# GEOLOGY OF THE DYER MOUNTAIN QUADRANGLE, UTAH

by

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# Abstract

The Dyer Mountain quadrangle, located in Utah approximately 200 km east of Salt Lake City and 20 km north of Vernal, lies on the south flank of the east-west trending Uinta anticline. The topography of the area varies from mountain peaks to deep canyons, with rolling hills of uplands in between. The elevation in the quadrangle ranges from 3124 m (10248 ft) at the top of Dyer Mountain to 1835 m (6020 ft) at the lowest point of Big Brush Creek. Most of the northern portion of the quadrangle is vegetated by aspens and pines, whereas the southern part of the quadrangle is covered with sagebrush and grasses.

Due to its location on the anticline, the quadrangle contains bedrock that dips gently to the south and southeast. The ages of the rocks within the quadrangle range from the Precambrian Uinta Mountain Group to the Quaternary and Tertiary gravels. Also present are the following formations: Cambrian Lodore; Mississippian Madison, Doughnut, and Humbug; Pennsylvanian Round Valley and Morgan; Pennsylvanian to Permian Weber; Permian Meade Peak Member of the Phosphoria and Franson Member of the Park City; and various Quaternary sediments. The Lodore Formation and the Madison Limestone rest on major unconformities, and the Quaternary and Tertiary gravels overlie the Gilbert Peak erosion surface. The Uinta anticline and southerly dip of the Proterozoic and Paleozoic rocks are a result of Late Cretaceous uplift during the Laramide orogeny; Tertiary rocks within the area show little to no deformation.

Limestone and various types of ores have been mined in the quadrangle, and phosphorous is currently being mined for fertilizer production. Several landslides, common at the juncture of the Quaternary and Tertiary gravels and Permian shales, were identified within the quadrangle. An anticline and syncline, trending northwest to southeast, lie in the southeast portion of the quadrangle and transect Big Brush Gorge.

Geologic hazards of the area include landslides, erosion and failure of road grades, and cliffs near trails. The karst topography of the area presents dangers of sink holes, and evidence of ceiling collapse is present within Big Brush Cave, a popular destination for tourists and cavers.

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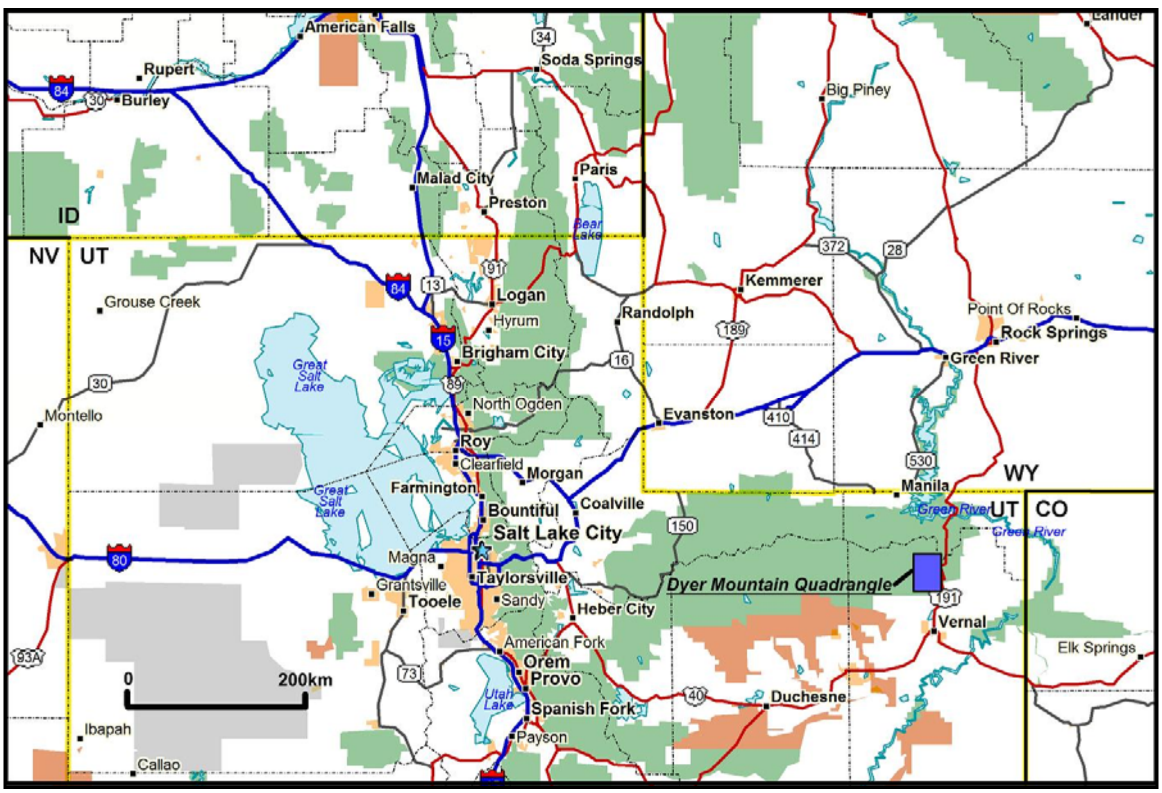
# CHAPTER 1 - Introduction

