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

Geologic map of the White Pockets quadrangle, northern Mohave County, Arizona

by
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INTRODUCTION

The White Pockets 7.5′ quadrangle (96 sq km) is located in northern Mohave County, Arizona, about 27 km south of the Arizona/Utah State line and Colorado City, Arizona, the nearest settlement, northwestern Arizona (fig. 1). Elevations range from about 1,396 m (4,580 ft) at the northwest corner of the quadrangle to 1,634 m (5,361 ft) at the southwest corner of the quadrangle. Access to the quadrangle is by improved dirt road, locally referred to as the Navajo Trail road, from Colorado City, Arizona. Several unimproved dirt roads lead from the Navajo Trail to various locations within the quadrangle area. Travel on these roads can be done with 2 wheel drive vehicles except on unimproved trails during muddy conditions.

The entire area is managed by the U.S. Bureau of Land Management, including about three sections belonging to the state of Arizona. The topography is relatively flat and supports sparse growths of sagebrush, cactus, and various grasses. Tamerisk trees (Salt Ceder) are restricted to stock tanks, diversion dams, and along the drainage of Clayhole Wash.

PREVIOUS WORK

Previous work includes photogeologic mapping of this area published on two Arizona state geologic maps, one at a scale of 1:500,000 by Wilson and others (1969), and the other at a scale of 1:1,000,000 by Reynolds (1988). The first geologic quadrangle maps bordering this quadrangle on the north, northeast, and east are by Marshall (1956a, b, c). Recently, new geologic quadrangle maps by Billingsley (1993a, b, and in press), superseds those of Marshall.

MAPPING METHODS

A preliminary detailed geologic map was made from 1:24,000-scale aerial photographs. In particular, many of the Quaternary alluvial units having similar lithologies were mapped using aerial photographs. Detailed field investigations were then conducted to check photo interpretations and to obtain descriptions for all map units.

GEOLOGIC SETTING

The map area lies within the Uinkaret Plateau, a subplateau of the southwestern part of the Colorado Plateaus physiographic province (fig. 1). Strata in this part of the Uinkaret Plateau is characterized by relatively flat lying Permian and Triassic sedimentary rocks that have an average regional dip of about 2° northeast, and are locally gently folded.

The eastern half of the quadrangle is underlain by Triassic strata of the Moenkopi Formation, whereas the western half is underlain by the Permian Kaibab Formation. Thickness of the Triassic strata is based on exposures about 25 km north of this quadrangle where the entire Lower, Middle(?), and part of the Upper(?) Triassic sequence is well exposed at Lost Spring Mountain (Billingsley, 1993a, b). Cenozoic deposits of fluvial pediment, alluvial fans, and terrace deposits cover much of the quadrangle area. The surficial units are useful in the study of local geomorphology and generally have intertonguing and gradational contacts. The distribution of Quaternary alluvium is an important factor to consider in future environmental, land, and range management planning projects in this area by federal, state, and private organizations.

A few northwest-trending normal faults offset Permian and Triassic strata in the quadrangle. If there are other faults within the quadrangle,

