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

Geologic map of the Dutchman Draw quadrangle, northern Mohave County, Arizona

by
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INTRODUCTION

The Dutchman Draw 7.5′ quadrangle (96 sq km) is located in northern Mohave County, Arizona, about 60 km southwest of Colorado city, Arizona, the nearest settlement (fig. 1). Elevations range from about 1,317 m at the northeast corner of the quadrangle to 1,644 m at the southwest corner of the quadrangle. Access to the quadrangle from St. George, Utah, is by improved dirt roads, locally referred to as the Sunshine Trail and the Mount Trumbull Road and access from Colorado City, Arizona, is by the Navajo Trail (fig. 1). Several unimproved dirt roads lead from the Mount Trumbull Road, Sunshine and Navajo Trails to various locations within the quadrangle area.

The area is managed entirely by the U.S. Bureau of Land Management including about one section belonging to the state of Arizona. The area supports moderate to thick growths of sagebrush, cactus, cliffrose bush, and various high desert shrubs. Sparse growths of pinyon pine and juniper trees dot the landscape in the west half of the quadrangle.

PREVIOUS WORK

The geology of the area is presented on two Arizona state geologic maps by Wilson and others (1969) and Reynolds (1988). A geologic map is available for the Wolf Hole Mountain and vicinity, Arizona (Billingsley, 1993) which borders this area on the northwest. Geologic maps of the Hole-N-Wall Canyon quadrangle (Billingsley, 1992) borders the area on the north, and the Sullivan Draw North quadrangle (Billingsley, 1991) borders the area on the west.

MAPPING METHODS

A preliminary geologic map was made from aerial photographs, scale 1:24,000. In particular, many of the Quaternary alluvial units have similar lithologies and physical properties; consequently, these units are differentiated by using photogeologic methods based on regional geomorphic characteristics. Many alluvial map units generally have an arbitrary map contact where they merge together. Detailed field investigations were then conducted to insure accuracy and consistency of all map units for descriptive purposes.

GEOLOGIC SETTING

The map 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 about 1° northeast. About 30 m of Triassic and 125 m of Permian strata are exposed in this quadrangle.

The structural fabric of this quadrangle consists of several normal faults which form several local horst and grabens. The north-northwest striking Main Street and Sunshine Faults are the main structural features of this quadrangle.

Cenozoic deposits are widely distributed in the map area consisting of surficial alluvial deposits of Quaternary age. These surficial deposits are identified by photogeologic techniques based on their geomorphic relations to structural features and erosional surfaces. The distribution of Quaternary alluvial deposits are an important factor in future environmental, land, and range management planning in this area by federal, state, and private organizations. The surficial units are useful in the study of local geomorphology and have intertonguing and gradational contacts.

