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

Geologic map of the Little Tanks quadrangle, northern Mohave County, Arizona

by
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INTRODUCTION

The Little Tanks 7.5′ quadrangle (96 sq km) is located in northern Mohave County, Arizona, about 67 km south of St. George, Utah, the nearest settlement, and about 15 km north of the abandoned settlement of Mt. Trumbull (Bundyville), Arizona (fig. 1). Altitudes range from about 1,493 m at the northeast corner of the quadrangle to 1,920 m at Diamond Butte at the east-central edge of quadrangle. Vehicle access to the quadrangle is an improved dirt road locally referred to as the Mt. Trumbull Road from St George, Utah (fig. 1). Several unimproved dirt roads lead from the Mt. Trumbull Road to various locations within the quadrangle area.

The area is managed by the U.S. Bureau of Land Management including about eight sections belonging to the state of Arizona. There are about one and a half sections of private land in the southeast-central part of the quadrangle at Walter Shelley Reservoir. The area supports moderate growths 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 South 7.5′ quadrangle borders the west edge of this quadrangle (Billingsley, 1991), and the Dutchman Draw 7.5′ quadrangle borders the north edge (Billingsley, 1993b).

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 for descriptive purposes.

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 335 m of Triassic strata and about 95 m of Permian strata are exposed in the quadrangle.

Bedrock strata and some surficial units are offset by the Main Street Fault, the main structural feature of this quadrangle. The Main Street Fault has a northwest strike in the north half of the quadrangle and a southwest strike in the south half. The associated fault scarp forms a ridge of low relief about 30 m high along the east side of Main Street Valley in the north half of the quadrangle, and up to 80 meters of relief along the Little Hurricane Rim in the south half of the quadrangle (fig. 2). A large unnamed fault in the southwest half of the quadrangle parallels the southwest strike of the Main Street Fault and forms the northwest side of a 3.4 km wide graben.

