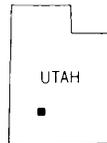


**GEOLOGIC MAP OF THE  
CIRCLEVILLE MOUNTAIN QUADRANGLE,  
BEAVER, PIUTE, IRON, AND GARFIELD COUNTIES, UTAH**

*By John J. Anderson*  
U.S. Geological Survey



**UTAH GEOLOGICAL AND MINERAL SURVEY**

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**MAP 80**

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# GEOLOGIC MAP OF THE CIRCLEVILLE MOUNTAIN QUADRANGLE, BEAVER, PIUTE, IRON, AND GARFIELD COUNTIES, UTAH

*By John J. Anderson<sup>1</sup>*

U.S. Geological Survey

## INTRODUCTION

The Circleville Mountain quadrangle lies in the southeastern Tushar Mountains in the southern High Plateaus subprovince of the Colorado Plateau physiographic province. This subprovince is structurally transitional between the block-faulted Basin and Range Province to the west and the more stable Colorado Plateaus to the east.

The Marysvale volcanic field, one of the largest eruptive piles in the western United States, straddles the High Plateaus and extends into the Basin and Range. The Circleville Mountain quadrangle in the southern part of the field contains part of one of its most voluminous and extensive accumulations. This accumulation, the Mount Dutton Formation, consists of rock erupted from a series of clustered stratovolcanos distributed in a crudely defined east-trending zone (Rowley and others, 1978) across the southern Tushar Mountains. The eastern end of this zone occurs about 10 miles (16 km) east of the mapped area, in the southwestern Sevier Plateau; the western end of the zone is found in the northern Black Mountains, about 25 miles (40km) to the west. Because of repetition by numerous high-angle dip-slip faults, and because of the resistant nature of the rocks, a significant part of this volcanic vent complex is well exposed in the quadrangle. The Osiris Tuff, a regional ash-flow tuff interbedded high in the Mount Dutton section, and minor accumulations of local volcanic rocks postdating the Mount Dutton Formation also occur in the quadrangle. General discussions of the geology in and near the Circleville Mountain quadrangle are given in Anderson and others (1975), Rowley and Anderson (1975), Rowley and others (1978, 1979), Shawe and Rowley (1978), and Steven and others (1978, 1979). Geologic mapping has been done of areas to the north of the mapped area by Callaghan and Parker (1962), Anderson and others (1980), and Cunningham and others (1983); to the west by Anderson and others (in press); to the east by Anderson, Rowley, and Blackman (1986); and to the south by Anderson and Grant (1986).

## STRATIGRAPHY

From Oligocene to Holocene, rocks exposed in the Circleville Mountain quadrangle total nearly 7,000 feet (2150 m). The oldest and most widely exposed rocks belong to the Oligocene and Miocene Mount Dutton Formation; they consist chiefly of lava flows, autoclastic flow breccia, and volcanic mudflow breccia derived from a series of simultaneously active stratovolcanos that were located within and close to the mapped area. Other volcanic units intertongue with or overlie the Mount Dutton Formation but are locally distributed and therefore have not been formally named. During late Tertiary and Quaternary block faulting activity, downthrown blocks locally were filled with clastic sedimentary rocks derived from the erosion of nearby upthrown blocks. During the Pleistocene, glaciation took place on the high peaks in the area, resulting in morainal deposits and rock glaciers.

## TERTIARY SYSTEM

### Mount Dutton Formation

This unit, of Oligocene and Miocene age, consists of volcanic rocks of intermediate (dacite to andesite) composition, interbedded locally with felsic volcanic rock and tuffaceous sandstone. In accordance with the concepts of Parsons (1965, 1969) and Smedes and Prostka (1973), the formation is subdivided into a vent facies and an alluvial facies, both the products of a series of stratovolcanos trending more-or-less eastward across what today comprises the southernmost Tushar Mountains. Vent facies rocks, the near-source products of the stratovolcanos, consist of lava flows and autoclastic flow breccia with subordinate volcanic mudflow breccia, conglomerate, and tuffaceous sandstone.

