

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

Geologic map of the Littlefield quadrangle,  
northern Mohave County, Arizona

by  
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1995

## INTRODUCTION

The Littlefield 7.5' quadrangle lies in the extreme northwestern corner of Mohave County, Arizona (fig. 1). Elevations range from about 536.5 m (1,760 ft) at the Virgin River (south-central edge of quadrangle) to 975 m (3,200 ft) in the Beaver Dam Mountains (northeastern corner of quadrangle). Interstate Arizona Highway 15 and U.S. Highway 91 provides a general access to the quadrangle while several unimproved dirt roads lead to remote areas of the quadrangle. The community of Littlefield, Arizona is just southeast of Interstate 15 along the west bank of the Virgin River, and the community of Beaver Dam, Arizona is just northwest of Interstate 15 in the valley of Beaver Dam Wash (fig. 1). Population of both communities is about 300 people. The environment, topography, and geography is typical of the Mohave Desert of Nevada and California.

There are about 9 sections of private land in the quadrangle and 5 sections belonging to the state of Arizona. The balance is public land administrated by the U.S. Bureau of Land Management, Arizona Strip District in St. George, Utah. The area supports sparse growth of desert shrubs, mainly creosote bush and cactus. Dense growths of tamarisk (Salt Cedar), cottonwood, and willow trees thrive along the alluvial terraces and banks of the Virgin River. A variety of water loving plants thrive in warm spring waters on the east side of the Virgin River near the Interstate 15 bridge, and in Beaver Dam Wash, northwest corner of the quadrangle.

## PREVIOUS WORK

The quadrangle area is included on two Arizona state geologic maps, one by Wilson and others (1969), and the other by Reynolds (1988), but these maps show only regional geology at a scale 1:500,000 and 1:1,000,000. A regional geologic map showing a little more geologic detail of the area at 1:62,500 scale was published by Moore (1972). A preliminary geologic map of the Mountain Sheep Spring quadrangle, east of this quadrangle, was made by Hintze (1986). Another geologic map of the Mountain Sheep Spring quadrangle was made by Bohannon and others (1991).

## MAPPING METHODS

A preliminary geologic map of this quadrangle was made from 1:24,000 scale 1976 aerial photographs. In particular, many of the Quaternary alluvial units having similar lithologies and intertonguing boundaries were mapped using photogeologic methods. These units were differentiated from one another by topographic expression, amount of dissection by washes, difference in albedo, morphologic character, physical position, and amounts and types of covering vegetation. Field investigations were then conducted to check photo interpretations and to obtain descriptions of map units. All Quaternary map units are mapped as shown on 1976 aerial photos. Some terrace deposits along Beaver Dam Wash and the Virgin River will change because of erosion and flood alterations.

## GEOLOGIC SETTING

The Littlefield quadrangle lies along the eastern edge of the Virgin River depression (Bohannon and others, 1993), one of several basins in the eastern part of the Basin and Range physiographic province of northwestern Arizona. The Virgin River depression abuts the Beaver Dam Mountains (northeast corner of the quadrangle) and the Virgin Mountains (southeast corner of the quadrangle). The Beaver Dam and Virgin Mountains are the easternmost mountains in this part of the Basin and Range, and they are

