UTAH GEOLOGICAL AND MINERAL SURVEY
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UTAH DEPARTMENT OF NATURAL RESOURCES

Base map from U.S. Geological Survey, Boulder Mountain 7.5' quadrangle, 1969

Dr. Linda B. McCollum, Thesis Advisor
J.W. Parker, Cartographer

(PORCUPINE RESERVOIR) 3667 II SW

(CURTIS RIDGE) 3767 III SW

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

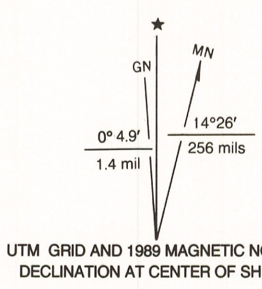
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

PROVISIONAL GEOLOGIC MAP OF THE BOULDER MOUNTAIN QUADRANGLE, CACHE COUNTY, UTAH

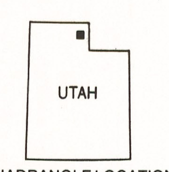
by

Andrew R. Mork

1990

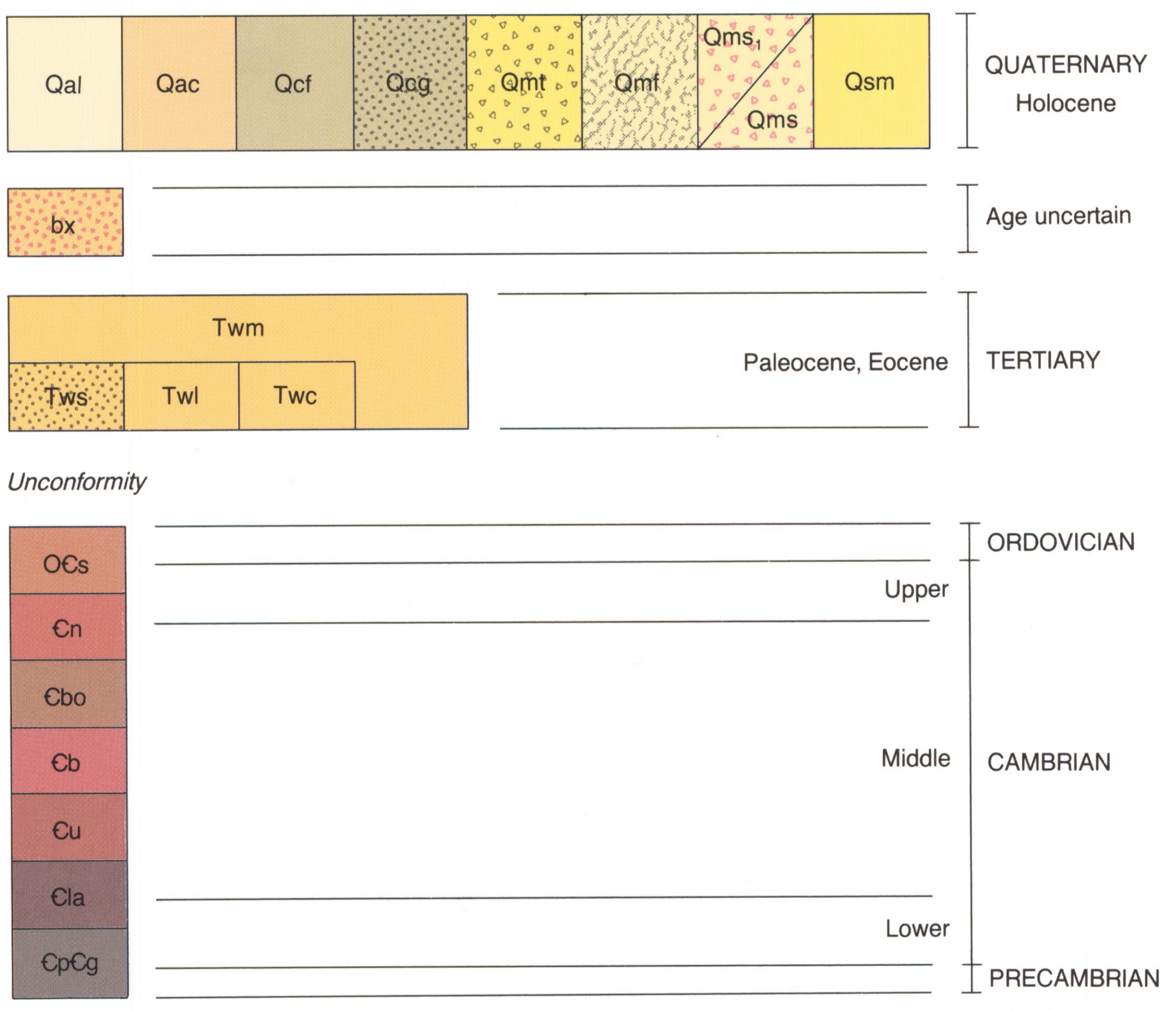


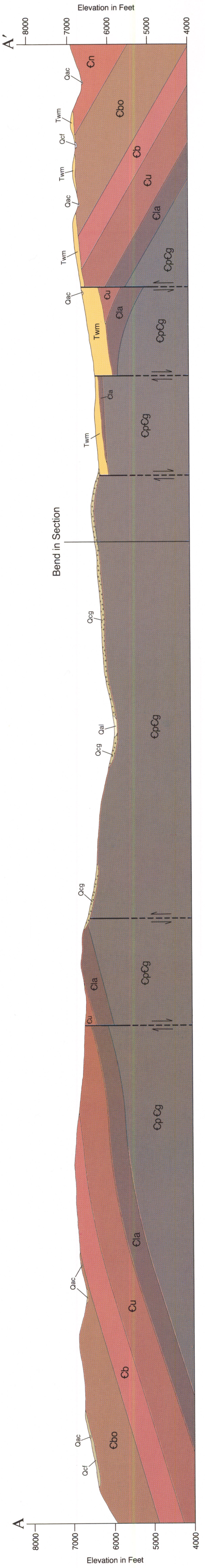
UTM GRID AND 1989 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



