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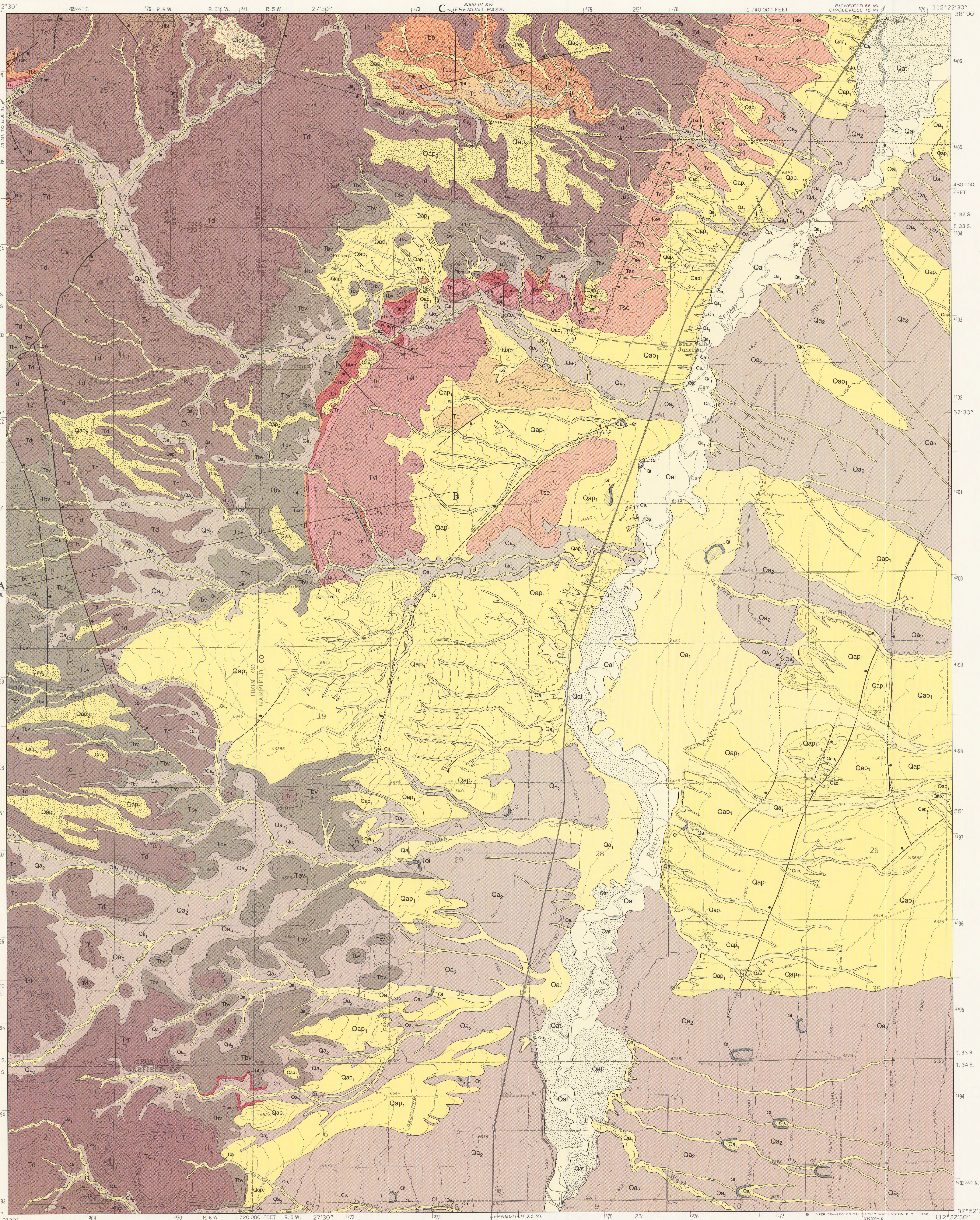
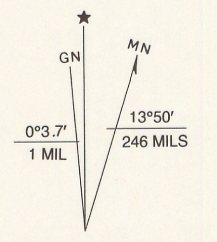


Base map from U.S. Geological Survey,
Panguitch NW Quadrangle, 1966

Mapped by authors in 1963, 1964, and 1966
Field checked in 1984
J. Parker, Cartographer

