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

Geologic map of the St. George Canyon quadrangle, northern Mohave County, Arizona

by
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Open-File Report 91-561

1991

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INTRODUCTION

The St. George Canyon quadrangle (96 sq km) is located in northern Mohave County Arizona, about 90 kilometers south of the Utah-Arizona state line (fig. 1). Elevations range from about 3,560 ft at Hidden Canyon to about 6,005 ft, in the southeast corner of the quadrangle. The nearest settlement is St. George, Utah, about 72 kilometers north of the quadrangle. Access to the quadrangle area is by dirt road locally referred to as the Mt. Trumbull road south from St. George, Utah to Wolf Hole, Arizona, an abandoned ranch. An unimproved dirt road leads southwest from Wolf Hole about 21 kilometers to the quadrangle area (fig. 1).

The area is managed entirely by the U.S. Bureau of Land Management except for 3 sections belonging to the State of Arizona in the central part of the quadrangle. Below about 4,500 ft, the area is sparsely vegetated with sagebrush, cactus, pinion pine and juniper trees, apache plume brush, and cliff rose bush. At higher elevations, thick growths of sagebrush in alluvial valleys and a moderate cover of pinion pine and juniper trees are common.

PREVIOUS WORK

There are no previous small-scale geologic maps of this area. The area was included in two Arizona state geologic maps, one at a scale of 1:500,000 (Wilson and others, 1969), and the other at 1:1,000,000 (Reynolds, 1988). Geologic maps in preparation of bordering areas include, on the north, the Mustang Knoll 7.5 quadrangle, Arizona, on the west, the Cane Springs SE 7.5 quadrangle, Arizona; and to the east, the Sullivan Draw South 7.5 quadrangle, Arizona.

GEOLOGIC SETTING

The quadrangle lies within the Shivwits and Sanup Plateaus, sub-physiographic plateaus of the southwestern Colorado Plateau geologic province (fig. 2). The physiographic boundary between the higher Shivwits and lower Sanup Plateaus is drawn along the rim of the erosional scarp cut into the Shivwits Plateau (fig. 2). The quadrangle is characterized by nearly flat-lying Mesozoic and Paleozoic strata with a regional northeast dip of about 4° in the southwest half of the quadrangle, and about 1° northeast in the northeast half. The area is dissected by the Hidden Canyon drainage and its tributaries exposing more than 640 m of Permian and Triassic strata. Hobble graben transects the east-central half of the quadrangle and displaces strata about 244 m. Smaller grabens with a north strike are located in southwest quarter of the quadrangle.

Cenozoic deposits are widely distributed and characterized as geomorphic surficial or mass-moved erosional deposits based on landform development and their relationship to underlying structures and erosional changes. The surficial units often merge or intertongue and share an arbitrary map boundary.

STRATIGRAPHY

The sedimentary bedrock strata include, in ascending order, Pakoon Limestone, Esplanade Sandstone, Hermit Shale, Coconino Sandstone, Toroweap and Kaibab Formations, (Lower Permian), and Moenkopi Formation (Middle? and Lower Triassic). The Moenkopi Formation is present in scattered outcrops in Hobble graben. The oldest map unit, the Pakoon Limestone, crops out in Hidden Canyon drainage, southwest quarter of the quadrangle. About two-thirds of the