The Dyer Mountain quadrangle is located on the south slope of the Uinta Mountains in northeast Utah. It lies within the Ashley National Forest, approximately 200 km east of Salt Lake City and 20 km north of Vernal (Figure 1.1). There is about 1300 m (4,000 ft) of relief within the quadrangle, from the top of Dyer Mountain at 3124 m (10,248 ft) to the bottom of Big Brush Gorge at 1835 m (6,020 ft). Three distinct terrains can be seen: the steep walls and talus of Big Brush Gorge, the rolling topography of the highlands, and the steep slopes and ridges formed by the Madison Limestone.

**Figure 1.1 Northern Utah. Blue rectangle depicts Dyer Mountain quadrangle. Figure modified from Google.maps.com.**




The Dyer Mountain quadrangle lies on the south flank of the east-west trending Uinta anticline, resulting in bedrock that dips gently to the south and southeast. The ages of rock units within the map area range between Precambrian and Tertiary. Major unconformities underlie the Mississippian Madison Limestone, the Cambrian Lodore Formation, and the Quaternary and Tertiary gravels (Gilbert Peak erosion surface). The Uinta anticline, and southerly dip of the Proterozoic and Paleozoic rocks within the quadrangle, is a result of Late Cretaceous uplift during the Laramide orogeny; therefore Tertiary rocks within the area show little to no deformation.

The most recent geologic mapping of the area was a 1:100,000-scale map of the Dutch John 30x60-minute quadrangle (Sprinkel, 2006). Sprinkel's map covered an area the size of thirty two 7.5-minute quadrangles, providing an excellent comprehensive view of Uinta Mountain geology, but lacking detail needed for policy and engineering issues within the public lands of the study area. Since this project produced a 1:24,000 scale depiction, subtle geologic features could be included and lithologic contacts could be drawn with more precision than in previous maps of the area (Plate 1). An anticline and syncline are exposed by the Big Brush Gorge in the southeast portion of the quadrangle (Figure 1.2), and are depicted on the map. Although these were previously recognized, they have not appeared on any geologic map of the area until now. Several unmapped landslides were located, and current locations of human-disturbed land were mapped. A major phosphorus mine operates in the southeast corner of the quadrangle, and the location of the active wall of this open-pit mine as of June 2008 is depicted. Based on field observations, some portions of the map have been reassigned different geologic units than what appeared on the Sprinkel (2006) map.

**Figure 1.2 Anticline (A) and syncline (S) axes seen across Big Brush Gorge. Image taken looking southwest from vicinity of UTM Zone 12T 0623000 E, 4501500 N (NAD27), in the southeast portion of the study area. The cliff in the center of the image is approximately 4 km from the camera and about 150 m of exposed Weber Sandstone can be seen.**


Road and trail access to most areas of the quadrangle is excellent. Route 191, which runs north and south from Vernal, UT to Rock Springs, WY, is just east of the Dyer Mountain quadrangle. The Red Cloud Loop, an improved road that is a popular tourist and sightseer route, runs east-west across the north-central part of the quadrangle. Military Road joins Red Cloud Loop and runs down the west side of the quadrangle. Various other improved and unimproved roads provide access to many places within the quadrangle for farmers and summer campers, as most of the quadrangle is reserved for either cattle grazing or recreational camping.

