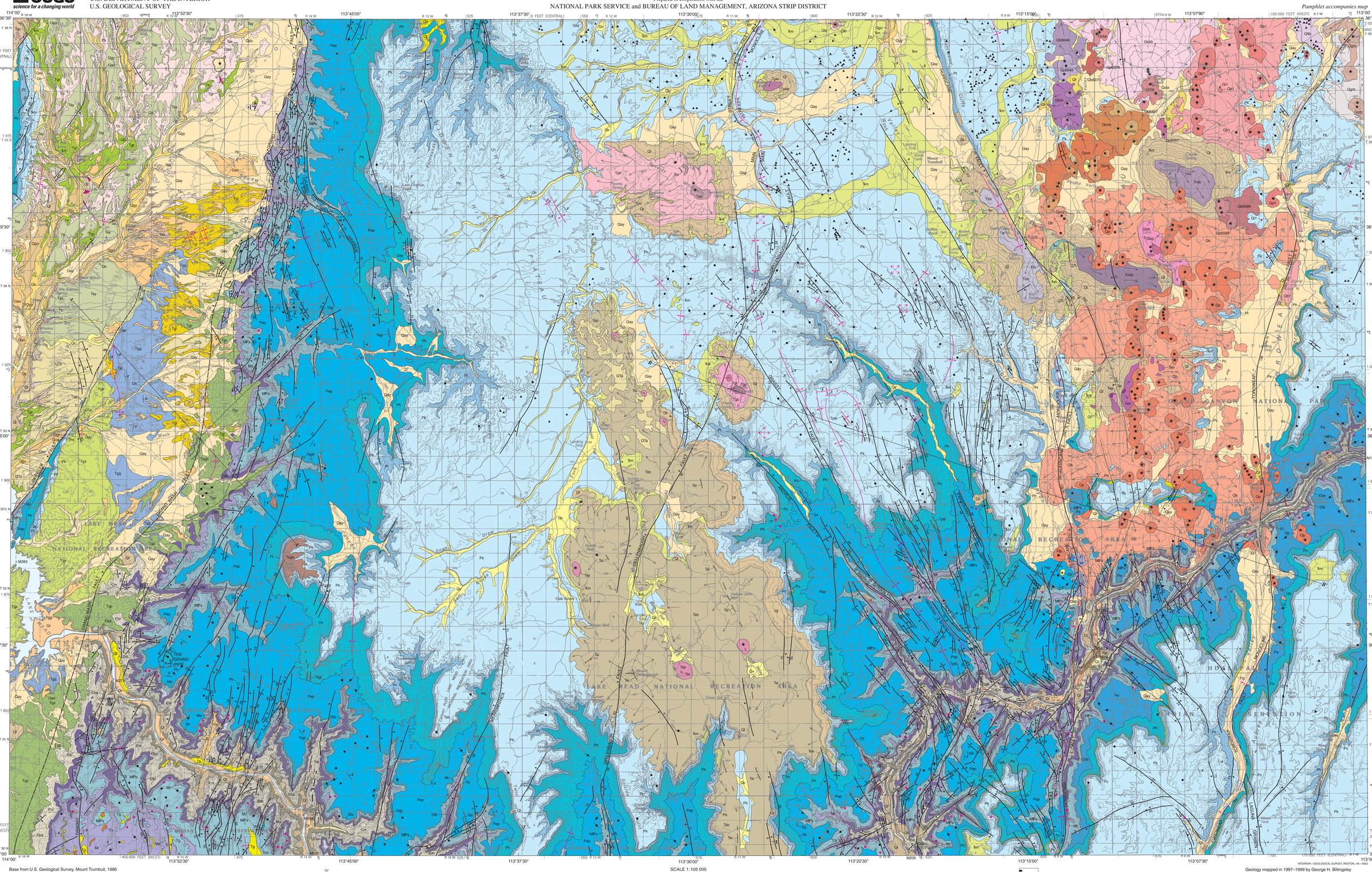
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NATIONAL PARK SERVICE and BUREAU OF LAND MANAGEMENT, ARIZONA STRIP DISTRICT

GEOLOGIC INVESTIGATIONS SERIES I–2766
Pamphlet accompanies map



Base from U.S. Geological Survey, Mount Trumbull, 1986
Universal Transverse Mercator Projection

