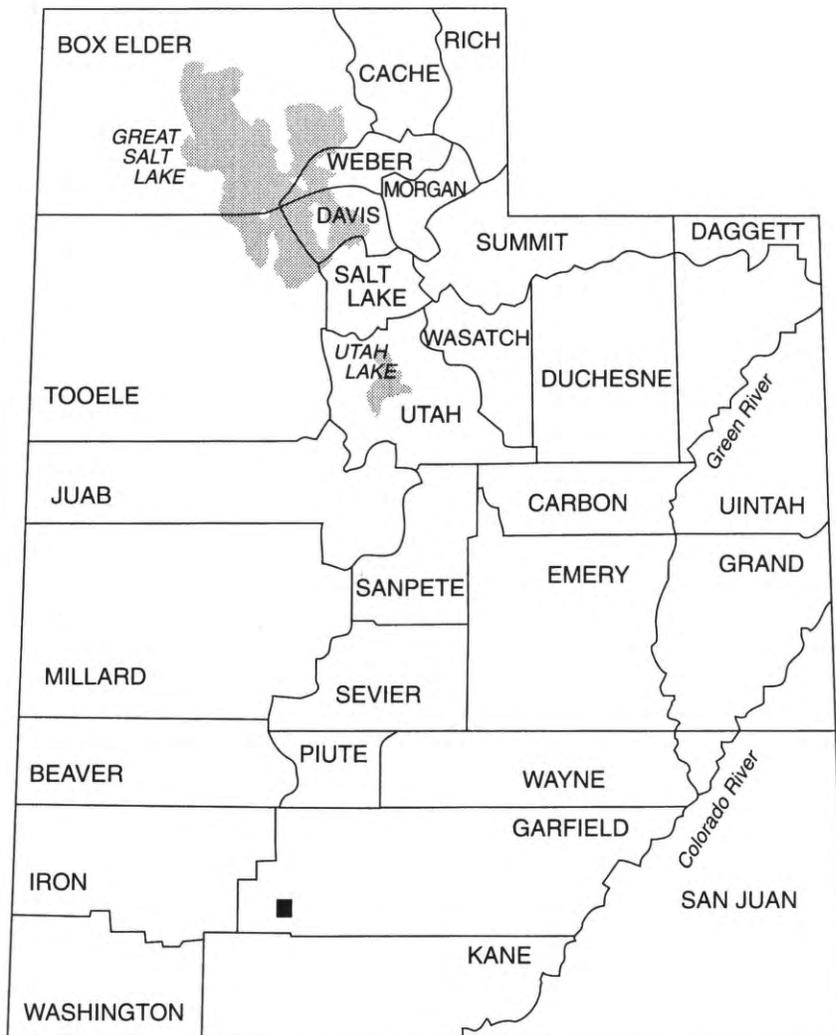


GEOLOGIC MAP OF THE HATCH QUADRANGLE, GARFIELD COUNTY, UTAH

by

Richard A. Kurlich III and John J. Anderson



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GEOLOGIC MAP OF THE HATCH QUADRANGLE, GARFIELD COUNTY, UTAH

by
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ABSTRACT

The Hatch 7.5 minute quadrangle lies along the Sevier River Valley between the eastern edge of the central Markagunt Plateau and the western Paunsaugunt Plateau. Exposed stratigraphic units range from Late Cretaceous to Holocene in age and consist dominantly of tuffaceous sedimentary strata with minor basalt, ash-flow tuff, and air-fall tuff. The oldest exposed unit is the Straight Cliffs Sandstone, which is exposed in the footwall of the Sevier fault. Younger units include terrigenous clastic and carbonate strata of the Oligocene Brian Head Formation, ash-flow tuff of the Oligocene Isom Formation, and a heterogeneous assemblage of dominantly volcanoclastic fluvial and lacustrine strata, herein formally named the Limerock Canyon Formation. Potassium-argon ages on samples from the Limerock Canyon Formation range from 21.5 ± 0.5 Ma (biotite) to 19.8 ± 0.8 Ma (feldspar), indicating an early Miocene age.

Unconformably overlying these bedrock units are a variety of late Cenozoic surficial and valley-fill deposits. During the late Tertiary to early Quaternary, thick alluvial-fan deposits of local origin filled the upper Sevier River Valley area. The later superposition of younger drainage networks stripped large volumes of these sediments from the quadrangle.

Two separate basalt flows are present in the quadrangle. An older basalt flow is interbedded with the late Tertiary valley-fill sediments and a younger flow of Pleistocene age is exposed only along Mammoth Creek at the southern margin of the quadrangle.

Northeast- and northwest-striking high-angle faults form a rhombic pattern across the quadrangle. The faults

commonly cut Quaternary alluvial deposits, typically with offsets of only a few feet. Records of seismic activity suggest that these faults are potentially still active.

INTRODUCTION

The Hatch 7.5-minute quadrangle (figure 1) lies along the Sevier River Valley between the eastern edge of the central Markagunt Plateau and the western edge of the Paunsaugunt Plateau. The Markagunt and Paunsaugunt Plateaus are the southernmost of several eastward-tilted fault blocks that comprise the High Plateaus subprovince of the Colorado Plateau Physiographic Province. The High Plateaus form a structural transition zone between the Basin and Range Province to the west and the Colorado Plateau Province to the east. They share stratigraphic similarities with both provinces, but the fault blocks are more characteristic of the former, and the high relief and elevation more closely resemble the latter (Stokes, 1977).

The geology of the southern High Plateaus has been described by various investigators. Anderson and Rowley (1975) described the geology of portions of the Markagunt Plateau. Gregory (1949; 1951), Wagner (1984), Anderson and Christenson (1989), Anderson and Kurlich (1989), Kurlich (1990), Moore and others (1994), and Moore and Straub (1995) described the geology in the vicinity of the Hatch quadrangle. Fieldwork for this report was performed mostly in the summers of 1986 and 1988. The Hatch quadrangle includes private and public land. Public land is managed by the Bureau of Land Management and Dixie National Forest.

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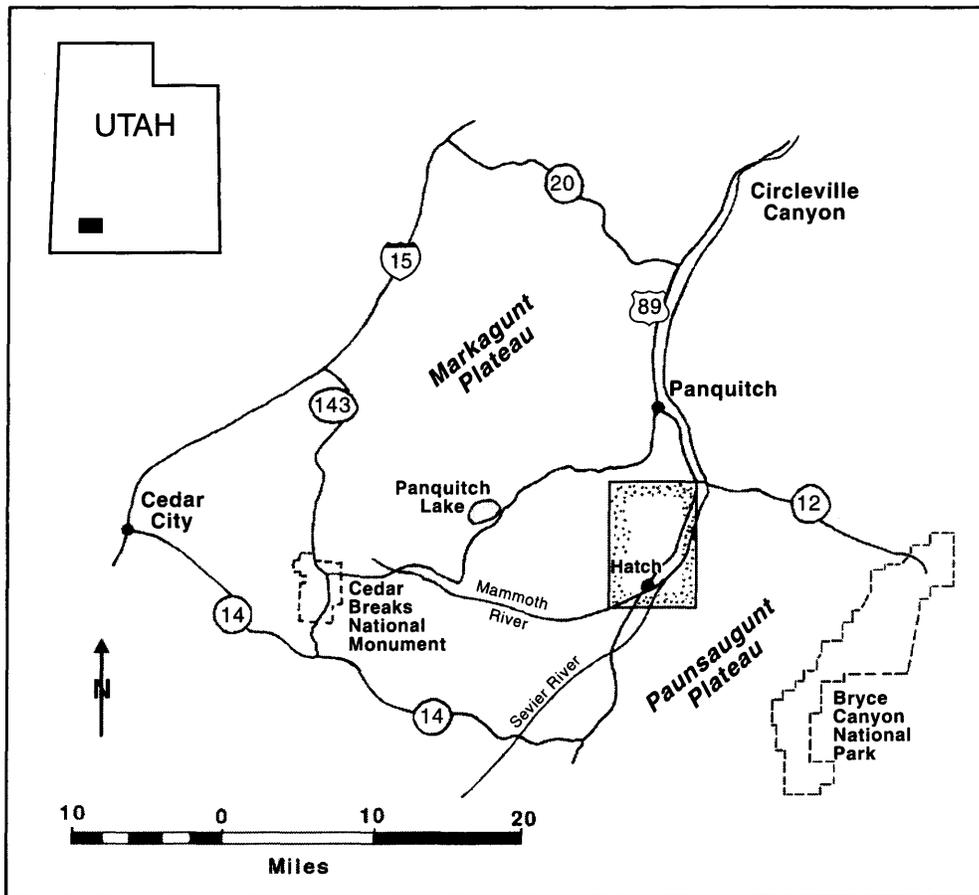


Figure 1. Location map of the Hatch 7.5 minute quadrangle, Garfield County, Utah.

STRATIGRAPHY

Cretaceous System

Straight Cliffs Sandstone (Ks)

Cretaceous strata are exposed in the footwall scarp of the Sevier fault in the southeast corner of the quadrangle. They are greater than 500 feet (150 m) thick just east of the quadrangle at the mouth of Proctor Canyon (in the adjacent Wilson Peak quadrangle), and consist of tan, massive to cross-bedded, fine- to medium-grained sandstone. They probably correlate with the Straight Cliffs Sandstone. Thin-section petrography indicates that the sandstone is composed dominantly of quartz grains and small amounts of lithic sparry calcite, and trace amounts of microcline, magnetite, and hematite. The sandstone is well sorted, texturally mature, and cemented with small amounts of hematite and sparry calcite. The Straight Cliffs Sandstone is Late Cretaceous in age (Gregory, 1951).