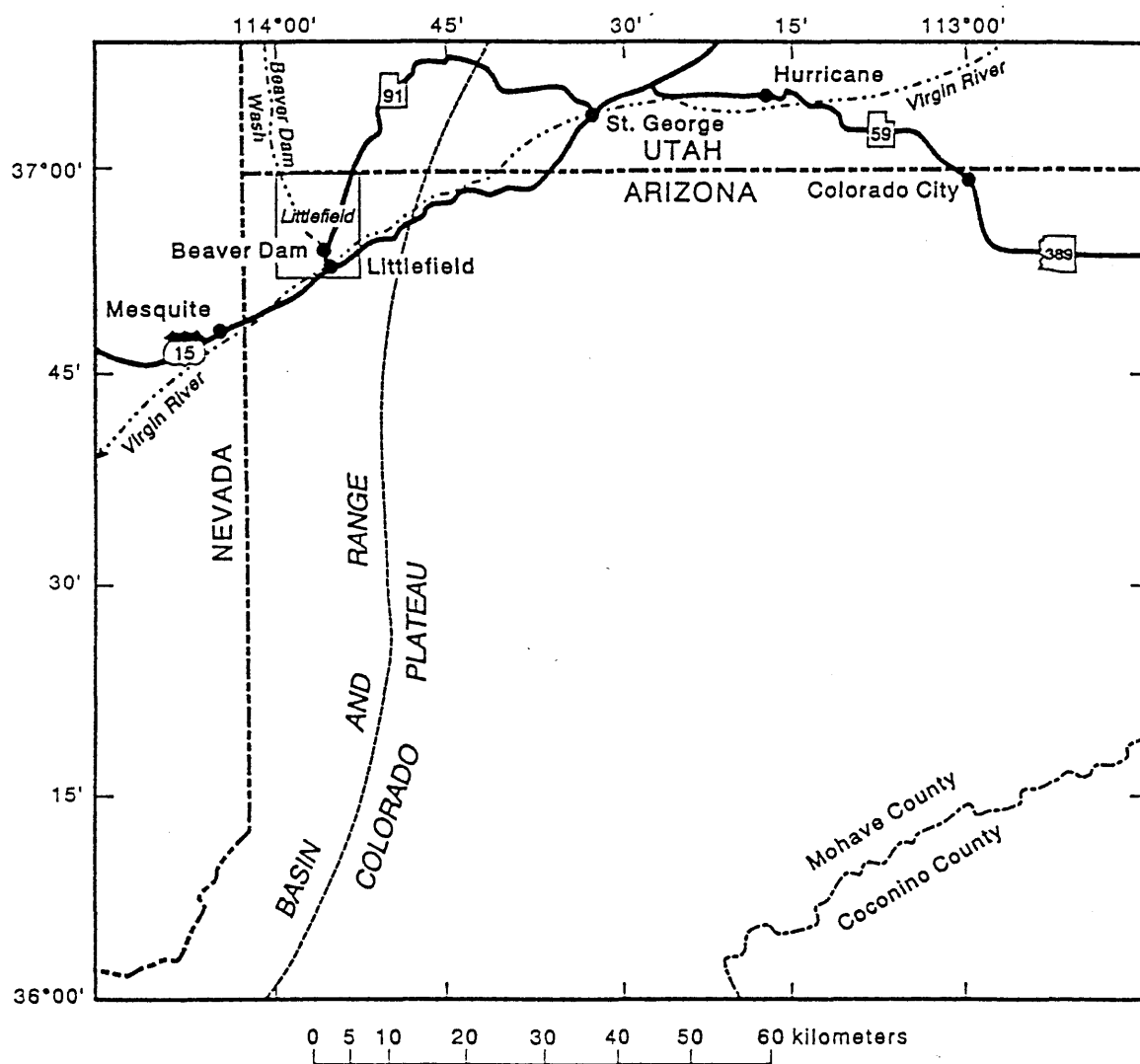


Figure 1. Index map of northern Mohave County, northwestern Arizona, showing the Littlefield 7.5' quadrangle.

separated from the Colorado Plateau province by the Grand Wash Fault about 13 km (8 mi) east of this quadrangle.

The Virgin River depression is approximately 4,875 m (16,000 ft) deep and filled with intra-basin alluvial sediments (Bohannon and others, 1993). Only the top 60 m (200 ft) of these sediments, the Muddy Creek Formation (Miocene and Pliocene), which includes ancestral conglomerate of Beaver Dam Wash and the Virgin River, are exposed in this quadrangle. The Beaver Dam and Virgin Mountains were formed by middle Miocene extension and strike-slip faulting resulting in the exposure of Proterozoic crystalline metamorphic and igneous rocks that are overlain by extensively faulted and folded Paleozoic and Mesozoic strata.

The Paleozoic and Proterozoic rocks in the Beaver Dam and Virgin Mountains of this quadrangle correlate with those described by Hintze (1986), Bohannon and others (1991), and Bohannon and Lucchitta (1991). Tertiary strata of the Muddy Creek Formation include siltstone, sandstone, calcrete, and conglomerate. Conglomerate beds within the Muddy Creek consists of an older multicolored, well-rounded quartzite clasts about 30 to 35 m (100 to 115 ft) below the top-most exposed beds of the Muddy Creek about 1 km south and southwest of this quadrangle (sec. 15, T. 40 N., R. 16 W.). A younger conglomerate contains rhyolitic clasts near Beaver Dam Wash, and basaltic clasts near the Virgin River. These conglomerates represent an ancestral deposit of Beaver Dam Wash and the Virgin River that pinch out within the upper fine-grained sediments of the Muddy Creek Formation (see correlation chart). The basaltic clasts within the conglomerate are probably Pliocene age or younger based on mapping and K-Ar ages of basalt flows upstream of the Virgin River in Utah and Arizona, which are late Pliocene and Pleistocene (Billingsley 1993; in press). The ancestral conglomerates of Beaver Dam Wash and the Virgin River have mixed together below the confluence of Beaver Dam Wash and the Virgin River to become one conglomeratic deposit of the ancestral Virgin River.

The Tertiary Muddy Creek Formation is overlain by a relatively thin Cenozoic deposit of pediment calcrete, except east of the Virgin River where alluvial fan deposits of unknown thickness bury the Muddy Creek Formation. The Cenozoic deposits include stream-channel deposits, sand sheets and dunes, terrace-gravels, alluvial fans, talus and colluvium, and minor landslide debris. These alluvial deposits form distinctive geomorphic features and have intertonguing or gradational contacts. The distribution of the Tertiary and Quaternary deposits are important for future considerations of human resource development and environmental and range management planning of this area by federal, state, and private organizations. Resource considerations include flood-control, roads, buildings, erosion control, farming, and endangered plant or animal habitats. The composition of materials in surficial units may have significant impact to urban and range management development.

The Quaternary age assigned to the surficial alluvial deposits in this quadrangle are based on the similarity of desert-varnish development observed for Quaternary deposits at the Nevada Test Site, (Hoover and others, 1981), to similarity of established Quaternary deposits of the Colorado Plateau area (Billingsley, 1993; 1994; in press), and to geomorphic field relationships.

#### GEOLOGIC STRUCTURE

The Virgin River depression is a large tectonic basin extensionally deformed during Miocene time and filled with a thick sequence of basin-fill deposits. The reddish-brown or light-gray siltstone, sandstone, and calcrete

of the upper Muddy Creek Formation is exposed in erosional cuts along Beaver Dam Wash, the Virgin River, and their tributaries. Thickness of the Muddy Creek Formation averages about 884 m (2,900 ft) in this area (Bohannon and others, 1993), but only the upper 60 m (200 ft) is exposed in this quadrangle.