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They also include all volcanic strata that exhibit primary dips resulting from their emplacement by an active volcano onto the flanks of its growing edifice. Vent facies rocks grade outward into, and intertongue with, the alluvial facies to form a broad apron of volcanic mudflow breccia and subordinate conglomerate, tuffaceous sandstone, lava flows, and flow breccia. The map units, originally defined by Anderson and Rowley (1975), are described separately below.

**Vent facies:** This unit consists of moderately resistant, generally medium- to dark-gray and grayish-brown, generally dense lava flows and autoclastic flow breccia making up at least one-half of the exposed section, and subordinate volcanic mudflow breccia, conglomerate, tuffaceous sandstone, and felsic ash-flow, air-fall, and water-laid tuff. Both flows and clasts in the sedimentary beds consist largely of amphibole and(or) pyroxene andesite and dacite; textures range from aphanitic to conspicuously porphyritic with phenocrysts of plagioclase, hornblende, and(or) augite set in a microcrystalline and largely devitrified glass groundmass. The unit locally shows significant hydrothermal alteration.

Individual lava flows range from a few feet to many tens of feet thick and were in part probably derived from fissure eruptions in the area of what today is the upper South Creek drainage basin. There, large dikes of amphibole andesite cut across a local accumulation of Mount Dutton Formation tuffaceous sandstone. Other known sources include dikes and stratovolcanos both east and west of the quadrangle. Potassium-argon age determinations of about 27 to 21 m.y.\* (Fleck and others, 1975) indicate a late Oligocene and early Miocene age for the formation. No complete section of the formation is exposed, but maximum thickness within this quadrangle is about 3,000 feet (915 m). The section thins toward the west, south, and east; about 10 miles north of the quadrangle boundary the unit laps onto and intertongues with slightly older and contemporaneous volcanic rocks of the central Marysvale field.

\*Where necessary, isotopic ages have been corrected for the new decay constants of Steiger and Jäger (1977).

**Alluvial facies:** This unit consists of soft to moderately resistant, mostly light- to dark-gray and brown volcanic mudflow breccia, fluvial conglomerate, and tuffaceous sandstone making up more than one-half of the exposed section; lava flows and autoclastic flow breccia, identical to their counterparts in the vent facies, with subordinate ash-flow, air-fall, and water-laid felsic tuff make up the remainder. The predominant mudflow breccia is characterized by sub-rounded to angular clasts of volcanic rock, identical to that of the vent facies, most commonly suspended in a muddy to muddy and sandy matrix. The ratio of clasts to matrix varies widely in different mudflows, and the thickness of the flows ranges from a foot to many tens of feet. Conglomerate is largely fluvial, and tuffaceous sandstone is partly fluvial and partly eolian; the conglomerate and sandstone consist almost exclusively of reworked volcanic de-

tritus doubtlessly derived largely from the Mount Dutton volcanic units. The conglomerate and sandstone occur as local channel fillings and as lenses ranging from a few feet to several tens of feet thick. The age of the unit is late Oligocene and early Miocene based on interfingering with the dated vent facies. A partial section at least 1,300 feet (396 m) thick is exposed in the southern part of the quadrangle.

**Sandstone member:** This unit is made up of light- to dark-gray, greenish-gray, and yellowish-gray, soft and friable, eolian and fluvial tuffaceous sandstone and fluvial conglomerate that occur at or near the top of the Mount Dutton Formation. The tuffaceous sandstone consists largely of sub-angular to sub-rounded volcanic rock fragments together with 5 to 25 percent grains of plagioclase and subordinate hornblende, pyroxene, and Fe-Ti oxides; the sand is poorly cemented by zeolite (clinoptilolite?). The conglomerate consists of granule- to cobble-sized clasts of volcanic rock in a matrix of volcanic sandstone. Locally, as in the saddle between Birch Creek Mountain and Circleville Mountain, the unit has been selectively and intensively silicified by hydrothermal activity; such silicified rock has taken on striking pale pastel colors of blue, green, pink, and other rainbow shades. Where exposures are few and poor, the sandstone member is mapped with vent facies rock of the Mount Dutton Formation. The age of the unit is Miocene based on its stratigraphic position between the Mount Dutton vent facies and the lava flows of Kents Lake. Generally its thickness is only a few tens of feet; locally, as in the upper reaches of the South Creek drainage basin, it is more than 500 feet (152 m) thick.