Tertiary System

Claron Formation (Tc - cross section only)

Leith and Harder (1908) defined the Claron Formation from exposures in the Iron Springs mining district west of Cedar City, Utah. Usage of "Claron Formation" in the southern High Plateaus did not become established until much later through the work of Anderson and Rowley (1975). The Claron Formation is informally subdivided into a lower "red" member and an upper "gray" or "white" member. The Claron is interpreted by various investigators (Anderson and Rowley, 1975; Moore and others, 1994; Rowley and others, 1994) to have been deposited in fluvial and lacustrine environments.

Rocks of the Claron Formation are not exposed in the Hatch quadrangle and are shown only on cross-section

A-A'. In areas adjacent to the Hatch quadrangle, the red member of the Claron Formation consists of a basal quartzite conglomerate overlain by massive cliffs of dense to fine-grained, argillaceous limestone and calcareous mudstones that are red, reddish pink, orange, yellow, and pale gray. These lithologies grade upward into less-resistant, tan and red, calcareous sandstone, calcareous mudstone, and lesser amounts of conglomerate. This description is modified from Wagner (1984) and Thomas (1985). The white member consists of an interbedded sequence of white to light gray and tan calcareous claystone, sandstone, conglomerate, and massive, argillaceous limestone (Anderson, 1993; Moore and others, 1994).

The thickness of the Claron Formation in the area is greater than 600 feet (180 m) based on a measured stratigraphic section on Mammoth Ridge in the Asay Bench quadrangle just south of the Hatch quadrangle (Moore and others, 1994). The age of the Claron Formation ranges from Paleocene to late Eocene(?) (Rowley and others, 1979; Goldstrand, 1994).

Brian Head Formation (Tbh)

Originally defined by Gregory (1944), the Brian Head Formation was later abandoned by Anderson and Rowley (1975) and the strata were divided into the Claron, Needles Range, Isom, Bear Valley, Leach Canyon, and Mt. Dutton Formations. Recent mapping in the High Plateaus has recognized a sequence of strata that paraconformably overlies the Claron Formation and has been proposed for formational status as the Brian Head Formation (restricted) by Anderson (1993). These rocks consist of strata previously mapped as "local sedimentary and volcanic strata" elsewhere in the High Plateaus (Anderson and Rowley, 1987) or by others as the uppermost, tuffaceous part of the informal "white" member of the Claron Formation in areas proximal to the Hatch quadrangle (Wagner, 1984). Kurlich (1990) mapped this interval in the Hatch quadrangle as the "white" Claron Formation, but later field examination indicated these rocks are the Brian Head Formation (restricted) (E.G. Sable, written communication, 1993; D.W. Moore, written communication, 1994).

Rocks of the Brian Head Formation (restricted) are located in the southwest corner of the Hatch quadrangle. The base is not exposed; the top of the unit is unconformably overlain by the Limerock Canyon Formation. The Brian Head Formation consists of a heterogeneous assemblage of massive to poorly bedded, white to tan and gray, argillaceous limestone, calcareous shale, siltstone, sandstone, and conglomerate. The rocks generally have a secondary pale-green coloration. Vugs filled with calcite crystals are common. Nodules, green and black siliceous veinlets, dendritic pyrolusite, brecciation, stylolitization, and caliche-related alteration also are common. Maximum exposed thickness is approximately 180 feet (55 m). The Brian Head Formation is early Oligocene in age (Rowley and others, 1994).

Baldhills Tuff Member of Isom Formation (Tib)

The Isom Formation (Mackin, 1960) consists of ash-flow tuff, locally interbedded with lava flows and tuffaceous sedimentary strata that were erupted from the Indian Peak caldera complex along the southern Utah-Nevada border (Best and others, 1989). The Isom crops out over an area greater than 9,600 square miles (25,000 km²) in southwestern Utah and its volume is in excess of 300 cubic miles (1,300 km³) (Best and others, 1989). Only the Baldhills Tuff Member of the Isom Formation is present in the quadrangle. It is exposed in the northwest corner where it consists of two cooling units of resistant, densely welded, crystal-poor, vitric ash-flow tuff. The lower cooling unit is light- to medium-bluish-gray, with partings 1 to

6 inches thick (2.5 - 15.2 cm) that radically change attitudes over a distance of a few to 10 feet (1 - 3 m). The upper cooling unit is dark-brown to reddish-purple and more massive, with platy partings as much as 3.3 feet (1 m) thick. The upper cooling unit weathers into a granule- to pebble-size, "popcorn"-textured gravel. Thickness of the member is at least 100 feet (30 m), but the upper and lower contacts of the unit are not exposed. The age of the Baldhills Tuff Member is late Oligocene based on a potassium-argon age determination of about 26 to 27 Ma (Fleck and others, 1975; Best and others, 1989).

Limerock Canyon Formation (Tl)

The Limerock Canyon Formation (formally named in this report) is here defined to include a heterogeneous assemblage of dominantly volcanoclastic fluvial and lacustrine strata of early Miocene age that unconformably overlie the Brian Head Formation (restricted) in the Hatch quadrangle. The Isom Formation is mostly absent due to erosion. This sequence of strata is deemed worthy of formational status because of its lithologic uniqueness, age, and stratigraphic position bounded by unconformities. At present, the known areal extent of the Limerock Canyon Formation is limited to within the Hatch quadrangle and westward into the Haycock Mountain quadrangle. Prior to radiometric dating of the rocks at 20 to 21.5 million years, rocks of the Limerock Canyon Formation were correlated with tuffaceous sedimentary strata that now are assigned to the Brian Head Formation (restricted). However, these new dates indicate that the Limerock Canyon Formation is early Miocene, whereas the Brian Head Formation (restricted) is Oligocene. The Limerock Canyon Formation is lithologically similar to the Sevier River Formation of Callaghan (1939), but the two units are not correlative because of age differences and the lack of lateral continuity between them. In the Hatch quadrangle, Gregory (1944; 1949) mapped sediments of the Limerock Canyon Formation as part of his unrestricted Brian Head Formation. Wagner (1984) mapped green tuffaceous sediments and multi-colored chalcedony beds contiguous with the Limerock Canyon Formation as part of the Claron Formation in the adjacent Haycock Mountain quadrangle.

The unconformable lower contact of the Limerock Canyon Formation has relief of a few to 10 feet (1 - 3 m). The erosional nature of this contact is further emphasized by a significant time interval of at least 8 million years between deposition of the Brian Head Formation (restricted) and the Limerock Canyon Formation, and by only local preservation of welded ash-flow tuffs of the Isom Formation. In the quadrangle, the lower Limerock Canyon contact is placed at the top of a massive, non-tuffaceous,

resistant, white to gray limestone in the Brian Head Formation (restricted). The Limerock Canyon Formation is unconformably overlain by late Tertiary alluvial-fan deposits. The upper contact of the Limerock Canyon Formation is placed at the change from well-consolidated to poorly consolidated or unconsolidated sediment.

No single, complete section of the Limerock Canyon Formation is present in the Hatch quadrangle. The composite type section was measured and described at two localities (figure 2; appendix), one with an exposed top, the other with an exposed base. The first section is located in the ledges and cliffs on the north side of Limerock Canyon (NE $\frac{1}{4}$ NE $\frac{1}{4}$ section 25, T. 36 S., R. 6 W.). The second section is located on the south side of a prominent hill in an unnamed drainage east of Spring Hollow (NE $\frac{1}{4}$ NW $\frac{1}{4}$ section 36, T. 36 S., R. 6 W.) (figure 2). The variable nature of the Limerock Canyon Formation makes correlation of laterally disconnected strata difficult. However, we believe that such correlation is possible for the composite type section due to the presence of a prominent, cliff-forming, conglomeratic, marker bed. The correlative bed is identified as unit 29 in stratigraphic section 1 and as unit 35 in section 2 (appendix).

The basal strata of the Limerock Canyon Formation consist of pale- to olive-green, granular volcanic arenite (sandstone) that grades laterally into volcanic arenite or tuffaceous pebble conglomerate. Within the formation the dominant rock type is texturally immature to submature, pale- to dark-green, and white to bluish-white tuffaceous volcanic wacke (poorly sorted sandstone), with lesser amounts of calcareous to silicic mudstone, tuffaceous volcanic arenite, tuffaceous siltstone, air-fall tuff, and tuffaceous conglomerate; and minor shale and tuffaceous limestone. In Rock Canyon and Spring Hollow, pods and lenses of chalcedony about 3.3 feet (1 m) thick are common in the formation and range in color from pale-olive-green to dark yellowish orange, black, light to dark reddish-brown, light to moderate red, white, and dark blue. The presence of chalcedony beds in older, unnamed tuffaceous sedimentary strata elsewhere in the High Plateaus contributed to the confusion of the Limerock Canyon beds being correlated with the older strata.

Extensive bioturbation has reworked much of the strata, especially the tuffaceous sandstones (arenites and wackes), so that original stratification has been largely destroyed. Evidence of bioturbation consists of pervasive, calcite-filled burrow casts that commonly weather out of the parent rock and collect below the outcrop as gnarled calcite "fingers".

Sandstones (arenites and wackes) of the Limerock Canyon Formation are commonly bimodal, containing considerable amounts of granule- and pebble-sized clasts. The clastic rocks are texturally and compositionally immature

to submature and consist dominantly of volcanic rock fragments (as much as 60 percent) and lesser grains of quartz, plagioclase, hornblende, pyroxene, and sanidine (individually up to as much as 14 percent) in a matrix of clay, sericite, and chlorite (as much as 62 percent). Trace minerals or phases present in less than 5 percent modal abundances include biotite, muscovite, glass, lamprobole, calcite, analcite, zircon, and various iron oxides (magnetite, hematite, and limonite). Plutonic, metamorphic, and sedimentary rock fragments also occur in trace amounts. Tuffs are devitrified. Cementing agents include calcite, silica, and zeolite (as much as 36 percent). Authigenic clays, sericite, and zeolite are also common. Clasts in conglomerate beds of the composite type section include: (1) mafic volcanic rocks, commonly olivine basalt (about 42 percent); (2) silicic volcanic rocks (40 percent); (3) intermediate volcanic rocks (9 percent); (4) quartzite (7 percent); and (5) sandstone (2 percent) (Kurlich, 1990). Kurlich (1990) described additional stratigraphic sections and detailed petrography of the Limerock Canyon Formation.