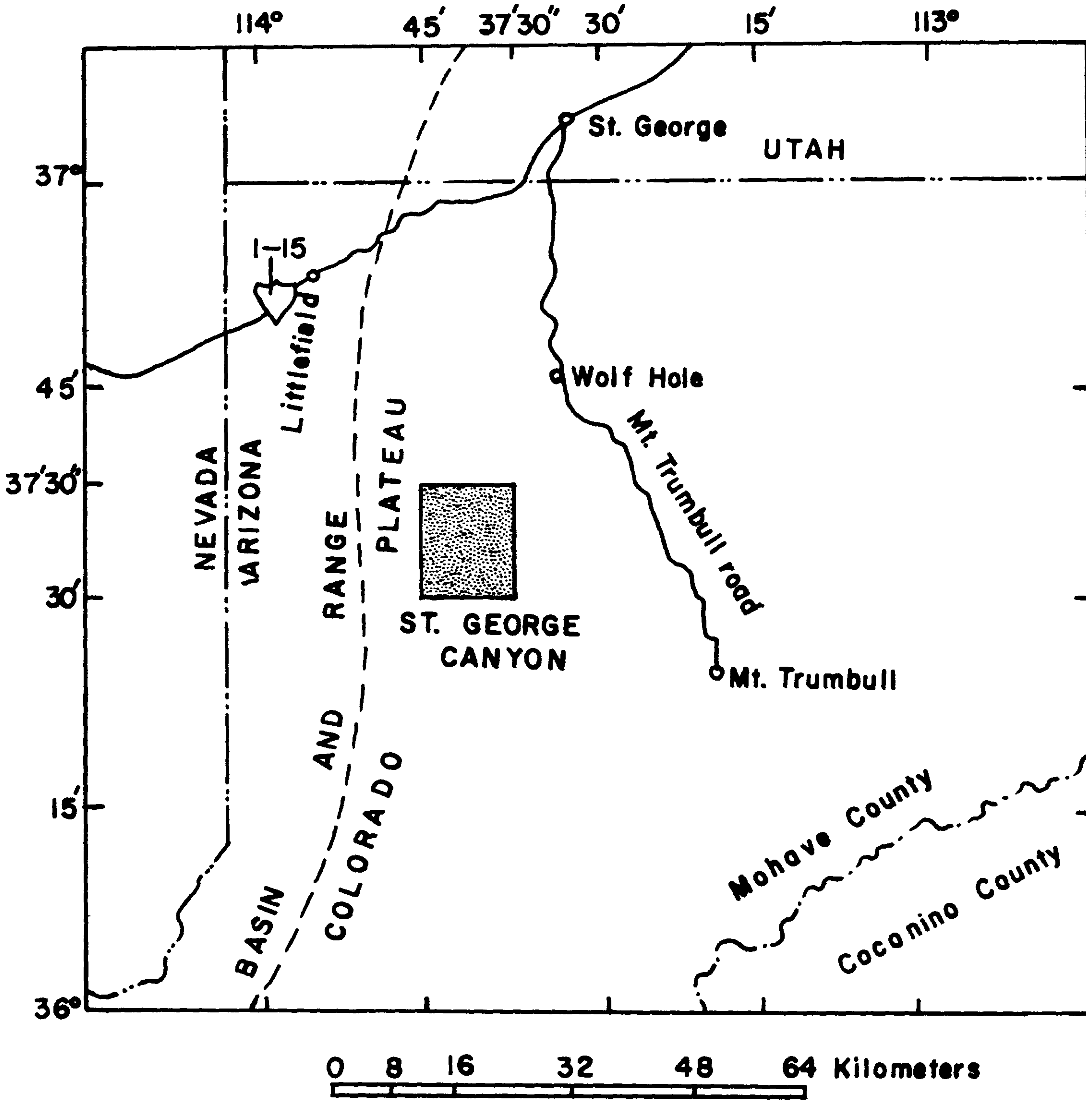


Figure 1. St. George Canyon 7.5 quadrangle, northern Mohave County, northwestern Arizona, showing 7.5 quadrangle mapped in this report.