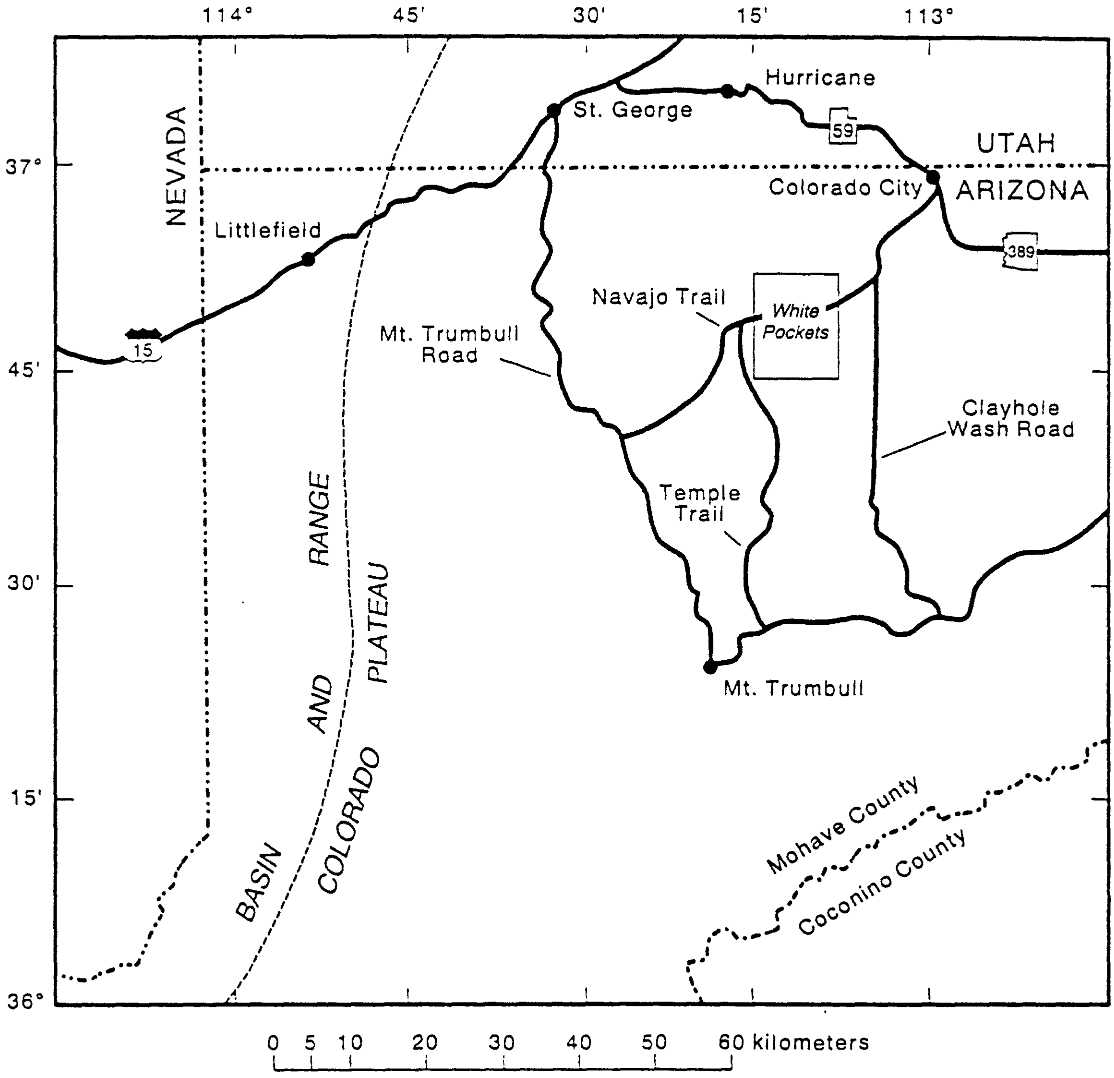

Figure 1. Index map of northern Mohave County, northwestern Arizona, showing the White Pockets, AZ 7.5′ quadrangle.

they are covered by extensive alluvial deposits. A large dome structure, here named Clayhole Dome for reference, is in the east-central edge of the quadrangle.

STRATIGRAPHY

The sedimentary bedrock strata include members of the Moenkopi Formation (Middle(?) and Lower Triassic), and the Kaibab Formation (Lower Permian). Outcrops of igneous rock consist of one basaltic flow of Pleistocene age. The basalt came from a pyroclastic volcano named Antelope Knoll about 6.5 km south of this quadrangle (secs. 13 and 24, T. 38 N., Rs. 8 and 9 W.), northern Mohave County, Arizona. The basalt is here named Antelope Knoll Basalt from the volcano of that name, and has a K-Ar age of 0.83±0.28 Ma (Harold Mehnert, U.S. Geological Survey Isotope Laboratories, Denver, Colorado, written commun., 1993).