Sometime during the Pliocene, specific time unknown, the finer-grained and lower (older) quartzite conglomerate deposits within the Muddy Creek was subsequently eroded by an ancestral Beaver Dam Wash and Virgin River drainage. This erosion was incised about 200 m (650 ft) into the Muddy Creek Formation below the town of Mesquite, Nevada (Van Williams, U.S. Geological Survey, written commun., 1995) and resulted in a local erosional unconformity filled with an ancestral Virgin River conglomerate inset into the finer-grained Muddy Creek sediments and overlain by fine-grained sediments of the Virgin River.

In this quadrangle, the ancestral erosion of Beaver Dam Wash and the Virgin River is less than that below the town of Mesquite with an average depth of about 35 m (115 ft). However, the Beaver Dam Wash and Virgin River conglomerate do not appear to be inset into the fine-grained Muddy Creek Formation, but instead, appear to pinch out into the Muddy Creek. Thus, the fine-grained sediments that overly the Beaver Dam Wash and Virgin River conglomerate are not readily separated from one another where the conglomerate deposits are absent. The fine-grained sediments overlying the conglomerate may be reworked deposits of the Muddy Creek Formation redeposited by Beaver Dam Wash and the Virgin River, but because of the lack of an unconformity or mappable boundary beyond the conglomerate pinchout, all fine-grained sediments below and above the conglomerate are mapped as part of the upper Muddy Creek Formation in this quadrangle.

Subsequent tilting of the Muddy Creek deposits, including the ancestral Beaver Dam Wash and Virgin River conglomerate, allowed for development of a thick calcrete soil over the Muddy Creek sediments during the late Pliocene and early Pleistocene that formed a low-angular unconformable contact. The calcrete deposits and underlying Muddy Creek sediments were later subjected to further tilting and faulting, probably during the early Pleistocene.

Sometime in the early Pleistocene? a modern Beaver Dam Wash and Virgin River drainage eroded headward from the southwest into the pediment calcrete and upper Muddy Creek deposits as much as 100 m (300 ft) deep. The modern Beaver Dam Wash and Virgin River were subsequently filled with fluvial conglomerate, gravel, and sand deposits that form terraces. The modern Beaver Dam Wash and Virgin River drainages appear to alternate between periods of aggradational accumulation of sediments and degradational downcutting. The Quaternary terraces and adjacent inset alluvial fans along Beaver Dam Wash and the Virgin River are the result of cyclical aggradation and degradation probably caused mostly by climatic fluctuations. The Quaternary deposits are partly modified by Tertiary and Quaternary tectonic deformation associated with uplift of the Virgin Mountains and subsidence of the Virgin River depression.

Pliocene? and Pleistocene faulting and folding is common in the western part of the Littlefield quadrangle. Sediments of the Muddy Creek Formation and the pediment calcrete deposits, have been gently tilted east with dips as much as 4 degrees in the western half of the quadrangle. A brief reconnaissance of the Muddy Creek and calcrete deposits west of this quadrangle indicate a gentle west-dipping limb of a broad anticlinal crest, the axis of which lies about 6 km west of this quadrangle. The east dipping Muddy Creek Formation and calcrete sediments are offset by several normal high

angle faults and grabens that have general displacements down to the west. Maximum offset on a single fault is 36 m (118 ft), northwest quarter of quadrangle.

Faulting of older alluvial fans south and north of this quadrangle are probably associated with the faulting in the Beaver Dam Wash area. Young stream deposits (Qls and Qas), sand (Qd), intermediate and younger terrace-gravel (Qg<sub>1</sub>, Qg<sub>2</sub>, and Qg<sub>3</sub>), and intermediate and younger alluvial fan (Qa<sub>1</sub> and Qa<sub>2</sub>) deposits are not faulted or folded in this quadrangle. Thus, faulted strata of the upper Muddy Creek Formation, the ancestral Beaver Dam Wash and Virgin River conglomerate, and the pediment calcrete deposits suggests that the latest pulse of tectonic activity in this quadrangle began during the late Pliocene? and probably continued into the middle Pleistocene. It is probable that tectonic activity is still potentially active in this quadrangle.

The Virgin River depression is separated from the Beaver Dam and Virgin Mountains by the Piedmont Fault (Moore, 1972). The Piedmont Fault is mostly covered by several sequences of alluvial fan deposits, three of which are identified in the Littlefield quadrangle. The Piedmont Fault offsets older and intermediate alluvial fan (Qa<sub>3</sub> and Qa<sub>2</sub>) deposits along the west side of the Virgin Mountains in the Elbow Canyon quadrangle (south of this quadrangle; Bohannon, 1991), and along the western part of the Beaver Dam Mountains (Mountain Sheep Spring quadrangle; Hintze, 1986; Bohannon and others, 1991) northeast of this quadrangle. The Piedmont Fault does not offset all intermediate (Qa<sub>2</sub>) alluvial fans, and none of the younger (Qa<sub>1</sub>) alluvial fans, talus and colluvium (Qt), or stream (Qls and Qas) deposits in this quadrangle. Faulting of older and intermediate alluvial fan (Qa<sub>3</sub> and Qa<sub>2</sub>) deposits indicate the location of the Piedmont Fault trace along the base of the Virgin Mountains in this quadrangle. Other faults similar to the Piedmont Fault are suspected under thick alluvial fan cover in the northeast corner of the Littlefield quadrangle, but are not identified on aerial photographs or by ground inspection.