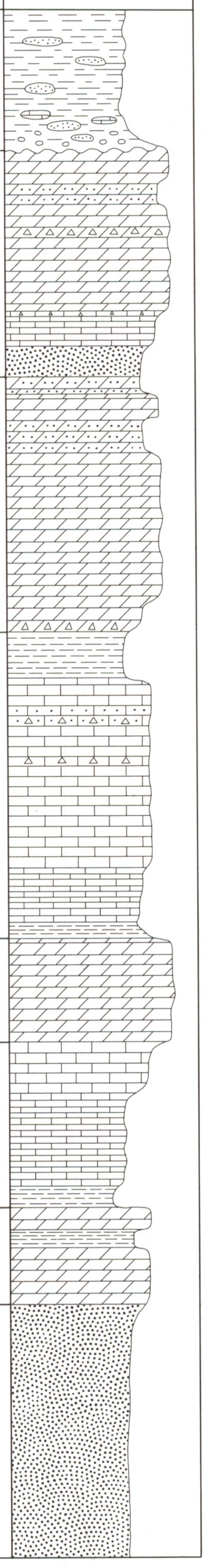
QUADRANGLE LOCATION

CORRELATION OF MAP UNITS





FORMATION	SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
WASATCH FORMATION	Twm Tws Twl Twc	605 (185)	
ST. CHARLES FORMATION	OЄs	980 (299)	
NOUNAN DOLOMITE	Єn	1115 (340)	
BLOOMINGTON FORMATION	Єbo	1305 (398)	
BLACKSMITH DOLOMITE	Єb	460 (140)	
UTE FORMATION	Єu	720 (220)	
LANGSTON DOLOMITE	Єla	420 (128)	
GEERTSEN CANYON QUARTZITE	ЄpCg	1100+ (335+)	



MAP SYMBOLS

CONTACT — *Dashed where approximately located.*

NORMAL FAULT — *Dashed where approximately located, dotted where concealed, queried where probable; bar and ball on downthrown side.*

10 STRIKE AND DIP OF BEDDING

AXIAL TRACE OF ANTICLINE — *Dotted where covered.*

ADIT INACCESSIBLE ADIT SHAFT

DESCRIPTION OF MAP UNITS

- **Qal** Alluvium — *Silt, sand, and gravel in channels and on floodplains.*
- **Qac** Colluvial alluvium — *Alluvium having a large colluvial component, along low-order ephemeral streams.*
- **Qcf** Fine colluvium — *Fine-grained colluvium; poorly sorted.*
- **Qcg** Gravelly colluvium — *Fine-grained colluvium; including cobbles and boulders; poorly sorted.*
- **Qmt** Talus — *Boulder-sized rock-fall deposits.*
- **Qmf** Debris flows — *Poorly sorted, angular clasts in a mud matrix.*
- **Qms,** Younger landslides — *Continuing, successive landslides, as a result of renewed slope instability.*
- **Qms** Slides and slumps — *Includes small rotational slumps and large complex slides.*
- **Qsm** Marsh deposits — *Organic-rich mud associated with some springs.*
- **bx** Silicified breccia — *Dense, resistant, dark brown, silicified quartzite, altered carbonate rocks, and brecciated jasperoid.*
- **Twm** Wasatch Formation, mudstone — *Moderate red mudstone, with scattered, small interbeds of sandstone, conglomerate, and pisolitic limestone.*
- **Tws** Wasatch Formation, sandstone — *Moderate red, medium bedded, poorly sorted sandstone; commonly crossbedded.*
- **Twl** Wasatch Formation, pisolitic limestone — *Yellowish brown pisolites in a yellowish gray, sparry matrix.*
- **Twc** Wasatch Formation, conglomerate — *Pebble to small boulder size sandstone and carbonate clasts in a reddish-brown sandstone matrix.*
- **OЄs** St. Charles Formation — *Medium-gray, massive dolomite, dark-gray, thin-bedded limestone, and moderate orange, medium bedded, calcareous sandstone.*
- **Єn** Nounan Dolomite — *Light gray, massive, vuggy dolomite, sandy at top, cherty at base.*
- **Єbo** Bloomington Formation — *Blue-gray, thin to medium bedded limestone and silty limestone, and olive gray to dusky yellow, laminated, calcareous shale.*
- **Єb** Blacksmith Dolomite — *Light gray, massive, cliff-forming dolomite, zones of solution breccia common in middle portion.*
- **Єu** Ute Formation — *Medium to light gray, thin to medium bedded limestone and silty limestone, and dusky yellow, laminated, siliceous shale. Grades into light gray, thick bedded, oolitic limestone towards top.*
- **Єla** Langston Dolomite — *Light gray, tan weathering, thick bedded dolomite. Includes light gray, calcareous shale in upper third.*
- **ЄpCg** Geertsen Canyon Quartzite — *Orange-pink to dark olive gray, medium bedded quartzite with occasional pebble lags.*