## Methods

Mapping was conducted using traditional field geology methods in conjunction with Geographic Information Systems (GIS) software. The most efficient way to visit numerous sites within the quadrangle was to combine vehicle travel on jeep trails and foot travel to more inaccessible places. Rock descriptions and Global Positioning System (GPS) coordinates were taken at outcrops. All locations, and coordinates described in this paper, use the UTM coordinate system, NAD 27 Datum, within Zone 12T. When possible, unit thicknesses were measured with a Jacob's staff, and bed orientation was ascertained using a Brunton pocket transit. Five hundred seventy eight waypoints describing lithology, bed orientation, and location were entered into a spreadsheet, which was then imported into the GIS software. The GIS program contained geo-referenced digital elevation models, topographic maps, and true and infrared color images, which were used with waypoints taken in the field to enable most geologic contact lines to be drawn with a high degree of certainty and accuracy. In many cases, the previous 1:100,000-scale geologic map (Sprinkel, 2006) was used as a hypothesis for field-checking. Where units were not exposed at the surface, topography, vegetation, and mathematical predictions (Compton, 1985) yielded inferred contact lines.

# CHAPTER 2 - Stratigraphy

The Precambrian Uinta Mountain Group makes up the basement rock of this area and is seen in the northern portions of the Dyer Mountain quadrangle. It is overlain in most of the map by Cambrian shale. Between this shale and Carboniferous limestones is a major erosion surface. Ordovician and Silurian rocks were probably never deposited, and the Devonian rocks that were probably deposited have been eroded (Haun and Kent, 1965). Permian sandstone, limestone, and shale units overlie the Carboniferous limstones. These Permian rocks and all units underlying them were deformed and tilted to the south and southeast during the Cretaceous Period. Atop this surface were deposited the Quaternary and Tertiary gravels. Other than simultaneous deposition of some of the Quaternary units, the following descriptions are in order of deposition.

## Unit Descriptions

### *Uinta Mountain Group, Undivided (Zu)*

This Precambrian unit is predominately a red to brown, poorly sorted feldspathic and lithic sandstone and conglomerate interbedded with soft green shale up to four centimeters thick. Within the Dyer Mountain quadrangle, the top of the unit that lies beneath the unconformity with the Madison Limestone is a matrix-supported pebbly conglomerate containing sub-rounded quartz pebbles up to 3 mm in diameter. Most areas of the Uinta Mountain Group display large, angular, and in some places tabular boulders of this conglomerate. These characteristics distinguish the Uinta Mountain Group from the smaller, rounded, and finer-grain boulders usually seen in the Quaternary and Tertiary gravels. Highly weathered areas show sub-angular boulders which may be bleached to medium tan, probably as a result of water movement through the permeable rock that carries away iron oxide pigments. The most common vegetation atop the Uinta Mountain Group is lodgepole pine and other conifers. The strata of differing grain size and composition of the Uinta Mountain Group have been interpreted as the deposits of the various energy environments found in a braided river system (De Grey and Dehler, 2005).

Thickness of the Uinta Mountain Group in northeast Utah ranges from 4000 m in the western Uinta Mountains to 7300 m in the eastern Uintas. Quartzite has been identified lower in the section (Sprinkel, 2006), resulting from low-grade burial metamorphism. Various isotopes, including K-Ar and Rb-Sr, have been used to determine the maximum age of the unit to be 1400 to 925 Ma.; although when correlating the Uinta Mountain group with other similar units in North America, ages on the order of 1050 to 825 Ma have been determined (Bressler 1981). Fossil assemblages within the Uinta Mountain Group are mostly made up of prokaryotes, and according to Nagy and Porter (2005), usually include little more than ***Leiosphaeridia*** sp. and ***Bavlinella faveolata***.

### *Lodore Formation (Cl)*

This Cambrian unit unconformably overlies the Uinta Mountain Group and is typically a red or green shaley siltstone and sandstone with metallic nodules. Some areas may be a tan calcareous shaley limestone. This unit is commonly covered by soil and colluvium from the overlying Madison Limestone, and is mostly characterized by a distinct shallowing in slope as the hard Madison meets the soft Lodore. This unit was once mined for ore, and numerous prospect pits help identify the Lodore within the Dyer Mountain quadrangle. The unit pinches out 1 to 3 km southwest of Dyer Mountain in the vicinity of 062000 E, 4509500 N (Sprinkel, 2006), but the exact location is difficult to locate because the thin and soft Lodore is rarely exposed within the quadrangle. The Lodore is best exposed within the quadrangle at Dyer Mines, an abandoned excavation site high on the northeast slope of Dyer Mountain.