**Undivided:** This unit consists of either vent or alluvial facies rock of the Mount Dutton Formation mapped in transitional areas between the two facies where exposures are inadequate to determine the percent of each present in the stratigraphic section.

**Dikes:** Dikes of porphyritic amphibole andesite occur as large tabular bodies cutting strata of the Mount Dutton Formation. These dikes are similar in lithology to flows and clasts of the Mount Dutton Formation and, in all likelihood, were the feeders of some of the Mount Dutton lava flows.

### Osiris Tuff

The Osiris Tuff, of Miocene age, consists of ledge-forming, reddish-brown to pinkish- or purplish-gray, densely welded vitric-crystal ash-flow tuff made up of 10 to 20 percent small (1 to 3 mm) phenocrysts of plagioclase, subordinate sanidine, and minor biotite, augite, and Fe-Ti oxides set in a groundmass of devitrified glass shards and dust; the rock commonly has the texture and appearance of unglazed porcelain. The unit in many places includes a brownish-black basal vitrophyre 1 to 15 feet (.30 -5 m) thick and commonly contains pancake-shaped ash-flow tuff lenticules. In some places, the Osiris Tuff is capped by a

light-gray to cream, pumice-like vapor-phase zone. Secondary flowage and brecciation features also are common in the upper part of the tuff.

Within this quadrangle, the Osiris Tuff is intertongued with the upper part of the Mount Dutton Formation; in adjacent areas to the west it caps the Mount Dutton. Source area of the Osiris Tuff is in the northern Sevier Plateau, where its eruption led to the formation of the Monroe Peak caldera (Cunningham and others, 1983; Steven and others, 1984). The Osiris Tuff, formally adopted by Anderson and Rowley (1975), was mapped by Willard and Callaghan (1962) northeast of the quadrangle boundary as the quartz latite member of the Dry Hollow Formation, a term abandoned by Steven and others (1979). The K-Ar age of the unit is about 23 m.y. (Fleck and others, 1975). Its maximum thickness is about 100 feet (30 m), and locally it pinches out against pre-existing topography.

#### **Lava flows of Kents Lake**

This unit consists of moderately resistant, light- to medium-gray, dense, medium- to thick-bedded andesite porphyry containing 20 to 40 percent phenocrysts of plagioclase (1 to 10 mm, typically 2-4 mm long), subordinate pyroxene (0.1 to 3 mm, typically 0.5 mm), and minor Fe-Ti oxides (0.1 to 1 mm), amphibole (0.1 to 0.5 mm), and biotite (0.1 to 0.3 mm) in a partially devitrified glass groundmass commonly containing aligned microlites, chiefly plagioclase. It occurs mainly as lava flows but includes at least one ash-flow tuff of similar mineralogy set in a densely welded glass groundmass. Lava flows commonly exhibit a pronounced sub-horizontal platy parting that reflects primary flow lamination. This unit is distinguished from the bulk of the Mount Dutton Formation by the presence of biotite and from the Beaver Member of the Mount Dutton Formation, which is found in adjacent areas to the west, by the absence of quartz.

Lava flows of Kents Lake were considered by Anderson and Rowley (1975) as part of the Dry Hollow Formation (Callaghan, 1939) but, with the abandonment of the Dry Hollow Formation as a rock stratigraphic unit (Steven and others, 1979), it now is designated by the present informal name. An age determination of 34 m.y. was made by Fleck and others (1975) on a specimen of "andesite" that belongs to the lava flows of Kents Lake. This age is anomalous because the stratigraphic position of the unit is very close to that of the Osiris Tuff, which is about 23 m.y. old (Fleck and others, 1975). The age of the lava flows of Kents Lake therefore probably is Miocene. The thickness of the unit over most of its outcrop area, which is almost entirely within this quadrangle, ranges from 100 to 300 feet (30 - 91 m) with a maximum thickness of 800 feet (244 m). The location of the source vents of the unit is unknown.