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

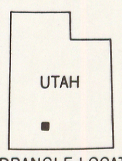


UTM GRID AND 1987 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

GEOLOGIC MAP OF THE PANGUITCH NW QUADRANGLE, IRON AND GARFIELD COUNTIES, UTAH

by
John J. Anderson and Peter D. Rowley
U.S. Geological Survey

1987



QUADRANGLE LOCATION

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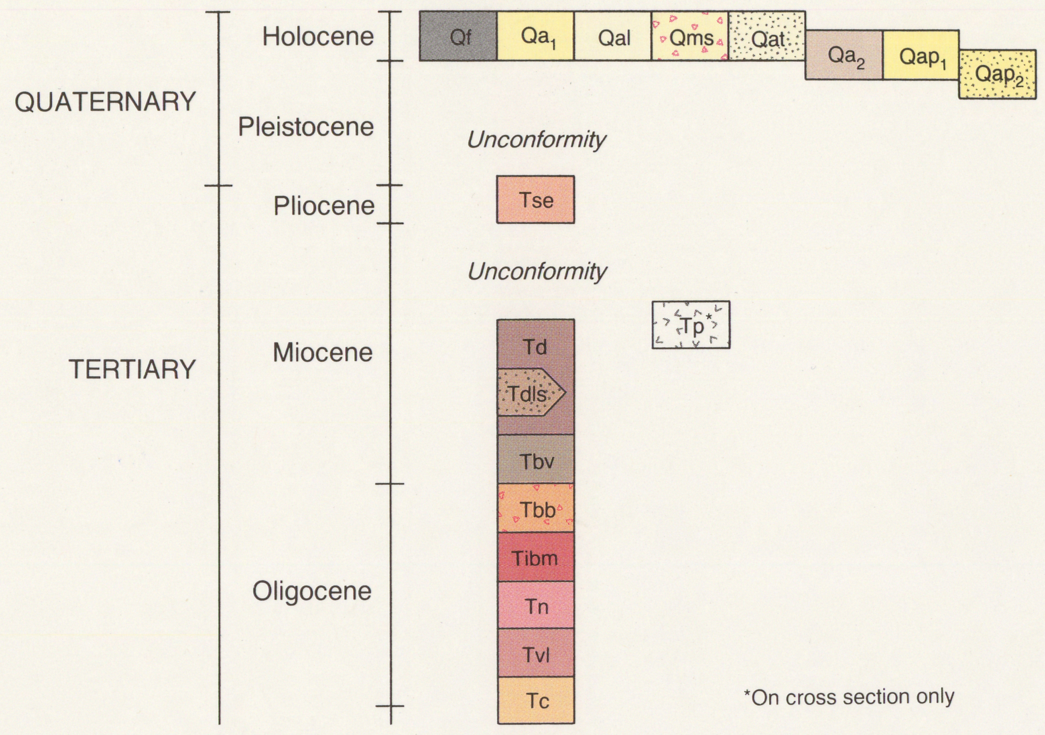
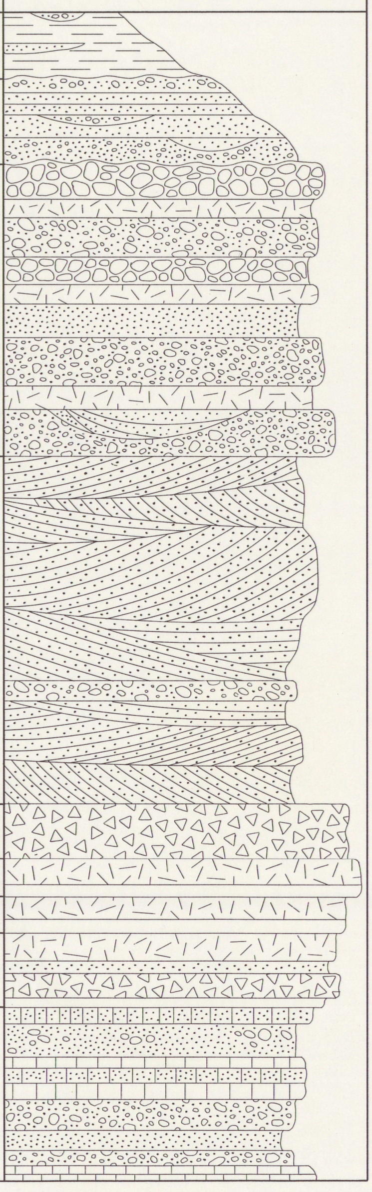
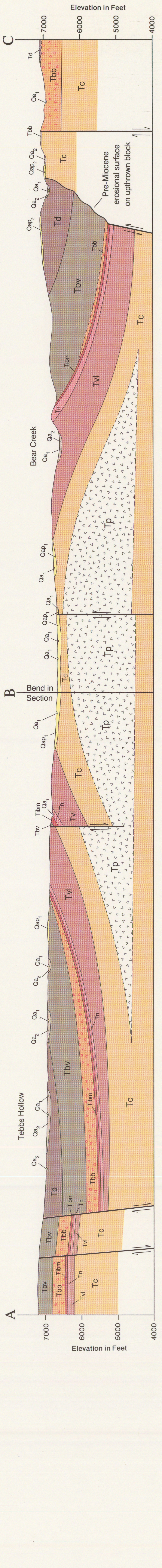
CORRELATION OF MAP UNITS



SYSTEM	SERIES	STRATIGRAPHIC UNIT	SYMBOL	Thickness in Feet (Meters)	LITHOLOGY
QUATERNARY	Holocene	Surficial deposits	Qa1/Qal/Qms/Qat/Qa2/Qap1/Qap2	0-100+ (0-30+)	
QUATERNARY	Holocene / Pleistocene	Sevier River Fm.	Tse	0-250 (0-80)	
QUATERNARY / TERTIARY	Pleistocene / Pliocene / Miocene	Mt. Dutton Formation	Td	0-600± (0-200±)	
		• Local sandstone mbr.	Tdls		
TERTIARY	Oligocene	Bear Valley Formation	Tbv	500-1000 (150-300)	
TERTIARY	Oligocene	Buckskin Breccia	Tbb	0-150 (0-50)	
TERTIARY	Oligocene	Isom Fm.—Blue Meadows Tuff Mbr.	Tibm	0-100 (0-30)	
TERTIARY	Oligocene	Needles Range Group	Tn	0-150 (0-50)	
TERTIARY	Oligocene	Local volcanic and sedimentary strata	Tvl	0-750 (0-230)	
TERTIARY	Eocene	Claron Formation	Tc	900± (275±)	





DESCRIPTION OF MAP UNITS

- **Qf** — Artificial fill—*Earthen dam material.*
- **Qa1** — Alluvium—*Unconsolidated silt, sand, and gravel along active streams and washes.*
- **Qal** — Flood-plain and channel deposits—*Unconsolidated silt, sand, and gravel along the Sevier River.*
- **Qms** — Landslide debris—*Disaggregated rock and surficial deposits.*
- **Qat** — Terrace deposits—*Silt, sand, and gravel on terrace remnants along the Sevier River.*
- **Qa2** — Older alluvium—*Dissected deposits of unconsolidated silt, sand, and gravel along active streams and washes.*
- **Qap1** — Piedmont-slope deposits—*Unconsolidated, poorly sorted silt, sand, and gravel occurring on broad, sloping surfaces (piedmont slopes) formed by deposition (as alluvial fans) and by erosion (as pediments).*
- **Qap2** — Older piedmont-slope deposits—*Poorly indurated, poorly sorted silt, sand, and gravel mantling erosional remnants of pediments that formed graded to the Sevier River as much as 300 feet (90 m) above present drainage levels.*
- **Tse** — Sevier River Formation—*Light-gray, light-brown, and pinkish, poorly to moderately consolidated silt, pebbly sandstone, and conglomerate deposited in the valleys of the Sevier River and its tributaries.*
- **Td** — Mount Dutton Formation—*Gray and brown, volcanic mudflow-breccia of intermediate composition and subordinate conglomerate, tuffaceous sandstone, and lava of intermediate and mafic composition.*
- **Tdls** — Local sandstone member of Mount Dutton Formation—*Pale- to dark-gray and yellowish, weak, cross-bedded, zeolite-cemented tuffaceous sandstone.*
- **Tbv** — Bear Valley Formation—*Pale- to dark-gray, yellowish, and greenish-gray, weak, cross-bedded, zeolite-cemented, tuffaceous sandstone and subordinate volcanic mudflow-breccia and ash-flow tuff.*
- **Tbb** — Buckskin Breccia—*Light-colored, well-bedded, moderately resistant, lithic ash-flow tuff.*
- **Tibm** — Blue Meadows Tuff Member of Isom Formation—*Pale- to grayish-red and reddish-gray, ledge-forming, densely welded vitric and vitric-crystal ash-flow tuff.*
- **Tn** — Needles Range Group—*Reddish-brown to salmon-pink, ledge-forming, moderately welded, crystal-vitric ash-flow tuff.*
- **Tvl** — Local volcanic and sedimentary strata—*Local accumulations of lava, tuff, volcanic mudflow-breccia, and tuffaceous sedimentary strata.*
- **Tc** — Claron Formation—*Reddish-brown and grayish-white, well-bedded, calcareous shale and siltstone, argillaceous freshwater limestone, sandstone, and conglomerate.*

MAP SYMBOLS

Contact
Dashed on cross section where approximately located

Gravity-slide block contact
Sawteeth on slide block

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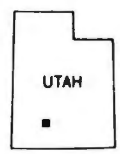

UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
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MAP 103 **1987**

UTAH GEOLOGICAL AND MINERAL SURVEY

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Salt Lake City, Utah 84108-1280

THE UTAH GEOLOGICAL AND MINERAL SURVEY is one of eight divisions in the Utah Department of Natural Resources. The UGMS inventories the geologic resources of Utah (including metallic, nonmetallic, energy, and ground-water sources); identifies the state's geologic and topographic hazards (including seismic, landslide, mudflow, lake level fluctuations, rockfalls, adverse soil conditions, high ground water); maps geology and studies the rock formations and their structural habitat; and provides information to decisionmakers at local, state, and federal levels.