The Limerock Canyon Formation was deposited largely in a fluvial environment, as evident from channel fills and poorly preserved trough, tabular, and horizontal bedforms. Less common are varved shales and mudstones that probably were deposited in a lacustrine environment. Soft-sediment deformation features are present in some beds. At least ten thin beds of air-fall tuff are interbedded within the Limerock Canyon Formation in Limerock Canyon, indicating that volcanism was active during deposition.

The source area of the Limerock Canyon Formation is believed to lie to the north-northwest (Kurlich, 1990) based on ripple-mark orientations in Limerock Canyon (appendix). However, clasts derived from the Oligocene and early Miocene volcanic and volcano-sedimentary strata exposed to the northwest (Needles Range, Isom, Bear Valley, and Mt. Dutton Formations) have not been identified in the Limerock Canyon Formation. The lack of these clasts in the Limerock Canyon Formation and the absence of Needles Range, Bear Valley, and Mt. Dutton strata in the Hatch quadrangle is problematic. Hypotheses to explain this include: (1) the older units were never deposited in the Hatch area or source area of the Limerock Canyon Formation; (2) the older units were removed by an erosional episode prior to deposition of the Limerock Canyon Formation; or (3) the older strata underwent gravity sliding northward to become incorporated in the megabreccia that mantles the northern Markagunt Plateau (Anderson, 1993).

The Limerock Canyon Formation is as much as 290 feet (88 m) thick. Its age is early Miocene based on potassium-argon age determinations of 21.5 ± 0.6 Ma (biotite) and

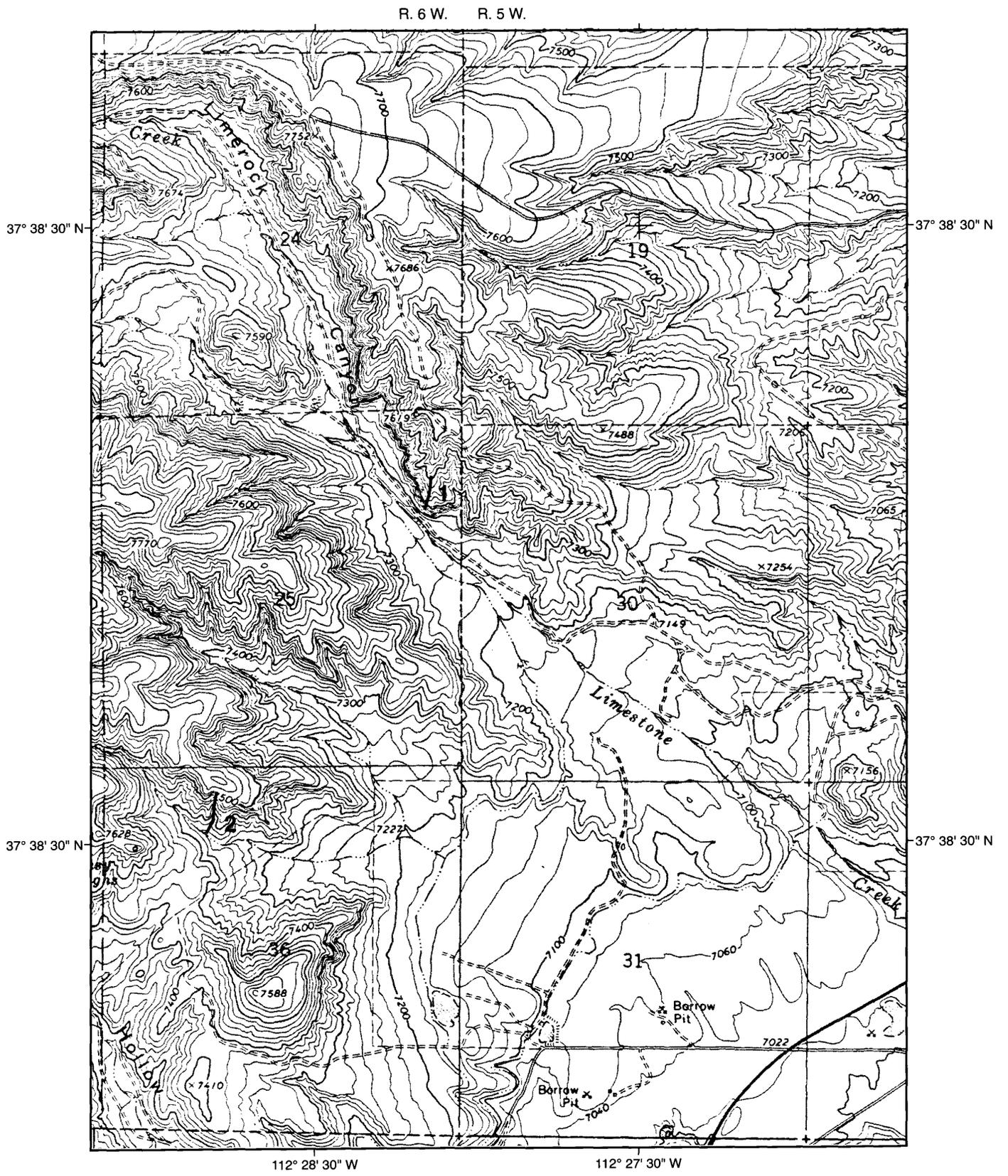


Figure 2. Location of the composite type section of the Limerock Canyon Formation.

21.0 ± 1.0 Ma (feldspar) for air-fall tuff samples collected approximately 100 feet (30 m) above the basal contact (NE¼NW¼ section 36, T. 36 S., R. 6 W.), and 20.2 ± 1.4 Ma (biotite) and 19.8 ± 0.8 Ma (feldspar) for samples collected approximately 200 feet (61 m) above the basal contact (NE¼ NE¼ section 25, T. 36 S., R. 6 W.) (H.H. Mehnert, U.S. Geological Survey, written communication, 1992). These sampling locations correspond to stratigraphic sections 1 and 2.

Late Tertiary Alluvial-Fan Deposits (Taf)

Moderately to poorly consolidated, tan, pink, and salt-and-pepper-colored, tuffaceous siltstone, sandstone, pebbly sandstone, and pebble conglomerate are dominant lithologies of this unit. Sparse air-fall tuff, lacustrine limestone, and Tertiary basalt (Tb) are interbedded with these clastic sediments. The age of this unit is considered to be late Miocene and Pliocene based on the presence of the interbedded basalt which is believed to be latest Miocene to Pliocene in age.

Petrographically, late Tertiary alluvial-fan deposits are texturally immature to submature and consist of predominantly volcanic rock fragments with lesser amounts of sanidine, plagioclase, pyroxenes, quartz, devitrified glass, and iron oxides in a silica- or calcite-cemented clay matrix. Pebble count data of rock fragments are as follows: mafic volcanoclastic rocks (49.1 percent), silicic igneous rocks (27.3 percent), intermediate igneous rocks (18.5 percent), quartzite (3.6 percent), and sandstone (1.7 percent). The source and origin of this clastic material are discussed in the geomorphology section of this report. Descriptions of measured stratigraphic sections and detailed petrography of the late Tertiary alluvial-fan deposits are included in Kurlich (1990) under the heading "Quaternary-Tertiary Valley Fill."

Bedforms preserved in the late Tertiary alluvial-fan deposits suggest an aggrading alluvial environment with poorly defined channels and fluctuating ephemeral stream volumes. Caliche cement is common, and some calcite-filled burrow and rootlet casts also are present. The thickest exposure of these deposits is about 760 feet (230 m). We believe these deposits were probably considerably thicker at the conclusion of their deposition.

Late Tertiary Alluvium (Tal)

A deposit of moderately to poorly consolidated, pink alluvium (Tal) is exposed below Tertiary basalt (Tb) in the late Tertiary alluvial-fan deposits (Taf) along the west side of the Sevier River (SE¼ SW¼ section 15, T. 36 S., R.

5 W.). The alluvium consists of silt, sand, and gravel of unknown provenance that appears to fill a large channel incised into Tertiary alluvial-fan deposits. Part of the channel bank may be preserved in the outcrop. The Tertiary basalt (Tb) overlies both alluvial units at this location, indicating that the pink channel alluvium (Tal) is correlative with part of the alluvial-fan gravels (Taf). The channel alluvium may have been deposited in a paleovalley of the ancestral Sevier River. The unit may be as much as 100 feet (30 m) thick.

Tertiary Basalt (Tb)

Tertiary basalt is dark reddish brown and steel gray, vesicular to scoriaceous, and rich in olivine and plagioclase phenocrysts. Olivine commonly is altered to iddingsite. Plagioclase varies from labradorite to bytownite (anorthite [An] content ranging from 68 to 75.5 percent). Only discontinuous exposures of Tertiary basalt are present in the northern half of the quadrangle. However, late Tertiary alluvial fans, folding, faulting, and erosion may obscure a more continuous basalt flow(s). The Tertiary basalt is believed correlative with a basalt located approximately 3 miles (4.8 km) north of the Hatch quadrangle that has been dated at 5.3 ± 0.5 Ma (Anderson and Christenson, 1989). Alternatively, the Tertiary basalt may correlate with a Quaternary basalt in Red Canyon, just east of the quadrangle, that Best and others (1980) dated at 0.56 ± 0.07 Ma. The thickness of the Tertiary basalt is variable, with a maximum of about 100 feet (30 m).