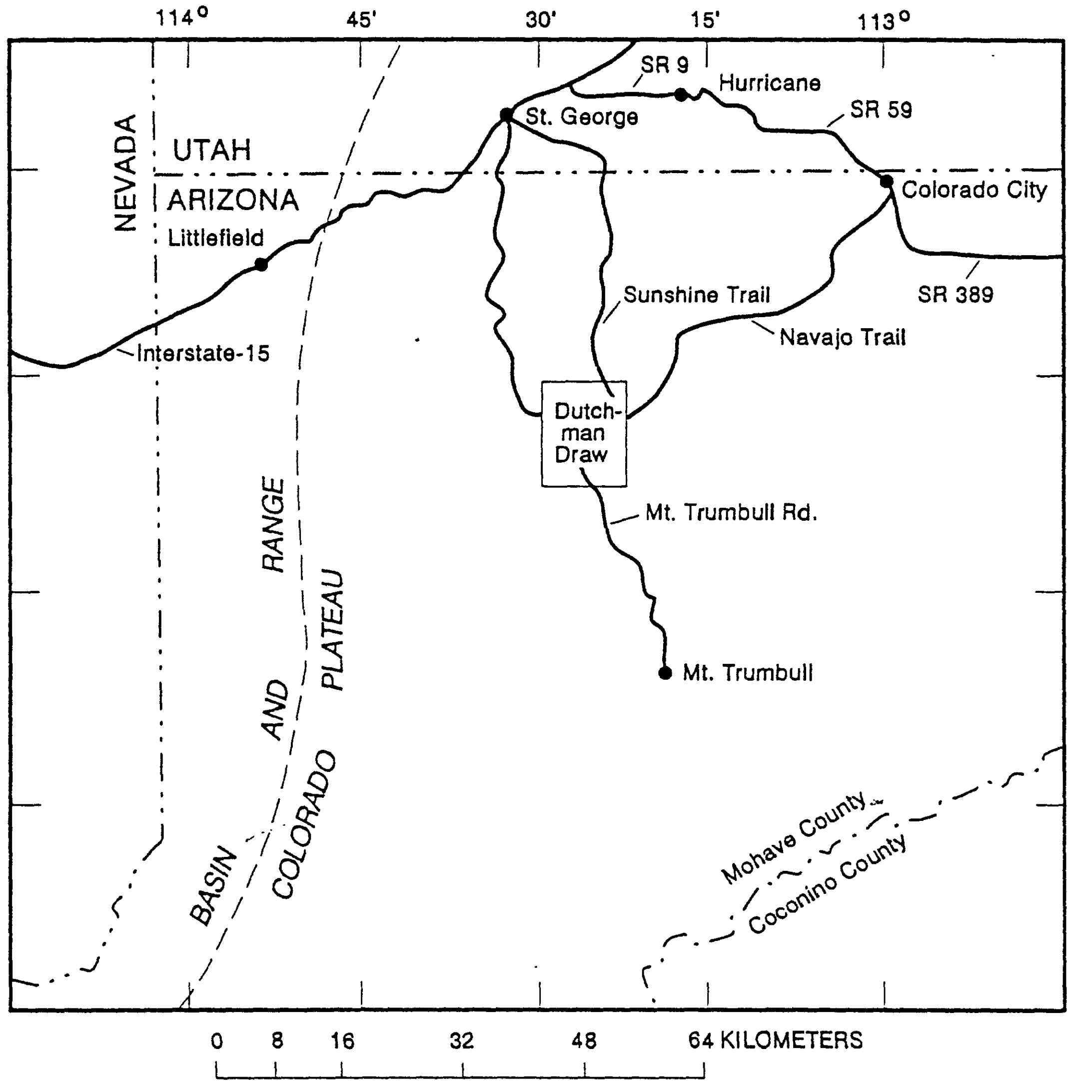

Figure 1. Index map of northern Mohave County, northwestern Arizona, showing the Dutchman Draw 7.5′ quadrangle mapped in this report. SR = State route.

STRATIGRAPHY

The sedimentary bedrock strata of this quadrangle include, in ascending order, the Kaibab Formation (Lower Permian), and part of the Moenkopi Formation (Middle? and Lower Triassic). Most of the surface bedrock of the quadrangle area is gray cherty limestone and gray to white siltstone and gypsum of the Kaibab Formation. The Main Street Horst has been subjected to erosion more then adjacent areas which allows the Fossil Mountain Member of the Kaibab Formation to be exposed. Red siltstone, gray sandstone, and gray conglomerate of the Moenkopi Formation crop out in the north-central part of the quadrangle in a Triassic paleovalley.

The predominantly Quaternary age assigned to the alluvial deposits in this quadrangle is based mainly on field relationships of these deposits to the Pleistocene and Pliocene basalts just north of this quadrangle (Billingsley, 1992, 1993). Many alluvial deposits containing basalt clasts lie downslope from basaltic outcrops of known K-Ar age. The basalt ages range from about 3.5 Ma to less than 800,000 years old. Thus, given time for erosion and deposition, it is likely that all alluvial and surficial deposits of this quadrangle are probably Pleistocene age and younger. Details of the stratigraphic sequence of alluvial deposits are given in the description of map units.