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GEOLOGIC MAP OF THE PANGUITCH NW QUADRANGLE, IRON AND GARFIELD COUNTIES, UTAH

By John J. Anderson[1] *and Peter D. Rowley*[2]
U.S. Geological Survey

INTRODUCTION

The western portion of the Panguitch NW quadrangle lies in the northeastern corner of the Markagunt Plateau and the eastern portion in the Sevier ("Long") Valley within the High Plateaus subprovince of the Colorado Plateaus physiographic province (figure 1). The High Plateaus are north-trending, flat-topped mountain masses, separated by intermontane valleys. In many ways, the High Plateaus are transitional between the Colorado Plateaus to the east and the Basin and Range province to the west; their stratigraphy is similar in many aspects to that of both provinces, whereas physiographically they display the elevation and high relief of the former and structurally they resemble the latter. The geology of the central High Plateaus is dominated by the Marysvale volcanic field of Tertiary age, one of the largest eruptive piles in the western United States. The Panguitch NW quadrangle lies on the southern flank of the Marysvale field.

Rocks exposed in the Panguitch NW quadrangle are about evenly divided between volcanic flows of the Marysvale field, and volcanic and sedimentary strata that were derived from the south and west. Northwest-trending faults controlled the emplacement of many of these strata. Following their emplacement, the strata were domed, probably by a small intrusion, in the central part of the quadrangle. Later they were cut throughout the quadrangle by numerous, generally northeast-trending, high-angle, dip-slip faults. General discussion of the geology in and near the Panguitch NW quadrangle has been provided by Anderson and others (1975), Rowley and Anderson (1975), Rowley and others (1978, 1979), and Steven and others (1979).

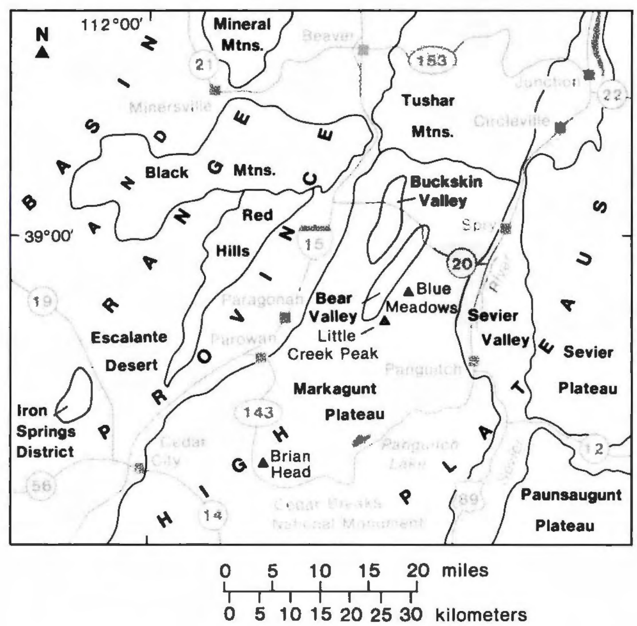

Figure 1. Map of southwestern High Plateaus and adjacent areas; shading denotes area of quadrangle.

STRATIGRAPHY

The exposed stratigraphic section in the Panguitch NW quadrangle is less than 3000 feet (915 m) thick, but it represents a section that just outside the mapped area is at least twice as thick. The lowest unit, only the uppermost part of which is exposed, is the Claron Formation, the basal Tertiary unit over much of southwestern Utah. The uppermost volcanic bedrock unit in the quadrangle consists of volcanic mudflow breccia and some lava flows of the Mount Dutton Formation; although only a few hundred feet thick in this quadrangle, they are the remnant of a great volcanic apron that was shed from the Marysvale pile and inundated the area of the northern Markagunt Plateau to a depth of at least 1000 feet (300 m), and perhaps several times this amount. Between the Claron and Mount Dutton Formations lies a sequence of local and

[1]Currently Dept. of Geology, Kent State University, Kent, Ohio
[2]Geologist, U.S. Geological Survey, Denver, Colorado

regional rock units. The lowest of these is a heterogeneous assemblage of volcanic and sedimentary strata of local origin to which no formal name has been given. This is overlain by one or two formations of the Needles Range Group, volumetrically and areally perhaps the largest succession of ash-flow tuffs in the western United States. The Needles Range Group in turn is overlain by very extensive ash-flow tuffs of the Isom Formation. These are followed in the section by lithic ash-flow tuffs of the Buckskin Breccia, which occur in patches of variable thickness because the unit was erupted onto a block-faulted terrain. The Bear Valley Formation lies below the Mount Dutton Formation. It is a blanket dune-sand deposit that covered virtually the entire northern Markagunt Plateau as well as the Red Hills and Black Mountains to the west.

The block faulting that produced the southern High Plateaus began during the Miocene. Erosion of upfaulted blocks led to the deposition of clastic sediments in downfaulted areas; these sediments comprise the Sevier River Formation. Later development of through-flowing drainage led to downcutting into and erosion of these sediments. Quaternary deposits in many parts of the quadrangle reflect the episodic nature of this period of drainage integration.

TERMINOLOGY

Tuff may be classified by its content of crystal, vitric, and lithic material. We modify the classification of Cook (1965; figure 2 of this report), by preceding the root name of the rock derived from this particle composition triangle with the names of the pyrogenic minerals that make up more than 15 percent of the phenocrysts; they are listed in quantitatively descending order, that is, major before minor. Isotopic ages have been converted where necessary for the new decay constants of Steiger and Jäger (1977).

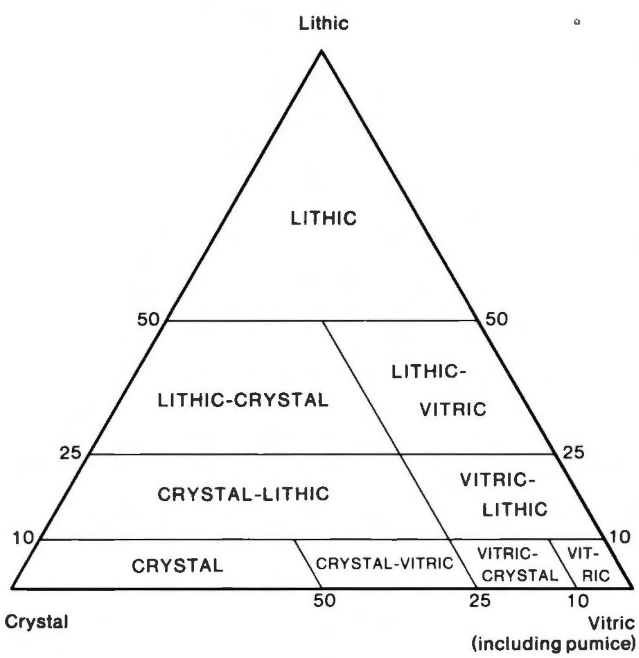

Figure 2. Particle composition triangle for ash-flow tuffs.