Quaternary System

Older Alluvial-Fan Deposits (Qaf₃)

Older alluvial-fan deposits consist of moderately to poorly consolidated, texturally immature to submature, buff, pink, yellow, orange, and red silt, sand, and small gravel. Located east of the Sevier River, the older alluvial-fan deposits are dominated by sedimentary clasts derived from the Claron Formation and Cretaceous strata exposed on the Paunsaugunt Plateau and in the upper Sevier River Valley. These deposits originated as coalescing alluvial fans, with deposition of some sediments in channel and overbank environments. Their exposed thickness is as much as 200 feet (61 m), but may be considerably thicker in the Sevier River Valley. Older alluvial-fan deposits probably are Pleistocene in age but may be as old as latest Pliocene.

Quaternary Basalt Flow (Qb)

This is a Quaternary basalt flow consisting of a steel-gray to black, vesicular to scoriaceous basalt rich in olivine and plagioclase phenocrysts. Plagioclase phenocrysts have an anorthite content of approximately 70 percent (labradorite to bytownite). Outcrops of Quaternary basalt are unvegetated and relatively unoxidized. Gregory (1951) reported that this basalt originated from a crater 8 miles (13 km) west of the quadrangle and flowed down the paleo-course of Mammoth Creek into the Hatch quadrangle area. The lack of vegetation on the flow has been used by some investigators as a relative indicator of a youthful, possibly Holocene, age (Gregory, 1949; Rowley, 1968; Anderson and Rowley, 1975). We consider its age to be earliest Holocene to Pleistocene. Maximum thickness is approximately 20 feet (6 m).

Basaltic Cinder Cone (Qbc)

This unit consists of unconsolidated, angular blocks of brick-red, highly scoriaceous basaltic debris. The subdued, cone-shaped mound of debris suggests it may be the remains of a volcanic cinder cone. Its age is estimated as earliest Holocene to Pleistocene due to its stratigraphic position overlying the late Tertiary alluvial-fan deposits. Exposed thickness ranges from a thin veneer to a maximum of only a few feet.

Intermediate Alluvial-Fan Deposits (Qaf₂)

Intermediate alluvial-fan deposits consist of unconsolidated silt, sand, and gravel that occur as elevated mounds and ridges dissected by younger drainage networks. These erosional remnants are believed to have been deposited on broad, sloping surfaces as alluvial fans derived from older, underlying units. Locally these deposits include colluvium and alluvium in small drainages. Intermediate alluvial-fan deposits (Qaf₂) are similar to younger alluvial-fan deposits (Qaf₁) in mode of deposition and lithology. However, the intermediate deposits are believed to be Pleistocene in age because they cap recognizable landforms, and are at elevations as much as 140 feet (43 m) above present drainages. Exposed thickness is as much as 13 feet (4 m), but total thickness may exceed this in the Sevier River Valley.

Younger Alluvial-Fan Deposits (Qaf₁)

Younger alluvial-fan deposits consist of unconsolidated silt, sand, and gravel capping broad, sloping surfaces and in drainages between erosional remnants of older units.

This unit results from deposition on erosional surfaces cut on underlying units. The setting and lithology for younger alluvial-fan deposits are similar to those of alluvium and colluvium (Qac). However, the two units are mapped separately to emphasize the degree of recent dissection in the Hatch quadrangle. Younger alluvial-fan deposits are up to 13 feet (4 m) thick, but the total thickness may be greater within the Sevier River Valley. Their stratigraphic position suggests a late Pleistocene to Holocene age.

Alluvium and Colluvium (Qac)

Alluvium and colluvium consist of unconsolidated silt, sand, and gravel in ephemeral and perennial channels that are tributaries to the Sevier River and Mammoth Creek, in locally derived deposits bordering these channels, and in some alluvial fans. The thickness rarely exceeds a few feet but locally may be considerably thicker in alluvial fans. Alluvium and colluvium are Holocene in age.

Terrace Deposits (Qat)

Terrace deposits consist of unconsolidated silt, sand, and gravel on abandoned floodplains above the Sevier River and Mammoth Creek. This unit locally includes minor slopewash. The thickness of these sediments is less than 25 feet (8 m), their maximum height above the Sevier River. This unit is early Holocene and possibly late Pleistocene in age.

Channel and Floodplain Alluvium (Qal)

Channel and floodplain alluvium consists of unconsolidated silt, sand, and gravel located along the course of the Sevier River and Mammoth Creek. The alluvium was deposited by in-channel and over-bank depositional processes along these larger drainages. The deposits are less than 20 feet (6 m) thick and are Holocene in age.

Colluvium (Qc)

Colluvium consists of silt, sand, and gravel accumulations at the base of cliffs along the Sevier fault in the southeast corner of the quadrangle. Abundant rockfall talus as well as slopewash are included in this deposit. Deposit thickness is variable and may exceed several tens of feet. The age of these deposits is Quaternary.

Artificial Fill (Qf)

Artificial fill is composed of excavated fill material derived from local sources for use in earthen dams and

along drainage ditches. It is latest Holocene in age. Alluvium deposited behind dams generally is mapped as part of the underlying alluvium.

GEOMORPHOLOGY

Origin of Alluvial-Fan Deposits Filling the Valley

We interpret the late Tertiary alluvial-fan deposits (Taf) as being distinctly older and of different provenance from the Quaternary older alluvial-fan deposits (Qaf₃). Two distinct source areas for these valley-filling deposits have been identified. Older Quaternary alluvial-fan deposits (Qaf₃), located east of the Sevier River, are dominated by sedimentary clasts derived from the Claron Formation and Cretaceous strata exposed on the Paunsaugunt Plateau and in the upper Sevier River Valley. Deposition of these sediments reflects the more recent domination of a local source from the east. Tertiary alluvial-fan deposits (Taf), located west of the Sevier River, are dominated by tuffaceous sedimentary strata, including mafic and intermediate lava clasts. These western gravels were deposited at the distal margin of an alluvial fan that can be traced north and west back to its source area in the Panguitch Lake area. This Tertiary alluvial-fan deposit thickens eastward into the Sevier River Valley and northward toward Panguitch (figure 1).

We believe that the late Tertiary alluvial-fan deposits were shed as the result of the structural uplift of the High Plateaus, which probably took place during the latest Miocene and Pliocene. At that time the Markagunt, Sevier, and Paunsaugunt Plateaus probably were mantled with thick lahar deposits of the Mount Dutton Formation (Anderson and Rowley, 1975). These intermediate volcanic deposits provided the major source rock for the late Tertiary alluvial fans. We further believe that the uplift of the southern High Plateaus created a structurally closed basin at what is presently the upper Sevier River Valley (the portion of the Sevier River Valley south of the Circleville Canyon structural uplift). The late Tertiary alluvial fans were deposited by consequent drainage into this basin, eastward from the Markagunt Plateau and westward from the Sevier and Paunsaugunt Plateaus, and it filled to a height equal to the structural uplift of the Circleville Canyon area. It was only after this basin-filling episode concluded that the heretofore interior drainage of the upper Sevier River Valley found an exit toward the north to form the present Sevier River. We therefore believe that the upper Sevier River of today is a superposed stream.

The superposed origin of the drainage of the southern

High Plateaus was first suggested by Anderson (1987). At that time, Anderson correlated the valley-fill deposits (Taf), on top of which superposition occurred, with the Sevier River Formation of Callaghan (1939). We no longer believe that such a correlation is valid, given the distinctly different lithologies of the late Tertiary alluvial-fan deposits and the Sevier River Formation, and what we interpret as the unique depositional setting of the former.

Quaternary older alluvial-fan deposits (Qaf₃) were deposited on an erosion surface formed on the underlying late Tertiary alluvial fans (Taf) in the vicinity of the Sevier River. The basal Quaternary erosion surface formed during lateral planation and was covered by the older alluvial-fan deposits (Qaf₃) shed from the uplands to the east. Later Quaternary alluvial-fan deposits (Qaf₂ and Qaf₁) were laid down during later cyclical periods of down-cutting (incision) and deposition (backfilling) controlled by the Sevier River and its tributaries. The source areas for these deposits were the Paunsaugunt Plateau, the Markagunt Plateau, and older valley-fill deposits. The Quaternary alluvial-fan deposits have subsequently been dissected by current drainages as a result of downcutting by the Sevier River.

Origin of Drainage

We interpret the Sevier River to be a superposed stream. Evidence of this superposition is found approximately 24 miles (39 km) north of the Hatch quadrangle where the Sevier River flows through the narrow gorge of Circleville Canyon. The canyon is cut into a structural uplift that we believe should have blocked exterior drainage northward out of the upper Sevier River Valley. Additional evidence of superposition of drainage is found at two locations in the Hatch quadrangle. The first is approximately 2 miles (3 km) north of Hatch, where the Sevier River has incised 80 feet (24 m) through older Quaternary alluvial-fan deposits (Qaf₃) and underlying Tertiary basalt (Tb). The second is in eastern Rock Canyon, where Rock Creek locally flows opposite the dip of the surrounding strata. This suggests that Rock Creek is a superposed stream, instead of a consequent stream flowing eastward down the dip slope of the Markagunt Plateau.

In the valley of Mammoth Creek, drainage was locally disrupted as Quaternary basalt (Qb) flowed down the old channel of Mammoth Creek to its confluence with the Sevier River. Mammoth Creek later shifted its course to the south, off the edge of the flow, leaving the outcrop perched above creek level and exposing the underlying Claron Formation and late Tertiary alluvial-fan deposits. The knickpoint where Mammoth Creek flows off the edge of the basalt is west of the Mammoth Creek fish hatchery in the Haycock Mountain quadrangle.