SCALE 1:100 000

CONTOUR INTERVAL 50 METERS

APPROXIMATE MEAN DECLINATION, 2002

MAP LOCATION

Geology mapped in 1997–1999 by George H. Billingsley
Geologic photos by George H. Billingsley
Digital database by Jessica L. Wellmeyer
Edited by Jan L. Zigler and Theresa Iki; cartography by Helen Dyer, Debra Block, Darlene A. Ryan, and Beatrice C. Landavazo
Manuscript approved for publication March 26, 2002

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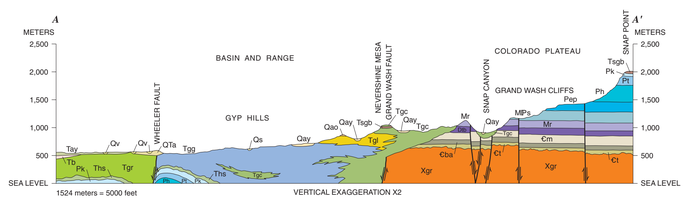
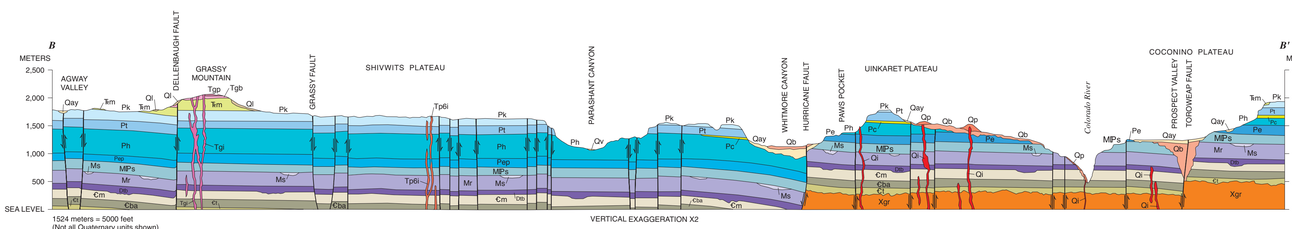
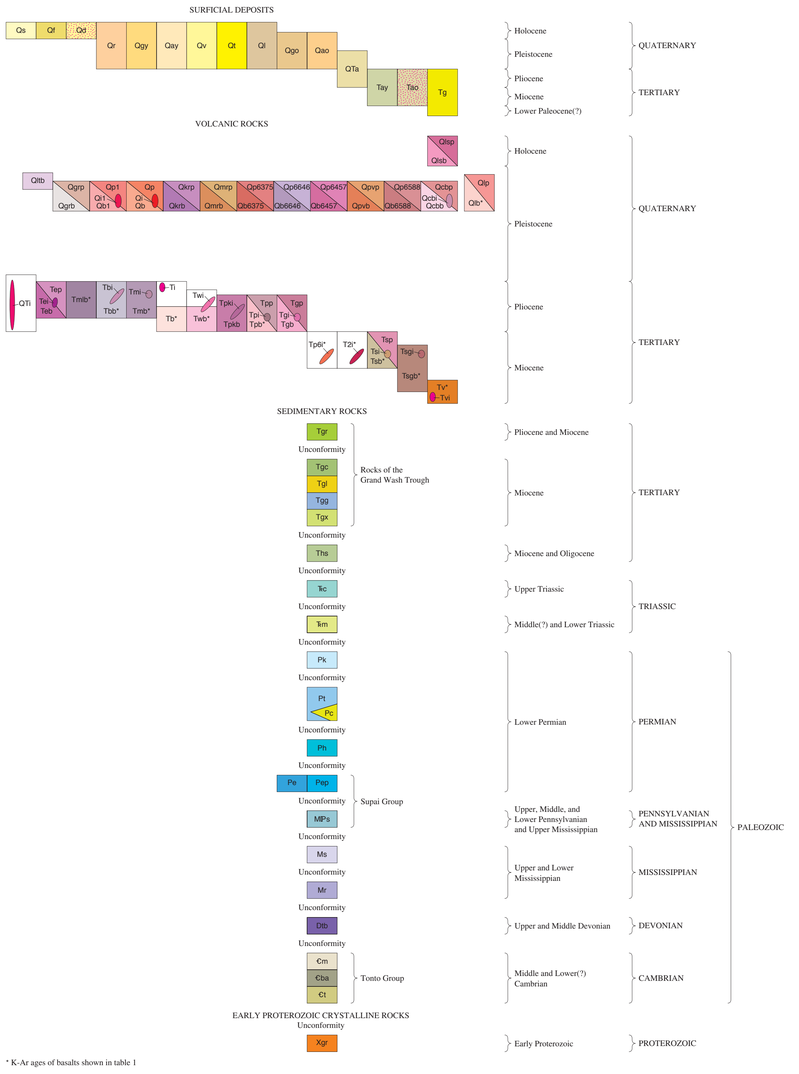