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

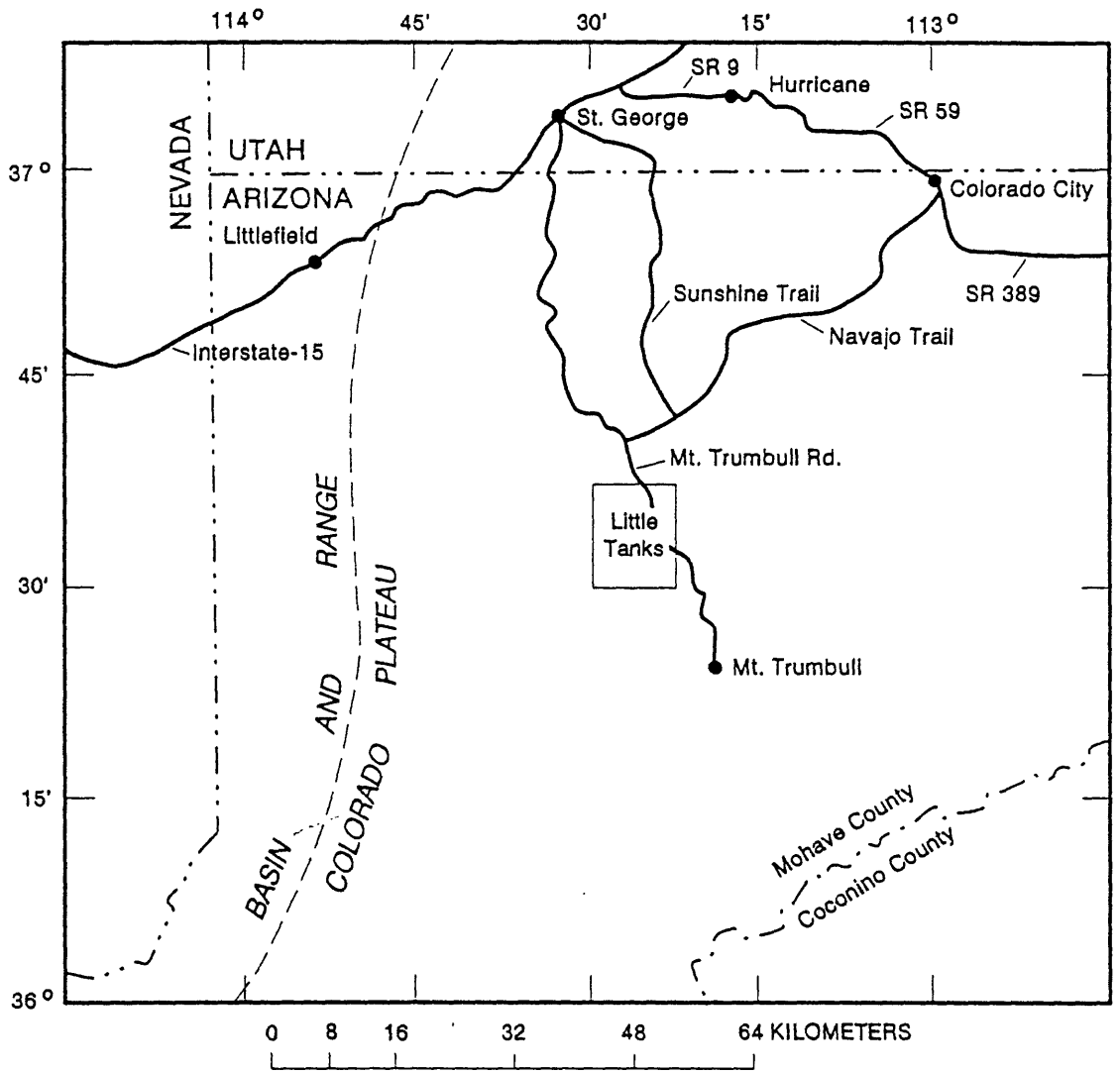


Figure 1. Index map of northern Mohave County, northwestern Arizona, showing Little Tank 7.5′ quadrangle mapped in this report. SR = State route.

STRATIGRAPHY

The sedimentary bedrock strata of this quadrangle include, in ascending order, the Kaibab Formation (Lower Permian), and the Moenkopi Formation (Upper, Middle? and 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. The Moenkopi is mainly exposed in the east-central part of the quadrangle but minor outcrops are found in paleovalleys at various locations of the quadrangle (fig. 2).

A basalt flow on Diamond Butte, herein referred to as the Diamond Butte Basalt, yielded a K-Ar age of 4.3±0.6 Ma (Harold Mehnert, U.S. Geological Survey Isotope Laboratories, Denver Colorado, written commun., 1993). This basalt overlies the lower strata of the upper red member of the Moenkopi Formation which dips east about 3 degrees. Remanent of the Diamond Butte Basalt are found on Twin Butte, about 5 kilometers east, in the Russell Spring 7.5′ quadrangle where basalt overlies the upper strata of the upper red member of the Moenkopi Formation. The source vents or dikes for the Diamond Butte Basalt are not exposed because of extensive landslide and talus debris cover and may not be present in the Russell Spring quadrangle.

Younger basaltic dikes, pyroclastic deposits, and flows are located about 1 to 2 km south of Diamond Butte and are 340 m lower than the Diamond Butte Basalt. The lower basalt has yielded a K-Ar age of 1.0±0.4 Ma (Harold Mehnert, U.S. Geological Survey Isotope Geology Branch, Denver, Colorado, written commun., 1993). The younger basalt overlies the Harrisburg Member of the Kaibab Formation, the lower red member and Virgin Limestone Member of the Moenkopi Formation, and alluvial fan deposits. The young basalt appears to have spread out radially over relatively flat terrain at the time of eruption. Hurricane Wash is about 1.5 km east of and currently about 62 m below the young basalt flow base. Assuming the Hurricane Wash drainage area was at or near its present location 1 million years ago, then erosion of Hurricane Wash has removed approximately 62 m of vertical landscape during the past million years.

The Quaternary age assigned to all alluvial deposits of the quadrangle is based on field relationships to the Quaternary and Pliocene basalts of this quadrangle and to those west and north of this quadrangle (Billingsley, 1992a,b, 1993a, 1994). Many of the alluvial deposits contain Pliocene and Pleistocene basalt clasts downslope from the basaltic outcrops. The young million year old basalt overlies the oldest alluvial deposit of this quadrangle, alluvial-fan (Qa_3), suggesting that most, if not all other alluvial deposits in this part of the Shivwits Plateau, are younger than 1 million years. The oldest alluvial deposit (Qa_3), extreme southeast corner of quadrangle) contains basalt clasts from Poverty Knoll about 10 km southwest of this quadrangle. The basalt at Poverty Knoll is assumed to be of a similar age as the Diamond Butte Basalt because it occupies a similar stratigraphic position and elevation as that of Diamond Butte.