Other tributaries of the Sevier River in the Hatch quadrangle are dominantly consequent and flow along faulted valleys and down the dip slope of the tilted Markagunt Plateau. Less common subsequent drainages are the result of headward erosion along joints and faults. Channels that zig-zag, commonly in rhombic patterns paralleling the principal joint and fault orientations, help identify structurally controlled streams.

STRUCTURE

The Hatch quadrangle lies in the structural and physiographic transition zone between the Basin and Range Physiographic Province to the west and the Colorado Plateau Province to the east (Stokes, 1977). Major faults have a north-northeast trend, and block faulting and block rotation dominate the local structure, as it does throughout the eastward-tilted Markagunt Plateau. The overall dip of strata in the Hatch quadrangle averages 2 to 3 degrees to the east, but locally may increase to 5 degrees or more along the flanks of folds and faulted blocks. Two sets of northeast- and northwest-striking high-angle joints and faults, with small displacements, impart a rhombic fabric on the rocks. This fabric is especially prominent in the northwest corner of the quadrangle where it controls drainage.

The Sevier fault is a major basin-and-range fault that crosses the extreme southeast corner of the Hatch quadrangle. At this location the fault trends northeast and does not appear to offset surficial deposits. Estimated throw on the fault in this area is approximately 1,200 feet (366 m) (Gregory, 1951). The Sevier fault is a high-angle, down-to-the-west normal fault that extends along the western side of the Paunsaugunt Plateau.

Some of the notable structural features in the Hatch quadrangle are described below. Two prominent anticline/syncline fold pairs, and associated faults are conspicuous in the quadrangle. These features appear to be part of a structural zone, 16 miles (25 km) long, that extends from northeast of Panguitch, Utah into the quadrangle and are genetically related to the Sevier fault (Anderson and Christenson, 1989). One syncline/anticline pair crosses the east end of Rock Creek (sections 4 and 9, T. 36 S., R. 5 W.), where it is visible in a Tertiary basalt flow (Tb). A northwest-trending graben, also cutting the Tertiary basalt, is visible on the north side of the mouth of Rock Creek. The other syncline/anticline pair is in DD Hollow (sections 21 and 28, T. 35 S., R. 5 W.), where a northeast-trending graben with approximately 60 feet (19 m) of displacement is centered on the axis of the anticline.

On Hatch Mountain in the southwest corner of the quadrangle, several northeast-striking faults have down-to-the-southeast displacement. The absence of marker

beds in the late Tertiary alluvial-fan deposits (Taf) makes it difficult to determine the amount of displacement on these faults. These faults are further obscured because of the rapid erosion of scarps formed in the poorly consolidated or unconsolidated sediments. For these reasons, many faults in the quadrangle are shown on the geologic map as buried (dotted) or inferred or approximately located (dashed). Where faults cut more consolidated underlying units, displacements of less than a few feet are common.

Faults west of the Sevier River have displaced the Quaternary alluvial fans, indicating Quaternary movement. Anderson and Christenson (1989) indicate that the last scarp-forming movement of the Sevier fault was late Pleistocene based on offset of a 0.56 Ma basalt flow in Red Canyon east of the quadrangle. The last period of movement on faults in the quadrangle was middle to late Pleistocene, but possibly may extend into the Holocene (Anderson and Christenson, 1989).

Conspicuous linear features on aerial photographs are designated as lineaments on the geologic map. These features probably represent joints or small-displacement faults that have been accentuated by erosion. Lineaments cross the landscape in essentially straight lines, indicating nearly vertical geometry.

GEOLOGIC RESOURCES

Sand and gravel are apparently the only geologic resources that have been developed in the Hatch quadrangle. The sand and gravel are extracted from various Quaternary and Tertiary alluvial deposits. Utah Department of Transportation records identify 13 borrow pits located in the quadrangle. The dominant commodity is sand and gravel used as fill, roadbase, and surfacing material. Some clay is available. One pit along U.S. Highway 89 is identified as a source of basalt for use as rip-rap (Utah Geological Survey, Utah Mineral Occurrence System [UMOS] files).

WATER RESOURCES

Unconsolidated Quaternary and Tertiary alluvium makes an excellent ground-water aquifer that, because of the semi-arid climate, plays a major role in development of the local economy. The thick alluvial deposits in the Sevier River Valley may be a significant source of ground water that is largely untapped, except for a few domestic wells. In general, the chemical quality of the ground water is suitable for irrigation, domestic and public supply, livestock, and industry (Carpenter and others, 1967). Abundant catchment ponds and irrigation canals help to collect and transfer ground and meteoric waters for farming and

livestock. The perennial Sevier River and its major tributary, Mammoth Creek, serve as local base levels.

GEOLOGIC HAZARDS

The Hatch quadrangle lies in the southern Intermountain seismic belt (Smith and Arabasz, 1991) and is in area 2B of the Uniform Building Code seismic zone map (International Conference of Building Officials, 1991). The Sevier fault is capable of generating large earthquakes with moderate to high surface rupturing potential. Non-surface rupturing earthquakes may also be expected locally and regionally (Arabasz and others, 1992; Christenson and others, 1987). Moderate ground-shaking hazards and liquefaction of unconsolidated valley fill are possible. Faults offsetting Quaternary deposits are common in the quadrangle, giving evidence that the area is likely to experience earthquakes in the future. To the north, in the central Sevier River Valley, the post-1850 earthquake record includes nine earthquakes with an estimated magnitude of 5.0 or greater, indicating that the area is still tectonically active (Anderson and Barnhard, 1984).

Flash floods in ephemeral stream channels commonly wash out roads and undercut bridges after torrential downpours. Periodic flooding can be expected along the Sevier River floodplain. In 1921, a debris flow due to heavy rainfall on the Paunsaugunt Plateau flowed out of Proctor Canyon, burying approximately 200 acres (81 hectares) of fertile farm land under tons of debris (Gregory, 1951). Effects of the "great wash-out" are still visible, including erratic boulders weighing several tons in the Sevier Valley

nearly one-half mile (0.8 km) from the mouth of the canyon.

The overall low relief in the quadrangle does not promote large landslides, rock-falls, or slope stability problems except along the Sevier fault in the southeast corner. Small-scale mass-wasting can be expected in road cuts, in cliff faces exposed in the Limerock Canyon Formation and basalts, and in deeply incised stream cuts.

A moderate radon hazard exists in the quadrangle due to the potential for elevated uranium levels in the moderately to highly permeable soils. Two areas containing abundant radioactive material that may be contributing sediments to the quadrangle are on the Paunsaugunt Plateau near Proctor Canyon and in the upper Sevier River Valley near its confluence with Asay Creek (Black, 1993).

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APPENDIX

Composite Type Section of Limerock Canyon Formation

Stratigraphic Section 1 Upper part of formation

Located on south-facing slope in Limerock Canyon (NE $\frac{1}{4}$ NE $\frac{1}{4}$, section 25, T. 36 S., R. 6 W.)(figure 2). Measured and described by R. A. Kurlich, III, 1986; descriptions modified by E.G. Sable, 1991. Base of section is covered. An erosional unconformity separates this unit from the overlying late Tertiary alluvial-fan gravels.

Top of Section

Unit	Thickness (feet)	Limerock Canyon Formation (part)
51	1.0	Tuffaceous sandstone , pale green, very fine- to fine-grained sand matrix containing medium-grained sand to pebbles as much as 0.6 inches in diameter but generally under 0.1 inches; larger clasts are of olive-green mudstone; moderately cemented, poorly sorted, argillaceous; forms slope.
50	1.7	Mudstone , mottled olive-green to brown, well to moderately sorted, massive, resistant; gradational with unit 49.
49	1.0	Tuffaceous sandstone , pale-green, weathers tan to red, bimodal fine- to coarse-grained sand with granule-sized clasts as much as 0.1 inch in diameter and mudstone rip-up clasts; well-cemented, poorly sorted, fines upward; forms slope.
48	0.6	Mudstone , chocolate-brown, well-cemented, contains minor dendritic pyrolusite, massive, resistant, highly fractured; sharp lower contact with unit 47.
47	17.9	Tuffaceous sandstone , bluish-gray, weathers gray, mostly fine- to medium-grained sand but containing coarse- to very coarse-grained fraction, moderately well cemented, moderately to well sorted, massive; forms slope; includes several 2.0-inch-thick mudstone interbeds; thin zone in middle of unit contains abundant bedding-parallel root-cast traces suggesting burial of fallen tree; upper part contains trough crossbeds.
46	0.9	Tuffaceous sandstone , bluish-gray, weathers tan, fine-grained; massive, resistant, with sharp lower contact.
45	0.9	Tuffaceous pebbly sandstone , similar to unit 43.
44	1.5	Mudstone , brown, well cemented, well to moderately sorted, highly fractured; resistant, gradational with unit 43; includes tan, well-sorted, fine-grained tuffaceous sandstone lenses.
43	0.8	Tuffaceous pebbly sandstone , pale-green to very pale-pink, bimodal, fine-grained sand and granule- to cobble-size clasts as much as 5 inches in diameter but generally less than 0.1 inch; well-cemented, poorly sorted, massive, resistant; gradational with unit 42.
42	0.7	Tuffaceous sandstone , tan, bimodal, fine-grained sand and granule-size clasts, well cemented, poorly sorted, massive, resistant; becomes pebbly upwards with clasts to 5 inches in diameter but average 1 to 2 inches; pebble size increases upward.
41	1.3	Mudstone to pebbly mudstone , brown to tan, well cemented, well to poorly sorted; grades upwards and laterally to fine-grained tuffaceous sandstone; resistant; gradational with unit 40.
40	0.2	Mudstone , dark olive-green, well cemented, contains minor pyrolusite and biotite; includes burrow casts that extend into underlying unit; resistant; gradational with unit 39.
39	1.0	Tuffaceous sandstone , pale-green with orange limonitic staining, fine grained, well cemented, well sorted;