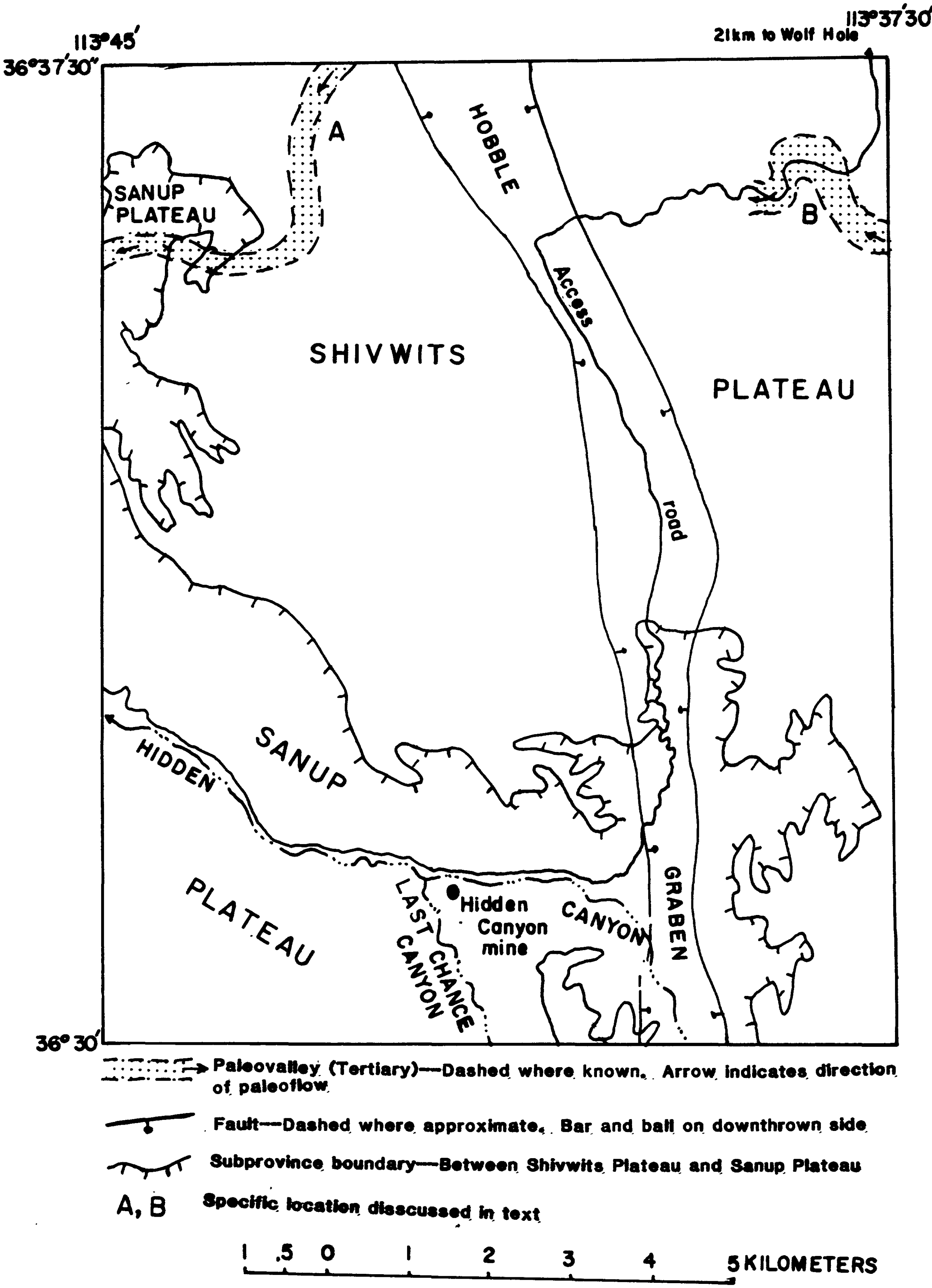


Figure 2. Selected geographic and geologic features of the St. George Canyon 7.5 quadrangle, northwestern Arizona.

surface bedrock of this quadrangle is gray cherty limestone, and gray to white siltstone and gypsum of the Kaibab Formation. Another third of the surface bedrock is red siltstone and sandstone of the Hermit Shale and Esplanade Sandstone, and gray limestone of the Pakoon Limestone.