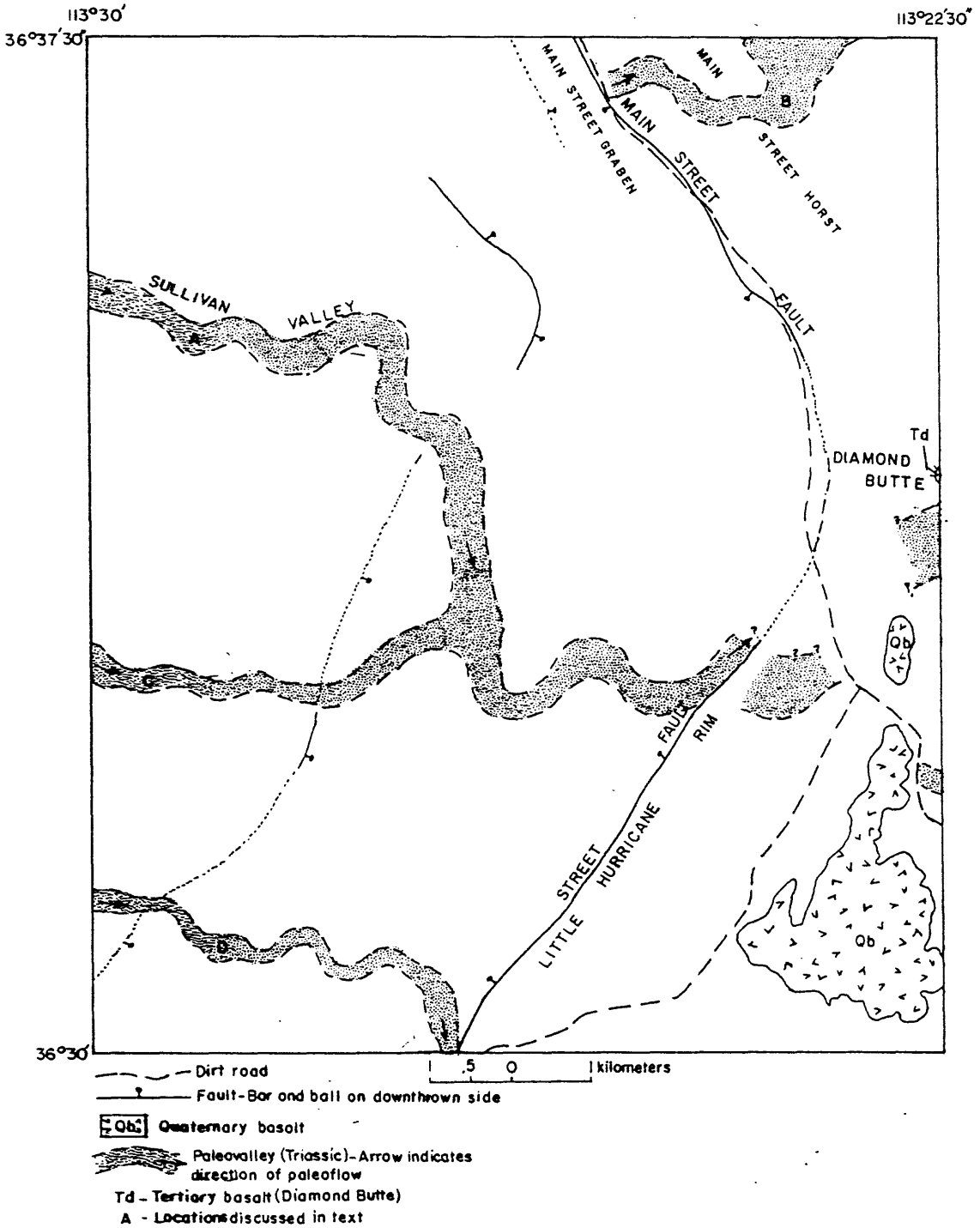


Figure 2. Selected geographic and geologic features of the Little Tanks quadrangle, northwestern Arizona.