Herr and Picard (1981) determined through petrographic analysis that the underlying Uinta Mountain Group was the source rock for the Lodore. Herr et al. (1982) suggest that the Lodore was deposited as shallow seas transgressed from the east. Brachiopods and trilobites are rare in the formation, but can be seen in red, green, and gray sandstone and shale outcrops at Dinosaur National Monument, roughly 60 km southeast of the Dyer Mountain quadrangle (Hanson, 1969). The Lodore was originally described by Powell (1876) as Carboniferous in age. Fossil assemblages alone have since been used to date the Lodore to the Cambrian Period, and Herr et al. (1982) used K-Ar dating to further constrain the age to the Middle to Late Cambrian Period. The thickness of the Lodore varies, from as much as 180 m at Lodore Canyon, to 63 m at Johnson Draw, and it pinches out within the Dyer Mountain quadrangle. Trace fossils are relatively abundant on bedding planes within the Lodore, and are interpreted to be evidence of crawling and feeding trilobites and burrowing worms. (Herr et al., 1982).

### *Madison Limestone (Mm)*

This Mississippian unit, sometimes referenced as the Lodgepole Limestone (Spangler, 2005), is a medium to dark gray, medium to fine grain crystalline limestone with occurrences of light and dark gray chert nodules. Zebra chert, with light and dark bands that form twisting and convoluted designs (Figure 2.1), is found in weathered areas. Outcrops of medium and light gray brecciated limestone with grains approximately 2 mm in diameter are present. Fossils are usually highly altered, with horn corals common in the lower Madison (Figure 2.2) and brachiopods common in the upper portions (Figure 2.3). The formation is best seen on the barren top of Dyer Mountain (0620300 E, 4509600 N) and at the entrance of Big Brush Cave (Figure 2.4, 0619700 E, 4505950).

This unit was deposited in the warm shallow sea that covered much of the continent during the Carboniferous Period (Hanson, 1969). The thick, hard Madison is responsible for much of the dip-slope terrain seen on the south flank of the Uinta Mountains in this area, including the south slope of Dyer Mountain. Dissolution of the Madison produces many sinkholes and caves in the area, including Big Brush Cave and Little Brush Cave, which are the largest known caves in Utah. Runoff and shallow groundwater flowing south from the Uinta Mountain Group is acidic due to meteoric processes and percolation through the pine forest soil. This water is also not buffered by the sandstones of the Uinta Mountain Group, and dissolves many sinkholes and caves in the Madison Limestone as it flows south (Spangler, 2005).

Peale described the Madison in 1893, but never communicated precisely where he worked. Sloss and Hamblin (1942) and Holland (1952) agree Peale was working on the Gallatin River across from Logan, Montana, and have assigned this area as the type section for the Madison Limestone. Peale indicated that the Madison is underlain by Devonian rocks at this location. Devonian rocks are also seen underlying the Madison in Logan, Utah, approximately 100 km north of Salt Lake City. At one time these Devonian rocks covered all of Utah and east into roughly half of Colorado, but were removed in many places during a short period of uplift during the early Mississippian Period (Haun and Kent, 1965). The erosion associated with this uplift is the cause of the unconformity seen under the Madison Limestone in the Dyer Mountain quadrangle. No Silurian or Ordovician rocks were deposited in the area of the present-day Uinta Mountains (Haun and Kent, 1965).