The Hobble basalt flow, northwest quarter of the quadrangle, is assumed to be Pliocene and probably equivalent to Pliocene basalt flows capping Black Rock and Wolf Hole Mountains 16 kilometers north of this quadrangle. The basalt flow occupies a Tertiary paleovalley with a gradient of about 85 m per kilometer towards the southwest (A in fig. 2). Another and perhaps younger Tertiary valley is located in the northeast corner of the quadrangle and extends eastward into the adjoining Sullivan Draw South quadrangle (B in fig. 2). Sediments of this valley are eroded away in the St. George quadrangle and the valley eroded deeper by Holocene erosion. Tertiary sediments are found in this valley about 3 kilometers east of the quadrangle with basalt cobbles suggesting a west flowing drainage of the depositing stream.

STRUCTURAL GEOLOGY

Hobble graben is the main structural feature of this quadrangle and extends both north and south of the quadrangle. It averages about 1.2 kilometers wide for about 16 kilometers with a north 10° west strike. The east fault of the graben has about 244 m of displacement and the west fault about 182 m, thus, the overall displacement of strata across the graben is about 61 m down to the west. Maximum displacement within the graben is about 250 m in the northern part, lesser to the south. A few small grabens are located in the lower reaches of Hidden Canyon, southwest quarter of the quadrangle.

Numerous small sags and folds associated with solution of gypsum in the Kaibab Formation, especially in drainages, are too small and irregular to show at map scale in the northeast quarter of the quadrangle.

Collapse Structures

Circular collapse structures, and other surface irregularities are mostly due to solution of gypsum and gypsiferous siltstone. However, some circular, bowl-shaped areas that have inward-dipping strata may be collapse-formed breccia pipes originating in the deeply buried Mississippian Redwall Limestone (Wenrich and Huntoon, 1989). Such features on this quadrangle, commonly with inward-pointing dip symbols, are marked by a dot and the letter "C" to denote possible deep-seated breccia pipes. They cannot with certainty be distinguished by surface forms from shallow collapse structures caused by removal of gypsum. Moreover, some deep-seated breccia pipes are known to be overlain by gypsum collapse features (Wenrich and others, 1986). However, those collapse features in the Pakoon Limestone, Esplanade Sandstone, and Hermit Shale have a high potential to be breccia pipes based on inward dipping strata, field investigations, and some alteration. The deep-seated breccia pipes are potential host for economic deposits of copper and uranium (Wenrich, 1985). The Hidden Canyon breccia pipe (junction of Hidden and Chance Canyons, fig. 2) does contain copper minerals and minor amounts of uranium based on 1982 drilling information of Pathfinder Mines Corporation, St. George, Utah (oral commun. 1991).

Shallow sinkholes and karst caves are associated with the solution of gypsum in the Harrisburg Member of the Kaibab Formation and Woods Ranch Member of the

Toroweap Formation. The sinkholes are denoted with the letter "S" and a triangle symbol when the feature forms an enclosed depression or cave on the land surface. The sinkholes are young features, Holocene and probably as old as Pleistocene.

DESCRIPTION OF MAP UNITS

Surficial Deposits

Qs **Stream-channel alluvium (Holocene)**--Unconsolidated, unsorted, interlensing silt, sand, and pebble to boulder gravel. Intertongues and merges with alluvial fan (Qa_1), terrace-gravel (Qg_1 and Qg_2), talus (Qt), and valley-fill (Qv) deposits. Subject to high-energy flows and flash floods. Little or no vegetation. Contacts approximate. Estimated thickness 1 to 4.5 m

Qg_1 **Low terrace-gravel deposits (Holocene)**--Unconsolidated light-brown, pebble to boulder gravel composed about equally of well-rounded limestone, sandstone, and angular to subrounded chert; includes interstratified lenses of silt, sand, and gravel. Locally includes some basalt clasts in northwest quarter of quadrangle. Commonly merges with stream-channel (Qs), alluvial fan (Qa_1), terrace-gravel (Qg_1 and Qg_2), talus (Qt), and valley-fill (Qv) deposits. Forms a bench about 1 to 2.4 m above modern stream beds. Thickness averages about 1 to 6 m