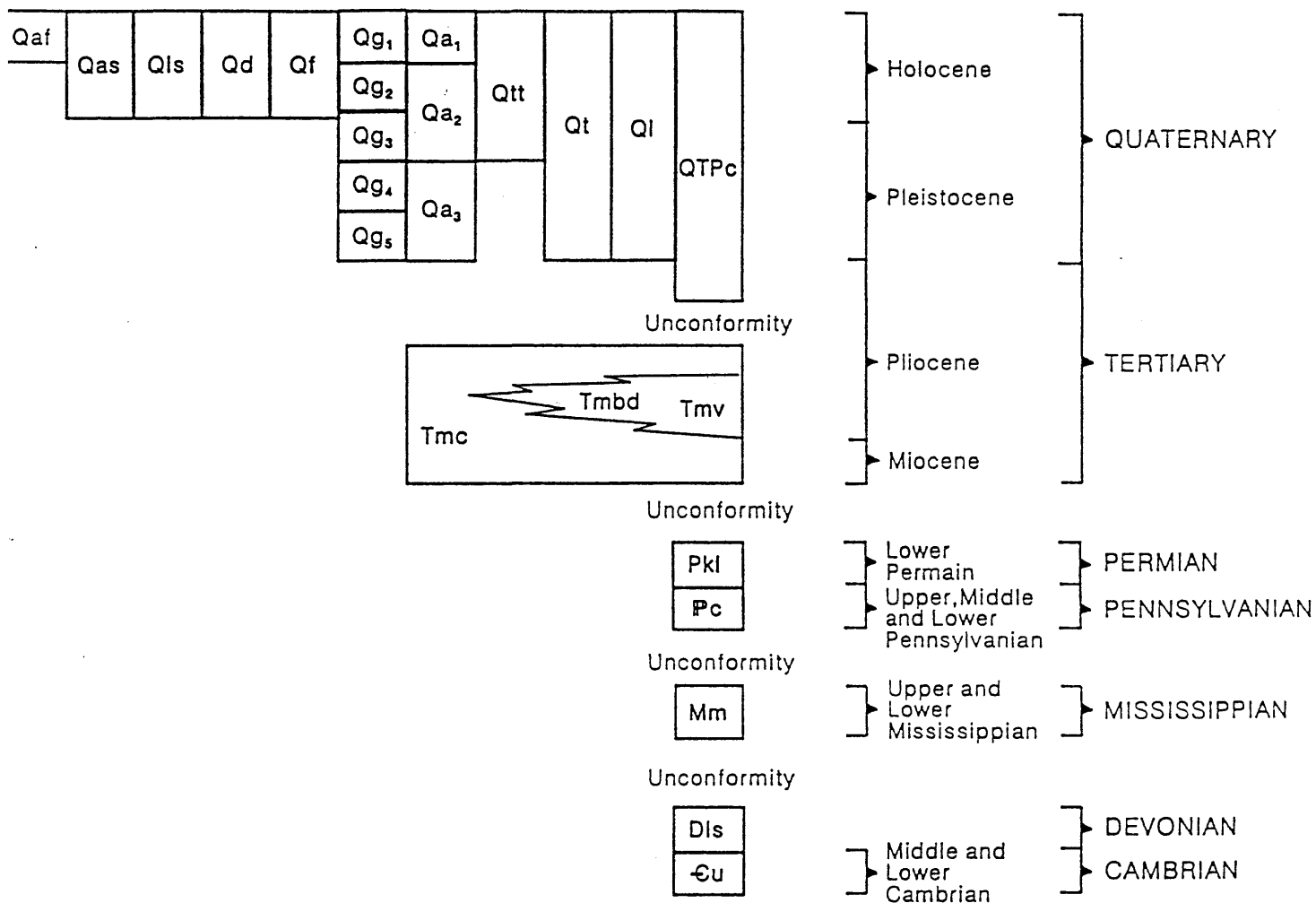
#### DESCRIPTION OF MAP UNITS

**Surficial deposits (Holocene and Pleistocene)**--Surficial deposits are differentiated from one another chiefly by photogeologic techniques on the basis of difference in albedo, morphologic character, physiographic position and, to some extent, amount and types of vegetation cover as of 1976 aerial photographs

- Qaf Artificial fill and quarries (Holocene)**--Alluvial and bedrock material removed from pits and trenches to build stock tanks, roads, and drainage diversion dams. Includes quarries for sand and gravel
- Qas Alluvium of active stream channels (Holocene)**--Interlensing silt, sand, and pebble to boulder gravel; unconsolidated and poorly sorted. Locally overlies or inset to younger and intermediate alluvial fan (Qa<sub>1</sub> and Qa<sub>2</sub>) and floodplain (Qf) deposits; inset to intermediate and older terrace gravel (Qg<sub>2</sub> and Qg<sub>3</sub>) deposits. Stream channels subject to high-energy debris flows and flash floods. Supports little or no vegetation. Contacts with other alluvial deposits approximate. Only most active channel deposits shown as on 1976 aerial photography. Exposed thickness 1 to 2 m