**Figure 2.1 Zebra chert from the Madison Limestone.**

**Figure 2.2  Horn coral taken near the base of the Madison Limestone.**


**Figure 2.3  Brachiopod taken near the top of the Madison Limestone.**

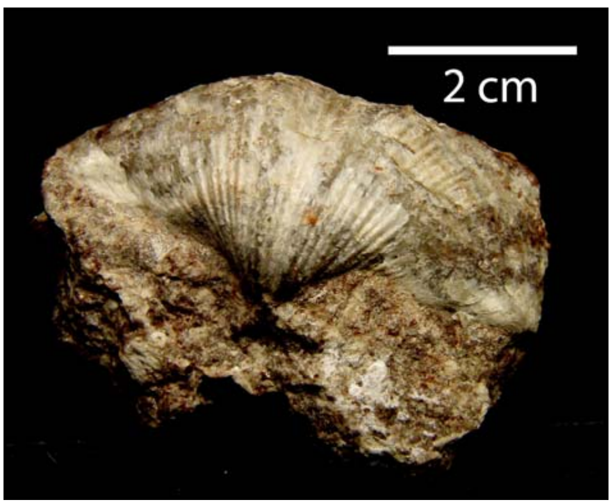


**Figure 2.4 The Madison Limestone at the entrance of Big Brush Cave, 0619700 E, 4505950. The mouth of the cave is approximately 15 m tall.**

### *Doughnut Shale and Humbug Formation (Mdh)*

These two Upper Mississippian formations are poorly exposed in the Dyer Mountain quadrangle, and have been combined for mapping proposes because they cannot be accurately differentiated. They are composed of gray to brown soft shale that erodes to slopes, valleys, and rounded hills. An organic-rich black shale within these units can be seen along Route 191 off the east border of the quadrangle, just north of Little Brush Cave. Much of the east-west route of the Red Cloud Loop runs over the Doughnut and Humbug. A small portion of the Humbug is exposed on the southeast valley wall containing the meadow above Big Brush Cave (0619690 E, 4505860 N).

The fine shales of these units were most likely deposited in the quiet waters far offshore beneath the broad seas that covered much of the continent during the Mississippian Period. Sprinkel (2006) indicates that the thickness of the Humbug within the Dutch John 30x60-minute quadrangle ranges from 30 to 90 m.

The Doughnut Shale is also called the Manning Canyon Shale at other localities, and attains a maximum thickness of 170 m (Spangler 2005). Sprinkel (2006) indicates that the thickness of the Doughnut ranges from 24 to 91 m within the Dutch John 30x60-minute quadrangle. The soft and impermeable Doughnut is also involved in a number of landslides throughout the Uinta Mountains (Kowallis and Bradfield, 2005).

### *Round Valley Limestone (lPrv)*

This Lower Pennsylvanian unit is up to 150 m thick (Spangler, 2005) and is predominately composed of meter-scale beds of gray limestone and soft red and brown shale. Although crinoids and brachiopods are present in certain beds, they are not common. Red, blue-gray, and yellowish-gray chert nodules and chert beds up to 1 m thick are common. Some beds of tan cross-bedded calcareous sandstone are seen. The Round Valley forms rounded, tall hills, such as those seen north and west of Big Lake in the central part of the quadrangle.

The shale beds and low fossil occurrence within the Round Valley indicate that this unit was deposited well offshore (Hansen, 1969). Whereas some karst features are present in the unit, like Big Lake within the Dyer Mountain quadrangle, no significant caves or sinkholes, such as those in the Madison Limestone, have been found (Spangler, 2005).

### *Morgan Formation (lPm)*

This fossiliferous Middle Pennsylvanian unit is predominately a light gray crystalline limestone with beds of light purple crystalline limestone. Brachiopods are common, and crinoids measuring up to 2 cm in diameter are abundant. Microvugs can be discerned with a hand lens. There are also numerous beds of light tan to orange fine-grained sandstone up to several meters thick, most of which are calcareous. Beds up to 10 cm thick of medium and dark red chert nodules can be found. Chert and fossil occurrence in the Morgan were found to vary laterally within the Dyer Mountain quadrangle.

The Morgan was deposited unconformably over the Round Valley Limestone in a near-shore environment (Hansen, 1969). It has been reported as having a maximum thickness of 36 m, and beds of reddish shale and siltstone elsewhere in the Uinta Mountains (Spangler, 2005). Sprinkel (2006) reports that the thickness of the Morgan varies from 11 to 290 m within the Dutch John 30x60-minute quadrangle.