The distribution of Quaternary alluvial deposits are an important factor in future environmental, land, and range management planning projects 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. 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). This imagery helps 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 Fault, named by Hamblin and Best (1970), and the Main Street Horst and Graben (Billingsley, 1992a) are located in the northeast quarter of the quadrangle area. The Main Street Fault displaces Pliocene basalts and Triassic strata down to the west about 26 km north of this quadrangle indicating that the fault there is at least younger then late Pliocene (Billingsley, 1992b). About a 1 km segment of the Main Street Fault near Diamond Butte is not exposed on the land surface and is inferred to arc from a northwest to a southwest strike. The SAR imagery od this area strongly suggests this configuration for the fault near Diamond Butte. This bend of the Main Street Fault is similar to a bend of the Hurricane Fault 8 km east of the quadrangle. The Main Street Graben does not appear to extend south to the Diamond Butte area but continues north of this quadrangle for many kilometers (Billingsley, 1993b). Main Street Horst dies out in this quadrangle and the Russell Spring quadrangle to the east.

Holocene movement has likely occurred along parts of some faults in the quadrangle area. Fault scarps in talus and alluvial deposits are common along parts of several faults but they are not as easily recognized in the field as they are on aerial photographs. Because erosion by mass-wasting and solution of gypsum within the Kaibab Formation 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. All fault structures in this quadrangle are probably Pleistocene age because Pleistocene basalts and underlying pre-Cenozoic strata are equally offset by faults north of this quadrangle (Billingsley, 1992a,b, 1993a, 1994).

A small monocline (northwest quarter of the quadrangle) and a small syncline (southwest quarter of quadrangle) are probably related to early Laramide compressional stresses (Huntoon, 1989). Locally, warped and bent strata are too small to show at map scale and 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.

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 in age as judged by 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 by a triangle symbol.

DESCRIPTION OF MAP UNITS

SUEFICIAL 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)**--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_3), terrace-gravel (Qg_1 and Qg_2), 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 to 2 m

Qf **Flood-plain deposits (Holocene)**--Unconsolidated light-gray or brown silt, sand, and lenses of pebble gravel in flat-valley areas. Deposits intertongue, merge with, inset against, or locally overlie valley-fill (Qv), alluvial fan (Qa_1), and low terrace (Qg_1) deposits. Forms wide flat valley floors as opposed to narrow concave valley profiles of valley-fill (Qv) deposits. Deposits are sparsely vegetated by sagebrush, cactus, and grass. Locally cut by arroyos. Flood-plain subject to flooding and local temporary ponding. As much as 20 m 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, Qa_2, and Qa_3), terrace-gravel (Qg_2), valley-fill (Qv), and talus (Qt) deposits. Forms alluvial benches about 1 to 3 m above local stream beds and supports moderate growths of cactus and grass. Averages about 1 to 4 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, sandstone derived from the Kaibab and Moenkopi Formations. Locally includes basalt clasts in east half of quadrangle; partly cemented by gypsum and calcite. Overlaps or intertongues with stream-channel alluvium (Qs), upper part of valley-fill deposits (Qv), floodplain (Qf), and young terrace-gravel (Qg_1) deposits. Overlaps and partly includes reworked materials from low terrace-gravel (Qg_1) and older alluvial-fan (Qa_2 and Qg_3) deposits near their downslope ends. Alluvial-fan subject to erosion by sheet wash and flash floods. Supports sparse to moderate growths of sagebrush, cactus, and grass. As much as 6 m 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 growths of sagebrush, grass, and cactus. As much as 4 m thick

Qt **Talus deposits (Holocene and Pleistocene)**--Unsorted debris consisting of breccia composed of 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, and upper part of valley-fill (Qv), and terrace-gravel (Qg_1 and Qg_2) deposits. Supports sparse to moderate growths of sagebrush, cactus, grass, and occasionally a pinion pine or juniper tree. Only relatively extensive deposits shown. As much as 5 m 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 side of Diamond Butte. Only large masses are shown. Supports sparse growths of sagebrush, cactus, grass, juniper and pinyon trees. Unstable when wet. As much as 40 m 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 6 m 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 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 Diamond Butte. Supports moderate growths of sagebrush, cactus, and grass. Ranges from 3 to 5 m 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 Diamond Butte in northeast quarter of quadrangle. Often adjacent to or overlapped by younger alluvial fan (Qa_1 and Qa_2), and talus (Qt) deposits. Contains well-rounded basalt clasts derived from Poverty Knoll about 10 km southwest of this quadrangle in extreme southeast corner of quadrangle. Partly consolidated by calcite and gypsum cement. As much as 6 m thick