# CORRELATION OF MAP UNITS

## SURFICIAL DEPOSITS and SEDIMENTARY ROCKS



- Qls **Alluvium of low-gradient stream channels (Holocene)**--Similar to active stream channels (Qas), but locally subject to sheet wash flooding or temporary ponding due to sand accumulation or minor tectonic adjustment of stream gradient. Grades laterally into sand sheet (Qd), talus and colluvial (Qt) deposits, and upper part of pediment calcrete (QTpc) deposits. Locally confined to small valleys or low-gradient channels partly blocked with sand or tectonic fault movement. Contacts with other alluvial deposits approximate. Supports moderate to heavy growth of desert shrubs and grass. Exposed thickness, about 3 m
- Qd **Dune sand and sand sheet deposits (Holocene)**--Light-reddish-orange sand on pediment calcrete (QTpc) deposits; light-gray sand along Virgin River. Very fine- to fine-grained, well-sorted, unconsolidated sand. Forms isolated sand sheets and small complex dunes on pediment calcrete (QTpc) surfaces and on floodplain (Qf) or young terrace-gravel (Qg<sub>1</sub>) deposits along Virgin River. Forms falling dunes in minor tributary drainages and along west bank of Beaver Dam Wash. Sand locally derived from eroded and weathered outcrops of Muddy Creek Formation (Tmc), Beaver Dam Wash and Virgin River conglomerate (Tmbd, and Tmv), pediment calcrete (QTpc), and talus and colluvium (Qt); distributed by southwesterly and northwesterly winds. Sand along Virgin River is locally derived from active stream channels (Qas) and floodplain (Qf) areas in dry seasons. Supports sparse to moderate growth of desert vegetation and grass. Only active sand sheets and dunes mapped, thin stabilized sand sheets not mapped. Thickness ranges from 1 to 5 m
- Qf **Floodplain deposits (Holocene)**--Light-red or brown silt, sand, and gravel; mostly well-sorted, poorly bedded, unconsolidated. Contains reworked silt, sand, gravel and subangular to well rounded pebbles and boulders of gneiss, schist, rhyolite, basalt, pegmatite, quartzite, limestone, dolomite, sandstone, and chert derived from ancestral conglomerates of Beaver Dam Wash (Tmbd) and Virgin River (Tmv) and Muddy Creek Formation (Tmc). Also includes material eroded from alluvial fans (Qa<sub>1</sub> through Qa<sub>3</sub>), and terrace gravels (Qg<sub>1</sub> through Qg<sub>5</sub>). Contacts with other alluvial deposits approximate. Intertongues with active stream (Qas) deposits of Virgin River and Beaver Dam Wash, and inset to terrace-gravel (Qg<sub>1</sub> and Qg<sub>2</sub>) deposits. Forms bench 1 to 1.5 m above active stream channel of Virgin River and Beaver Dam Wash. Subject to frequent flooding and local erosion or accumulation of sediment several times per year. Supports moderate growth of grass and shrubs. Exposed thickness 0.5 to 1.5 m
- Qg<sub>1</sub> **Young terrace-gravel deposits (Holocene)**--Pale-reddish-brown, gray, and light-brown silt, sand, and gravel; moderate to well-sorted, thin to massive bedded sand and silt. Contains reworked material from floodplain (Qf), alluvial fans (Qa<sub>1</sub>, Qa<sub>2</sub>, and Qa<sub>3</sub>), talus and colluvium (Qt), Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv). Forms bench about 2 to 3 m above active stream channels; inset against low intermediate terrace-gravel (Qg<sub>2</sub>), alluvial fans (Qa<sub>1</sub> and Qa<sub>2</sub>), Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate

(Tmbd), and Virgin River conglomerate (Tmv). Supports moderate to heavy growth of vegetation, mainly tamarisk, willow, and ash trees along Virgin River, desert bushes, shrubs, cactus, grass, and some cottonwood trees along parts of Beaver Dam Wash. Subject to yearly flooding and severe erosion or accumulation of sediment along Virgin River and Beaver Dam Wash. Exposed thickness, about 3 m

- Qa<sub>1</sub>    **Young alluvial fan deposits (Holocene)**--Light-gray and brown silt, sand, pebbles, and boulders, poorly sorted, unconsolidated. Includes lenses of poorly sorted, thin-bedded gravelly sand and pebbles. Includes boulders as much as 0.5 m diameter. Pebble and boulder clasts are angular to rounded, gneiss, schist, granite, pegmatite, quartzite, sandstone, limestone, dolomite, and chert derived from Virgin Mountains east of Virgin River, and Beaver Dam Mountains east of Beaver Dam Wash. Locally, in Beaver Dam Wash, includes reworked deposits of ancestral Beaver Dam Wash conglomerate (Tmbd), terrace-gravels (Qg<sub>1</sub> through Qg<sub>5</sub>), and intermediate alluvial fan (Qa<sub>2</sub>) deposits. In Virgin River channel, includes reworked deposits of ancestral Virgin River conglomerate (Tmv), terrace-gravels (Qg<sub>2</sub> through Qg<sub>5</sub>), and intermediate alluvial fan (Qa<sub>2</sub>) deposits. Overlaps intermediate and older alluvial fan (Qa<sub>1</sub> and Qa<sub>2</sub>) deposits on lower alluvial fan slopes, inset against intermediate and older alluvial fan deposits on upper fan slopes. Intertongues with younger terrace-gravel (Qg<sub>1</sub>) deposits, and overlaps low intermediate terrace-gravel (Qg<sub>2</sub>) deposits along Beaver Dam Wash and Virgin River. Subject to sheet wash erosion and high-energy flash floods and debris flows. Supports sparse growth of desert shrubs, creosote bush, and cactus. As much as 4 m exposed, estimated as much as 12 m thick
- Qtt    **Travertine deposits (Holocene and Pleistocene?)**--Gray porous travertine. Thin-bedded calcium carbonate deposits derived from warm fresh water spring outlets along east bank of Virgin River at and near Interstate Highway 15 bridge crossing. Locally includes silt, sand, pebbles and cobbles derived from sheet wash of pediment calcrete (QTpc) and intermediate alluvial fan (Qa<sub>2</sub>) sediment. Includes encrustation of roots, leaves, and plants of local vegetation preserved as modern fossils. Forms cliff or resistant bench. Ranges from 1 to 4 m thick
- Qt    **Talus and colluvial deposits (Holocene and Pleistocene)**--Light-reddish-brown to yellowish-gray silt, sand, pebbles, boulders, and breccia debris as loose incoherent mass of weathered or broken rock; unsorted and partly consolidated along Beaver Dam Wash. Locally includes reworked decomposed weathered material from pediment calcrete (QTpc), Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv), partly cemented by calcite and gypsum. Forms secondary and thinner pediment calcrete deposit similar to pediment calcrete (QTpc) in faulted terrain along western part of quadrangle. Intertongues with low-gradient stream (Qls) deposits. Supports sparse growth of desert shrubs and creosote bush. As much as 2 m thick