Qa_1 **Young alluvial fan deposits (Holocene)**--Unconsolidated silt and sand; contains lenses of coarse gravel composed of subangular to rounded pebbles to cobbles of limestone, chert, and sandstone, also some basalt clasts in Jump Canyon, northwest corner of quadrangle; partly cemented by gypsum and calcite. Merges with stream-channel (Qs), valley-fill (Qv), terrace-gravel (Qg_1, and Qg_2), and older alluvial fan (Qa_2, and Qa_3) deposits near their downslope ends. Subject to erosion by sheet wash and flash flooding. Sparse to moderate vegetation by pinion pine and juniper trees, sagebrush, cactus, and grass. Thickness as much as 6 m

Qv **Valley-fill deposits (Holocene and Pleistocene?)**--Partly consolidated silt, sand, and interbedded lenses of pebble to small cobble gravel. Consists of and merges with talus (Qt), terrace-gravel (Qg_1) and alluvial fan (Qa_1) deposits. Subject to sheetwash and temporary ponding; cut by arroyos in larger drainages. Thickly vegetated by sagebrush, grass, and cactus. Thickness as much as 10 m

Qg_2 **Intermediate terrace-gravel deposits (Holocene and Pleistocene?)**--Similar to low terrace-gravel deposits (Qg_1), partly consolidated; on benches and abandoned stream channels about 4 to 12 m above modern stream beds. Merges with or locally overlain by talus (Qt), alluvial fan (Qa_1), and stream channel (Qs) deposits. Thickness about 1.5 to 7 m

Qa_2 **Intermediate alluvial fan deposits (Holocene and Pleistocene?)**--Similar to low alluvial fan deposits (Qa_1), partly cemented by calcite and gypsum; generally lies above but merges with younger alluvial fan (Qa1) and valley-fill (Qv) deposits at downslope ends, merges with or inset against alluvial fan Qa_3 and talus (Qt) deposits. Moderately vegetated by pinion pine and juniper trees, sagebrush, cactus, and some grass. Thickness about 3 to 12 m

Qt **Talus deposits (Holocene and Pleistocene)**--Unsorted debris consisting of brecciated gravel and blocks up to 1 m diameter. Includes some sand and silt, partly cemented by calcite and gypsum. Merges with alluvial fans (Qa_1, Qa_2 and Qa_3), valley-fill (Qv), stream channel (Qs), and terrace-gravel (Qg_1 and Qg_2) deposits. Sparse to moderate vegetation of pinion pine or juniper trees, sagebrush, cactus, and grass. Only relatively extensive deposits shown. Thickness as much as 9 m

Ql **Landslide debris (Holocene and Pleistocene)**--Unconsolidated masses of unsorted rock debris, including blocks of strata that have rotated backward and slid downslope. Occurs principally around canyon rims where strata of Kaibab Formation has detached from rim and slid down as loose incoherent jumbled mass of broken rock and deformed strata. Includes rock glacier debris below basalt outcrops. Sparsely vegetated by sagebrush, cactus, pinion pine and juniper trees. Unstable when wet. Thickness probably as much as 43 m

Qg_3 **High terrace-gravel deposits (Pleistocene)**--Similar to low and intermediate terrace-gravel deposits (Qg_1 and Qg_2), but 6 to 11 m higher than Qg_2 and about 11 to 18 m above modern drainages. Composed of rounded to well-rounded clasts of limestone, sandstone and chert interbedded with sandy gravel. Partly consolidated with calcite and gypsum cement. Thickness as much as 6 m

Qa_3 **Older alluvial fan deposits (Pleistocene)**--Similar to younger and intermediate alluvial fan deposits (Qa_1 and Qa_2). Merges with talus (Qt), valley-fill (Qv), terrace-gravel (Qg_1), and alluvial fan (Qa_1 and Qa_2) deposits. Thickness about 3 to 4.5 m