- contains minor burrow casts in lower part and at top; becomes granular to pebbly upwards with average clast size 0.3 inch in diameter but ranging to 0.6 inch; resistant.
- 38 1.0 **Tuffaceous sandstone**, similar to unit 30.
- 37 0.3 **Air-fall tuff**, white to tan, highly fractured, lenticular.
- 36 1.2 **Tuffaceous sandstone**, similar to unit 30.
- 35 0.3 **Air-fall tuff**, white to tan, highly fractured, lenticular.
- 34 1.7 **Tuffaceous sandstone**, similar to unit 30.
- 33 0.3 **Air-fall tuff**, white to tan, highly fractured, lenticular.
- 32 1.2 **Tuffaceous sandstone**, similar to unit 30.
- 31 0.8 **Mudstone**, tan to chocolate-brown, partially silicified, well cemented; contains minor pyrolusite, extensive burrow casts and small-scale trough-crossbed laminae; resistant.
- 30 3.0 **Tuffaceous sandstone**, bluish-white, weathers red and gray, fine grained but includes minor 2-inch-thick stringers of granules and pebbles; poorly cemented, well sorted, argillaceous; massive, moderately resistant; contains trough crossbeds and poorly developed channel fill of tuffaceous pebble conglomerate; sharp lower contact with unit 29.
- 29 6.0 **Tuffaceous cobble and pebble conglomerate and tuffaceous sandstone** that interfinger; massive, resistant; scoured lower contact with unit 28; conglomerate is clast supported with well-rounded clasts to 5 inches in diameter; sandstone is similar to that in unit 28. This unit is correlative with unit 35 of section 2, described below.
- 28 5.0 **Tuffaceous sandstone**, white, weathers tan to red, very fine to fine grained, moderately to well cemented, well sorted; contains pyrolusite; tabular bedding in lower part becomes massive upwards; grades laterally to medium-grained, trough-crossbedded sandstone that contains channel fill of tuffaceous pebble conglomerate; resistant; sharp lower contact with unit 27.
- 27 1.2 **Air-fall tuff and tuffaceous sandstone**, three tuff beds 1.5 to 6 inches thick alternating with sandstone; tuff is gray to purple, moderately cemented, with common biotite and minor rootlet casts; sandstone is purplish-white to gray, weathers tan, fine grained, moderately cemented, well sorted; contains traces of flattened burrow casts; massive; forms slope.
- 26 0.7 **Tuffaceous sandstone**, purplish-white, weathers tan, very fine grained but includes beds of medium-grained, generally well-sorted sand; small-scale trough crossbeds; upper part contains oscillation(?) ripple marks oriented N18°W and N2°E.
- 25 0.3 **Air-fall tuff**, light-gray, moderately cemented, highly fractured; forms slope; sharp lower contact with unit 24.
- 24 1.7 **Tuffaceous sandstone**, grayish-white to tan, weathers reddish-tan, fine to very fine grained, well cemented, well sorted, slightly calcareous; asymmetrical ripple marks indicating flow directions of S12°E and S16°E; massive, cliff former; sharp lower contact with unit 23; upper part contains minor grass and branch impressions; middle part includes tuffaceous pebble conglomerate and tuffaceous sandstone with average clast size 0.3 inch in diameter and as much as 0.5 inch that is well cemented, poorly sorted, and with channel-shaped lens 1.3 feet thick; upper and lower surfaces are bounded by thin siltstone layers with grass impressions; forms ledge.
- 23 0.4 **Air-fall tuff**, tan, moderately cemented, common biotite; massive; forms slope.
- 22 2.6 **Tuffaceous sandstone**, purple, weathers tan to gray, medium to fine grained, poorly cemented, well sorted, argillaceous; upper 8 inches is trough crossbedded; massive, moderately resistant; sharp lower contact with unit 21.

- 21 2.2 **Tuffaceous sandstone**, white, weathers tan, fine to medium grained, moderately cemented, well sorted; calcareous, moderately resistant; upper half contains small-scale trough crossbedding; lower half has been disrupted by squeeze-up structures from underlying unit; sharp lower contact with unit 20.
- 20 1.0 **Tuffaceous sandstone**, white, fine to very fine grained, well cemented, well sorted, moderately calcareous; contains common biotite, and minor calcite-filled burrow casts; moderately resistant; sharp lower contact with unit 19.
- 19 0.3 **Sandstone**, white, very fine grained, well cemented, moderately sorted, very calcareous; contains minor biotite, calcite-filled burrow casts, and small-scale trough crossbedding; resistant; sharp lower contact with unit 18.
- 18 0.6 **Air-fall tuff**, tan, moderately cemented, well sorted; contains common biotite and minor dendritic pyrolusite; highly fractured; exhibits faint tabular bedding; forms slope; sharp lower contact with unit 17.
- 17 0.8 **Tuffaceous mudstone to tuffaceous siltstone** in alternating 0.4-inch-thick beds; white, poorly cemented, well sorted, very calcareous; contains common biotite, paper-thin bedding layers, and desiccation cracks; forms slope; probably of lacustrine origin.
- 16 0.7 **Silicified mudstone**, dark olive-green, well cemented, slightly calcareous; contains minor dendritic pyrolusite and trace of biotite; conchoidally fractured; calcite fillings common; massive, resistant.
- 15 3.5 **Claystone**, pale-green, moderately cemented, well sorted, moderately calcareous; contains minor pyrolusite; coarsens upward; massive; forms slope.
- 14 0.4 **Siltstone**, pale-green to olive-green, well cemented, well sorted; contains minor pyrolusite, common biotite, poorly developed planar bedding; forms slope; upper and lower contacts gradational.
- 13 6.4 **Tuffaceous sandstone**, whitish-blue to white, weathers tan, moderately to well cemented, poorly sorted, generally fine to medium grained but with locally abundant coarse- and very coarse-grained fractions; slightly calcareous, argillaceous; contains trace burrow casts; massive, resistant.
- 12 2.0 **Air-fall tuff**, white; contains minor pyrolusite and common opaline nodules and veinlets; highly fractured; upper 9 inches are sandy; massive; sharp lower contact with unit 11.
- 11 3.6 **Tuffaceous sandstone**, whitish-blue, fine to medium grained, bioturbated; contains minor horizontal to low-angle planar crossbeds; upper 10 inches are coarse to very coarse grained; sharp lower contact with unit 10; grades laterally to tuffaceous clast-supported pebble conglomerate.
- 10 5.6 **Tuffaceous sandstone**, white to very pale olive-green, weathers tan, fine to medium grained, moderately cemented, moderately sorted, moderately calcareous; middle contains sparse burrow casts; forms slope.
- 9 0.4 **Tuffaceous sandstone**, brownish-green, fine to very fine grained, well cemented, poorly sorted, slightly calcareous, partly silicified; contains sparse burrow casts; resistant.
- 8 2.9 **Tuffaceous sandstone**, fine to medium grained, moderately to well cemented, poorly sorted, very calcareous; contains burrow casts in lower 8 inches; massive, resistant.
- 7 0.3 **Mudstone**, dark olive-green, well cemented, slightly calcareous; contains common biotite and sparse burrow casts; partially silicified; massive, resistant.
- 6 2.3 **Calcareous claystone or limestone**, similar to unit 4, with 2-inch-thick bed of calcareous mudstone; white, moderately cemented, marly, highly bioturbated; forms slope.
- 5 0.7 **Shale**, alternating white and siliceous olive-green laminae; slightly calcareous; contains common biotite and sparse black carbonaceous(?) material; moderately resistant; probably lacustrine.

4	3.7	Calcareous claystone or limestone , pale- to olive-green, well sorted, conchoidal fractures; contains common biotite; generally massive but with minor tabular bedding; forms slope; sharp lower contact with unit 3.
3	27.6	Tuffaceous sandstone , whitish-blue, weathers white, fine to medium grained, moderately to poorly cemented, moderately to well sorted; sparse lenses up to 1.3 feet thick of bimodal medium- to very coarse-grained sand; extensive calcite-filled burrow casts, bioturbated; massive, becoming finely bedded upwards; semi-resistant; four 0.2- to 2-inch-thick beds of white air-fall tuff occur in upper 5 feet; sparse, 2-inch-thick lenses of siltstone (air-fall tuff?) in middle of unit; gradational lower contact with unit 2.
2	1.8	Tuffaceous sandstone , white, weathers tan, very fine grained, poorly to moderately cemented, well sorted, moderately calcareous; contains common bronze biotite and minor calcite-filled rootlet casts which increase upwards; forms slope; gradational lower contact with unit 1.
1	1.0+	Tuffaceous sandstone , bluish-white, weathers tan, bimodal, fine grained and medium to very coarse grained with minor granule-sized clasts, moderately cemented, poorly sorted, very calcareous; contains a few calcite-filled burrow casts; forms slope.

Base of section in contact with Quaternary alluvium about 30 feet above stream level.

125+ feet (38+ m) - Thickness of Section 1

39.3 feet (12 m) - Thickness down to the top of marker bed (unit 29)

Stratigraphic Section 2 Lower part of formation

Located on south-facing slope in unnamed drainage 1.3 miles (2.1 km) southeast of Hatch Mountain (NE $\frac{1}{4}$ NW $\frac{1}{4}$ section 36, T. 36 S., R. 6 W.)(figure 2). Measured and described by R. A. Kurlich, III, 1986; descriptions modified by E. G. Sable, 1991. Overlies Brian Head Formation (restricted). Top of section eroded.