The Antelope Knoll Basalt flowed north down a low-gradient, ancestral Clayhole Wash drainage. In the last 830 thousand years since the flow, Clayhole Wash has migrated eastward about 3 km and has eroded an average of 60 m deeper. Thus, Clayhole Wash is cutting an average of 0.075 m per 1,000 years.

Pale red, gray, and brown pediment and other fluvial deposits cover more than one-half of the bedrock surface area in this quadrangle. The pediment surfaces has a thin lag gravel forming a thin desert pavement made up of multicolored, well-rounded chert and quartz pebbles derived from the Shinarump Member of the Chinle Formation which crops out east of this quadrangle. In general, the desert pavement distinguishes the pediment deposits from younger alluvial fan and terrace deposits.

The Quaternary age assigned to the alluvial deposits in the quadrangle area is based mainly on field relationships of these deposits to the Antelope Knolls Basalt and similar age volcanic deposits west and north of this quadrangle (Billingsley, 1993a, b, c, in press). Stratigraphic details of the alluvial deposits are given in the description of map units.

STRUCTURAL GEOLOGY

Most of the normal faults offset strata down to the southwest and have a north-northwest strike. In general, the normal faults form grabens in strata that dip gently northeast. Geologic mapping just west of the quadrangle area (Billingsley, 1993c, in press), indicates that faulting was partly late Pliocene, but mostly Pleistocene and Holocene in age.

Several gently folded anticlines and synclines are present near Clayhole Dome in the east-central part of the quadrangle. Clayhole Dome may be a laccolith in conjunction with nearby pleistocene volcanic eruptions. The dome is roughly 1.6 km in diameter and has dips as much as 20° on its flanks. Vertical relief of the dome averages about 30 m above the surrounding landscape. The surface bedrock of Clayhole Dome, and surrounding terrain, is composed of strata of the Harrisburg Member of the Kaibab Formation. Local drainages encircle and erode headward into the dome from the east, suggesting a probable late development of the dome as Clayhole Wash continued its downward erosion.

Part of a circular bowl-shaped collapse structure, at the southwest edge of the quadrangle, may reflect a deep-seated solution collapse-formed breccia pipe that originates in the deeply buried Mississippian Redwall Limestone (Wenrich and Huntoon, 1989; Wenrich and Sutphin, 1989). An abandoned copper mine is near the collapse structure (Sec. 26, T. 39 N., R. 9 W.). Copper minerals are commonly associated with collapse breccia pipes on the Colorado Plateau (Wenrich, 1985). The copper mine is little more than a prospect with two small mine shafts.

More recently, numerous exploration trenches were dug near the mine. Copper minerals of azurite and malachite are sparsely present in a sandy limestone of the middle part of the Harrisburg Member of the Kaibab Formation. A small pile of copper minerals on the ground near one of the shafts suggests a possible small production of copper ore from the mine in its early days. It is not know when the mine was operational. The mine was claimed by Energy Fuels Nuclear Inc. of Fredonia, Arizona sometime in the early or middle 1980's.

DESCRIPTION OF MAP UNITS

Surficial deposits

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

Qs **Stream-channel alluvium (Holocene)**--Unconsolidated and poorly sorted, interlensing silt, sand, and pebbles. Overlaps or inset into alluvial fan (Qa_1), terrace-gravel (Qg_1 and Qg_2), and upper part of pediment (Qp) 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

Qf **Flood-plain deposit (Holocene)**--Chiefly gray silt and fine-grained sand and clay; locally cemented by clay, gypsum, and calcite. Subject to frequent temporary ponding. Supports thick growths of salt ceder trees. Estimated thickness 2 to 3 m