TERTIARY SYSTEM

Claron Formation

The Claron Formation, a colorful sequence of fluvial and lacustrine strata, is the oldest Tertiary rock unit throughout much of southwestern Utah; it is exposed most spectacularly at Bryce Canyon National Park, some 20 miles (30 km) to the southeast of the Panguitch NW quadrangle, and at Cedar Breaks, some 25 miles (40 km) to the southwest. First described in the southern High Plateaus by Howell (1875) and Dutton (1880), these strata were first defined as the Claron Formation by Leith and Harder (1908) in the Iron Springs mining district west of Cedar City, Utah. The nomenclature of these deposits, especially the confusion resulting from reference to them as "Wasatch Formation," has been reviewed by Anderson and Rowley (1975).

The Claron Formation is divisible in most areas into a lower red member and an upper white member; the contact between the two commonly is at the base of a conspicuous, massive, resistant limestone bed. Reddish-brown rocks below the limestone suggest that they were deposited under oxidizing conditions, whereas the grayish-white rocks above the limestone suggest deposition under reducing conditions (Thomas, 1985).

Only a partial section of the red member, eroded at the top and buried at the bottom, is exposed near the northern edge of the quadrangle. About 200 feet (60 m) thick, it consists of well-developed but irregular beds of calcareous shale and siltstone, argillaceous limestone, sandstone, and conglomerate. The thickness of these beds varies for the most part between 6 inches and 3 feet (15 cm - 1 m). Intertonguing and lateral gradation of rock types are common. Almost all of the finer grained strata have been extremely bioturbated, so much so that most primary structures have been destroyed, but these beds have yielded no fossils.

Strata of the white member may be present, but mantled by Quaternary deposits, near the center of the dome southwest of the junction of U. S. Highway 89 and Utah Highway 20, here named the Bear Valley Junction dome. Exposures of the white member in adjacent quadrangles suggest that the strata, if present, are similar to those of the red member: they are of fluvial and lacustrine origin but with fewer conglomerate beds, dolomite is as common as limestone, and bedding is thinner and more regular. Also, rock of the white member is tuffaceous, increasingly so toward the top of the unit.

The age of the Claron Formation is uncertain. The possibility exists that the lowermost strata may be as old as Paleocene(?) or even Late Cretaceous(?). This possibility has been suggested by stratigraphic studies of the Claron Formation in the western Markagunt Plateau where it overlies, seemingly conformably, strata that probably are correlative with the Iron Springs Formation of Late Cretaceous age (Moore, 1982; Hilton, 1984). Deposition of the Claron continued until at least the late Eocene, the age of freshwater fossils from the uppermost strata at Cedar Breaks National Monument reported by Gregory (1950). Deposition probably continued well into the Oligocene, however. This is suggested by an isotopic age of about 32 Ma determined by Fleck and others (1975) on a tuff that conformably overlies the Claron in the northern Markagunt Plateau; the tuff itself has been included within the unnamed volcanic and sedimentary rocks that locally separate the Claron Formation and Needles Range Group (Anderson and Rowley, 1975).

The thickness of the Claron Formation within the map area is unknown. To the south, complete sections are more than 1400 feet (420 m) thick, but the thickness of the Claron Formation decreases northward and probably is 800-1000 feet (250-350 m) in the quadrangle.

Local Volcanic and Sedimentary Strata

The Claron Formation in the northern Markagunt Plateau is overlain by a heterogeneous assemblage of volcanic and sedimentary strata that differs markedly from place to place. These deposits are assigned to an unnamed rock-stratigraphic unit designated as local volcanic and tuffaceous sedimentary strata. The base of the unit is defined as the base of the first rock stratum of volcanic origin (lava, ash-flow tuff, autoclastic flow-breccia, or volcanic mudflow-breccia, but not air-fall tuff or tuffaceous sandstone) that overlies the Claron Formation; the top is defined as the base of the first overlying regional rock unit of volcanic origin (in most places, an ash-flow tuff of the Needles Range Group). The age of the unit is Oligocene, based on its position between formations with well-established Oligocene ages, as well as on an age determination of about 32 Ma made on ash-flow tuff from the unit (Fleck and others, 1975). The source of the volcanic rocks in this unit is concealed, but the limited distribution of the strata suggests the source was in or near the quadrangle.

The unit is exposed near the center of the Bear Valley Junction dome, where it reaches its greatest known thickness of about 750 feet (230 m). It consists of tuffaceous sandstone and siltstone and volcanic mudflow-breccia complexly interbedded with several kinds of lava as well as ash-flow tuff. The lavas are porphyritic latite and trachyandesite. The latite is grayish-red where vesicular and medium-gray where dense; the trachyandesite is medium-gray where vesicular and dark-gray where dense. The tuff is hornblende-sanidine vitric-crystal welded tuff. The top of the exposed section is marked by a massive (>100 feet [>30 m]), medium-gray, volcanic mudflow-breccia, or autoclastic flow-breccia, that weathers into distinctive hoodoos along lower Bear Creek.

Needles Range Group

Wah Wah Springs and Lund Formations: The Needles Range Group (formerly Formation) may well comprise what is areally the most extensive and volumetrically the largest related succession of ash-flow tuffs in North America. First described by Dutton (1880), it was defined by Mackin (1960) in the Needle Range (Mountain Home Range) that lies near the border of southwestern Utah and Nevada.

Best and Grant (in press) provide an excellent summary of what is known about the Needles Range Group and contribute many significant new data concerning it; it is they who have raised its stratigraphic rank from formation to group. They estimate that the ash flows of the group had a minimum volume of 1500 miles^3 (6600 km^3) and spread over an area of at least 8500 miles^2 (22,000 km^2). This vast outpouring of tuff had its source along the southern Utah-Nevada border, where it formed the large Indian Peak caldera.

From the base upward, the formations of the Needles Range Group are the Escalante Desert Formation, Cottonwood Wash Tuff, Wah Wah Springs Formation, Ryan Spring Formation, and Lund Formation. Only ash-flow tuffs of the Wah Wah Springs and Lund Formations are present in the quadrangle.

The part of the Wah Wah Springs Formation that crops out in the map area forms a prominent ledge 50-150 feet (15-45 m) thick. The base of the unit is densely welded but has not formed a vitrophyre. The rock that characterizes the bulk of the overlying section is a moderately welded, plagioclase-hornblende-biotite crystal-vitric or crystal tuff that also contains minor quartz, augite, and Fe-Ti oxides, as well as trace amounts of apatite and zircon. This dense, reddish-brown to salmon-pink, crystal-rich rock easily could be confused in hand specimen with a hypabyssal intrusive rock.