Top of Section

Unit	Thickness (feet)	Limerock Canyon Formation (part)
35	18.9	Tuffaceous pebbly sandstone to pebble conglomerate , tan, fine to coarse grained, well cemented, poorly sorted, trace of burrow casts; massive with faint bedding, resistant; conglomerate is matrix supported; grades laterally to tuffaceous sandstone containing faint trough crossbedding; includes a prominent cliff-forming layer 12 feet thick at the top and a 1-foot-thick tuffaceous pebble conglomerate channel fill in uppermost part; sharp lower contact with unit 34. <u>Correlative with unit 29 of the upper Limerock Canyon section.</u>
34	10.5	Tuffaceous sandstone , white to very pale-green, bimodal, fine to medium grained with granule-size clasts, poorly to moderately cemented, poorly sorted, moderately calcareous; mostly massive; upper part of unit weathers tan and contains burrow casts.
33	0.3	Silicified mudstone , olive-green; contains minor pyrolusite; massive, resistant.
32	7.9	Tuffaceous sandstone , similar to unit 26.
31	8.1	Mudstone , similar to unit 27.
30	0.1	Shale , similar to unit 28.
29	0.8	Mudstone , similar to unit 27.
28	0.1	Shale , alternating white and olive-green laminae, highly siliceous; contains minor pyrolusite; resistant.

- 27 0.8 **Tuffaceous mudstone**, olive-green, moderately cemented, moderately calcareous; contains common bronze biotite; massive; forms slope.
- 26 4.6 **Tuffaceous mudstone**, olive-green to tan, bimodal, fine- to medium-grained sand and very coarse-grained sand to granule-size clasts and minor pebbles, poorly cemented, moderately well sorted, slightly calcareous; contains calcite-filled burrow casts; forms slope.
- 25 5.0 **Tuffaceous sandstone**, bluish-white to white, bimodal, fine grained sand and granules, common burrow casts; massive, very resistant.
- 24 1.3 **Tuffaceous sandstone**, similar to unit 23, but weathers to 1-inch-diameter nodules.
- 23 8.1 **Tuffaceous sandstone**, bluish-white to white, fine grained, well cemented, well sorted; contains common root casts; coarsens to pebbly sandstone upwards; massive, moderately resistant.
- 22 0.8 **Tuffaceous sandstone**, pale-green, fine grained, well cemented; root casts common; massive, moderately resistant.
- 21 0.4 **Air-fall tuff**, grayish-white, root casts common.
- 20 1.7 **Tuffaceous sandstone**, pale-green, fine grained, well cemented; contains abundant vertical rootlet casts; massive, moderately resistant.
- 19 3.7 **Tuffaceous sandstone**, white to very pale-green, fine to medium grained, contains abundant 0.1-inch-diameter calcite-filled vertical root casts; massive.
- 18 6.7 **Tuffaceous sandstone**, white, fine grained, poorly to moderately cemented, well sorted; basal zone 0.8 feet thick weathers to 1-inch-diameter nodules; massive, resistant.
- 17 5.7 **Tuffaceous sandstone**, olive-green, bimodal, sand and granules, fines upwards, moderately cemented, poorly to moderately sorted, slightly calcareous; massive, resistant.
- 16 10.8 **Tuffaceous sandstone**, white, fine to medium grained, moderately to well cemented, moderately well sorted, slightly calcareous, vertical root casts 0.3 feet in diameter; moderately resistant ledge and slope former.
- 15 2.9 **Tuffaceous sandstone**, similar to unit 13.
- 14 1.7 **Calcareous mudstone or limestone**, olive-green, poorly cemented, partly silicified; contains minor pyrolusite; moderately resistant, forms slope.
- 13 3.3 **Tuffaceous sandstone**, tan to brown, medium grained, moderately to poorly cemented, moderately sorted, slightly calcareous; massive; forms slope.
- 12 5.4 **Tuffaceous sandstone**, bluish-white, bimodal, fine- to medium-grained sand and coarse- to very coarse-grained sand, well cemented, poorly sorted, very calcareous; contains trace burrow casts; massive, resistant; grades laterally into tuffaceous pebble conglomerate.
- 11 3.7 **Tuffaceous pebbly sandstone**, similar to unit 8.
- 10 1.2 **Tuffaceous pebbly sandstone**, similar to unit 8, but weathers to 1-inch-diameter nodules.
- 9 2.5 **Tuffaceous pebbly sandstone**, similar to unit 8.
- 8 48.6 **Tuffaceous sandstone to tuffaceous pebbly sandstone**, tan, weathers white, poorly sorted to bimodal with fine- to coarse-grained sand and pebbles; moderately to well cemented by silica that increases upwards; massive; forms slope; at 27 feet above base of unit two 1-inch-thick, white air-fall tuff layers are separated by 0.7 feet of tuffaceous sandstone; at 16 feet below top of unit is a 0.2-foot-thick zone of irregularly shaped white to grayish-white, flattened siliceous nodules; unit is extremely resistant.

- 7 1.2 **Air-fall tuff**, white; contains small flakes of biotite; forms slope.
- 6 0.2 **Air-fall tuff**, white, with chocolate-brown chalcedony in alternating irregular replacement bands, minor biotite throughout; resistant unit.
- 5 0.2 **Tuffaceous limestone**, white to very light-blue, well cemented, speckled with abundant dendritic pyrolusite and minor biotite; contains a thin bed of air-fall tuff; resistant unit.
- 4 21.6 **Tuffaceous sandstone**, whitish-blue, weathers tan, medium grained, well cemented, poorly sorted, calcareous, medium bedded; has highly silicified zones; resistant; gradational with unit 3.
- 3 27.0 **Tuffaceous sandstone**, whitish-blue, weathers white, generally medium to fine grained but also bimodal with coarse-grained and fine- to medium-grained sand, moderately cemented, moderately to poorly sorted, calcareous; moderately resistant; 2-foot-thick basal part weathers into 1-inch-diameter nodules.
- 2 19.6 **Tuffaceous sandstone**, white to very pale-green, generally fine to coarse grained, becomes bimodal upwards containing fine- to very coarse-grained sand, moderately to well cemented, poorly to moderately sorted, calcareous, resistant; upper part contains zone of poorly preserved calcite-filled burrow casts.
- 1 16.2 **Tuffaceous sandstone**, pale-green, generally fine to medium grained, bimodal with coarse-grained sand, coarsens upwards, moderately well cemented, moderately to poorly sorted, calcareous; contains minor bronze biotite; lower contact sharp; slope and ledge former.

Base of Limerock Canyon Formation

251.6 feet (76.7 m) - Thickness of Section 2

232.7 feet (71 m) - Thickness up to the base of marker bed (unit 35)

Brian Head Formation (restricted), part

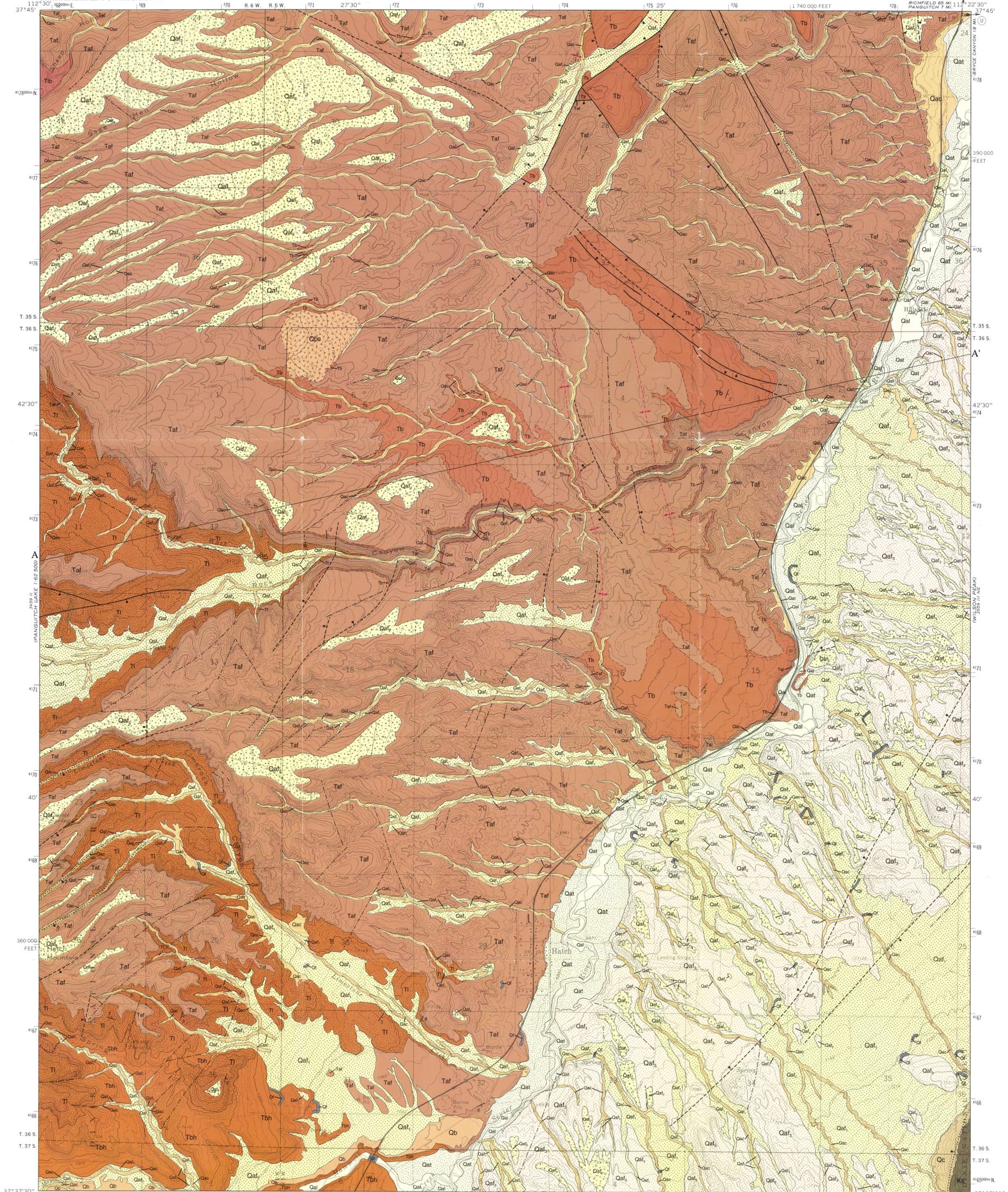
- 29.0+ **Limestone**, white to very pale green, weathers gray, vuggy, nodular; vugs filled with calcite crystals or green limestone; contains minor dendritic pyrolusite, minor brecciation and stylolites; massive to poorly bedded, resistant; contains minor green and black siliceous veinlets and nodules in uppermost part.