PROVISIONAL GEOLOGIC MAP OF THE BOULDER MOUNTAIN QUADRANGLE, CACHE COUNTY, UTAH

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MAP 125 **1990**

PROVISIONAL GEOLOGIC MAP OF THE BOULDER MOUNTAIN QUADRANGLE, CACHE COUNTY, UTAH

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ABSTRACT

The Boulder Mountain 7.5-minute quadrangle is located in the Bear River Range of north-central Utah. The quadrangle is underlain by allochthonous strata ranging in age from the late Proterozoic to Early Ordovician, which are unconformably overlain by Cenozoic deposits. The late Proterozoic to early Paleozoic section is composed of seven formations with an aggregate thickness of at least 6100 feet (1860 m). In ascending order, the stratigraphic sequence includes the late Proterozoic to early Middle Cambrian Geertsen Canyon Quartzite, the Middle Cambrian Langston Dolomite, Ute Formation, Blacksmith Dolomite, Bloomington Formation, the Upper Cambrian Nounan Dolomite, and the Upper Cambrian to Lower Ordovician St. Charles Formation.

Late Cretaceous to early Tertiary thrusting within the Sevier orogenic belt gently folded and transported the Cache allochthon eastward approximately 62 miles (100 km) to its present location. Erosion of the Sevier uplands provided sediments for the early Tertiary Wasatch Formation.

The Wasatch Formation rests with angular unconformity upon a regional erosion surface of low to moderate relief. The heterogeneous Wasatch consists predominantly of moderate red mudstone with interbedded lenses of sandstone, pebble to cobble conglomerate, and pisolitic limestone that are generally restricted to the lower 100 feet (30 m). Maximum thickness of the Wasatch Formation within the quadrangle is approximately 605 feet (185 m).

A series of north-trending high-angle faults were emplaced during late Tertiary extension. Displacement on the faults is approximately 400 feet (120 m).

Quaternary surficial deposits consist of colluvial, alluvial, and paludal sediments. Landslides, debris flows, and flash floods pose the greatest potential as geologic hazards.

INTRODUCTION

The Boulder Mountain 7.5-minute quadrangle lies within the Logan and Blacksmith Fork drainage basins in the central Bear River Range of northern Utah. This region was included in the Middle Rocky Mountain physiographic province by Fenneman (1946), and in the southern portion of the Cache allochthon by Crittenden (1972).

The Cache allochthon is bounded on the south and east by the Willard-Woodruff-Paris thrust system, and on the west by the high-angle Wasatch Fault (Crittenden, 1972; Royse and others, 1975). To the north it is believed to extend under the Snake River Plain (Blackstone, 1977). Estimates of tectonic displacement during the Late Cretaceous to early Tertiary Sevier orogeny (Armstrong, 1968) range from a minimum of 30 miles (48 km) by Armstrong (1968), to 65 miles (105 km) by Royse and others (1975). Rocks of the allochthon include a thin basal phyllitic schist about 1.5 billion years old (Crittenden, McKee, and Peterman, 1971), overlain by the Late Proterozoic Brigham Group and a thick section of Paleozoic carbonate and clastic rocks typical of the Cordilleran miogeocline (Crittenden, 1972).

Erosion of the Sevier uplands during the early Tertiary resulted in the deposition of the Wasatch Formation on a Paleozoic bedrock surface of low relief. The Wasatch forms a clastic wedge that thickens and has finer texture to the east, intercalating with the coeval Green River Formation in southwest Wyoming.

Rocks of Wasatch age and older are displaced by late Tertiary Basin and Range extensional faults. Substantial displacement has occurred along high-angle faults bordering

[1]Dames and Moore, San Francisco, California

Cache Valley, but offset within the Boulder Mountain quadrangle is generally less than 395 feet (120 m).

Maximum relief in the area is 2467 feet (752 m). Elevations range from 5587 feet (1703 m) where the Left Hand Fork of the Blacksmith Fork River exits the quadrangle, to 8055 feet (2455 m) on the ridge at the headwaters of Corral Hollow in the northeast corner of the map area.

STRATIGRAPHY

Strata in the Boulder Mountain quadrangle are restricted to the Precambrian Erathem and Cambrian and Tertiary Systems and have an aggregate exposed thickness of at least 6710 feet (2045 m). The Cambrian sequence was originally described by Walcott (1908a, b), who designated the Bear River Range as an important reference section for the Cambrian System in this region. Subsequent work by Richardson (1913), Mansfield (1927), Deiss (1938), Resser (1939), Williams and Maxey (1941), Denson (1942), Maxey (1958), Crittenden, Schaeffer, Trimble, and Woodward (1971), Campbell (1974), and Taylor and Landing (1982) has refined Walcott's original designations and age assignments.

GEERTSEN CANYON QUARTZITE (Precambrian-Middle Cambrian)

The Geertsen Canyon Quartzite forms rounded hills covered with quartzite rubble. Although the base of the unit is not exposed, topographic relationships indicate a minimum thickness of 1100 feet (335 m). The Geertsen Canyon Quartzite consists of highly indurated, orange-pink to dark olive-gray quartzite beds 1 to 3 feet (0.3 to 1 m) thick. The beds are composed of medium- to coarse-grained, moderately sorted, subround to round quartz, with occasional lags or isolated, well-rounded pebbles of white quartz or jasper. The grains are cemented by silica, or locally by iron oxide. Where iron oxide cement predominates, the rock is friable. Pebbly beds are common in the lower 804 feet (245 m). The upper 295 feet (90 m) are characterized by frequent micaceous shale partings between quartzite beds. In this upper interval *Scolithos* is common in the quartzites and the shales contain numerous epistratal traces.