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). These images give an overall perspective of the structural fabric of this part of Arizona, especially in flatland areas (S.A.R. System, 1988).

The Main Street Graben and Horst have a northwest strike and are the major structural features of this quadrangle. The Main Street Graben averages about 1 km wide. The Main Street Horst is about 2 km wide at the north edge of the quadrangle widening to more than 7 km in the southeast quarter of the quadrangle. The Main Street Horst is east of Main Street Graben forming a highland area throughout the central part of the quadrangle (fig. 2). The Main Street Fault forms the east bounding fault of Main Street Graben and the west bounding fault of Main Street Horst (fig. 2). The Sunshine Fault forms the east bounding fault of Main Street Horst.

The Main Street Fault, first described by Hamblin and Best (1970), displaces strata down to the west-southwest about 120 m at the north edge of the quadrangle, decreasing to about 60 m near the south edge of the quadrangle. Bedrock strata dips gently east or northeast on the both sides of the fault.

The Main Street and Sunshine Faults (Billingsley, 1992) are normal faults inferred to be Pleistocene age with probable Holocene activity based on the young-looking character of the fault scarps. The Sunshine Fault is easily recognized in the field and on aerial photos but is partly covered with talus debris or alluvial fan deposits for most of its length. Displacement along the Sunshine Fault averages about 122 m with flat-lying bedrock strata either side of the fault.

In the northeast quarter of the quadrangle, small faults form several horsts and grabens that parallel the northwest strike of the Sunshine Fault. Fault scarps in talus and alluvial deposits are common along parts of many small faults but they are not always easily recognized in the field as they