#### **Mafic lava flows of Birch Creek Mountain**

This sequence of lava flows is made up of moderately resistant, dark-gray to black, vesicular to dense olivine basalt(?) or olivine-bearing mafic rock. It seems to con-

formably overlie strata of either the Mount Dutton Formation or the lava flows of Kents Lake. Typical rock of the unit consists mostly of anhedral phenocrysts of olivine (altered in whole or in part to iddingsite), augite, and plagioclase (labradorite), generally less than 1 mm in size, set in a groundmass of largely devitrified glass containing microlites of plagioclase, augite, and magnetite. The rock probably is a trachybasalt of the potassic alkaline series (Wickstrom, 1982) according to the classification of Irvine and Baragar (1971). The unit itself is correlative with the potassium-rich mafic lava flows mapped by Cunningham and others (1983) and Anderson and others (1980, 1981) in the southern Tushar Mountains. Isotopic dating of a sample from the flows of Birch Creek Mountain has yielded an age of 22 m.y. (Fleck and others, 1975). The thickness of the unit typically is 200 feet (61 m) and maximum thickness is more than 300 feet (91 m).

#### **Mafic lava flows of Circleville Mountain**

Capping the high scarp of Circleville Mountain, this unit consists of resistant, medium-gray to black, commonly dense lava flows and autoclastic flow breccia of porphyritic basalt(?) or basaltic andesite. Locally it is markedly vesicular and amygdaloidal, and consists of abundant (10 to 20 percent), large (2 to 10 mm), subhedral phenocrysts of augite and minor hypersthene, and small amounts of plagioclase generally only 1 mm or so in size, set in a hyalopilitic groundmass containing microlites of plagioclase, pyroxene, and Fe-Ti oxides. Maximum thickness of the unit is about 1,100 feet (335 m) near Circleville Mountain. Apparently the flows were emplaced into structural and(or) erosional lows developed on older rocks; on which they locally rest unconformably. Two of the flows have yielded K-Ar ages of 23 m.y. (Fleck and others, 1975). Both age dates are somewhat older than the determination made on a sample of the mafic lava flows of Birch Creek Mountain, but field evidence suggests that most rocks of the latter are slightly older than those of Circleville Mountain. Contact relations between the two, however, are obscured by dense forest cover, and on the map this contact is approximately located. A source area is east of Little Dog Valley in the southeastern corner of the quadrangle where several large, composite dikes of the same lithology cut strata of the Mount Dutton Formation.

#### **Dikes of mafic lava flows of Circleville Mountain**

Dikes of porphyritic basalt(?) or basaltic andesite occur as large tabular bodies cutting strata of the Mount Dutton Formation. The dikes are identical in lithology to the mafic lava flows of Circleville Mountain.

#### **Mafic gravels of Gunsight Flat**

This unit consists of poorly consolidated conglomerate and fanglomerate made up almost exclusively of gravel derived from the mafic lava flows of Birch Creek Mountain and Circleville Mountain. The gravels appear to have been shed northward from paleo-fault scarps located near the

present Kents Lake. Contacts between the gravel and the two sequences from which it was derived are poorly exposed and therefore are only approximately located on the map. It has been established, however, that some of the mafic lava flows of Birch Creek Mountain occur interbedded with or on top of the gravels. The age of the mafic gravels of Gunsight Flat therefore probably is about 22 m.y. Maximum thickness is about 600 feet (183 m).

## QUATERNARY SYSTEM

### Rock glacier gravel

Lobate rock glaciers of Pleistocene age are present in cirques east of and just below the crest of Circleville Mountain. These deposits are made up of unconsolidated, angular, and poorly sorted cobble- and boulder-sized gravel consisting mostly of the mafic lava flows of Circleville Mountain. The thickness of the unit is several tens of feet.

### Piedmont slope deposits

This unit consists of unconsolidated, poorly sorted silt, sand, and gravel occurring as thin mantles on pediments and as thicker accumulations in alluvial fans. The unit locally occurs within small, downfaulted basins. Most of these deposits are dissected by present streams. The Holocene and Pleistocene unit includes alluvium of small drainages and locally colluvium, alluvial slope wash, and talus. Its maximum exposed thickness is about 50 feet (15 m), but the unit may be considerably thicker in downfaulted basins.