Walcott (1908a, b) designated the name Brigham for the thick series of quartzites that underlie the Middle Cambrian carbonates in his Blacksmith Fork section. Crittenden, Schaeffer, Trimble, and Woodward (1971) elevated the name Brigham to group status and established the Late Proterozoic to Middle Cambrian Geertsen Canyon Quartzite as the uppermost formation of the Brigham Group. Faunas of the Lower Cambrian *Olenellus* through the Middle Cambrian *Albertella* trilobite zones have been found within the Geertsen Canyon Quartzite at other locations in northern Utah (Campbell, 1974).

LANGSTON DOLOMITE (Middle Cambrian)

The Langston Dolomite consists of two dolomite units separated by a calcareous shale and is 420 feet (128 m) thick. It crops out as ledges and small discontinuous cliffs that weather to a distinctive moderate yellowish brown. The lower dolomite is 280 feet (85 m) thick, light to medium gray, and medium to thick bedded. It is sandy at the base, passing up through subequal, superjacent 66-foot (20 m) zones of pisolitic, birdseye, and cross-laminated silty dolomite. Neither the Naomi Peak Limestone nor Spence Shale are present in this section. Both members pinch out from the north and west into the thick lower dolomite unit (Maxey, 1958). The 66-foot-thick (20 m) middle shale is light gray, finely laminated and calcareous, with several thin interbeds of dark-gray, medium-grained, fossiliferous limestone. The upper dolomite unit is 75 feet (23 m) thick and texturally similar to the lower dolomite. Patches up to 20 feet (6 m) thick of the upper unit remain undolomitized, and the relict limestone is grayish blue, thick bedded, and contains abundant oncolites. Fossils of the *Albertella* and *Glossopleura* trilobite zones are present in the Langston Dolomite (Campbell, 1974).

UTE FORMATION (Middle Cambrian)

The Ute Formation consists of thin- to thick-bedded limestone and laminated shale between the cliff-forming Langston and Blacksmith Dolomites. The lower 460 feet (140 m) consists of medium-gray to dark-gray, thin to medium wavy bedded, silty limestone alternating with dusky yellow, finely laminated, siliceous shale. The basal contact of the Ute is drawn at the base of a 30-foot-thick (9 m) shale containing a mixed *Glossopleura-Ehmaniella* fauna. An *Ehmaniella* zone fauna is present throughout the Ute. Thin but laterally extensive horizons of oolitic and stromatolitic limestone at 102 and 361 feet (31 and 100 m) above the base make good marker beds. The upper Ute is composed of medium-gray to light-gray, medium- to thick-bedded, oolitic limestone, and intraformational conglomerate, with minor amounts of wavy bedded, silty limestone. Discontinuous dolomite lenses occur above 492 feet (150 m). The top of the Ute Dolomite is irregular due to uneven dolomitization; minimum thickness is 720 feet (220 m).

BLACKSMITH DOLOMITE (Middle Cambrian)

The prominent light-gray cliffs of the Blacksmith Dolomite stand in sharp contrast to the shaly units above and below. The Blacksmith consists of very light-gray to medium-gray, fine- to medium-crystalline, thick-bedded to massive dolomite, and it is 460 feet (140 m) thick. The basal limestones of the Blacksmith contain elements of the long-ranging *Bolaspidella* trilobite zone locally, and of the *Ptychagnostus gibbus* agnostid zone further to the southwest. Cryptalgal laminae are common in the lower 95 feet (29 m). Oolitic beds 1 to 5 inches (3 to 13 cm) thick, birdseye structures, vertical burrows and wavy bedded silty laminae are characteristic of the upper Blacksmith Dolomite. Within the top 62 feet (19 m) are two closely spaced bands of white laminated dolomite, together about 23 feet (7 m) thick, that form distinctive white stripes on cliff faces.

A diagnostic feature of the Blacksmith Dolomite in this quadrangle is the multiple concordant, tabular breccia zones. Brecciation ranges in a continuum from slight to intense, from small white silica stringers parallel to bedding to chaotic fractures up to 8 inches (20 cm) across. The clasts are rotated (cannot be reassembled in place like a jigsaw puzzle) but not appreciably rounded or "milled." The most intense brecciation occurs in a 39-foot-thick (12 m) zone starting about 289 feet (88 m) above the base. Beds above and below the breccias do not appear disturbed. This horizon may represent a zone of horizontal adjustment within the allochthon. As there are no references to this texture in the literature, the brecciation is assumed to be a local feature.

BLOOMINGTON FORMATION
(Middle Cambrian)

The Bloomington Formation usually crops out as shaly slopes with abundant flaggy carbonate clasts. However, between Gray Cliff Spring and Bear Hollow it forms high discontinuous cliffs capped by the lighter weathering Nounan Dolomite. Float from the Bloomington Formation can be distinguished from the lithologically similar Ute Formation because it weathers to a dark bluish-gray, in contrast to the yellowish browns and grays of the Ute Formation.