The Lund Formation is present within the area of the Bear Valley Junction dome, where it is a single cooling unit about 50 feet (15 m) thick that has been described in detail by Kreider (1970). Its basal part is densely welded but has not formed a vitrophyre; the remainder of the unit is only slightly welded. The rock is grayish-orange-pink, plagioclase-quartz-biotite crystal-vitric tuff that also contains minor hornblende and Fe-Ti oxides and a trace of sphene.

Locally, the Lund Formation is separated from the overlying Isom Formation by a few feet of rock similar to the Buckskin Breccia (see below). This unit is mapped with the Needles Range Group.

The age of the Needles Range Group is Oligocene. This has been established by numerous isotopic-age determinations that range from about 27 to 32 Ma. The average age for tuffs of the Wah Wah Springs Formation is 29.5 Ma, that for tuffs of the Lund Formation 27.9 Ma (Best and Grant, in press).

Isom Formation

The Isom Formation, defined by Mackin (1960), consists largely of rock that is radically different in appearance from that of the Needles Range Group. Both, however, originated as ash flows, and together they form a stratigraphic couplet that in an area of more than 5000 miles^2 (12,500 km^2) serves as an ideal stratigraphic and structural reference datum. The two units in the map area are conformable.

Three tuff members have been defined within the Isom Formation: the Blue Meadows Tuff Member at the base (Anderson and Rowley, 1975), the Baldhills Tuff Member in the middle, and the Hole-in-the-Wall Tuff Member at the top (Mackin, 1960). Only the Blue Meadows Tuff Member, which is limited to the area of the northern Markagunt Plateau, crops out in the quadrangle. It is a single cooling unit 30-100 feet (9-30 m) thick, commonly marked by a brownish-black basal vitrophyre a few feet (1-2 m) thick. The bulk of the unit is resistant, pale- to grayish-red and pale- to grayish-red-purple rock with the texture and appearance of unglazed porcelain. Locally, it exhibits secondary flowage features, including autobrecciation and flow layering; it also contains numerous horizontal, pancake-shaped, light- to medium-gray ash-flow tuff lenticules that are either collapsed pumice or the products of devitrification by gas trapped during the vapor phase of cooling and compaction. The lower half of the member consists of plagioclase crystal-vitric welded tuff containing 15-20 percent phenocrysts that resemble rock of the Baldhills Tuff Member elsewhere in the region. The upper half of the Blue Meadows Tuff Member, however, is plagioclase vitric-crystal welded tuff containing 5-10 percent phenocrysts.

The age of the Blue Meadows Tuff Member is late Oligocene. This has been established by a K-Ar age of about 26 Ma on a sample obtained in this quadrangle (Fleck and others, 1975).

Buckskin Breccia

The Buckskin Breccia, defined by Anderson and Rowley (1975), consists of lithic ash-flow tuff, autoclastic flow breccia(?), and mudflow breccia(?) that contain clasts of rock identical with that of the Spry intrusion, a batholith-sized body of quartz latite porphyry that is exposed a few miles north of the Panguitch NW quadrangle (Grant, 1979; Grant and Anderson, 1979). The formation's areal extent is about 250 miles^2 (650 km^2). Its thickness is highly variable, ranging from a few feet to more than 700 feet (>200 m), because it was erupted onto a terrain marked by northwest-trending fault blocks. The type section of the unit is in the adjacent Little Creek Peak quadrangle, north of Utah Highway 20 and just a few hundred feet (about 100 m) west of the Panguitch NW quadrangle.

The Buckskin Breccia consists of at least four separate, moderately resistant, light-colored, well-bedded, conformable units of tuff or breccia that in places are separated by a few feet of tuffaceous sandstone. Although they differ in composition of included lithic fragments, all contain clasts of the Spry intrusion in a matrix that in thin-section appears as dusty, devitrified glass enclosing fragmented grains of plagioclase, hornblende, biotite, augite, and Fe-Ti oxides. From thin-sections, three of the units are identifiable as ash flows; they exhibit compaction effects either as compressed glass shards or as deformed biotite flakes around and between phenocrysts that exhibit horizontal parallelism. The fourth unit may have had a similar origin, but the evidence has been obscured by devitrification; thus it may have been autoclastic flow-breccia or mudflow-breccia.

The Panguitch NW quadrangle has poor exposures of the Buckskin Breccia, except in the extreme northwestern and north-central parts; there it is about 150 feet (50 m) thick. Elsewhere within the quadrangle, outcrops are patchy and generally only a few tens of feet (about 10 m) thick. It is possible, however, that several hundred feet of the unit are buried in the west-central part of the quadrangle, because this area is on strike with a graben exposed a few miles to the west that contains the formation's greatest known thickness of more than 700 feet (>200 m).

About 5 miles (8 km) north of the Panguitch NW quadrangle, an ash-flow tuff of the Isom Formation is interbedded with strata of the Buckskin Breccia. Thus the two are the same age, about 26 Ma, or late Oligocene. The K-Ar age of the Spry intrusion also is 26 Ma according to a recent isotopic age determination (H. H. Mehnert, U.S. Geological Survey, personal commun., 1985). This suggests that the Buckskin Breccia originated as an eruptive phase of the igneous activity that emplaced the Spry intrusion. An earlier isotopic age of about 32 Ma on the Spry intrusion (Damon, 1968) created interpretative problems as to the relationship between the Spry intrusion and the Buckskin Breccia (Anderson and Rowley, 1975).

Bear Valley Formation

The Bear Valley Formation, defined by Anderson (1971), is largely a wind-blown sand deposit that blanketed an area of some 1000 miles^2 (2500 km^2) in the northern Markagunt Plateau, Red Hills, and Black Mountains immediately before this same area was inundated by volcanics of the Marysvale pile. Its type section is in this quadrangle, north of Utah Highway 20 about 1.5 miles (2.4 km) west of Bear Valley Junction, from SE¼ NW¼ sec. 5, T. 33 S., R. 5 W., to NE¼ SE¼ sec. 32, T. 32 S., R. 5 W.

Most of the Bear Valley Formation is poorly resistant, pale-gray, yellow or green (in places quite vivid) tuffaceous sandstone generally in well-developed cross-beds. Two members can be distinguished. The lower is made up largely of subangular to well-rounded sand, consisting of volcanic rock fragments and pyrogenic mineral grains (plagioclase, sanidine, pyroxene, amphibole, biotite, and very sparse quartz). The upper member contains, in addition, many subangular to angular glass shards, apparently produced by contemporaneous volcanism and scarcely reworked. It also contains interbeds and lenses of welded and unwelded ash-flow tuff and scarce beds of air-fall tuff, all probably from nearby vents. Both members are poorly to moderately cemented by clinoptilolite, a zeolite that locally has altered to chlorite to impart a striking green color to the rock.