Tb **Basalt flows (Pliocene)**--Dark-gray, olivine basalt; finely crystalline olivine in an aphanitic groundmass. Similar to basalt flows on Black Rock and Wolf Hole Mountains about 19 kilometers north of quadrangle (3.7 to 3.1 Ma., Billingsley, in press). Unconformably caps less resistant beds of Moenkopi and Kaibab Formations in Tertiary paleovalley, northwest quarter of quadrangle (fig. 2). Unit consists of one flow, maximum thickness about 9 m

Sedimentary Rocks

Moenkopi Formation (Middle? and Lower Triassic)--Includes, in descending order, middle red, Virgin Limestone, and lower red members as defined by Stewart and others (1972) ᵲmm **Middle red member**--Interbedded, red-brown, laminated siltstone and sandstone, white and gray gypsum, minor white platy dolomite, green siltstone, and gray-green gypsiferous mudstone. Upper part is eroded. Forms slope. Thickness as much as 30 m

ᵲmv **Virgin Limestone Member**--Consists of two, light gray, ledge forming, limestones (1.5 to 3 m thick), separated by pale-yellow and light-red, slope-forming, thin-bedded gypsiferous siltstone. Lowest limestone contains abundant star shaped crinoid plates and poorly preserved Composita brachiopods. Upper contact placed at top of highest gray limestone unit. Thickness about 40 m

ᵲml **lower red member**--Red, thin-bedded, sandy siltstone interbedded with gray, white, and pale-yellow laminated gypsiferous siltstone and sandstone. Upper contact placed at base of lowest bed of Virgin Limestone; forms slope. Thickness about 9 to 18 m

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

Pkh **Harrisburg Member**--Consists of light-gray, fine- to medium-grained, fossiliferous, sandy limestone interbedded with red and gray gypsiferous siltstone, sandstone, and gray gypsum. Includes gray, thin-bedded, cherty limestone and sandy limestone which forms resistant cliff or ledge near top of unit. Forms surface rock of north two-thirds of quadrangle. Undetermined amount of upper units are eroded away. Solution of interbedded gypsum has locally distorted bedding. Upper contact is unconformable and locally obscure where overlain by surficial deposits. Forms slope with limestone ledges at top. Thickness as much as 76 m

Pkf **Fossil Mountain Member**--Light-gray, fine- to medium-grained, thin-bedded, fossiliferous, sandy, cherty limestone. Chert weathers black. Gradational with overlying Harrisburg Member; arbitrary contact between limestone cliff and siltstone slope. Forms cliff. Thickness about 107 m

Toroweap Formation (Lower Permian)--Includes, in descending order, Woods Ranch, Brady Canyon, and Seligman Members as defined by Sorauf and Billingsley (1991)

Ptw **Woods Ranch Member**--Gray, gypsiferous siltstone and pale-red silty sandstone interbedded with medium-bedded white gypsum. Commonly covered by talus. Subsidence and distortion of beds due to solution of gypsum. Unconformable upper contact marked by solution and channel erosion with relief as much as 4.5 m. Map contact generalized because of extensive talus cover. Gradational with underlying Brady Canyon Member; contact placed between slope-forming siltstone and cliff-forming limestone. Thickness about 55 m

Ptb **Brady Canyon Member**--Gray, medium-bedded, medium- to coarse-grained, fetid, fossiliferous limestone; weathers dark gray. Includes thin-bedded dolomite in upper and lower part. Gradational contact with underlying Seligman Member, arbitrary contact placed at bottom of limestone cliff. Forms cliff. Thickness about 85 m

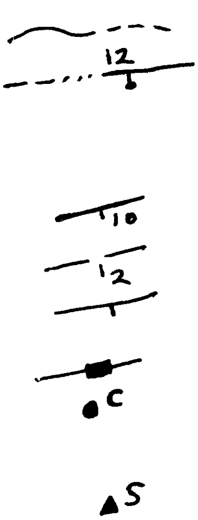
Pts **Seligman Member**--Consists of basal brown and yellow, fine-grained, thin-bedded, low-angle crossbedded and flat-lying sandstone, a middle unit of gray to red, thin-bedded, interbedded, siltstone, sandstone and gray gypsum, and an upper gray unit of interbėdded, thin-bedded, dolomite and gypsiferous sandstone. Unconformable, sharp, planar contact with underlying tan Coconino Sandstone or red Hermit Shale. Forms slope with ledges in upper and lower part. Thickness about 55 m