The Bloomington Formation includes three members: the basal Hodges Shale Member (Richardson, 1913), a middle carbonate member, and the upper Calls Fort Shale Member (Denson, 1942). The Bloomington is 1305 feet (398 m) thick in a section measured approximately 2 miles (3.2 km) west of the southwest corner of the Boulder Mountain quadrangle in Blacksmith Fork Canyon. As noted by Deiss (1938), shale is subordinate to carbonate in the Hodges Shale Member at the Blacksmith Fork Canyon. The Hodges Shale Member consists of 361 feet (110 m) of medium-gray, finely crystalline, thin, wavy bedded, silty limestone and intraformational conglomerate. Interbedded with the carbonates are pale-yellowish-orange to light-olive-gray, laminated, calcareous, micaceous shales with many epistratal traces. The middle carbonate member is composed of limestone that is medium dark gray, fine to medium crystalline, medium to thick bedded, and silty limestone, with subordinate amounts of oolitic limestone, intraformational conglomerate, and chert nodules and lenses. Calcite-filled vertical fractures are common. Some beds have a petroliferous odor on freshly fractured surfaces. The Calls Fort Shale Member is 184 feet (56 m) thick, consisting of light-olive-gray to dusky yellow, finely laminated, calcareous shale, with thin interbeds of intraformational conglomerate and thin-bedded limestone. The Bloomington Formation contains a fauna characteristic of the *Bolaspidella* trilobite zone (Denson, 1942).

NOUNAN DOLOMITE
(Upper Cambrian)

In the map area the Nounan Dolomite crops out as a lighter colored unit in the cliffs above Gray Cliff Spring, and as small ledges on steep slopes elsewhere. The base is marked by 95 feet (29 m) of medium-gray, thin-bedded dolomite containing many oolitic beds and chert nodules. These pass upward into a 705-foot-thick (215 m) interval of very light-gray to medium-gray, medium-bedded to massive, cliff-forming dolomite, with subordinate amounts of intraformational conglomerate, wavy bedded silty dolomite, and thin-bedded petroliferous limestone. Much of the middle interval is vuggy and extensively recrystallized. The upper 315 feet (96 m) are dominated by light-gray, thin-bedded sandy dolomite that weathers to a distinctive purplish red. The sparsely fossiliferous Nounan Dolomite includes strata from the *Cedaria* through *Dunderbergia* trilobite zones. It is 1115 feet (340 m) thick in a section measured about 2.3 miles (3.7 km) west of the Boulder Mountain quadrangle in Blacksmith Fork Canyon.

ST. CHARLES FORMATION
(Upper Cambrian-Lower Ordovician)

The lower 400 feet (122 m) of the St. Charles Formation are exposed on the ridge between Herd and Seep Hollows (section 8 and 9, T. 11 N., R. 3 E.). Here, the St. Charles crops out as low ledges of limestone that weather into abundant blocky float. The massive dolomite of the upper St. Charles is exposed in isolated outcrops on the east side of Herd Hollow, in Ricks and Little Ricks Canyons, and in upper Bear Hollow east of Sheep Creek Spring. The top of the St. Charles is not exposed in the quadrangle. The St. Charles Formation is 980 feet (299 m) thick in Blacksmith Fork Canyon approximately 2.6 miles (4.2 km) west of the Boulder Mountain quadrangle.

The St. Charles is divided into the basal Worm Creek Quartzite Member (Richardson, 1913), a middle thin-bedded limestone unit, and an upper unit of massive dolomite. The 79-foot-thick (24 m) Worm Creek Quartzite is a grayish-orange to yellowish-gray, fine- to medium-grained, massive, calcareous sandstone, with thin interbeds of medium-gray, coarse-grained limestone. It is poorly exposed and difficult to differentiate from the sandy dolomite of the upper Nounan Formation. The middle unit is composed of 161 feet (49 m) of medium-gray to light-gray, finely crystalline, thin- to medium-plane-bedded, fossiliferous limestone, passing upward into thick-bedded, silty dolomite with interbedded chert nodules. The 741-foot-thick (226 m), cliff-forming upper unit consists of medium-light-gray to medium-gray, massive dolomite with chert lenses and layers, and crossbedded oolitic dolomite. Faunas of the St. Charles Formation range from the basal Franconian *Elvinia* to the Lower Ordovician *Missiquoia* trilobite zones (Taylor and Landing, 1982).

WASATCH FORMATION
(Paleocene-Eocene)

The Paleocene-lower Eocene Wasatch Formation (Hayden, 1869) unconformably overlies all older formations. It is poorly exposed, usually forming smooth slopes covered in aspen or grass. There are no persistent correlatable horizons within the Wasatch Formation, although the coarse clastic and carbonate units are generally restricted to the lower 98 feet (30 m). Because bedding in the formation is indistinct to absent, attitudes are difficult to determine. Based on topographic relationships, its maximum thickness in the map area is probably close to 605 feet (185 m).

Four lithologies were mapped within the Wasatch Formation: pebble-to-cobble conglomerate, sandstone, pisolitic limestone, and mudstone. The conglomerate (Twc) consists of sandstone and carbonate clasts in a reddish-brown to moderate-orange, poorly sorted matrix of sand, silt, and clay. The clasts are angular to sub-round, and average 2 inches (5 cm) in diameter, although they range up to 24 inches (61 cm). Clasts show no preferred orientation. Pebble counts of 100 clasts from each of nine conglomerate outcrops averaged 81 percent sandstone, 15 percent carbonate, and 4 percent chert. H. Doelling (personal communication, 1986) identified some of the sandstone clasts as derived from the Jurassic Nugget Sandstone and Arapien Formation. Relatively few clasts are locally derived from either lower Paleozoic carbonates or Precambrian quartzites.