### *Weber Sandstone (PlPw)*

This Lower Permian to Middle Pennsylvanian unit is predominately a sub-rounded, very well sorted and medium to fine-grained, light to very light tan, quartz arenite. Whereas it typically has silica cement, some outcrops effervesce and indicate that calcium carbonate is present. It contains large cross bedding up to several meters thick. The hardness and thick beds of this formation result in the cliffs seen at Big Brush Gorge and numerous other canyons in the southeast Uinta Mountains. Where exposed to the elements for long periods of time, this unit weathers to medium tan and crumbles easily between the fingers. Large and well exposed outcrops of this unit are seen in Big Brush Gorge (Figure 2.4). Many springs are seen in the Weber throughout the south flank of the Uinta Mountains. Groundwater, flowing down-dip to the south, migrates to the surface via numerous fractures within the Weber (Spangler, 2005). Big Brush Spring, located in the southeast corner of the quadrangle, discharges from the Weber.

Much research has been done into the Weber Sandstone, probably because it is an oil and gas producer further to the south in the Uinta Basin. Hansen (1969) described the Weber as a beach and dune deposit. Chidsey and Sprinkel (2005) interpreted the depositional environment to be an open, sand-sea, similar to the modern Sahara or Gobi deserts. This is consistent with what is seen in the Dyer Mountain quadrangle; grain size, sorting, bed thickness, and cross bedding indicate that this unit was an eolian deposit. Thin calcareous beds in the Weber could represent either short periods of sea level rise and proximal carbonate deposition of beach deposits (Hansen, 1969), desert playa and oasis deposits (Chidsey and Sprinkel, 2005), or post-deposition introduction of calcium carbonate. Spangler (2005) reported a thickness ranging from 305 to 455 m in the Uinta Mountains, and Sprinkel (2006) reported a thickness range of 186 to 472 m within the Dutch John 30x60-minute quadrangle.

**Figure 2.5  Strata Seen at Big Brush Gorge.  Image taken looking southeast from the east side of the canyon, at 0622650 E, 4501070 N.  The Meade Peak member is approximately 5 m thick here.**


### *Meade Peak Phosphatic Shale Member of the Phosphoria Formation (Pmpp)*

This Lower Permian light gray to greenish gray soft shale forms slopes at outcrops.  The base is composed of cherty gray conglomerate, grading up into a very light gray siltstone with calcareous nodules 1 to 5 cm in diameter and dark gray phosphate nodules approximately 5 mm in diameter.  This siltstone grades up into a tan limestone that is probably partially dolomitized, indicated by its mild reaction with hydrochloric acid.  Phosphate concentrations in the Meade Peak increase to the east as the unit thins. This unit is seen directly above the Weber Sandstone and below the lowermost limestone of the Franson in Big Brush Gorge (Figure 2.5), and is 3 to 5 m thick within the Dyer Mountain quadrangle.

The Meade Peak formed in an organic-rich shelf environment (Hanson, 1969) and is currently being mined for its high phosphate content approximately 15 km north of Vernal.  The unit has been cited as a source rock for petroleum being produced from the Weber sandstone in the Uinta Basin, south of Vernal.  The total organic carbon (TOC) of the Meade Peak is approximately 10 percent (Chidsey and Sprinkel, 2005).

### *Franson Member of the Park City Formation (Pfpc)*

This Lower Permian unit alternates between light gray shale and beds of light tan cherty limestone or dolostone. The base of the formation within the Dyer Mountain quadrangle is defined as the bottom of the lowest cliff-forming bed, which in most cases is a light tan, vuggy, lithic, poorly sorted calcareous sandstone, with fluvial cross bedding in many places. This unit is most accessible in the numerous draws in the southwest portion of the quadrangle and the dip-slope area not overlain by the Quaternary and Tertiary gravels in the southern areas of the quadrangle.

Based on grain size and composition, the Franson was deposited in a distal carbonate shelf. Alternating layers of shale and limestone indicate fluctuating sea level and depth of sedimentation. The unit is also identified as the Rex Chert Member or the C-member of the Phosphoria Formation in Idaho, Montana, and Wyoming (Mckelvey et al., 1956).

