedded, fossiliferous, sandy, cliff-forming cherty limestone. Unit characterized by black-weathering chert bands. Unconformable contact with underlying Woods Ranch Member of Toroweap Formation marked by solution and channel erosion with relief as much a 3 m (10 ft); contact locally covered by talus. About 120 m (390 ft) thick

Toroweap Formation (Lower Permian)--Includes, in descending order, Woods ranch, Brady Canyon, and Seligman Members as defined by Sorauf and Billingsley (1991). Only Woods Ranch Member exposed in Hidden Canyon drainage of this map area

Ptw **Woods Ranch Member**--Gray, yellow, and red, slope-forming gypsifereous siltstone and pale-red sandstone interbedded with white laminated gypsum. Beds are locally distorted due to gypsum solution. Only upper part of unit exposed within map boundary. About 18 m (60 ft) exposed

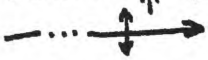

Contact--Dashed where approximately located


Fault--Dashed where inferred or approximately located; dotted where concealed; bar and ball on downthrown side. Number is estimated displacement in meters


Landslide scarp--Headward scarp of landslide, hachures point in direction of slide

Folds--Showing trace of axial surface and direction of plunge; dashed where approximately located; dotted where concealed


Syncline


Anticline

Strike and dip of beds--Showing dip where known


Inclined


Strike of vertical and sub-vertical joints--Interpreted from aerial photographs


Sinkholes--Enclosed depression or cave


Flow direction of basalt--Interpreted from aerial photographs of flow channels, collapsed lava tubes, marginal flow levees, and frontal lobes

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REFERENCES CITED

Best, M.G., McKee, E.H., and Damon, P.E., 1980, Space-time composition patterns of late Cenozoic mafic volcanism, southwestern Utah and adjoining areas: American Journal of Science, v. 280, p. 1035-1050.

Billingsley, G.H., 1994, Geologic map of the Sullivan Draw and vicinity, Mohave County, northwestern Arizona: U.S. Geological Survey Miscellaneous Investigations Map Series I-2396, scale 1:31,680.

___ in press a, Geologic map of the upper Hurricane Wash and vicinity, Mohave County, northwestern Arizona: U.S. Geological Survey Miscellaneous Investigations Map Series I-2539, scale 1:31,680.

___ in press b, Geologic map of the upper Parashant Canyon and vicinity, Mohave County, northwestern Arizona: U.S. Geologic Survey Miscellaneous Geologic Investigations I-xxx, scale 1:31,680.

Huntoon, P.W., 1990, Phanerozoic structural geology of the Grand Canyon: *in* Beus, Stanley S., and Morales, Michael, *eds.*, Grand Canyon Geology, New York Oxford, Oxford University Press, Museum of Northern Arizona, p. 261-310.

Morales, Mike, 1987, Terrestrial fauna and flora from the Triassic Moenkopi Formation of the southwest United States: Journal of the Arizona-Nevada Academy of Science, v. 22, p. 1-19.

Reynolds, S.J., 1988, Geologic map of Arizona: Arizona Geological Survey, Tucson, Arizona, Map 26, scale 1:1,000,000.

Reynolds, S.J., Florence, F.P., Welty, J.W., Roddy, M.S., Currier, D.A., Anderson, A.V., and Keith, S.B., 1986, Compilation of radiometric age determinations in Arizona: Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch, Bulletin 197, 258 p.

S.A.R. System, 1988, Grand Canyon, Arizona, Synthetic Aperture Radar Imagery X-band, near-range, east-look: Produced for the U.S. Geological Survey by Aero Service Division, Western Atlas International, Inc., Radar Image Mosaic, scale 1:250,000.

Sorauf, J.E., and Billingsley, G.H., 1991, Members of the Toroweap and Kaibab Formations, Lower Permian, northern Arizona and southwestern Utah: Rocky Mountain Geologists, v. 28, no. 1, p. 9-24.

Stewart, J.H., Poole, F.G., and Wilson, R.F., 1972, Stratigraphy of the Triassic Moenkopi Formation and related strata in the Colorado Plateau region, with a section on sedimentary petrology: *in* Cadigan, R.A., U.S. Geological Survey Professional Paper 691, 195 p.

Wilson, E.D., Moore, R.T., and Cooper, J.R., 1969, Geologic map of the State of Arizona: Arizona Bureau of Mines, University of Arizona, scale 1:500,000.

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS AND IGNEOUS ROCKS