Interbedded with the conglomerates are lithic arenites (Tws) that are moderate red, medium bedded to massive, poorly sorted, medium to coarse grained. Lithic fragments are predominantly chert. Beds are up to 4 feet (1.2 m) thick and frequently contain low-angle crossbeds. The sandstones lie unconformably with scoured contacts over the conglomerates.

The pinkish-gray pisolitic limestone (Twl) occurs as scattered lenses within the lower Wasatch. It consists of pale-yellowish-brown pisolites up to 1.2 inches (3 cm) in diameter, in a yellowish-gray, coarse-grained, sparry matrix. The unit typically weathers to conspicuous light-gray cobbles.

The mudstone lithofacies (Twm) is composed of moderate red, massive, poorly indurated mudstone and claystone, with scattered small sandstone lenses. This recessive weathering unit is best exposed on recent landslide scarps or in cutbanks along stream courses.

The only fossils collected from the Wasatch Formation in northeastern Utah are molds of terrestrial and fresh-water gastropods. A fauna collected by Mullens (1971) from the middle of the formation in the Morgan quadrangle 35 miles (56 km) southwest of the map area has been dated as Early Eocene (Taylor, in Mullens, 1971, p. D19).

The Wasatch Formation is unconformably overlain by the Norwood Tuff in the Morgan quadrangle. An upper age boundary for the Wasatch was established by Gazin (1959) and Evernden and others (1964) who dated the Norwood Tuff just south of the Morgan quadrangle as latest Eocene.

SILICIFIED BRECCIA
(age uncertain)

Pods of silicified breccia (bx) occur along some high-angle faults in the southern half of the quadrangle. They consist of a dark yellowish-brown to grayish-black, massive, dense, sparsely vuggy matrix of microcrystalline drusy quartz, often intruded by quartz veinlets. The breccias occur in outcrop as raised ribs, or in float as an aligned string of cobbles and boulders. Solution cavities are common in the altered carbonate rocks. Associated minerals identifiable in hand specimen include quartz, siderite, goethite, goethite after pyrite, and limonite.

UNCONSOLIDATED DEPOSITS
(Pleistocene and Holocene)

Quaternary surficial deposits in the map area consist of alluvial, colluvial, and paludal sediments. Unconsolidated sediments along stream courses are mapped as alluvium (Qal) in perennially flowing streams, or alluvium with a large colluvial component (Qac) in low-order ephemeral streams. Colluvium was divided into fine and gravelly units. Fine colluvium (Qcf) consists of a poorly stratified mixture of soil and bedrock granules and pebbles. The thin-bedded carbonates of the Ute and Bloomington Formations typically weather to fine colluvium. Components of gravelly colluvium (Qcg) are soil and bedrock pebbles, cobbles, and boulders. The thick-bedded, highly indurated Geertsen Canyon Quartzite typically weathers to gravelly colluvium. Colluvium in the map area has the appearance of reworked Wasatch Formation but can be distinguished by the homogeneity of source material. Marshy areas (Qsm) are associated with some undeveloped springs.

Mass movement deposits occur as talus, landslides, and debris flows. Talus (Qmt) aprons form below weathered outcrops of the more resistant units, especially in Left Hand Fork Blacksmith Fork Canyon. Landslides are mass movements involving rotational and translational movement of slump blocks along a rupture surface. They are recognized in this quadrangle by poorly drained, hummocky topography, frequently covered with aspens. Landslide deposits (Qms) consist of a chaotic assemblage of earth (Shroder, 1971) and bedrock fragments. Bedrock fragments range in size from pebbles to boulders up to several feet in diameter. The boulders are most conspicuous in the Rock Creek landslide (see appendix), where partially exhumed blocks of Langston Dolomite up to 16 feet (5 m) in diameter are found. At least two generations of landslides are present in the Rock Creek landslide. Rock Creek has undercut the tow of an older landslide, triggering renewed sliding (Qms_1) of old landslide material. Debris flows (Qmf) are masses of debris-laden mud that flow down drainage courses until they reach a gradient gentle enough for deposition. They are recognized in the field by a well-defined slide chute and by lobate outrun deposits consisting of angular lithic clasts in a fine-grained matrix. Selected Quaternary mass movement features within the quadrangle are described by DeGraff (1976).

STRUCTURAL GEOLOGY

Rocks in the Boulder Mountain quadrangle bear evidence for compressional and extensional tectonism. Precambrian and Cambrian strata were gently folded and thrust eastward as part of the Cache allochthon during the Late Cretaceous-early Tertiary Sevier orogeny. Late Tertiary Basin and Range normal faulting has displaced pre-Oligocene rocks. Structure expressed in the map area consists of the eastward-verging Strawberry anticline (Williams, 1948), which has been offset along high-angle faults.

Folds

Both limbs of the Strawberry anticline are exposed in the quadrangle. The gently dipping west limb is well exposed in the walls of Left Hand Fork Blacksmith Fork Canyon, and in the area south of the canyon. Along Rock Creek in the southeast corner of the quadrangle, the moderately dipping beds of the east limb are poorly exposed under the Wasatch Formation. The axis of the anticline is horizontal.

Dips within the Wasatch are discordant with fold deformation, implying a pre-Wasatch (pre-Eocene) folding event. The folding appears to be related to compressional deformation of the allochthon as a result of thrusting associated with the Sevier orogeny. Two lines of evidence support this: (1) the trend of the fold hinges is parallel to thrust fault traces (Beutner, 1977); (2) rocks of the allochthon lay relatively flat prior to thrusting (Eardley, 1944; Williams, 1948).