Cross-bedding shows that sand in the Bear Valley Formation was deposited for the most part by winds that blew from the south and west. The sand accumulated to its greatest thickness (>1000 feet [>300 m]) against a fault scarp that faced west-southwest in the northern part of the quadrangle. In most other parts of the quadrangle either the top of the unit has been eroded or its base is covered, but analogy with complete sections in the Little Creek Peak quadrangle to the west suggests that its thickness typically is 500-800 feet (150-250 m).

K-Ar ages of about 25 Ma on samples of both welded and unwelded tuff in the Bear Valley Formation indicate a late Oligocene age (Fleck and others, 1975).

Mount Dutton Formation

The Mount Dutton Formation, defined by Anderson and Rowley (1975), comprises most of the rock exposed on the southern flank of the Marysvale volcanic pile. It consists largely of volcanic rock of intermediate composition (dacite-andesite) interbedded locally with felsic tuff and tuffaceous sandstone. In accordance with the concepts of Parsons (1965, 1969) and Smedes and Prostka (1973), the formation is divided into a vent facies and an interfingering alluvial facies, both the products of stratovolcanos and dikes in the southernmost Tushar Mountains and of minor vents in the Black Mountains and northern Markagunt Plateau (figure 3).

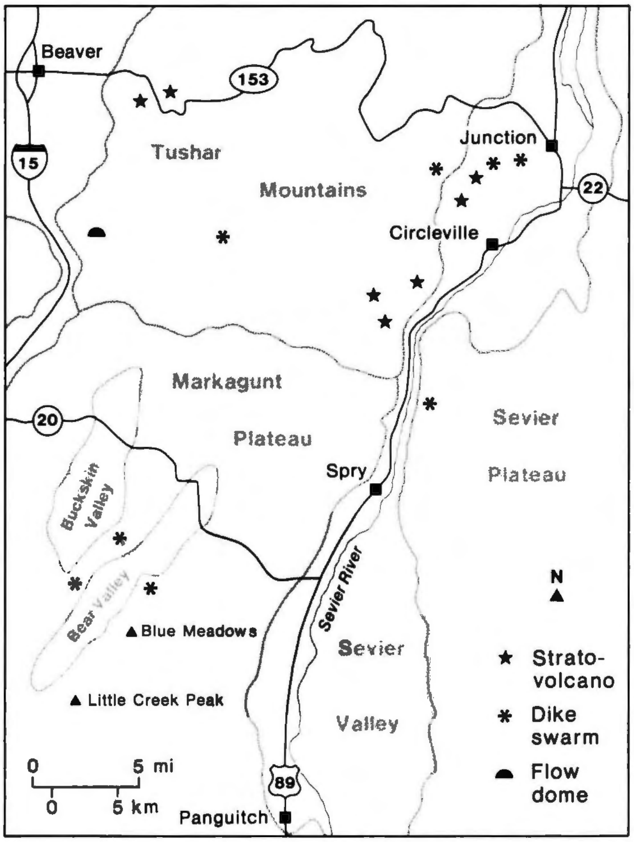

Figure 3. Volcanic vents of Mount Dutton Formation; shading denotes area of quadrangle.

Only rocks assigned to the alluvial facies of the Mount Dutton Formation are exposed in the quadrangle. They consist for the most part of soft to resistant, mostly light- to dark-gray and brown mudflow breccia and some fluvial conglomerate and tuffaceous sandstone. Andesitic and basaltic(?) lava flows and autoclastic flow-breccia, derived from local vents as well as from the Marysvale volcanic pile, and subordinate felsic tuff make up the remainder. The mudflow-breccia is characterized by subrounded to angular clasts of intermediate volcanic rock, which are mostly supported by a muddy to sandy matrix. The size of the clasts, the ratio of clasts to matrix, and the thickness of individual flows are widely variable. Typically, the clasts are cobbles and make up about one-third to one-half of the rock. Individual flows are 5-10 feet (2-3 m) thick. The conglomerate is of fluvial origin, and the tuffaceous sandstone is fluvial and eolian; both consist almost exclusively of reworked volcanic detritus, doubtlessly derived in large part from the vent facies. The conglomerate and sandstone occur as local channel fillings and as lenses as much as 30 feet (9 m) thick. Most of the lava flows apparently were from fissure eruptions in the area of the northern Markagunt Plateau during deposition of the Bear Valley and Mount Dutton Formations. They consist largely of amphibole and(or) pyroxene andesite and basalt(?); textures range from aphanitic to conspicuously porphyritic, with phenocrysts of plagioclase, hornblende and(or) augite set in a dark, microcrystalline and glassy groundmass. The flows rarely exceed 30 feet (9 m) in thickness.

Exposed sections of the Mount Dutton Formation in the quadrangle are as much as 600 feet (200 m) thick. Prior to erosion, however, locally the Mount Dutton Formation section was probably at least 1000 feet (330 m) thick, and perhaps several times that amount. The 1000-foot figure is attested to by the preserved section at Little Creek Peak, which lies about 5 miles (9 km) west of the quadrangle; the higher figures are suggested by sections in the western Markagunt Plateau and Black Mountains.

A local sandstone member of the Mount Dutton Formation crops out in a small area near the northwestern corner of the quadrangle. Stratigraphically, it occurs fairly low in the Mount Dutton Formation, making it distinguishable from a higher sandstone member that occurs at or near the top of the Mount Dutton Formation in the southern Tushar Mountains (Anderson, 1986).

The age of the Mount Dutton Formation is late Oligocene and Miocene. This has been established by K-Ar ages of about 26-20 Ma made on rocks of the vent facies, with which the alluvial facies interfingers (Fleck and others, 1975).

Intrusive Rock

Plutonic rock is not exposed in the Panguitch NW quadrangle, but the presence of the Bear Valley Junction dome suggests that it probably occurs at depth there, and consequently it is shown on the cross-section. Analogy with exposed plutons in adjacent quadrangles suggests that it is a laccolith of either monzonitic or dioritic-gabbroic composition, and that its age is Miocene (Anderson and Rowley, 1975).

Sevier River Formation

The Sevier River Formation is alluvium that was deposited in the valleys of the Sevier River and its tributaries by erosion of the upfaulted High Plateaus area (Callaghan, 1938). The alluvium consists of poorly to moderately consolidated, light-gray, tan, pinkish-gray, and white, silty, pebbly sandstone and conglomerate. The exposed formation in the quadrangle is as much as 250 feet (80 m) thick, but a greater thickness may be concealed. The contacts of this unit are poorly exposed, and on the map are approximately located.

Airfall tuff in the Sevier River Formation near its type locality in the Clear Creek area about 30 miles (50 km) to the north has fission-track ages of 14 and 7 Ma (Steven and others, 1979), indicating a Miocene age. The upper part of the formation, however, probably is Pliocene and may even be as young as Pleistocene.

QUATERNARY SYSTEM

Older Piedmont Slope Deposits

This unit consists of 10-30 feet (3-10 m) of poorly to moderately indurated, poorly sorted silt, sand, and gravel mantling erosional remnants of widespread pediments that formed and graded to the Sevier River at least as much as 300 feet (90 m) above present erosional levels. It includes alluvium of small drainages. The unit is thought to be of Pleistocene age because 1) the pediments which it caps still exist as recognizable landforms, and 2) the pediments stand so high above present drainage levels.