IGNEOUS ROCKS

Qi **Basalt intrusions (Pleistocene)**--Dark-gray, finely crystalline, aphanitic basalt that occurs as dikes and plugs. Carries black pyroxene. K-Ar whole rock age, 1.0±0.4 Ma. Source vents for basalt flows (Qb) and pyroclastic (Qbc) deposits south of Diamond Butte

Qbc **Basaltic pyroclastic deposits (Pleistocene)**--Red-brown and black clasts of angular vesicular cinder and scoria deposits. Includes dark-gray glass fragments; unconsolidated. Accumulated near vent and dike (Qi) intrusions. Forms slope. As much as 40 m thick

Qb **Basalt flow (Pleistocene)**--Dark-gray, massive basalt; finely crystalline, aphanitic groundmass. Surfaces are partly covered by cinder and scoria (Qbc) deposits. Derived from intrusions of dike vent (Qi) areas. Forms ledge as much as 3 to 6 m thick

Td **Diamond Butte Basalt (Pliocene)**--Dark, massive, finely crystalline, aphanitic groundmass with olivine phenocrysts. Source of basalt flow not exposed but may be covered by local landslide debris. K-Ar whole rock age, 4.3±0.6 Ma. Approximately 24 m thick

SEDIMENTARY ROCKS

Moenkopi Formation (Middle? and Lower Triassic)--Includes, in descending order, upper red member, 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 (Morales, 1987)

Ꝛmu **Upper red member**--Heterogeneous sequence of red sandstone, siltstone, mudstone, conglomerate, and minor gray gypsum. Upper part eroded away and overlain unconformably by Diamond Butte Basalt (Pliocene). Gradational and arbitrary contact with underlying Shnabkaib Member placed at top of highest thick white siltstone and dolomite bed of Shnabkaib. Forms slope and ledge sequence. About 42 m exposed

Ꝛms **Shnabkaib Member**--Interbedded, white, laminated, aphanitic 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. Forms steep slope with ledges. As much as 135 m thick

Ꝛmm **Middle red member**--Interbedded, red-brown, thin-bedded, laminated siltstone and sandstone, white and gray gypsum, minor white platy 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 slopes. About 90 m thick

Ꝛmv **Virgin Limestone Member**--Consists of two, sometimes three, light-gray, ledge-forming limestone beds 0.5 to 2 m thick, separated by white, yellowish-gray, and gray slope-forming, thin-bedded, gypsiferous siltstone. Includes thin beds of brown, red, and green siltstone, gray limestone, and brown platy calcarenite between limestone beds. Erosional unconformity at base of lowest gray limestone bed truncates underlying red siltstone of lower red member as much as 1 m of relief. Lower limestone bed thickens and thins as channel fill deposit. Forms ledges in slope. As much as 22 m thick

TRml **Lower red member**--Red, fine-grained, thin-bedded, gypsiferous 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 sandstone, or conglomerate of Timpoweap Member. Unconformable contact with Kaibab Formation. Locally fills paleovalleys eroded into underlying Kaibab Formation. Forms slope. Ranges from about 6 to 18 m. Locally thickens in paleovalleys eroded into Kaibab Formation

TRmt **Timpoweap Member**--Calcareous, light-gray 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. Source for dark-gray limestone and quartzite may be Paleozoic rocks west of quadrangle. Forms ledge or steep slope. Unconformable contact with Harrisburg Member of Kaibab Formation. Fills Triassic paleovalleys eroded into Kaibab Formation estimated as much as 76 m deep and about 300 m wide. Rocks of Timpoweap occupy 4 paleovalleys, Sullivan Valley (A, fig. 2; Billingsley, 1991, 1994), and 3 smaller unnamed paleovalleys (B, C, and D, fig. 2). Much of Timpoweap deposits have been eroded by modern streams. Imbrication of pebbles in lower conglomerate shows an eastward paleoflow in depositing streams for all four paleovalleys. Thickness from 6 to 76 m