**Landslide debris:** Landslide debris consists of mostly angular and very poorly sorted material that has moved downslope from nearby bedrock to form deposits of lobate form as well as broad aprons mantling steep valley walls and fault scarps. The unit includes talus and colluvium and, in northwest trending valleys heading near the crest of Circleville Mountain (e.g., Dry Hollow), it probably also is made up in large part of valley glacier deposits. The unit is of Holocene and Pleistocene age. Its thickness ranges from perhaps 15 feet (5 m) on valley slopes to probably several hundred feet in the large landslide deposit in the extreme northwestern corner of the quadrangle.

**Alluvium:** Alluvium consists of sand, silt, and gravel deposited by intermittent and perennial streams in their channels, on bordering floodplains, and in local depressions. Locally the unit also includes colluvium, alluvial slope wash, talus, and alluvial fan deposits. It is of Holocene age. Its maximum thickness may be several tens of feet or more where deposited in local basins, but elsewhere it is no more than 15 feet (5 m).

## STRUCTURAL GEOLOGY

The structural pattern in the Circleville Mountain quadrangle is dominated by normal faults. Several facts are worth noting about these faults, because in most ways they are typical of those found throughout the southern High Plateaus. First, no individual fault has a very long trace; the longest is about five miles (8 km), and most are half this

length or less. Second, almost all fault traces are arcuate or sinuous. Third, most of the faults do not die out along strike to form hinges but instead their throw remains undiminished until they join another fault. This results in locally anastomosing fault patterns. Fourth, all the faults are vertical or sub-vertical, and the dominant sense of movement on them is dip-slip. And fifth, most of the faults belong to one of two sets, one striking north-northeastward and the other north-northwestward. This results in a very pronounced rhombic fault pattern in the quadrangle, which is within one of the major upthrown blocks of the High Plateaus. On the margin of the block, both to the east and west of the mapped area, the two fault sets result in a zig-zag range front, a feature common to all the High Plateaus.

One major fault within the quadrangle does not fit into the pattern described above. This is the generally east-trending but curved fault in the southern part of the quadrangle. Its geometry suggests significant subsidence over a magma chamber that rapidly emptied vent facies rocks of the Mount Dutton Formation.

Major displacements along faults of the southern High Plateaus appear to date to Pliocene and Pleistocene time (Rowley and others, 1981). Faulting may have begun much earlier, however, inasmuch as extensional tectonics generally are associated in Utah with compositionally bimodal (alkali basalt and alkali rhyolite) volcanism, which began in other parts of southwestern Utah about 23 m.y. ago (Anderson and Rowley, 1975; Rowley and others, 1979). Mafic lava flows of Birch Creek Mountain and of Circleville Mountain may represent the first of these bimodal rocks. Furthermore, mafic gravels of Gunsight Flat appear to have been shed from a source area of high relief, probably one or more fault scarps. And lastly, the considerable abrupt thickening of the mafic lava flows of Circleville Mountain could be the result of flows ponding in downfaulted lows.

Faulting may have continued into Quaternary time, as suggested by small fault scarps cutting Quaternary sediments in several places in the northwestern part of the quadrangle. These faults may be settling features of large landslide deposits. In adjacent quadrangles, numerous faults of probable tectonic origin offset Quaternary basin-fill deposits indicating that tectonic faulting has continued into Quaternary time.

Numerous lineaments occur in the southern part of the mapped area which are not readily seen in the field but are clearly visible on aerial photographs. The parallelism of these lineaments with mapped faults suggests that the lineaments either are faults themselves or are joints related to the mapped faults.

## ECONOMIC GEOLOGY

By contrast with the eruptive centers near the central part of the Marysvale volcanic field, no economically viable mineral deposits have been discovered to date in the Circleville Mountain quadrangle. Extensive areas of hydrothermal alteration, including silicification, however, have been

mapped near the central part of the quadrangle. Altered areas show a strong spatial correlation with several major faults. These argillized and silicified rocks have not been sampled for metals.

## GEOLOGIC HAZARDS

Earthquakes have been felt in the Circleville Mountain area in the historic past, but there has been no recorded breakage of the surface or other evidence to indicate that these earthquakes here resulted from local faulting. Thus, despite the abundance of mapped faults in the Circleville Mountain quadrangle, potential hazards posed by earthquakes are difficult to assess. Of course, construction of houses or major buildings on mapped faults should be avoided.