Qg_1 **Young terrace-gravel deposit (Holocene)**--Unconsolidated, light-brown to pale-red siltstone, sandstone, and lenses of gravel containing pebbles of well rounded black, red, yellow, gray, and white quartzite. Locally contains minor amounts of petrified wood fragments. Includes reworked materials from alluvial fan (Qa_1 and Qa_2), pediment (Qp), and higher terrace-gravel (Qg_2 and Qg_3) deposits. Forms terrace bench about 0.5 to 1.5 m above local stream beds. Sustains moderate growth of salt cedar trees and some grass. Averages about 2 m thick

Qa_1 **Young alluvial fan deposit (Holocene)**--Unconsolidated reddish-gray silt and sand. Includes lenses of coarse gravel composed of multicolored, rounded pebbles of chert and quartzite east of Clayhole Wash; gray and white chert, limestone, and light red sandstone clasts west of Clayhole Wash. Partly cemented by calcite, gypsum, and clay. Intertongues with stream-channel alluvium (Qs), upper part of valley-fill (Qv), and terrace-gravel (Qg_1 and Qg_2) deposits. Includes material reworked from pediment (Qp) deposits, often overlaps older alluvial fan (Qa_2 and Qa_3) deposits. Alluvial fan subject to erosion by sheet wash and flash floods. Supports sparse vegetation composed of cactus, and grass. As much as 2 to 3 m thick

Qv **Valley-fill deposit (Holocene and Pleistocene)**--Grayish-brown, partly consolidated silt, sand, and lenses of pebble to cobble gravel, silt is dominant constituent. Contains red, yellow, and black, well-rounded pebbles, sand and silt, reworked from pediment (Qp) deposits; partly cemented by calcite and gypsum. Intertongues with terrace-gravel (Qg_1 and Qg_2), and alluvial fan (Qa_1 and Qa_2) deposits. Valleys subject to sheetwash flooding and temporary ponding; cut by arroyos in some larger valleys. Supports thick growths of vegetation composed of sagebrush, grass, and cactus. As much as 4 m thick

Qt **Talus deposit (Holocene and Pleistocene)**--Unsorted debris consisting of breccia composed of small and large 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, Qa_2, and Qa_3) deposits, valley-fill (Qv) deposits and terrace (Qg_1 and Qg_2) deposits. Supports sparse growths of grass. Only relatively extensive deposits shown. As thick as 2 m

Qg_2 **Intermediate terrace-gravel deposit (Holocene and Pleistocene)**--Similar to young terrace-gravel (Qg_1) deposits. Consists mainly of light-red and gray, fine-grained sand, silt, and clay; partly cemented by calcite and gypsum. Intertongues or overlapped by young alluvial fan (Qa_1 and Qa_2) deposits. Forms flat benches about 3 to 4 m above local stream beds. Sustains sparse growth of sagebrush and grass. Averages about 5 m thick

Qa_2 **Intermediate alluvial fan deposit (Holocene and Pleistocene)**--Similar to young alluvial-fan (Qa_1) deposits; partly cemented by gypsum and calcite cement; often overlapped by younger alluvial fans (Qa_1) deposits; inset against or overlapping pediment (Qp) and older terrace (Qg_3) deposits; intertongues or overlaps intermediate terrace gravel (Qg_2) and valley-fill (Qv) deposits. Locally includes abundant basalt clasts from Antelope Knoll Basalt (Qab) west of Clayhole Wash, and reworked material from pediment (Qp) deposits east of Clayhole Wash. Supports sparse growths of grass. Ranges from 1 to 3 m thick

Qg_3 **Older terrace-gravel deposit (Holocene and Pleistocene)**--brown and gray silt, sand, gravel, and small pebbles and cobbles. Contains subrounded to rounded basalt, chert, limestone, sandstone, and multicolored quartzite and quartz pebbles. Multicolored pebbles are derived from Shinarump Member of Chinle Formation averaging 6 mm in diameter. Basalt clasts derived from Antelope Knoll Basalt (Qab) and other Pleistocene volcanoes just south of quadrangle area. Forms bench about 3 to 6 m above modern stream beds; deposits are being eroded by modern erosion. About 3 to 4 m thick