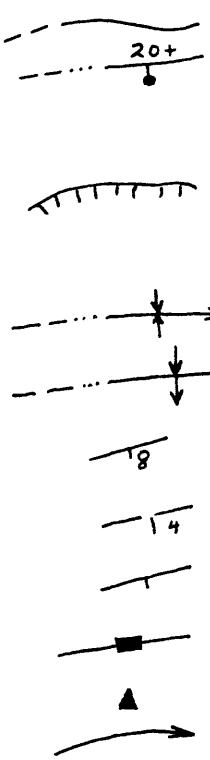
TRmlt **Lower red member and Timpoweap Member undivided**--Same lithologies as TRml and TRmt but interbedded. Consists of reddish conglomerate and sandstone lenses within interbedded red siltstone and gypsum. Occupies shallow paleovalleys as much as 30 m deep cut into underlying Harrisburg Member of Kaibab Formation. Unconformable contact with Harrisburg Member of Kaibab Formation. Deposits mostly eroded away by local stream drainages. Forms slope with ledges. Approximately 1 to 3 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 an upper, middle, and lower part. Upper part consists mainly of slope-forming, red and gray, interbedded gypsiferous siltstone, sandstone, gypsum, and thin-bedded gray limestone; mostly removed by erosion except at Diamond Butte. Middle part consists mainly of two 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, gypsiferous 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 94 m thick

Pkf **Fossil Mountain Member**--Light-gray, fine- to medium-grained, thin-bedded, fossiliferous, sandy, cherty limestone. Chert weathers black or dark gray. Only upper part of Fossil Mountain exposed along Little Hurricane Rim, southeast quarter of quadrangle. Forms cliff. 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

Landslide detachment--Headwall scarp of landslide, hachures point in direction of slide

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

Syncline

Monocline

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

Sinkholes--Steep-walled or enclosed depression or cave

Flow direction of basalt

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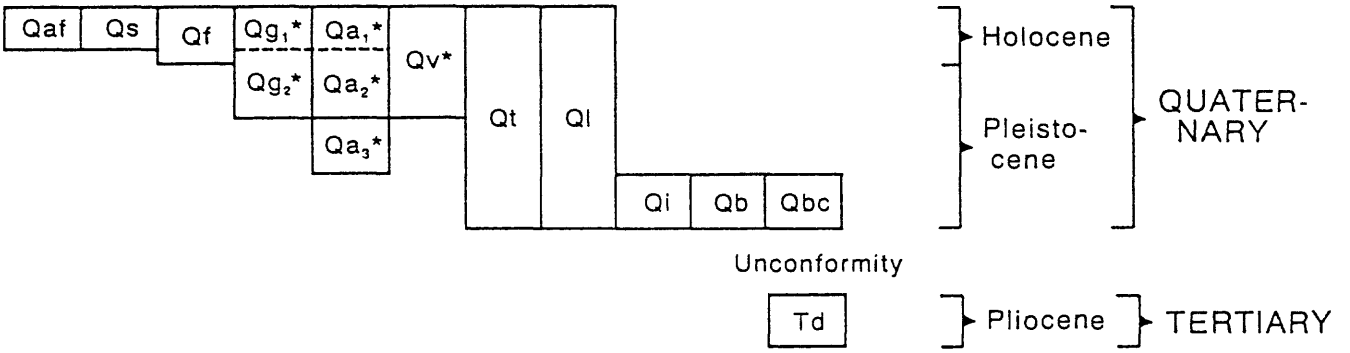
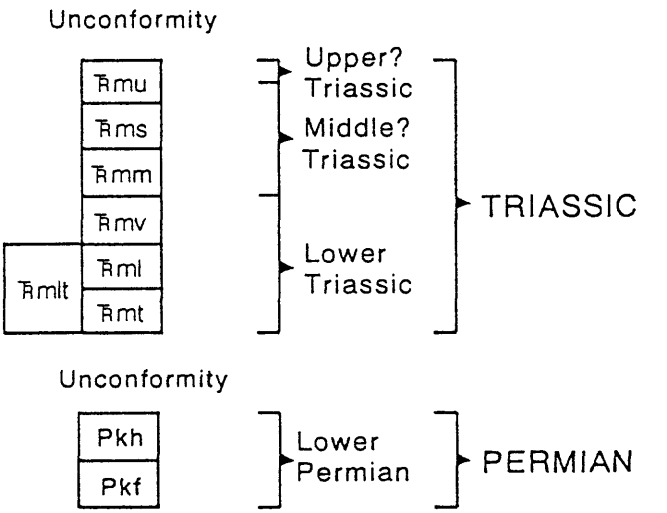
CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS AND IGNEOUS ROCKS



SEDIMENTARY ROCKS



* See description of map units for exact unit age assignment