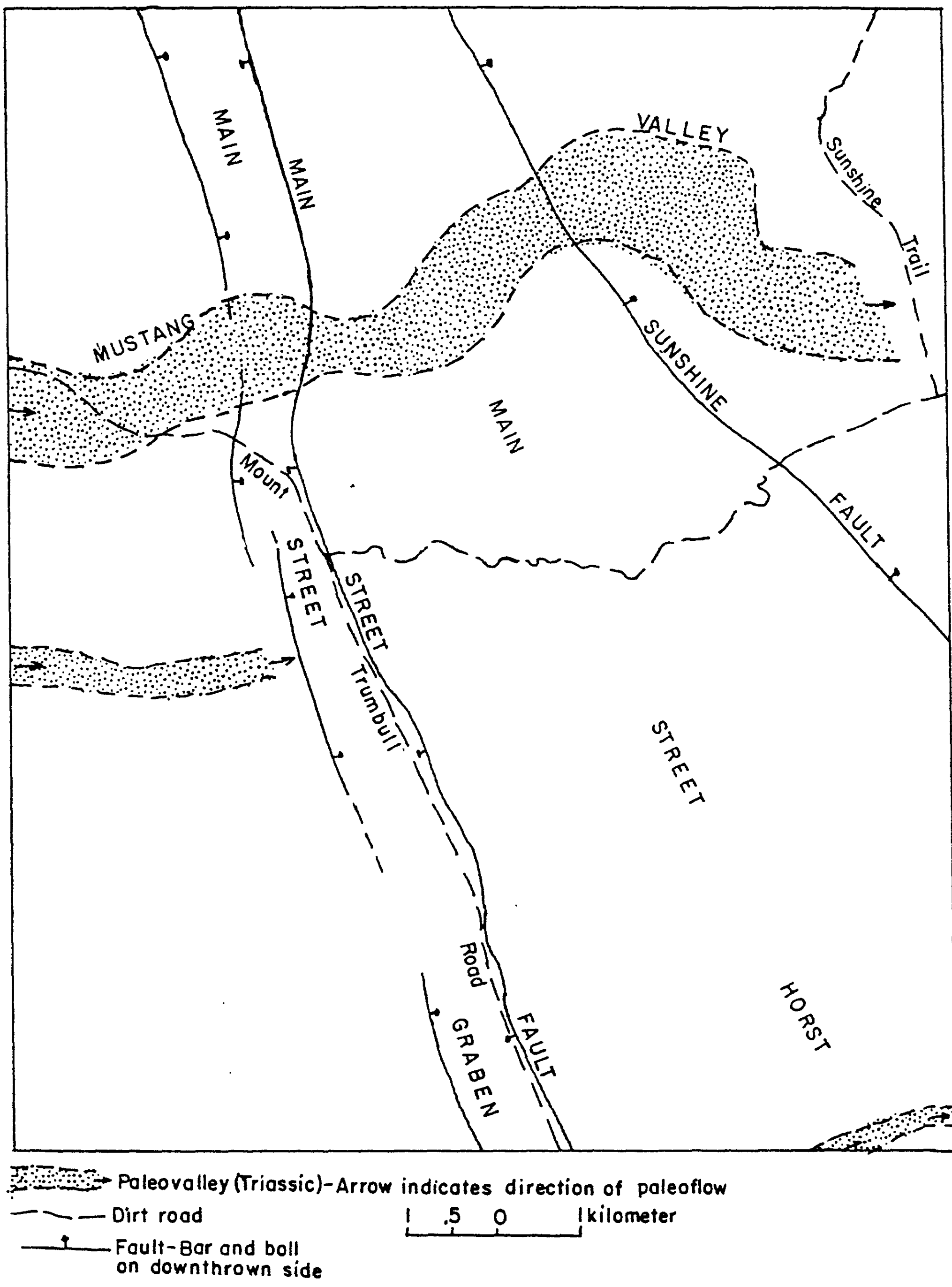

Figure 2. Selected geologic features of the Dutchman Draw quadrangle, northwestern Arizona.

are on aerial photos. Because erosion and mass-wasting has shed soft and loose debris over unconsolidated alluvial fault scarps, the faults are shown dotted on the map and often form alluvial contacts. A solid fault line is shown where faulting appears most recent in alluvial material. The fault structures in this quadrangle probably began to develop after deposition of late Pliocene and Pleistocene basalts north of this quadrangle. All basalts as young as 1.4 Ma have been offset by faults with equal displacement of the basalt and underlying strata (Billingsley, 1992, 1993).

The small folds present in the quadrangle are probably related to early Laramide compressional stresses (Huntoon, 1989). Some of the synclines reflect local graben development where soft strata of the Kaibab Formation has slumped or draped in these structures. Locally, warped and bent strata too small to show at map scale are the result of solution of gypsum in the Harrisburg Member of the Kaibab Formation. These bent strata are commonly associated with solution of gypsum along drainages.

A few circular bowl-shaped collapse structures, usually over 100 meters in diameter, are found on the surface of the quadrangle area and are mostly due to solution of gypsum and gypsiferous siltstone in the Harrisburg Member of the Kaibab Formation. However, some circular bowl-shaped areas that have strongly inward-dipping strata may be solution collapse-formed breccia pipes that originate in the deeply buried Mississippian Redwall Limestone (Wenrich and Huntoon, 1989; Wenrich and Sutphin, 1989). Such features on this map usually have inward dipping strata and are marked by a dot and the letter C to denote possible deep-seated breccia pipes. However, they cannot be distinguished with certainty from shallow collapse structures caused by the removal of gypsum in the Kaibab or Toroweap Formations. Moreover, some deep-seated breccia pipes are known to be overlain by gypsum collapse features (Wenrich and others, 1986). The deep-seated collapse breccia pipes potentially contain economic deposits of copper and uranium minerals (Wenrich, 1985).