Landslides, on the other hand, present a hazard in the Circleville Mountain quadrangle. This is especially true north of Birch Creek Mountain where landslide deposits of Quaternary age mantle the topography. Campgrounds and recreational facilities at Kents Lake and Anderson Meadows run some risk of landslides from the oversteepened north face of Birch Creek Mountain. A greater hazard is present in the extreme northwestern corner of the quadrangle, near Willow Lake and Stag Spring. In and around this area, numerous summer homes have been constructed, many of them close to fault scarps cutting thick landslide debris. Even though, as was noted above, these faults may not be of tectonic origin, they clearly indicate the lack of stability of landslide debris, and future construction should be avoided in this area.

## WATER RESOURCES

The Beaver River drainage, with headwaters in the Circleville Mountain quadrangle, is a vital source of culinary and irrigation water for the town of Beaver and surrounding areas. While the supply of water produced by this drainage system is perennial and plentiful, every year sees greater demands put on it. Furthermore, the thoughtless dumping of wastes into this water by campers may threaten its purity.

The drainage of South Creek and its tributaries also is an important source of water within this quadrangle. Unlike water in the Beaver River, however, it is used mostly for agricultural purposes.

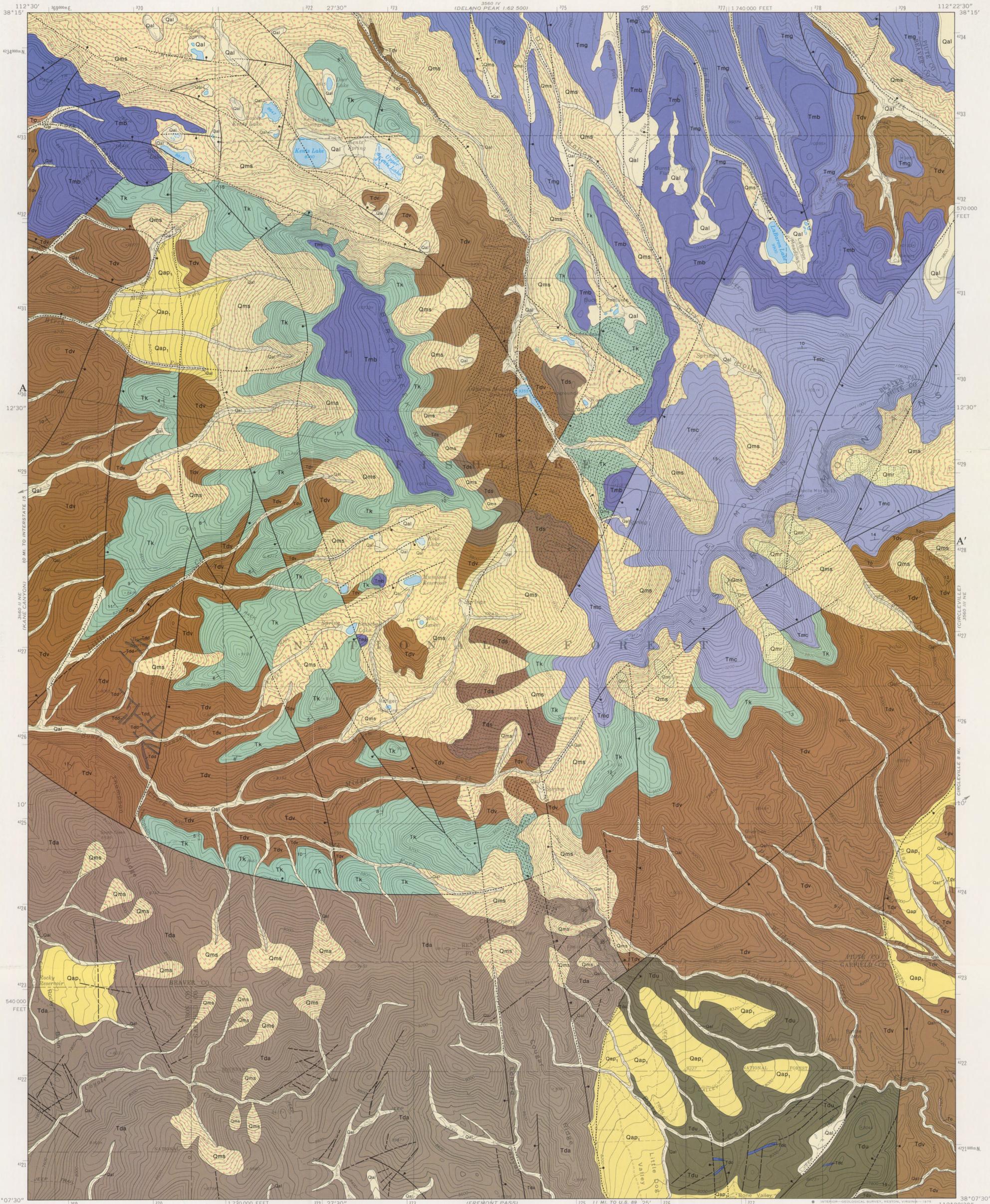
Elsewhere numerous springs occur throughout the quadrangle; many of these are utilized by cattlemen, who pipe the spring water into troughs. Most, but not all, of the springs flow throughout the year. Faults appear to be the major geologic control of most of the springs, although some are controlled by local permeable sandstone beds within the Mount Dutton Formation.