39.3 feet (12 m) - Thickness of Section 1 down to top of marker bed

18.9 feet (5.8 m) - Thickness of marker bed (unit 35) in Section 2

232.7 feet (71 m) - Thickness of Section 2 up to base of marker bed

290.9 feet (88.7) - **Total** measured thickness of Limerock Canyon Formation



GEOLOGIC MAP OF THE HATCH QUADRANGLE, GARFIELD COUNTY, UTAH

by

Richard A. Kurlich III
and
John J. Anderson

1997

The Miscellaneous Publication Maps provide an outlet for authors who are not Utah Geological Survey staff. Not all aspects of this publication have been reviewed by the UGS.

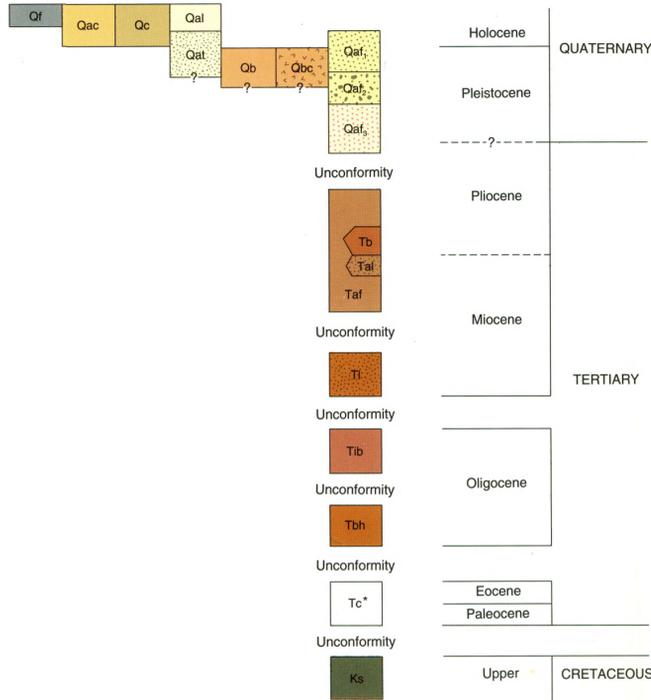
DESCRIPTION OF MAP UNITS

- Qf** Artificial Fill - Locally derived fill material in earthen dams and along drainage ditches.
- Qc** Colluvium - Talus and slopewash that accumulate at the base of cliffs; thickness variable, may exceed tens of feet.
- Qal** Channel and Floodplain Alluvium - Unconsolidated silt, sand, and gravel along the Sevier River and Mammoth Creek; thickness 20 feet (6 m) or less.
- Qat** Terrace Deposits - Unconsolidated silt, sand, and gravel on abandoned floodplains along the Sevier River and Mammoth Creek; thickness less than 25 feet (8 m).
- Qac** Alluvium and Colluvium - Unconsolidated silt, sand, and gravel in and next to small stream channels and locally in alluvial fans; thickness a few feet.
- Qaf** Younger Alluvial-Fan Deposits - Unconsolidated silt, sand, and gravel capping broad sloping plains and in drainages; thickness up to 13 feet (4 m).
- Qaf_s** Intermediate Alluvial-Fan Deposits - Unconsolidated silt, sand, and gravel in mounds and ridges that are erosional remnants as much as 140 feet (43 m) above present drainage levels; thickness up to 13 feet (4 m).
- Qbc** Basaltic Cinder Cone - Unconsolidated, angular blocks of brick-red, highly scoriaceous basaltic debris; possibly the remains of a cinder cone; thickness only a few feet.
- Qb** Quaternary Basalt Flow - Gray to black, vesicular to scoriaceous, phenocryst-rich, olivine basalt in the valley of Mammoth Creek; thickness approximately 20 feet (6 m).
- Qaf_s** Older Alluvial-Fan Deposits - Moderately to poorly consolidated, pink, yellow, orange, and red silt, sand, and gravel; located east of the Sevier River; exposed thickness up to 200 feet (61 m).
- Tb** Tertiary Basalt - Dark reddish-brown and steel gray, vesicular to scoriaceous basalt; rich in olivine phenocrysts; thickness variable, with a maximum of 100 feet (30 m).
- Tal** Late Tertiary Alluvium - Moderately to poorly consolidated, pink silt, sand, and small gravel of unknown provenance; "nested" in late Tertiary alluvial-fan deposits and overlain by Tertiary basalt; thickness estimated at 100 feet (30 m).
- Taf** Late Tertiary Alluvial-Fan Deposits - Moderately well to poorly consolidated tan, pink, and "salt-and-pepper" colored, tuffaceous siltstone, sandstone, pebbly sandstone, and conglomerate; interbedded sparse limestone and air-fall tuff; overlies and underlies Tertiary basalt; thickness approximately 760 feet (232 m).
- Tl** Limerock Canyon Formation - Pale- to dark-green, white and bluish-white tuffaceous sandstone and lesser conglomerate and mudstone, with interbedded, numerous air-fall tuffs, minor shale, and local chalcodony; thickness approximately 250 feet (76 m).
- Tib** Baldhills Tuff Member of the Isom Formation - Welded ash-flow tuff with lower, blue-gray cooling unit and upper, dark-brown and reddish-purple, massive cooling unit; thickness estimated to be 100 feet (30 m).
- Tbh** Brian Head Formation (restricted) - White to tan and gray, argillaceous limestone, calcareous shale, siltstone, sandstone, and conglomerate; maximum exposed thickness approximately 180 feet (55 m).
- Tc** Claron Formation (cross section only) - Basal quartzite conglomerate overlain by argillaceous limestone and calcareous mudstone; thickness greater than 600 feet (183 m).
- Ks** Straight Cliffs Sandstone - Tan, massive to cross-bedded, fine- to medium-grained, well-sorted sandstone; thickness greater than 500 feet (152 m).

MAP SYMBOLS

- Contact - Dashed where approximately located on surface, or of unknown depth and configuration in cross sections.
- Strike and dip of inclined beds.
- Fault - Dashed where inferred or approximately located, dotted where concealed, ball and bar on down-thrown block.
- Lineament - Conspicuous linear features on aerial photographs, probable joint or fault of small displacement, direction of movement unknown.
- Slump block - Break-away scarp at head of a coherent block of slumped bedrock, hachures on down-thrown side.
- Anticline - Dashed where inferred or approximately located, dotted where concealed.
- Syncline - Dashed where inferred or approximately located, dotted where concealed.

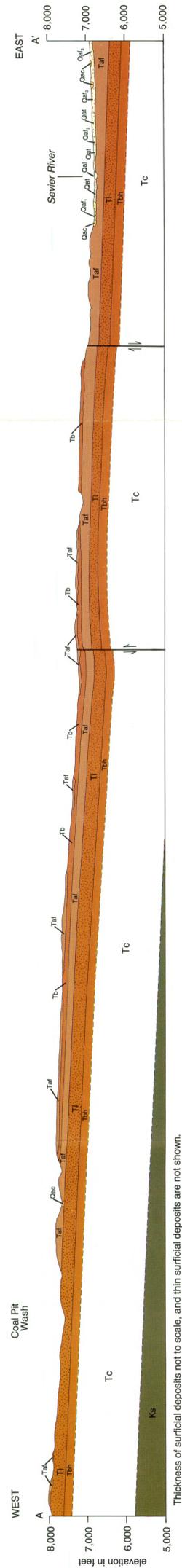
CORRELATION OF MAP UNITS



*Shown only in cross section

SYSTEM	SERIES	STRATIGRAPHIC UNITS	SYMBOL	THICKNESS in feet (meters)	LITHOLOGY
QUATERNARY	Holocene	Surficial Deposits	Qf Qal Qac Qc Qat Qaf Qaf _s	0 - 25* (0 - 8)	
	Pleistocene	Older Alluvial - Fan Deposits	Qaf _s	200+ (61+)	
TERTIARY	Pliocene	Tertiary Basalt	Tb	0 - 100 (0 - 30)	contact not exposed
		Late Tertiary Alluvium	Tal	0 - 100 (0 - 30)	Late Tertiary Alluvium
	Miocene	Late Tertiary Alluvial - Fan Deposits	Taf	760 (230)	
		Limerock Canyon Formation	Tl	290 (88)	
	Oligocene	Baldhills Tuff Member of Isom Formation	Tib	0 - 100+ (0 - 30+)	contact not exposed
		Brian Head Formation (restricted)	Tbh	180+ (55+)	contact not exposed
Eocene	Claron Formation	Tc	>600 (>180)	not exposed	
Paleocene	Claron Formation	Tc	>600 (>180)	not exposed	
CRETACEOUS	Cretaceous	Straight Cliffs Sandstone	Ks	500+ (150+)	

*Thickness of surficial deposits not to scale.



Thickness of surficial deposits not to scale, and thin surficial deposits are not shown.