An abandoned copper mine near the center of the quadrangle does not appear to be associated with a collapse structure or other structures (T38N, R10W, NW quarter of section 31, fig. 2). Copper minerals are commonly associated with collapse breccia pipes on the Colorado Plateau (Wenrich, 1985). The copper mine is not much more than a prospect pit and there is little evidence of any copper production from the small 2 meter deep shaft. The copper minerals present are azurite and malachite in a sandy limestone in the middle part of the Harrisburg Member of the Kaibab Formation.

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

DESCRIPTION OF MAP UNITS

Surficial deposits

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)**--Active wash or large arroyo. Contains unconsolidated and poorly sorted, interlensing silt, sand, and pebble gravel. Intertongues with or inset against alluvial-fan (Qa_1 and Qa_2), terrace-gravel (Qg_1), valley-fill (Qv), and floodplain (Qf) deposits. Stream channels subject to high-energy flows and flash floods and support little or no vegetation. Contacts approximate. Estimated thickness 1 m

Qf **Flood-plain deposits (Holocene)**--Flat-valley area. Contains unconsolidated light-gray or brown silt, sand, and lenses of pebble to cobble gravel. Deposits intertongue, merges with, or locally overlies valley-fill (Qv), alluvial-fan (Qa_1 and Qa_2), and talus (Qt) deposits. Forms flat wide valley floors as opposed to narrow concave valley profiles of valley-fill (Qv) deposits. Deposits are sparsely covered by growths of cactus and sagebrush. Locally cut by arroyos as much as 2 m deep. Floodplain subject to flooding and local temporary ponding. Thickness about 20 m

Qg_1 **Young terrace-gravel deposits (Holocene)**--Unconsolidated, light-brown, pebble to boulder gravel composed about equally of well-rounded limestone and sandstone and angular to subrounded chert derived locally from the Kaibab Formation. Includes lenses of silt and sand and reworked materials from alluvial-fans (Qa_1 and Qa_2), and talus (Qt) deposits. Forms alluvial benches about 0.5 to 2 m above local stream beds. Averages about 1 to 2 m thick

Qa_1 **Young alluvial-fan deposits (Holocene)**--Unconsolidated gray silt and sand. Includes lenses of coarse gravel composed of subangular to rounded pebbles and cobbles of limestone, chert, and sandstone locally derived from the Kaibab Formation. Partly cemented by gypsum and calcite. Overlaps or intertongues with stream-channel alluvium (Qs), valley-fill (Qv), young terrace-gravel (Qg_1), and floodplain (Qf) deposits near their downslope ends. Alluvial-fans subject to erosion by sheet wash and flash floods. Supports sparse growths of sagebrush, cactus, and grass. As much as 7 m thick

Qv **Valley-fill deposits (Holocene and Pleistocene?)**--Partly consolidated silt, sand, and interbedded lenses of pebble to small-boulder gravel. Intertongues or overlays talus (Qt), young terrace-gravel (Qg_1), and young alluvial-fan (Qa_1) deposits. Subject to sheetwash flooding and temporary ponding; cut by arroyos in larger valleys. Supports moderate growth of sagebrush, cliffrose bush, grass, and cactus. As much as 9 m thick

Qt **Talus deposits (Holocene and Pleistocene)**--Unsorted debris consisting of breccia composed of large and small angular blocks of local bedrock as much as 1 m in diameter. Includes silt, sand, and gravel; partly cemented by calcite and gypsum. Intertongues with alluvial-fan (Qa_1 and Qa_2), and valley-fill (Qv) deposits. Supports sparse to moderate growths of sagebrush, cactus, and grass. Only relatively extensive deposits shown. As much as 9 m thick

Ql **Landslide deposits (Holocene? and Pleistocene)**--Unconsolidated and unsorted rock debris, including blocks of detached segments of bedrock strata that have slid downslope. Unstable when wet. Only large masses are shown (Main Street Graben area). Thickness probably as much as 3 m