- Q1      **Landslide deposits (Holocene and Pleistocene)**--Unconsolidated mass of unsorted debris that have detached and slid downslope as loose incoherent mass of broken rock and deformed strata. Landslide masses are mostly composed of strata of Muddy Creek Formation (Tmc) and ancestral Beaver Dam Wash conglomerate (Tmbd) in upper Beaver Dam Wash. Supports little or no vegetation. Unstable when wet. Minor rockfall or landslides not shown; distinct potential of future rockfall or landslide hazard is prevalent along cliffed banks both sides of Beaver Dam Wash and Virgin River. Thickness as much as 6 m
- QTpc    **Pediment calcrete (Holocene and Pleistocene)**--Pale-yellowish-brown to light-gray, moderately sorted, massive to thin-bedded, cliff-forming siltstone and sandstone. Includes thick beds or nodules of white caliche and caliche-cemented siltstone that produces lighter tone surface on aerial photographs. Unit covered locally by dune sand (Qd). Exposed caliche nodules at surface are deeply pitted or etched by solution weathering. Generally forms flat to gently sloping surfaces, locally tilted as much as 4° east in western quarter of quadrangle; dissection is variable. Subject to modern sheet wash flow and local flooding. Base of unit generally forms low angular unconformable contact with underlying Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv). Generally less than 5 m thick
- Qg<sub>2</sub>    **Low intermediate terrace-gravel deposits (Holocene)**--Similar lithology to young terrace-gravel (Qg<sub>1</sub>) and floodplain (Qf) deposits. Consists mostly of sand and silt. Locally inset to middle, high, intermediate and old terrace-gravel (Qg<sub>3</sub>, Qg<sub>4</sub>, and Qg<sub>5</sub>) deposits. Forms benches about 1 to 2 m above young terrace-gravel (Qg<sub>1</sub>) deposits, and about 4 m above active stream (Qas) and floodplain (Qf) deposits along Virgin River and Beaver Dam Wash. Supports growth of mixed vegetation, mainly shrubs and tamarisk trees, some willow, ash and cottonwood trees. As much as 4 m thick
- Qa<sub>2</sub>    **Intermediate alluvial fan deposits (Holocene and Pleistocene?)**--Same lithologies as younger alluvial fan (Qa<sub>1</sub>) deposits but with lesser silt and sand, partly consolidated by calcite cement; stony surface. Includes boulders as much as 2 m in diameter. Rocky surface has minor to well developed desert varnish. Commonly overlapped by young alluvial fan (Qa<sub>1</sub>) deposits, and incised into older alluvial fan (Qa<sub>3</sub>) deposits in upper fan slopes. Partly interbedded with pediment calcrete (QTpc) deposits east of upper Beaver Dam Wash, but commonly overlaps pediment calcrete (QTpc) deposits near and east of Virgin River. Intermediate fan surfaces are heavily dissected in upper part as much as 2 m deep. Subject to sheet wash and gully erosion. Supports sparse growth of desert shrubs, creosote bush, cactus and grass. About 6 m exposed, estimated maximum thickness, 90 m or more

- Qg<sub>3</sub> Middle intermediate terrace-gravel deposits (Holocene and Pleistocene)**-- Similar color and lithology to young and low intermediate terrace-gravels (Qg<sub>1</sub> and Qg<sub>2</sub>), consists mostly of gray silt and sand; partly consolidated. Inset against or overlying high intermediate and older terrace-gravels (Qg<sub>4</sub> and Qg<sub>5</sub>), Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv). Forms benches about 4 to 12 m above modern stream beds of Beaver Dam Wash and Virgin River. Incised locally by arroyo erosion and eroded by Virgin River or Beaver Dam Wash. Supports sparse desert vegetation, mainly creosote bush, cactus, and grass. Averages about 5 m thick
- Qg<sub>4</sub> High intermediate terrace-gravel deposits (Pleistocene)**-- Similar color and lithology to younger terrace-gravels (Qg<sub>1</sub>, Qa<sub>2</sub>, and Qg<sub>3</sub>). Inset against older terrace-gravel (Qg<sub>5</sub>) deposits; inset against or overlying Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv). Exposed surface pebbles and boulders have desert varnish coating, limestone and dolomite clasts are pitted or deeply weathered; partly consolidated by calcite cement and incised by local erosion. Eroded material is redistributed as part of local young alluvial fan (Qa<sub>1</sub>) deposits. Forms benches 1 to 2 m above middle terrace-gravels (Qg<sub>3</sub>), 3.5 m above modern stream bed of Virgin River, and as much as 18 m above modern stream bed of Beaver Dam Wash. Supports sparse vegetation of desert shrubs, cactus, and grass. Averages 4 m thick along Virgin River and as much as 18 m thick along Beaver Dam Wash
- Qg<sub>5</sub> Old terrace-gravel deposits (Pleistocene)**-- Similar color and lithologies to younger terrace-gravels (Qg<sub>1</sub>, Qg<sub>2</sub>, Qg<sub>3</sub>, and Qg<sub>4</sub>), but clast characteristics are dominantly gray limestone and dolomite as opposed to mostly igneous and metamorphic clasts in younger and lower terrace gravels. Exposed surface pebbles and boulders have desert varnish and coating of caliche on underside of clasts. Limestone, dolomite, and sandstone clasts are strongly pitted and deeply weathered on exposed surface. Inset against pediment calcrete (QTpc) and sediments of Muddy Creek Formation (Tmc), Beaver Dam Wash conglomerate (Tmbd), and Virgin River conglomerate (Tmv). Intertongues or overlapped by young and intermediate alluvial fan (Qa<sub>1</sub> and Qa<sub>2</sub>), and talus and colluvial (Qt) deposits. Forms benches about 18 to 24 m above stream bed of Virgin River, and about 30 m above modern stream bed of Beaver Dam Wash. Supports sparse desert shrubs, cactus, creosote bush, and grass. As much as 3 m thick along Virgin River and as much as 6 to 30 m thick along Beaver Dam Wash
- Qa<sub>3</sub> Older alluvial fan deposits (Pleistocene)**-- Similar lithologies to younger alluvial fans (Qa<sub>1</sub> and Qa<sub>2</sub>) and active and low-gradient stream (Qas and Qls) deposits; has yellowish smooth lighter tone surface texture on aerial photos because of thin soil development as compared to younger alluvial fans (Qa<sub>1</sub> and Qa<sub>2</sub>); partly consolidated by calcite cement. Surface clasts have well developed desert varnish, and clasts within deposit have coating of caliche. Partly overlapped by younger alluvial fans (Qa<sub>1</sub> and