Qa_3 **Older alluvial fan deposit (Holocene(?) and Pleistocene)**--Similar to young (Qa_1) and intermediate (Qa_2) alluvial-fan deposits. Contains abundant basalt clasts from Antelope Knoll Basalt. Overlapped by younger alluvial fan (Qa_1) and valley-fill (Qv) deposits; unit is being eroded by modern erosion. About 2 to 4 m thick

Qp **Pediment deposit (Holocene(?) and Pleistocene)**--Pale red, tan, and brown, fine-grained sandstone, siltstone and multicolored, well-rounded to rounded quartz and quartzite pebbles derived from the Shinarump Member of the Chinle Formation; partly cemented with calcite, gypsum, and clay. Pebbles form minor desert pavement as lag gravel composed of black, brown, gray, white, red, and yellow, well-rounded pebbles averaging less than 2.5 cm in diameter; includes rare, rounded, wood pebbles derived from Shinarump Member of Chinle Formation. Includes integrated, poorly defined sand sheet deposits (not mapped). All material locally derived from Triassic sedimentary strata east of Clayhole Wash. Overlapped by young (Qa_1), intermediate (Qa_2) alluvial-fans, and valley-fill (Qv) deposits. Intertongues or overlapped by older terrace (Qg_3) deposits. Approximately 1 to 3 m thick

Qab **Antelope Knoll Basalt**--Here named for Antelope Knoll located in secs. 13 and 24, T. 38 N., Rs. 8 and 9 W., (Antelope Knoll 7.5′ quadrangle), Uinkaret Plateau, northern Mohave County, Arizona. Antelope Knoll is the type area for the Antelope Knoll Basalt, a pyroclastic volcano about 6.5 km south of this quadrangle. K-Ar whole-rock age is 0.83±0.28 Ma (Harold Mehnert, U.S. Geological Survey Isotope Laboratories, Denver, Colorado, written commun., 1993). In quadrangle, consists of one basalt flow, dark-gray, aphanitic groundmass containing sparse black phenocrysts. Occupies ancestral Clayhole Wash drainage. Ranges from 1 to 4 m thick

Sedimentary Rocks

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

TRmm **Middle red member**--Red-brown, thin-bedded, laminated siltstone and sandstone, red, white, and gray gypsum, minor white platy gypsiferous dolomite, green siltstone, and gray-green gypsiferous mudstone. Gradational contact with Virgin Limestone Member placed at top of highest gray limestone bed of Virgin Limestone. Forms slope. About 45 to 50 m thick

TRmv **Virgin Limestone Member**--Consists of three light-gray, thin-bedded to thinly laminated, ledge-forming limestone beds, 0.5 to 2 m thick, separated by white, pale-yellow, red, and gray slope-forming, thin-bedded, gypsiferous siltstone. Uppermost limestone bed locally missing. Includes thin beds of brown, red, and green siltstone, gray limestone, and brown platy, gypsiferous calcarenite between limestone beds. Includes star-shaped crinoids and poorly preserved brachiopods in top part of lowest limestone bed; fossil algae in second highest limestone bed. Erosional unconformity at base of lowest gray limestone truncates underlying red siltstone of lower red member as much as 5 m deep. Forms small ledges in slope. As much as 21 m thick

Ŧml **Lower red member**--Red, thin-bedded, sandy siltstone; gray, white, and pale-yellow laminated gypsum and minor sandstone. Lower beds contain reworked gypsum and siltstone of Harrisburg Member of Kaibab Formation. Includes gray to light-brown, coarse-grained, thin-bedded, calcareous, ledge-forming sandstone bed in lower part. Unconformable contact with Kaibab Formation. Forms slope. Ranges from 15 to 37 m thick