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 channels about 2 to 3 m above local stream beds and about 1 to 2 m above young terrace-gravel (Qg_1) deposits. Approximately 2 to 3 m 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. As grabens subside, younger alluvial-fan (Qa_1) deposits locally overlap older alluvial-fan (Qa_2), talus (Qt), and valley-fill (Qv) deposits. Partly eroded and dissected surfaces, subject to sheetwash erosion. Intermediate fans support moderate growth of sagebrush, cactus, and grass. Ranges from about 3 to 12 m thick

Sedimentary Rocks

Moenkopi Formation (Middle? and Lower Triassic)--Includes, in descending order, Virgin Limestone Member, lower red member, and Timpoweap Member as used by Stewart and others (1972)

Ŧmv **Virgin Limestone Member--Consists of one light-gray, fine-grained, thinly laminated, ledge-forming limestone bed averaging about 2 m thick. Upper part is eroded away and partly covered by alluvial deposits. Contact with lower red member is unconformable with less than 1 m of relief north and east of this quadrangle (Billingsley, 1992). Forms small ledge. As much as 3 m thick**

Ŧml **Lower red member**--Red, fine-grained, thin-bedded, gypsifereous sandy siltstone; gray, white, and pale-yellow laminated gypsum and minor sandstone. Mostly covered slope. Approximately 3 m thick

Ŧmt **Timpoweap Member**--Light-gray conglomerate and coarse-grained calcareous sandstone. Includes an upper and lower part. Upper part consists of light-gray, fine-grained, thick-bedded limestone and interbedded gray, coarse-grained, low-angle, trough cross-bedded sandstone forming gradational contact with lower part or unconformable contact with Harrisburg Member of Kaibab Formation. Lower part consists of conglomerate composed of subangular to rounded pebbles and cobbles of gray and dark gray limestone, white and brown chert, and minor rounded quartzite in gray to brown, coarse-grained sandstone, gravel, and fine-grained siltstone matrix derived from Kaibab Formation. Source of dark-gray limestone and quartzite may be Paleozoic rocks west of quadrangle. Locally clast supported. Fills Triassic paleovalleys eroded into Kaibab Formation estimated as much as 60 m deep and about 700 m wide. Rocks of Timpoweap occupy two paleovalleys, Mustang Valley (fig. 2; Billingsley, 1991, 1994), and smaller unnamed paleovalley southeast corner of quadrangle. Imbrication of pebbles in lower conglomerate shows an eastward paleoflow of depositing streams. Thickness ranges from 6 to 70 m

Ћmlt **Lower red member and Timpoweap Member undivided**--Same lithologies as Ћml and Ћmt but completely interbedded. Consists of conglomerate and limestone lenses within interbedded siltstone and gypsum. Occupies erosional paleovalleys with relief as much as 40 m cut into underlying Harrisburg Member of Kaibab Formation. Unconformable contact with Harrisburg Member of Kaibab Formation. Contact locally obscure where overlain by alluvial deposits. Forms slope with ledges. Approximately 1 to 18 m thick

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

Pkh **Harrisburg Member**--Includes a middle, and lower part. Upper part is present north of this quadrangle (Billingsley, 1992) consisting of reddish siltstone and gypsum and interbedded gray limestone eroded from this quadrangle. Middle part consists mainly of two cliff-forming marker beds. Top marker bed consists of gray, thin-bedded, cherty limestone; chert 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, fine- to medium-grained, gypsiferous siltstone, sandstone, medium-grained, thin-bedded gray limestone, and gray massive gypsum. Solution of gypsum in lower part has locally distorted limestone beds of middle part causing them 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 slope with middle limestone cliff. As much as 65 m thick

Pkf **Fossil Mountain Member**--Light-gray, fine- to medium-grained, thin-bedded, fossiliferous, sandy, cherty limestone. Chert weathers black. Contact with Woods Ranch Member of Toroweap Formation generalized on quadrangle because of extensive talus cover and gypsum solution. Forms cliff. About 100 m thick