Lastly, the Circleville Mountain quadrangle is dotted with numerous lakes, most resulting from the trapping of water by topographic irregularities produced by landslides. In some places, as at Kents Lake, humans have increased the size of these lakes by damming; in other places, such as at Anderson Meadows, the lakes are a direct result of damming.

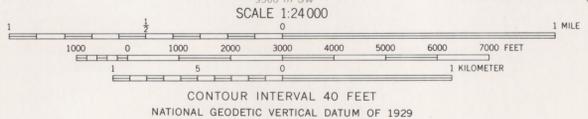
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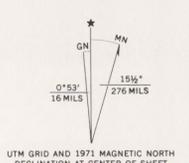
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Base map from U.S. Geological Survey Circleville Mtn. Quadrangle, Beaver, Piute, Iron, and Garfield Counties, Utah, 1971.



Field mapped in 1970-71, field checked in 1982-83.  
 Patricia H. Speranza, and Deborah A. Jenkins, Cartographers



**GEOLOGIC MAP OF  
 CIRCLEVILLE MOUNTAIN QUADRANGLE  
 BEAVER, PIUTE, IRON AND GARFIELD COUNTIES, UTAH**

by  
**John J. Anderson**  
 U.S. Geological Survey

FORMATION	SYMBOL	LITHOLOGY	THICKNESS feet (meters)
Surficial deposits	Qal Qms Qap <sub>1</sub> Qmr		0-300 (100)
Mafic gravels of Gunsight Flat	Tmg		0-600 (200)
Mafic lava flows of Circleville Mountain	Tmc Tdc		0-1100 (375)
Mafic lava flows of Birch Creek Mountain	Tmb		0-300 (100)
Lava flows of Kents Lake	Tk		0-800 (250)
Mount Dutton Formation	Sandstone member	Tds	0-500 (150)
	Osiris Tuff	To	0-100 (30)
	Alluvial facies	Tda	1300+ (400+)
	Vent facies	Tdv	3000+ (1000+)
	Dikes	Tdd	
	Undivided	Tdu	