Piedmont Slope Deposits

These deposits consist of unconsolidated, poorly sorted silt, sand, and gravel. They occur mainly as a thin mantle on pediments and as thicker accumulations in alluvial fans, but also include alluvium in small drainages and locally colluvium, slope wash, and talus. The thickness of these deposits, all of which have been dissected by present streams, varies greatly, from no more than a few feet or tens of feet on pediments to perhaps hundreds of feet in large alluvial fans in the Sevier Valley. The deposits probably range in age from Pleistocene to Holocene, judging from their mode of occurrence and stratigraphic position.

Older Alluvium

Older alluvium consists of silt, sand, and gravel deposited by intermittent and perennial streams in their channels, on bordering floodplains, and in terminal alluvial fans. Locally it also may include minor talus deposits, slope wash, and colluvium. The unit is identical with that mapped and described below as alluvium except for age. The two were mapped separately to emphasize the great amount of recent dissection that has taken place within the quadrangle. Indeed, in places this dissection, most if not all of which has taken place during historic times, exceeds 20 feet (6 m). This is the maximum exposed thickness of these older alluvial deposits, but they may be several times thicker. The unit may have considerable range in age, from Pleistocene(?) to Holocene, judging from its mode of occurrence and stratigraphic position, and some of it may be correlative with the piedmont slope deposits (Qap_1).

Terrace Deposits

Terrace remnants, underlain by as much as 30 feet (9 m) of silt, sand, and gravel mapped as terrace deposits, flank the Sevier River in the upper Sevier Valley. The absence of slope wash on these deposits indicates they are Holocene.

Floodplain and Channel Deposits

This unit, mapped along the Sevier River, consists of silt, sand, and gravel, locally cobbly and bouldery, as well as clay and silt overbank deposits. Its maximum thickness is about 25 feet (10 m) and its age is Holocene.

Landslide Debris

Landslide debris, from cliffs of the Mount Dutton Formation near the northwestern corner of the quadrangle, consists of mostly angular and very poorly sorted material and has a thickness of several tens of feet. Its age is Holocene.

Alluvium

The sediments here designated alluvium are identical with those of the older alluvium except that they are younger and topographically lower. They occur along the intermittent and perennial streams that have dissected the older alluvium. That some of this dissection occurred during historic times is evident where old roads and trails have been cut. The unit therefore is Holocene. Its maximum thickness is about 6 feet (2 m).

STRUCTURE

As elsewhere in the southern High Plateaus, the structure of the Panguitch NW quadrangle is dominated by block faulting. Two sets of high-angle, dip-slip faults, trending northeasterly and north-northwesterly, have produced zig-zag fronts along the plateaus and within them have imparted a pronounced rhombic structural pattern.

A lack of marker beds in the stratigraphic units displaced by faults makes estimates of displacement uncertain, but no displacement exceeds the thickness of either the Bear Valley or Mount Dutton Formations. Thus displacements are less than a few thousand feet and probably less than 1000 feet (300 m), the average probably being a few hundred feet (about 100 m).

Perhaps the most interesting fault is concealed. This is the inferred west-northwest-trending fault or fault zone, downthrown to the south, that crosses the northern part of the quadrangle, where it is buried by the Mount Dutton Formation. From stratigraphic relations, it is inferred that the fault was active during the late Oligocene. The northeasternmost exposure of the Isom Formation is located a short distance south of the fault. The area just to the south of the fault also contains the maximum known thickness of the Bear Valley Formation (1,000+ m feet; 300+ m). To the north of the fault, the Bear Valley either is missing or is much thinner, a maximum of about 300 feet (100 m) in the Fremont Pass quadrangle (Anderson and Grant, 1986). Thus it appears that this fault presented a south-facing scarp on which strata of the Claron Formation and the local volcanic and sedimentary strata were exposed, but which was too high to be overridden by either the ashflows of the Isom Formation or the entire thickness of the eolian sand that makes up the Bear Valley Formation, both of which were derived from the south and west. The displacement on the fault thus must have been about 700 feet (215 m), although the scarp produced by the fault need never have had this much relief if the fault were active during the time that the Bear Valley Formation was being deposited. Later the fault scarp was covered by mudflows of the Mount Dutton Formation.

Movement on this or a related fault probably accounts for the high dip on strata older than the Buckskin Breccia near the northwest corner of the quadrangle; there the Isom Formation and older units dip at angles as much as 45° beneath almost horizontal Buckskin Breccia. In adjacent quadrangles northwest-trending faults controlled the deposition of both the Isom Formation and the Buckskin Breccia.

The faults that cut Quaternary deposits in the eastern half of the quadrangle have displacements of almost 100 feet (30 m), evidence of significant tectonic activity during the Quaternary. Two of the faults cut alluvium of doubtless Holocene age in the bottom of a dry wash in NE¼ sec. 27 and NW¼ sec. 26, T. 33 S., R. 5 W., thereby indicating that faulting continues today.

ECONOMIC GEOLOGY

No ore deposits have been discovered in the Panguitch NW quadrangle, although a few prospect holes indicate some exploration activity. Sand and gravel exist in abundance, however, and are excavated as needed. In addition, green sandstone of the Bear Valley Formation has been quarried for building and decorative stone.

There is a possibility of oil and gas accumulations in the subsurface of the quadrangle. Buried beneath the Cenozoic section, the Paleozoic and Mesozoic rocks of the southern High Plateaus include units that elsewhere are petroleum reservoirs. They probably were folded and faulted by the late Mesozoic Sevier orogeny to produce structural traps. Of course Cenozoic faulting will have disrupted these traps but probably not destroyed all of them; and it may have created others.

WATER RESOURCES

Water and soil are the basis of the economy in the southern Sevier Valley, as together they make ranching possible. The Sevier River provides water that permits irrigation of hay on a fairly large scale. Cattle also use this water, as well as the surface run-off trapped by dams across dry washes and the few springs in the area.

Ground water also probably is plentiful in the late Tertiary and Quaternary fill of the Sevier Valley and in the Bear Valley Formation, which has the necessary attributes of a good aquifer. This resource has not been developed, however, except for a few shallow wells.

GEOLOGIC HAZARDS

Earthquakes have been felt periodically in the southern Sevier Valley during historic times, but none of them caused significant damage. Some of these quakes may have been of local origin, as suggested by the young fault traces that cut the bottom of a dry wash in the quadrangle, but most probably are from remote epicenters. The possibility of strong earthquakes certainly exists, however; the fault displacement by as much as 100 feet (30 m) of Quaternary surfaces in the Sevier Valley indicates that tectonism is far from dead in this area. It poses no great threat to humans in the quadrangle, however, as only a very few man-made structures are to be found there, and only a few of them are residences.