CORRELATION OF MAP UNITS



* K-Ar ages of basalts shown in table 1

LIST OF MAP UNITS

[Some unit exposures on the printed map are too small to distinguish the color for unit identification. These units are labeled where possible, and unlabeled units are attributed in the database.]

SURFICIAL DEPOSITS

- Qs — **Stream-channel alluvium (Holocene)**
- Qf — **Floodplain deposits (Holocene)**
- Qd — **Sand sheet and sand dune deposits (Holocene)**
- Qr — **Colorado River terrace and gravel deposits (Holocene and Pleistocene)**
- Qgy — **Young alluvial terrace deposits (Holocene and Pleistocene)**
- Qay — **Young alluvial fan deposits (Holocene and Pleistocene)**
- Qv — **Valley-fill alluvium, undivided (Holocene and Pleistocene)**
- Qt — **Travertine deposits (Holocene and Pleistocene)**
- Ql — **Landslide deposits (Holocene and Pleistocene)**
- Qgo — **Older alluvial terrace deposits (Holocene(?) and Pleistocene)**
- Qao — **Older alluvial fan deposits (Holocene(?) and Pleistocene)**
- QTa — **Old alluvium (Pleistocene and Pliocene)**
- Tay — **Alluvium and calcrete soil deposits (Pliocene and Miocene)**
- Tao — **Alluvial deposits (Pliocene and Miocene)**
- Tg — **Undifferentiated gravel deposits of the Hualapai Plateau (Pliocene to lower Paleocene(?))**

VOLCANIC ROCKS

Quaternary volcanic deposits (Holocene, Pleistocene, and Pliocene(?))

Little Spring Basalt (Holocene)

- Qlsp — **Pyroclastic deposits**
- Qlsb — **Basalt flows**

Basalt of Larimore Tank (Pleistocene)

- Qltb — **Basalt flows**

Basalt of Graham Ranch (Pleistocene)

- Qgrp — **Pyroclastic deposits**
- Qgrb — **Basalt flows**

Basalt of the Uinkaret Plateau (Pleistocene)

- Qt, Qt1 — **Intrusive rocks**
- Qp, Qp1 — **Pyroclastic deposits**
- Qb, Qb1 — **Basalt flows**

Basalt of Kenworthy Ranch (Pleistocene)

- Qkrp — **Pyroclastic deposits**
- Qkrb — **Basalt flows**

Basalt of Marshall Ranch (Pleistocene)

- Qmrp — **Pyroclastic deposits**
- Qmrb — **Basalt flows**
- Qp6375 — **Basalt of hill 6375 (Pleistocene)**
  - Qb6375 — **Pyroclastic deposits**
  - **Basalt flows**
- Qp6646 — **Basalt of hill 6646 (Pleistocene)**
  - Qb6646 — **Pyroclastic deposits**
  - **Basalt flows**
- Qp6457 — **Basalt of hill 6457 (Pleistocene)**
  - Qb6457 — **Pyroclastic deposits**
  - **Basalt flows**
- Qpvp — **Basalt of Potato Valley (Pleistocene)**
  - Qpvb — **Pyroclastic deposits**
  - **Basalt flows**
- Qp6588 — **Basalt of hill 6588 (Pleistocene)**
  - Qb6588 — **Pyroclastic deposits**
  - **Basalt flows**
- Qcbl — **Basalt of Craigs Knoll and Berry Knoll (Pleistocene)**
  - **Intrusive dikes or necks**
  - Qcbp — **Pyroclastic deposits**
  - Qcbb — **Basalt flows**
- Qlp — **Little Tanks Basalt (Pleistocene)**
  - **Pyroclastic deposits**
  - Qlb — **Basalt flows**
- QTi — **Hells Hole dikes (Pleistocene or Pliocene(?))**