Qa<sub>2</sub>) and active stream (Qas) deposits on upper slopes. Strongly incised and eroded by arroyos that contribute material to younger alluvial fans downslope from Qa<sub>3</sub>. Deposits are mostly at base of Beaver Dam and Virgin Mountains and locally faulted as much as 18 m along the Piedmont Fault. Supports sparse growth of grass and cactus. Exposed thickness is 18 m, estimated as much as 50 m

**Sedimentary rocks (Tertiary to Cambrian)**--Stratigraphic nomenclature established for rocks of the Colorado Plateau and Basin and Range Province are adopted from Hintze (1986), Bohannon and Lucchitta (1991), and Billingsley (1993). Because of limited outcrop and erosion in Beaver Dam and Virgin Mountains, part of Paleozoic stratigraphic sequence is not exposed in the quadrangle. Rocks of Mesozoic age are not present in this quadrangle. Includes upper strata of Muddy Creek Formation

**Muddy Creek Formation (Miocene and Pliocene?)**--Light-red and gray, fine-grained, slope-forming siltstone, sandstone, and calcrete beds (Tmc). Includes conglomeratic gravel of ancestral Beaver Dam Wash (Tmbd) and Virgin River (Tmv) that forms cliff in upper part of Muddy Creek Formation (Tmc; see correlation chart). Upper fine-grained Muddy Creek sediment mapped at upper part of Muddy Creek Formation (Tmc), may be ancestral Virgin River sediment. Only 60 m exposed

Tmc **Fine-grained sediments**--Lower part; light reddish-brown, gray, and white, slope-forming, fine-grained, thin- to thick-bedded, calcareous, gypsiferous, siltstone, sandstone, and calcrete. Calcrete beds, 1 to 2 m (3 to 6 ft) thick containing carbonate nodules as much as 20 cm (8 in) in diameter. Siltstone and sandstone weakly cemented with calcite and gypsum. Includes thin-bedded channel lenses of medium- to coarse-grained sandstone. Lower part separated from upper part by thick-bedded, cliff-forming ancestral Beaver Dam Wash and Virgin River conglomerates that pinch out laterally within 1 km of Beaver Dam Wash and Virgin River. No apparent unconformity between upper and lower part of fine-grained sediments where not separated by Beaver Dam Wash and Virgin River conglomerate. Upper part of Muddy Creek sediments may be reworked fine-grained deposits of Muddy Creek redistributed by Beaver Dam Wash and Virgin River. About 60 m thick

Tmbd **Beaver Dam Wash conglomerate**--Dark-gray to brown, cliff-forming conglomerate, gravel, and sandstone; poorly sorted, moderately well-bedded. Deposits pinch out or intertongue into fine-grained sediments of Muddy Creek Formation (Tmc); overlain by fine-grained sediments of Muddy Creek Formation that may be reworked Muddy Creek deposited by Beaver Dam Wash. No unconformity observed between lower and upper fine-grained beds of Muddy Creek (Tmc) beyond conglomeratic gravel pinch out. Conglomerate clasts characterized and composed of subrounded to well-rounded pebbles, cobbles, and boulders (as much as 18" in diameter) of reddish-brown, brown, red, grayish-green, and light-green rhyolite clasts;


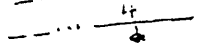


includes lesser amounts of well-rounded, black schist, gneiss, gabbro, diorite, red pegmatite and granite, white quartz, light-gray and dark-gray limestone and dolomite, and minor white, red, and multicolored chert and quartzite clasts. Clasts deposited in gray, coarse- to fine-grained gravel or gravely sandstone composed of same material as conglomerate; includes interbedded lenses of pale-red, fine-grained, thin-bedded siltstone and sandstone. Calcite cement common. Schist, gneiss, gabbro, diorite, granite, limestone, dolomite, and minor sandstone clasts increase in dominance northeastward toward Beaver Dam Mountains. Intertongues or mixes with Virgin River conglomerate (Tmv) within 1 km of Virgin River and Beaver Dam Wash confluence. Pebble imbrication indicates southward flowing paleocurrent of depositing stream. Muddy Creek strata and Beaver Dam Wash conglomerate locally tilted to form angular unconformity with overlying pediment calcrete (QTpc). Faulting and further tilting occurs after deposition of pediment calcrete. Thickness increases northeastward. As much as 43 m thick