Toroweap Formation (Lower Permian)--Includes, in descending order, Woods Ranch, Brady Canyon, and Seligman Members as defined by Sorauf and Billingsley (1991). Brady Canyon and Seligman Members are not exposed in this quadrangle

Ptw **Woods Ranch Member**--Gray gypsiferous siltstone and pale-red silty sandstone interbedded with medium-bedded white gypsum. Lower part not exposed. About 18 m 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. Number with plus denotes minimum estimated displacement

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

Syncline

Anticline

Monocline

Dome

Strike and dip of beds--Showing dip where known

Inclined

Approximate--Estimated from aerial photographs

Implied--Interpreted from aerial photographs, dip amount not determined

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

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

Sinkholes--Steep-walled or enclosed depression or cave

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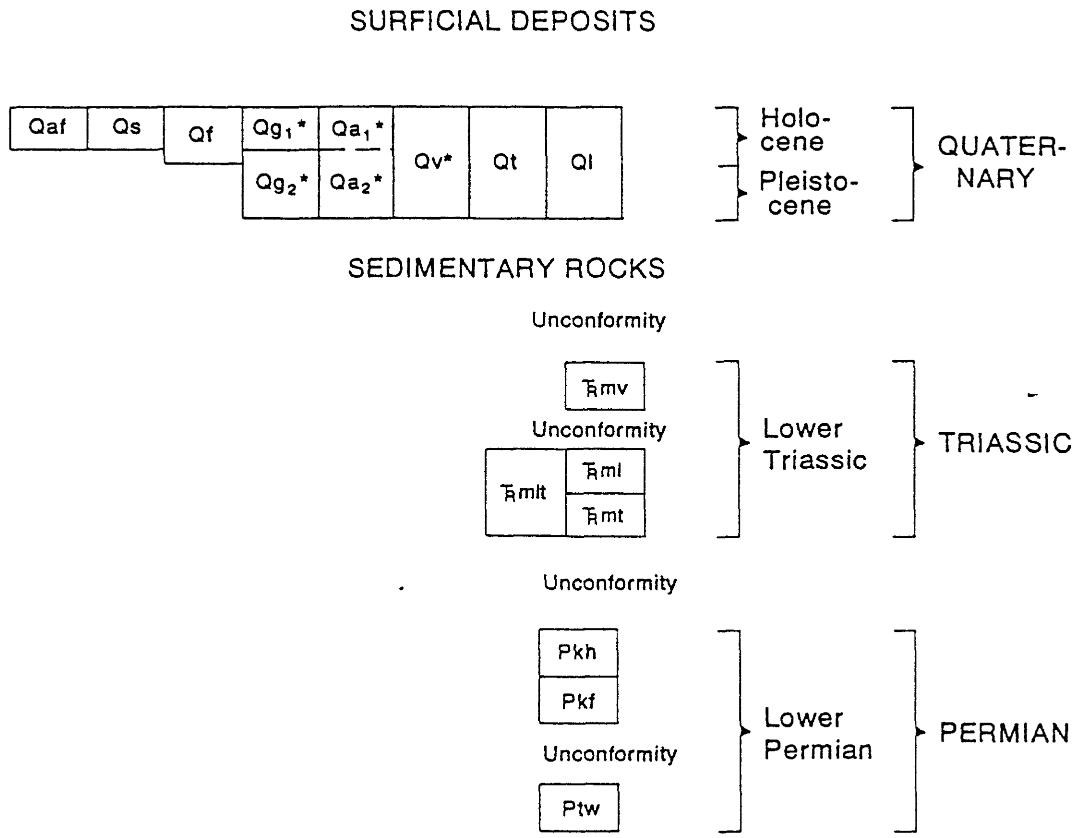
CORRELATION OF MAP UNITS



* See description of map units for exact unit age assignment