Tertiary volcanic deposits (Pliocene and Miocene)

- Tei — **Basalt north of Mount Emma (Pliocene)**
  - **Intrusive rocks**
  - Tep — **Pyroclastic deposits**
  - Teb — **Basalt flows**
- Tmlb — **Basalt of Mount Logan (Pliocene)**
  - **Basalt flows**
- Tbi — **Basalt of Bundyville (Pliocene)**
  - **Intrusive dikes**
  - Tbb — **Basalt flows**
- Tmi — **Basalt of Mount Trumbull (Pliocene)**
  - **Intrusive rocks**
  - Tmb — **Basalt flows**
- Ti — **Basalt of the Grand Wash Trough (Pliocene)**
  - **Dikes and necks**
  - Tb — **Basalt flows**
- Twi — **Whitmore dike swarm (Pliocene)**
  - **Intrusive dikes**
  - Twb — **Basalt flow**
- Tpki — **Basalt of Poverty Knoll (Pliocene)**
  - **Intrusive dike**
  - Tpkb — **Basalt flow**
- Tpi — **Poverty Mountain Basalt (Pliocene)**
  - **Intrusive neck**
  - Tpp — **Pyroclastic deposits**
  - Tpb — **Basalt flows**
- Tgi — **Grassy Mountain Basalt (Pliocene)**
  - **Intrusive dikes**
  - Tgp — **Pyroclastic deposits**
  - Tgb — **Basalt flows**
- Tpdi — **Dikes of Parashant Canyon and Hundred and Ninetysix Mile Creek (Miocene)**
- T2i — **Dikes of Colorado River Mile 202 (Miocene)**
- Tsi — **Basalt of the Shivwits Plateau (Miocene)**
  - **Intrusive rocks**
  - Tsp — **Pyroclastic deposits**
  - Tsb — **Basalt flows**
- Tsgi — **Snap Point Basalt and Garrett dikes (Miocene)**
  - **Intrusive dikes**
  - Tsgb — **Basalt flows**
- Tvi — **Volcanic rocks of the Hualapai Plateau, undivided (Early to middle Miocene)**
  - **Plug of The Grand Pipe**
  - Tv — **Basalt flows**

SEDIMENTARY ROCKS

Rocks of the Grand Wash Trough (Pliocene and Miocene)

- Tgr — **Red siltstone, sandstone, and conglomerate facies (Pliocene and Miocene)**
- Tgc — **Paleozoic-clast conglomerate facies (Miocene)**
- Tgl — **Limestone and siltstone facies (Miocene)**
- Tgg — **Gypsum and gypsiferous siltstone facies (Miocene)**
- Tgx — **Proterozoic-clast conglomerate facies (Miocene)**

Horse Spring Formation (Miocene and Oligocene)

- Ths — **Rainbow Gardens Member**
- Ŧc — **Chinle Formation, undivided (Upper Triassic)**
- Ŧm — **Moenkopi Formation, undivided (Middle(?) and Lower Triassic)**
- Pk — **Kaibab Formation, undivided (Lower Permian)**
- Pt — **Toroweap Formation, undivided (Lower Permian)**
- Pc — **Coconino Sandstone (Lower Permian)**
- Ph — **Hermit Formation (Lower Permian)**

Supai Group (Lower Permian, Upper, Middle, and Lower Pennsylvanian, and Upper Mississippian)

- Pe — **Esplanade Sandstone east of Hurricane Fault (Lower Permian)**
- Pep — **Esplanade Sandstone and Pakoon Limestone west of Hurricane Fault (Lower Permian)**
- MPs — **Wescogame Formation (Upper Pennsylvanian), Manakacha Formation (Middle Pennsylvanian), and Watahomigi Formation (Lower Pennsylvanian and Upper Mississippian), undivided**
- Ms — **Surprise Canyon Formation (Upper Mississippian)**
- Mr — **Redwall Limestone, undivided (Upper and Lower Mississippian)**
- Dtb — **Temple Butte Formation (Upper and Middle Devonian)**