**DESCRIPTION OF MAP UNITS**

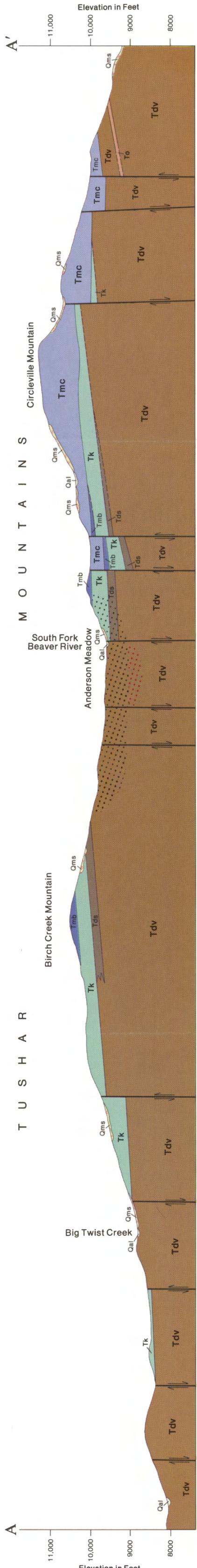
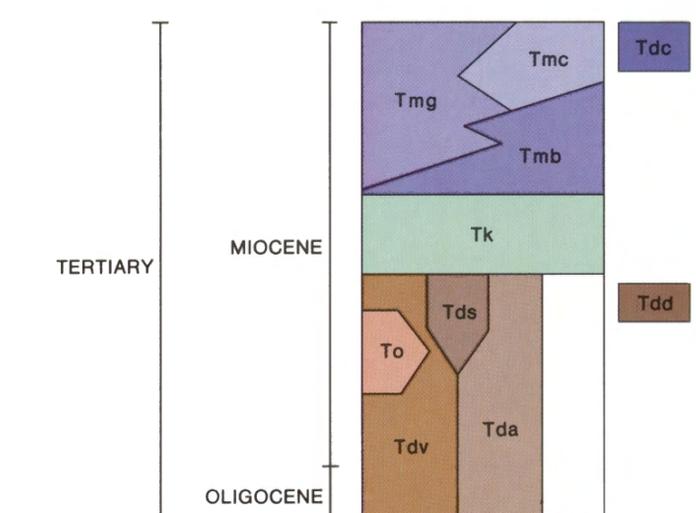
- QUATERNARY**
- PLEISTOCENE AND HOLOCENE
- Qal** Alluvium—Unconsolidated silt, sand, and gravel along active streams and washes.
  - Qms** Landslide debris—disaggregated rock and surficial deposits; locally consists of valley glacier deposits.
  - Qap<sub>1</sub>** Piedmont slope deposits—poorly sorted, unconsolidated silt, sand, and gravel on sloping surfaces from deposition (alluvial fans) and erosion (pediments).
  - Qmr** Rock glacier gravel—unconsolidated, angular, poorly sorted cobble- and boulder-sized gravel consisting almost exclusively of Tmc.

Unconformity

- MIOCENE**
- Tmg** Mafic gravels of Gunsight Flat—poorly consolidated conglomerate and fanglomerate derived from Tmc and Tmb.
  - Tmc** Mafic lava flows of Circleville Mountain—resistant, dark-gray to black, vesicular to dense, porphyritic lava flows that resemble plateau basalts.
  - Tdc** Dikes of mafic lava flows of Circleville Mountains—moderately resistant, dark-gray to black, generally dense, porphyritic mafic rock identical in lithology to Tmc.
  - Tmb** Mafic lava flows of Birch Creek Mountain—moderately resistant, dark-gray to black, vesicular to dense olivine basalt or olivine-bearing mafic rock.
  - Tk** Lava flows of Kents Lake—moderately resistant, light- to medium-gray, dense, andesite porphyry.
  - To** Osiris tuff—ledge-forming, reddish-brown to pinkish- or purplish-gray, densely welded, vitric-crystal ash-flow tuff.

**Mount Dutton Formation**

- OLIGOCENE AND MIOCENE**
- Tds** Sandstone member—soft, light-gray, yellow or tan, cross-bedded, zeolite-cemented tuffaceous sandstone.
  - Tdd** Dikes—dikes of porphyritic amphibole andesite.
  - Tdv** Vent facies—medium- to dark-gray and gray-brown, dense lava flows and autoclastic flow-breccia.
  - Tda** Alluvial facies—gray and brown volcanic mudflow-breccia, conglomerate, and tuffaceous sandstone.
  - Tdu** Undivided—undifferentiable vent and alluvial facies.



**CONTACT**  
 Dashed where approximately located

**FAULT**  
 Dashed where location inferred; dotted where covered; bar and ball on downthrown side

**STRIKE AND DIP OF BEDS**

**IDENTIFIABLE STRUCTURAL LINEAMENT**



**ALTERED ROCKS**

Hydrothermally altered rocks of the Mount Dutton Formation vent facies



**SILICIFIED ROCKS**

Selectively and intensively silicific rocks of the sandstone member of the Mount Dutton Formation