Faults

Four major high-angle normal fault sets are present in the quadrangle. The faults are generally poorly exposed, but where visible they display nearly vertical dips (E ½, section 22, T. 11 N., R. 3 E.; NE ¼, section 20, T. 11 N., R. 3 E.; SW ¼, section 36 T. 11 N., R. 3 E.). Throw on all major faults is approximately 400 feet (120 m), in most cases juxtaposing Cambrian strata with the Eocene Wasatch Formation. Discontinuous silicification occurs along some of the faults in the southern half of the map area.

The Saddle Creek-Squaw Flat, Cottonwood Creek, and Herd Hollow fault sets trend north-northeast. The Pole Hollow faults trend northwest. Numerous minor fault splays record small adjustment movements lateral to the major faults.

The Saddle Creek-Squaw Flat faults define a set of grabens in the eastern part of the map area. The Wasatch Formation is preserved in the grabens, which are flanked by horst blocks that expose the Geertsen Canyon Quartzite and Langston Dolomite. Displacement on these faults exceeds 375 feet (115 m), bringing Geertsen Canyon Quartzite into contact with mudstones of the Wasatch Formation.

The parallel Cottonwood Canyon faults in the southern part of the quadrangle can be traced at least 3.1 miles (5 km), from Pole Hollow southwest to the Blacksmith Fork River. They have similar apparent scissoring motions, with the west wall downthrown in the south and upthrown in the north. The point where the faults change direction of movement is near the NW corner, section 2, T. 10 N., R. 3 E. Maximum displacement occurs in the southern area, where most of the 420-foot-thick (128 m) Langston Dolomite is faulted out. Displacement is considerably less north of the articulation point.

The Herd Hollow faults border a valley of the same name in the northwestern part of the map area. The faults are difficult to trace northward to Cowley Canyon, but the alignment of Cowley Canyon with Herd Hollow strongly suggests a continuation of the faults. The fault system appears to terminate to the south in a set of splays that trend into Left Hand Fork Blacksmith Fork Canyon at Gray Cliff Spring. It may continue across the canyon to the south, but a mantle of fine colluvium covers the trace of the fault. The faults have a throw of at least 328 feet (100 m), bringing the Nounan Dolomite into contact with the Wasatch Formation.

The northwest-trending Pole Hollow faults bound a graben that defines Pole Hollow in the south-central part of the quadrangle. Outcrops of Geertsen Canyon Quartzite, Langston Dolomite, and Ute Formation within Pole Hollow are mantled by a thin veneer of Wasatch Formation. Preservation of the Wasatch Formation occurs only in the graben, and lack of fan-type sedimentary sequences proximal to the faults are evidence for post-Wasatch extension. Neither fault crosses Rock Creek to the east. The southern fault is bounded on the west by the Cottonwood Canyon fault. The northern fault is continuous to the northwest through Left Hand Fork Blacksmith Fork Canyon, where it is well exposed, and terminates to the northwest on a dip slope in the Bloomington Formation. The fault on the north side of Pole Hollow offsets almost the entire 460-foot-thick (140 m) Blacksmith Formation on the north wall of Left Hand Fork Blacksmith Fork Canyon.

ECONOMIC DEPOSITS

No major deposits of economic minerals have been found in the Boulder Mountain quadrangle. In the only production statistics from the quadrangle, Heikes (1920, p. 218) reports that 10 tons of "lead ore" were shipped during World War I from the Lucky Star Mine (SW ¼, SW ¼, section 12, T. 11 N., R. 3 E. — note incorrect placement on the U.S. Geological Survey topographic map). The Lucky Star is located on one of the slightly mineralized fault zones in Left Hand Fork Blacksmith Fork Canyon. Three other prospects are located in Left Hand Fork Blacksmith Fork Canyon. A shaft has been sunk into a small jasperoid body along the Pole Hollow Fault on the north side of the canyon. Two adits, one penetrating the Langston Dolomite and the other the Bloomington Formation, are located southeast of Hummingbird Spring and on the west side of Munson Hollow, respectively. Other features of potential economic interest include: (1) jasperoid bodies associated with high-angle faults occur in the southern half of the quadrangle; (2) the silicified solution breccia zones within the Blacksmith Formation may provide a suitable host for economic minerals; (3) the shaly limestone of the Bloomington Formation may be appropriate for the manufacture of cement; (4) pure dolomite of the Blacksmith Dolomite may prove a suitable source for magnesium or magnesium carbonate.

WATER

Springs are abundant in the Boulder Mountain quadrangle, in part due to the carbonate bedrock that readily dissolves to form solution channels, and to the high amount of snowfall which provides adequate recharge. Both fault and contact springs occur within the map area. Examples of fault springs include Gray Cliff Spring (section 21, T. 11 N., R. 3 E.), Pleasant Valley Spring (section 35, T. 11 N., R. 3 E.), and Cabin Spring (section 14, T. 11 N., R. 3 E.). Contact springs occur where water issues from carbonate rocks which overlie shales, such as at the base of the Langston Dolomite or Ute Formation, or where permeable portions of the Wasatch Formation overlie relatively impermeable bedrock. Lime Spring (section 23, T. 11 N., R. 3 E.), Boar Hole Spring (section 33, T. 11 N., R. 3 E.), and Humming Bird Spring (section 18, T. 11 N., R. 4 E.) are examples of contact springs. The large and fairly constant discharges of Gray Cliff and Lime Springs are important in maintaining perennial flow in Left Hand Fork Blacksmith Fork Canyon. Some of the small springs have been improved as a source of water for livestock. Discharge in most of the small springs varies markedly during the year as a result of recharge variations within local flow systems.