Tonto Group (Middle and Lower Cambrian)

- Ꞓm — **Muav Limestone (Middle Cambrian)**
- Ꞓba — **Bright Angel Shale (Middle Cambrian)**
- Ꞓt — **Tapeats Sandstone (Middle and Lower(?) Cambrian)**

EARLY PROTEROZOIC CRYSTALLINE ROCKS

Intrusive and metamorphic rocks as defined by Ilg and others, (1996) and Hawkins and others, (1996)

- Xgr — **Granite, granitic pegmatite, and aplites**

Contact—Approximate contact for surficial units and between the Harrisburg and Fossil Mountain Members of the Kaibab Formation

Fault—Dashed where inferred or approximately located; dotted where concealed; bar and ball on downthrown side. Number is estimated separation displacement in meters; number in parenthesis is estimated displacement of indicated units along the fault

Volcanic mar?—Olaf Knolls, northwest corner of map

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

Anticline

Plunging anticline

Syncline

Monocline

Dome

Strike and dip of beds—Measured in the field

Strike of vertical and subvertical joints

Collapse structure—Black dot shows circular collapse structure characterized by strata dipping inward toward central point. Magenta dot shows circular collapse structure characterized by strata dipping inward toward central point and brecciated rock. On Kaibab Formation surface (Pk) may reflect collapse of deep-seated breccia pipe that originated in Redwall Limestone

Sinkhole—Enclosed depression or cave

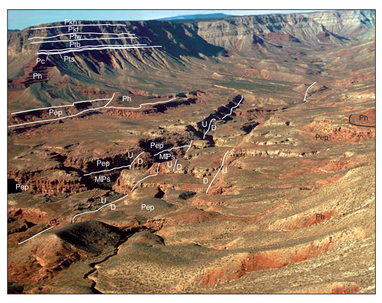
Flow direction of basalt

Volcanic vent

Mine

Colorado River Mile 188—Measured from Lees Ferry, Arizona (east of map area)

1986 photograph of the mouth of Grand Canyon looking northeast towards the lower Grand Wash Cliffs. Dashed line represents the approximate location of the Grand Wash Fault that separates the Colorado Plateau and Basin and Range geologic provinces (U, upthrown side; D, downthrown side). Rocks of the Grand Wash Trough (Tgw) of the Basin and Range cover the Grand Wash Fault and Paleozoic (Pz) rocks of the lower Grand Wash Cliffs of the Colorado Plateau. (See table 2 for correlation to map units.)



1972 photograph looking northwest into Parashant Canyon at Parashant Graben (U/D/U: D, downthrown side of fault; U, upthrown side) in bottom of canyon. Grassy Mountain is on the skyline. (See table 2 for correlation to map units.)

1985 photograph looking east at Colorado River Mile 190 landslide above and east of Colorado River Mile 190. Bottom of slide has moved horizontally along the top of the Rampart Cave Member (Ꞓr) of the Muav Limestone. There are two concave fault slip planes (arrows *A* and *B*). (See table 2 for correlation to map units.)

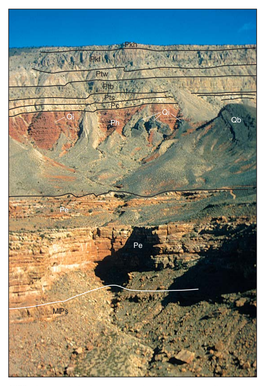
Table 2. *Geologic units unique to the photographs correlated with geologic map units*