Flooding, on the other hand, is a much more significant danger. From time to time, the Sevier River can be expected to overflow its banks and occupy its floodplain. Therefore structures built on the floodplain can be expected to experience periodic flooding. Every dry wash in the map area also can be expected periodically to be filled to overflowing by the brief, intense thunderstorms that during summer months pepper the High Plateaus. The principal damage that these local cloudbursts do is washing out roads, especially dirt, back-country ones that lie in the western part of the quadrangle.

Large landslides also pose no great threat within the quadrangle, because the relief within it is relatively low. Small-scale slides and slumps, however, probably can be expected occasionally along over-steepened road-cuts.

SCENIC AND RECREATIONAL AREAS

The Panguitch NW quadrangle provides little in the way of scenic or recreational areas but is crossed by countless thousands of tourists travelling to and from such scenic wonders as Bryce Canyon and Zion National Parks. Deer hunters, however, find this area to be an excellent one for pursuing their activities, especially its wooded and erosion-scarred western part.

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REFERENCES CITED

Anderson, J. J., 1971, Geology of the southwestern High Plateaus of Utah - Bear Valley Formation, an Oligocene-Miocene volcanic arenite: Geological Society of America Bulletin, v. 82, p. 1179-1205.

———1986, Geologic map of the Circleville Mountain quadrangle, Beaver, Piute, Iron, and Garfield Counties, Utah: Utah Geological and Mineral Survey Map 80, 6 p.

Anderson, J. J., and Rowley, P. D., 1975, Cenozoic stratigraphy of southwestern High Plateaus of Utah, *in* Anderson, J. J., Rowley, P. D., Fleck, R. J., and Nairn, A. E. M., 1975, Cenozoic Geology of Southwestern High Plateaus of Utah: Geological Society of America Special Paper 160, p. 1-51.

Anderson, J. J., Rowley, P. D., Fleck, R. J., and Nairn, A. E. M., 1975, Cenozoic geology of southwestern High Plateaus of Utah: Geological Society of America Special Paper 160, 88 p.

Anderson, J. J., and Grant, T. C., 1986, Geologic map of the Fremont Pass quadrangle, Iron and Garfield Counties, Utah: Utah Geological and Mineral Survey Map 81, 6 p.

Best, M. G., and Grant, S. K., in press, Stratigraphy of the volcanic Oligocene Needles Range Group in southwestern Utah: U.S. Geological Survey Professional Paper 1433A.

Callaghan, Eugene, 1938, Preliminary report on the alunite deposits of the Marysvale region, Utah: U.S. Geological Survey Bulletin 886-D, p. 91-134.

Cook, E. F., 1965, Stratigraphy of Tertiary volcanic rocks in eastern Nevada: Nevada Bureau of Mines Report 11, 61 p.

Damon, P. E., 1968, Correlation and chronology of ore deposits and volcanic rocks: University of Arizona Geochronology Laboratory, U.S. Atomic Energy Commission Contract AT(11-1)-689, Annual Progress Report COO-689-100, 75 p.

Dutton, C. E., 1880, Report on the geology of the high plateaus of Utah with atlas: U.S. Geographical and Geological Survey, Rocky Mountain Region (Powell), 307 p.

Fleck, R. J., Anderson, J. J., and Rowley, P.D., 1975, Chronology of mid-Tertiary volcanism in High Plateaus region of Utah, *in* Anderson, J. J., Rowley, P. D., Fleck, R. J., and Nairn, A. E. M., 1975, Cenozoic Geology of Southwestern High Plateaus of Utah: Geological Society of America Special Paper 160, 88 p.

Grant, T. C., 1979, Geology of the Spry intrusion, Garfield County, Utah: Kent State University M.S. thesis, 59 p.

Grant, T.C., and Anderson, J. J., 1979, Geology of the Spry intrusion, Garfield County, Utah: Utah Geology, v. 6, p. 5-24.

Gregory, H. E., 1950, Geology of eastern Iron County, Utah: Utah Geological and Mineral Survey Bulletin 37, 153 p.

Hilton, D. L., 1984, The petrology, sedimentology, and stratigraphy of the late Cretaceous(?) and early Tertiary sedimentary rocks of the southwestern Markagunt Plateau, Utah: Kent State University M.S. thesis, 137 p.

Howell, E. E., 1875, Report on the geology of portions of Utah, Nevada, Arizona, and New Mexico - Examined in the years 1872 and 1873: U.S. Geographical and Geological Explorations and Surveys West of the 100th Meridian (Wheeler), v. 3, pt. 3, p. 227-302.

Kreider, J.E., 1970, The Lund ash-flow tuff: University of Missouri M.S. thesis, 73 p.

Leith, C. K., and Harderr, E. C., 1908, The iron ores of the Iron Springs district, southern Utah: U. S. Geological Survey Bulletin 338, 102 p.

Mackin, J. H., 1960, Structural significance of Tertiary volcanic rocks in southwestern Utah: American Journal of Science, v. 258, p. 81-131.

Moore, R. C., 1982, Geology of the Parowan quadrangle, Iron County, Utah: Kent State University M.S. thesis, 112 p.

Parsons, W. H., ed., 1965, Structures and origin of volcanic rocks, Montana-Wyoming-Idaho: National Science Foundation Guidebook, Summer Conference, 1965, Detroit, Michigan, Wayne State University, 58 p.

———1969, Criteria for the recognition of volcanic breccia -review, *in* Igneous and Metamorphic Geology (Poldervaart volume): Geological Society of America Memoir 115, p. 263-304.

Rowley, P. D., and Anderson, J. J., 1975, Guidebook to the Cenozoic structural and volcanic evolution of the southern Marysvale volcanic center, Iron Springs mining district and adjacent areas: Geological Society of America Annual Meeting, Field Trip No. 11, 37 p.

Rowley, P. D., Anderson, J. J., Williams, P. L., and Fleck, R. J., 1978, Age of structural differentiation between the Colorado Plateaus and Basin and Range provinces in southwestern Utah: Geology, v. 6, p. 51-55.

Rowley, P. D., Steven, T. A., Anderson, J. J., and Cunningham, C. G., 1979, Cenozoic stratigraphic and structural framework of southwestern Utah: U.S. Geological Survey Professional Paper 1149, 22 p.

Smedes, H. W., and Prostka, H. J., 1973, Stratigraphic framework of the Absaroka volcanic Supergroup in the Yellowstone National Park region: U.S. Geological Survey Professional Paper 729-C, 33 p.

Steiger, R. H., and Jäger, E., 1977, Subcommission on geochronology - Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Steven, T. A., Cunningham, C. G., Naeser, C. W., and Mehnert, H. H., 1979, Revised stratigraphy and radiometric ages of volcanic rocks in the Marysvale area, west-central Utah: U.S. Geological Survey Bulletin 1469, 40 p.

Thomas, J., 1985, Petrology, sedimentology, and stratigraphy of the early Tertiary Claron Formation in the Red Canyon area, Sevier and Paunsaugunt Plateaus, Utah: Kent State University M.S. thesis, 87 p.