Ŧmlt **Lower red member and Timpoweap Member undivided**--Red and gray, interbedded conglomerate, siltstone, gypsum, and limestone beds. Timpoweap Member of the Moenkopi Formation consists of gray, calcite cemented, conglomerate and sandstone composed of chert, quartzite, and limestone cobbles and pebbles derived from the Harrisburg Member of the Kaibab Formation. Includes gray, fine-grained limestone beds in upper part north of this quadrangle. Timpoweap Member is not present in quadrangle, but lithologies similar to part of the Timpoweap and lower red members of the Moenkopi occupy shallow paleovalleys eroded into the Harrisburg Member of the Kaibab Formation as much as 10 m deep. Unconformable contact locally obscured where overlain by surficial deposits. Part of unit, as mapped, may be upper red siltstone, sandstone, and limestone beds of the Harrisburg Member of the Kaibab Formation because they are difficult to distinguish owing to similar lithologies. Forms slope with ledges. About 15-20 m thick

Kaibab Formation (Lower Permian)--Includes only upper part of the Harrisburg Member of the Kaibab Formation as defined by Sorauf and Billingsley (1991). Lower part of Harrisburg and Fossil Mountain Members are not exposed in quadrangle:

Pkh **Harrisburg Member**--Includes an upper, middle, and lower part, not mapped separately. Upper part consists mainly of slope-forming, red and gray, interbedded gypsiferous siltstone, sandstone, gypsum, and thin-bedded gray limestone. Includes an upper, resistant, pale-yellow or light-gray, fossiliferous, sandy limestone bed averaging about 1 m thick. Most of upper part is eroded from map area. Forms gradational contact with middle part. Middle part consists of two cliff-forming marker beds: an upper, gray thin-bedded, cherty limestone, which weathers dark brown or black, and a lower, light-gray, thin-bedded, sandy limestone. Middle part commonly forms bedrock surface, such as at Clayhole Dome, where upper part is eroded. Forms minor unconformable contact with lower part at base of sandy limestone. Lower part consists of slope-forming, light-gray, fine- to medium-grained, gypsiferous siltstone, sandstone, thin-bedded gray limestone, and gray gypsum. Solution of gypsum in lower part has locally distorted limestone beds of middle part causing them to slump or bend into local drainages. Harrisburg, in general, forms slope with middle limestone cliff. Contact with Fossil Mountain Member of Kaibab Formation not exposed. About 100 m thick

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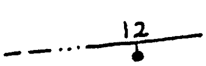
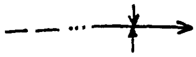
Contact--Dashed where approximately located



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

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


Syncline

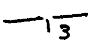

Anticline


Monocline


Dome

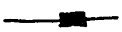
Strike and dip of beds

Inclined



Approximate--Estimated photogeologically


Implied--Determined photogeologically, amount of dip undetermined


Strike of vertical and near-vertical joints--Determined photogeologically

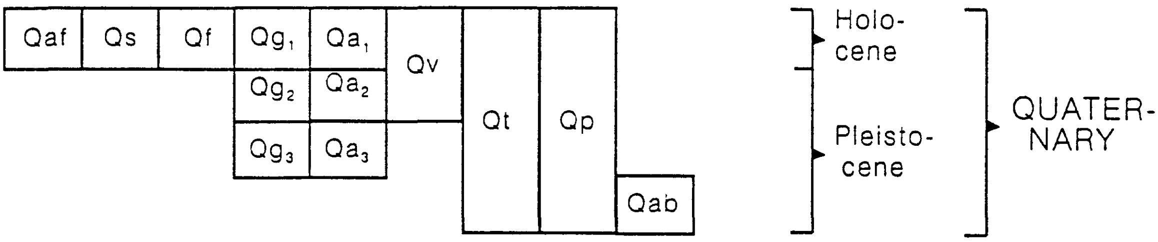
Collapse structure--Circular collapses, strata dipping inward toward central point. May reflect collapse of deep-seated breccia pipe that originated in Redwall Limestone.


Sinkhole--Steep-walled or enclosed depression


Flow direction of basalt

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS AND IGNEOUS ROCKS



SEDIMENTARY ROCKS