Unit label (photographs)	Unit label (map)	Unit name
Qwb	Qb	Basalt flow of Whitmore Canyon unit of Basalt of the Uinkaret Plateau (Hamblin, 1994)
Qbl	Qb	Black Ledge basalt unit of Basalt of the Uinkaret Plateau (Hamblin, 1994)
Qgl	Qb	Grey Ledge basalt unit of Basalt of the Uinkaret Plateau (Hamblin, 1994)
Tgw	Qay	Young alluvial fan deposits
Tgw	Qao	Older alluvial fan deposits
Tgw	Tgc	Surficial and sedimentary rocks of the Grand Wash Trough
Ŧmu	Ŧm	Upper red member of the Moenkopi Formation
Ŧms	Ŧm	Shnabkaib Member of the Moenkopi Formation
Ŧmm	Ŧm	Middle member of the Moenkopi Formation
Pz	Pk–Ꞓt	All Paleozoic units on the map
Pkh	Pk	Harrisburg Member of the Kaibab Formation
Pkf	Pk	Fossil Mountain Member of the Kaibab Formation
Ptw	Pt	Woods Ranch Member of the Toroweap Formation
Ptb	Pt	Brady Canyon Member of the Toroweap Formation
Pts	Pt	Seligman Member of the Toroweap Formation
Ꞓu	Ꞓm	Undifferentiated dolomites of the Muav Limestone
Ꞓh	Ꞓm	Havasu Member of the Muav Limestone
Ꞓg	Ꞓm	Gateway Canyon Member of the Muav Limestone
Ꞓk	Ꞓm	Kanab Member of the Muav Limestone
Ꞓp	Ꞓm	Peach Springs Member of the Muav Limestone
Ꞓs	Ꞓm	Unnamed shale of the Muav Limestone
Ꞓsp	Ꞓm	Spencer Canyon Member of the Muav Limestone
Ꞓsa	Ꞓm	Sanup Plateau Member of the Muav Limestone
Ꞓr	Ꞓm	Rampart Cave Member of the Muav Limestone
Ꞓrb	Ꞓba	Red-brown sandstone member of the Bright Angel Shale
Ꞓbm	Ꞓba	Unnamed shale and dolomite of the Bright Angel Shale

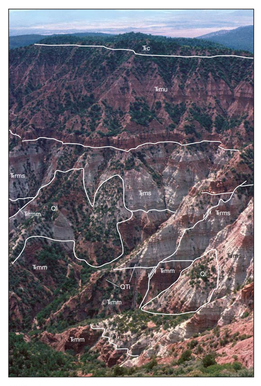
Table 1. *Table showing K-Ar ages of basalts*

Unit label	Unit	K-Ar ages (Ma)
Qlb	Little Tanks Basalt	1.0 ± 0.4
Tmlb	Basalt of Mount Logan	2.63 ± 0.34
Tbb	Basalt of Bundyville	3.6 ± 0.18
Tmb	Basalt of Mount Trumbull	3.6 ± 0.18 and 3.67 ± 0.09
Ttb	Basalt of the Grand Wash Trough	3.99 ± 0.06; 3.24 ± 0.05; 4.70 ± 0.07
Twb	Whitmore dike swarm	4.56 ± 0.12
Tpb	Poverty Mountain Basalt	4.75 ± 0.26
Tp6i	Dikes of Parashant Canyon and Hundred and Ninetysix Mile Creek	6.34 ± 0.1
T2i	Dikes of Colorado River Mile 202	5.76 ± 0.26
Tsb	Basalt of Shivwits Plateau	6.2 ± 0.30; 7.64 ± 0.30; 6.78 ± 0.15; 7.06 ± 0.49; 8.2 ± 0.1
Tsgb	Snap Point Basalt and Garrett dikes	9.07 ± 0.80; 9.2 ± 0.13
Tv	Volcanic rocks of the Hualapai Plateau, undivided	15.3 ± 0.3; 17.4 ± 0.3; 17.4 ± 0.9

1972 photograph looking north and upstream at Colorado River Mile 188 in Whitmore Canyon. Arrow on river shows current direction. Dashed line A–B indicates top of eroded Whitmore basalt dam. (See table 2 for correlation to map units.)



1972 photograph looking east at the west-facing wall of upper Whitmore Canyon near Paws Pocket showing Quaternary intrusive basalt dikes (Qb) and associated flow (Qb). Estimated age of basalt, about 200,000 years (Fenton, 1998). (See table 2 for correlation to map units.)



1987 photograph looking west into Hells Hole of upper Whitmore Canyon from the top of Mount Logan showing nearly 1,000 feet of the Moenkopi Formation. (See table 2 for correlation to map units.)

Geologic Map of the Mount Trumbull 30' X 60' Quadrangle, Mohave and Coconino Counties, Northwestern Arizona

By
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2003

ISBN 0-607-88889-6

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For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, CO 80225, 1–800–ASK–USGS
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Printed on recycled paper