Pc **Coconino Sandstone (Lower Permian)**--Tan to light-brown, fine- to medium-grained cross-stratified sandstone. Composed of well-rounded frosted quartz grains. Locally pinches out forming discontinuous lenticular units. Unconformable, planar contact with underlying Hermit Shale. Forms cliff. Thickness 0 to 12 m

Ph **Hermit Shale (Lower Permian)**--Red, pale-red and white, fine- to medium-grained, thin- to medium-bedded sandstone and siltstone. Ledge-forming sandstone beds common in upper and lower part, white sandstone common in lower part. Unconformable contact with underlying tan Esplanade Sandstone marked by shallow erosional channels with relief up to 3 m; contact difficult to place because of similar lenticular erosional channels within lower 30 m of unit. Forms steep slope. Thickness 232 to 244 m

Pe **Esplanade Sandstone (Lower Permian)**--Red and white, fine- to medium-grained, medium- to thick-bedded sandstone and siltstone. Includes gray, thin- to medium-bedded, cross-stratified, calcareous sandstone in lower slope. Gradational, disconformable contact with underlying Pakoon Limestone placed at top of first gray limestone bed of Pakoon Limestone. Forms tan to white sandstone cliffs with small interbedded red siltstone recesses in upper part, locally cross-stratified. Thickness about 134 m

Pkl **Pakoon Limestone (Lower Permian)**--Gray, medium- to coarse-grained, thin-bedded, fetid, limestone and sandy dolomite. Weathers brown-gray with sugary texture and locally trough cross-stratified (sets 0.6 to 1.5 m). Limestone and dolomite ledges separated by recesses of gray-purple, thin-bedded siltstone and sandstone. Limestone is fossiliferous in upper part, includes lenses and pods of brown chert. Forms cliffs and ledges. Lower part not exposed. Thickness 43 m



Contact--Dashed where approximately located

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

Strike and dip of strata

- **Inclined**
- **Approximate**--Estimated photogeologically
- **Implied**--Determined photogeologically, no estimate of amount determined

Strike and dip of vertical joints

Collapse structure--Circular collapse, strata dipping inward toward central point. May reflect deep-seated breccia pipe collapse originating in Redwall Limestone

Sinkholes--Steep walled or enclosed depression or cave

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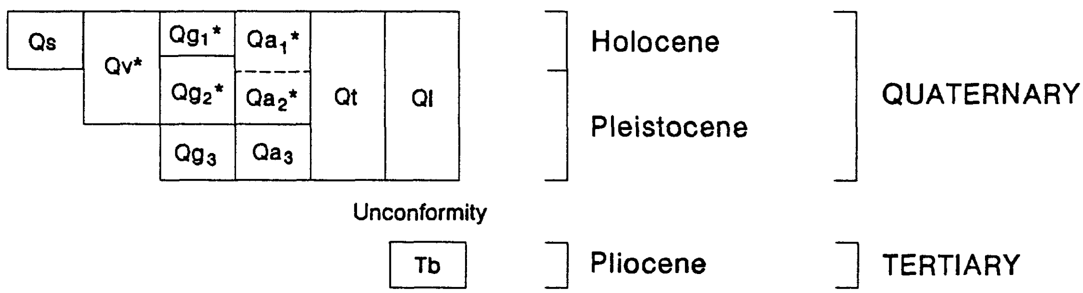
CORRELATION OF MAP UNITS

SURFICIAL AND VOLCANIC DEPOSITS

* See description of map units for exact unit age assignment



SEDIMENTARY ROCKS