Tmv

**Virgin River conglomerate**--Light-gray, cliff-forming, conglomeratic gravel similar to Beaver Dam Wash conglomerate (Tmbd), but characterized by abundant basalt, quartzite, limestone, dolomite, and sandstone clasts derived from northern Arizona and southern Utah; does not contain rhyolitic clasts along Virgin River 1 km above confluence of Beaver Dam Wash and Virgin River; intertongues or mixes with Beaver Dam Wash conglomerate (Tmbd) at and below confluence of Beaver Dam Wash and Virgin River, becoming Virgin River conglomerate. Unit presumably overlain by older alluvial fan (Qa<sub>3</sub>) deposits near base of Virgin Mountains because of increasing metamorphic clasts in that direction. Intertongues or unconformably overlies lower part of Muddy Creek Formation (Tmc), pinches out laterally into Muddy Creek Formation within 1 km of Virgin River; conformably overlain by upper part of finer-grained sediments of Muddy Creek Formation (Tmc) that may be reworked sediments of Muddy Creek redeposited by Virgin River. Merges with Beaver Dam Wash conglomerate near confluence of Beaver Dam Wash and Virgin River. Muddy Creek deposits and Virgin River conglomerate have been tilted to form low-angular unconformable contact with overlying pediment calcrete (QTpc). Faulting and further tilting occurs after deposition of pediment calcrete. Active stream deposits (Qas), floodplain (Qf), and terrace-gravels (Qg<sub>1</sub> through Qg<sub>5</sub>) are inset into Virgin River conglomerate (Tmv). Thickness ranges from 1 to 18 m

- Pk1 **Pakoon Limestone (Lower Permian)**--Light-gray and dark-gray, medium- to coarse-grained, thin- to medium-bedded dolomite, dolomitic sandstone, dark-gray cherty limestone, and white, arenaceous limestone; fossiliferous. Weathers brown-gray and yellow-brown with sugary texture. Bedding is 0.5 to 2 m thick. Limestone and dolomite beds separated by slope-forming, gray or purplish-gray calcareous siltstone and sandstone. Includes ledge-forming dolomitic sandstone with small-scale, low-angle crossbeds. Red and brown chert stringers and nodules common in limestone and dolomite beds. Top of unit not exposed. Contact with underlying Callville Limestone difficult to determine and appears gradational. Forms series of ledges and cliffs. Estimated thickness 130 m after erosion
- IPc **Callville Limestone (Upper, Middle, and Lower Pennsylvanian)**--Gray, light-gray, and white limestone, cherty limestone, arenaceous limestone, and light-yellow calcareous sandstone. Weathers gray and yellowish-brown; cherty limestone weathers brown. Crossbedding common in sandstone. Cherty limestone is about 10 to 30 percent of unit; arenaceous limestone and calcareous sandstone are interbedded with limestone and are about 10 to 20 percent of unit. Base of unit not exposed. Forms series of step-like ledges 0.5 to 2 m thick. Estimated exposed thickness, about 200 m
- Mm **Monte Cristo Limestone (Upper and Lower Mississippian)**--Medium gray, fine-grained, thick-bedded limestone, cherty limestone and dolomite. Lithologically equivalent to Redwall Limestone of Colorado Plateau Province (McKee, 1963). Upper part not exposed which includes Yellowpine, Arrowhead, and upper part of Bullion Members of Monte Cristo Limestone (Hewett, 1931). Equivalent to Horseshoe Mesa Member and upper part of Mooney Falls Member of Redwall Limestone (McKee, 1963). Includes medium- to coarse-grained bioclastic limestone and dolomite of Bullion Member of Monte Cristo Limestone (Mooney Falls Member of Redwall Limestone); medium-gray, medium- to coarse-grained bioclastic limestone and cherty limestone, chert beds generally white and as much as 0.5 m thick of Anchor Member of Monte Cristo Limestone (Thunder Springs Member of Redwall Limestone); medium-gray, coarse-grained, massive-bedded, crystalline and bioclastic dolomite and limestone of Dawn Member of Monte Cristo Limestone (Whitmore Wash Member of Redwall Limestone). All members tilted 70° to as much as 85° and form cliff that generally appears unbedded except where chert beds of Anchor Member are present. Estimated thickness, 200 m
- Dls **Limestone (Devonian)**--Light-gray to dark-gray, medium- to coarse-grained, medium-bedded (0.4 to 2 m thick), dolomite, dolomitic sandstone, and limestone. Weathers dark-gray. Tilted as much as 85°. Unconformable contact with overlying Monte Cristo Limestone. Conformable or gradational contact with underlying Nopah Formation. Unit is primarily equivalent to Valentine Member of Sultan Limestone of Hewett (1931), upper part may be equivalent to Crystal Pass Member (Lower Mississippian and Upper Devonian) of same formation. Equivalent to Temple Butte Formation of Colorado Plateau province (Beus, 1980). About 60 m thick

- Eu Undifferentiated limestone and dolomite (Middle and Lower Cambrian)--  
 Light-gray dolomite; weathers yellow, forms alternating cliffs and slope. Includes dark-gray limestone and interbedded green shale. Limestone beds as much as 5 m thick. Equivalent to unclassified dolomite and part of Muav Limestone of Colorado Plateau Province (McKee and Resser, 1945) Only upper part of Cambrian rocks exposed in quadrangle. About 300 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  
 Strike and dip of beds--Showing dip where known  
 Direction of prevailing winds

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