GEOLOGIC HAZARDS

Landslides are present throughout the quadrangle area. They range in geomorphic age from youthful to old age, based on criteria presented by Shroder (1971). One large landslide occurs on the south-facing slope of Left Hand Fork Blacksmith Fork Canyon. All other landslides occur on north- or west-facing slopes.

The landslides range in size from about 109 acres (44 hc) to less than 1.2 acres (0.5 hc). There are no large historic landslides. The appendix summarizes information on three large landslides and one major landslide zone within the quadrangle.

Debris flows originate on the steep, south-facing slope of the Bloomington Formation within Left Hand Fork Blacksmith Fork Canyon. The flows frequently overrun the canyon road in section 21, T. 11 N., R. 3 E. This area is at risk whenever there is sufficient moisture to saturate the regolith.

The gravel road along the Left Hand Fork of Blacksmith Fork River is susceptible to damage by high discharge from seasonal runoff or flash flooding. High water in the spring of 1983 destroyed two segments of the road; a 591-foot-segment (180 m) at Gray Cliff Spring has been reconstructed, however, there is no plan at present to replace the washed out segment in section 19, T. 11 N., R. 4 E.

ACKNOWLEDGMENTS

I wish to gratefully acknowledge Drs. Linda McCollum, Eugene Kiver, Roy Behm, Ernest Gilmour, Felix Mutschler, James Snook, and Mike McCollum for their contributions to this endeavor. Special thanks to the Utah Geological and Mineral Survey for their financial support, and to Genevieve Atwood, Dr. Hellmut Doelling, Mark E. Jensen, Bryce Tripp, and Robert Klauk for their guidance and critical reviews.

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APPENDIX

Landslide Descriptions

Bear Hollow Landslide

Location

North side of Left Hand Fork Blacksmith Fork Canyon, 0.35 miles (0.56 km) east of Bear Hollow.

Dimensions

Width: Head - 800 feet (244 m)
Toe - 350 feet (107 m)
Length: 1100 feet (335 m)
Area: 633,000 feet^2 (59,000 m^2)

Elevation

Head: 6360 feet (1939 m)
Toe: 5760 feet (1756 m)

Slope Exposure

Southwest

Vegetation

Sagebrush and juniper

Geologic Setting

Thin-bedded shale and limestones of the Bloomington Formation and dolomite of the Blacksmith Dolomite.

Geomorphic Age

Old age — based on strong cementation of landslide debris, erosional blunting of hummocky topography, elevation difference between present stream base level and lowest extent of landslide debris.

An outcrop of lithified debris is located about 0.35 mi. (0.56 km) east of Bear Hollow, some 40 feet (12 m) above the road. The elongate outcrop is about 36 x 20 x 7 feet (11 x 6 x 2 m); oriented long axis parallel to the fall line.

It appears the slide overran a seep. Connate waters of the seep facilitated rapid cementation of the unconsolidated material. The other debris has been almost entirely removed by erosion.

Rock Creek Landslide

Location

South side of Rock Creek SE ¼, Sec. 32. T. 11 N., R. 4 E.

Dimensions

Width: 3800 feet (1158 m)
Length: 1200-2200 feet (365-670 m)
Area: 6.46 million feet^2 (600,100 m^2)

Elevation

Head: 6860 feet (2090 m)
Toe: 6200 feet (1889 m)

Slope Exposure

Northwest

Vegetation

Small aspens and brush

Geologic Setting

Uppermost Geertsen Canyon Quartzite, Langston Dolomite and Ute Formation, overlain by the mudstone facies of the Wasatch Formation.

Geomorphic Age

Early maturity — based on presence of undrained depressions, moderate soil development, incomplete aspen succession.

The slide remains active. Downcutting action of Rock Creek has oversteepened the slope and undercut the toe of the slide. A recent small slide and the sinuous appearance of aspen trunks are evidence of continuing activity.

Little Peavine Landslide

Location

Little Peavine canyon. The major part of this slide is in the NE ¼, Sec. 32, T. 11 N., R. 4 E.

Dimensions

Width: Head - 1500 feet (457 m)
Toe - 1000 feet (335 m)
Length: 2100 feet (640 m)
Area: 2.73 million feet^2 (254,000 m^2)

Elevation

Head: 7000 feet (2133 m)
Toe: 6440 feet (1962 m)

Slope Exposure

West

Vegetation

Aspens and sagebrush

Geologic Setting

Uppermost Geertsen Canyon Quartzite and Langston Dolomite, overlain by mudstone facies of the Wasatch Formation. A high-angle fault passes under landslide.

Geomorphic Age

Middle maturity - based on slump block erosion, complete aspen succession, lack of undrained depressions.

Saddle Creek Landslide Zone

Location

East side of Saddle Creek, extending from near center of Sec. 17 northeastward to SE ¼, SW ¼, Sec. 4. T. 11 N., R. 4 E.

Dimensions

Width: 10,500 feet (3200 m)
Length: 600 feet (183 m)
Area: 6.3 million feet^2 (585,000 m^2)

Elevation

Head: 6640 feet (2023 m)
Toe: 6440 feet (1962 m)

Slope Exposure

Northwest

Vegetation

Aspens and sagebrush

Geologic Setting

Mudstone facies of the Wasatch Formation in graben containing Saddle Creek, adjacent to footwall of the Saddle Creek fault.

Geomorphic Age

Middle maturity — based on degree of slump block erosion, complete aspen succession, infilled depressions.

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