### *Quaternary and Tertiary Gravels (QTg)*

This unit contains poorly consolidated conglomerates and unconsolidated gravel deposits, both composed primarily of rounded Uinta Mountain Group clasts of red sandstone. Grain size typically ranges from silt to cobbles, but boulders measuring several meters in diameter are seen in the southeast portion of the quadrangle. This unit weathers and erodes to rounded hills that are covered by red, sandy soil. Uinta Mountain Group cobbles are common on the surface of sparsely vegetated areas because of the erosion and removal of the finer-grained matrix. Vegetation cover is usually sage brush and aspen (Figure 2.6). This unit was mapped by Sprinkel (2006) as two separate units; the Oligocene Bishop Conglomerate and the Pleistocene Older South Flank piedmont alluvium. Sprinkel’s Bishop Conglomerate is highly variable; in some places it consists of light gray or pink friable sandstone, in some places it consists of a poorly cemented pebble to boulder conglomerate, and in others multiple beds of volcanic tuff. Sprinkel described the Older South Flank piedmont alluvium as an unconsolidated to poorly consolidated gravel deposit with grain size ranging from silt to boulder. Both the Bishop and piedmont deposits are dominated by Uinta Mountain Group clasts of red sandstone and conglomerate. If the Bishop Conglomerate is actually present in the Dyer Mountain quadrangle, it consists of the poorly cemented conglomerate variety. I have been unable to reliably distinguish Bishop gravels from Quaternary gravels within the Dyer Mountain quadrangle, so I have combined them into a single map unit (QTg).

**Figure 2.6 All but farthest peak is composed of the Quaternary and Tertiary gravels. Image is taken looking west near the head of Colton Hollow, 0625750 E, 4502230 N. Note abundant aspen groves in the middle ground, common on this unit.**

### *Mass Movement, Slide (Qms)*

Four landslides have been located within the Dyer Mountain quadrangle that have not been previously mapped. The landslide seen in the south-central area of the quadrangle, upstream from Camp and Gompers Canyons in the vicinity of 0622000 E, 4498500 N, was mapped on the basis of the hummocky topography of transported material and the obvious failure scarp seen on stereo pairs. The small portion of a landslide in the southeast portion of the quadrangle, east of Trout Spring in the vicinity of 0626800 E, 4500500 N, was also mapped on these criteria. These two deposits are composed of the Quaternary and Tertiary gravels, and show no evidence of incorporation of the underlying Franson. The two landslides southwest of Dyer Mountain and east of Loco Creek in the northwest portion of the quadrangle (at 0618800 E, 4508200 N and 0619500 E, 4509400 N) lack hummocky topography and clear failure scarps. These landslides were identified on the basis of displaced Madison Limestone, topographic anomalies, apparent shift in drainage patterns, and a high occurrence of aspen trees, which preferentially inhabit unconsolidated sediment. The surfaces of these landslides show cobbles of both Madison Limestone and Uinta Mountain Group, and probably contain these two units throughout the deposit.

### *Alluvium and Colluvium (Qac)*

This unconsolidated and poorly sorted sediment in Big Brush Gorge ranges in size from pebbles to boulders. It is derived from rock falls, mass movement, and river transport during flood stage. This is predominately material from the Weber Sandstone, but also contains Franson material and Uinta Mountain Group boulders from the Quaternary and Tertiary deposits. Alluvial and colluvial deposits were combined for this unit because alluvial processes are relatively minor in these areas, but they do contribute to the deposition of sediments in the gorge, especially during high flow.

### *Alluvium (Qal)*

These areas primarily contain silt and mud and form small flood plains that correspond to areas of relatively low stream gradient. This unit is covered with grasses in most places and may contain pebbles and cobbles in addition to fine sediment. The alluvium is Quaternary in age, and in most cases it is actually accumulating on floodplains. The largest accumulations of alluvium within the Dyer Mountain quadrangle can be seen in the area of Davis Spring on Military Trail on the western edge of the quadrangle (0617500 E, 4504300 N) and in the northeast part of the quadrangle near National Forest road 20.

### *Human-Disturbed Land (Qd)*

This unit includes the small excavation and tailings piles at Dyer Mines, small quarries on the Madison Limestone, and the Simplot Phosphates mine in the southeast corner of the quadrangle. This phosphorous mine is the only active mining occurring within the quadrangle, and will continue to grow to the north.

In the northern portions of the quadrangle, where units were often covered by soil and vegetation, topography and the most upslope occurrence of

# CHAPTER 3 - Geologic Contacts

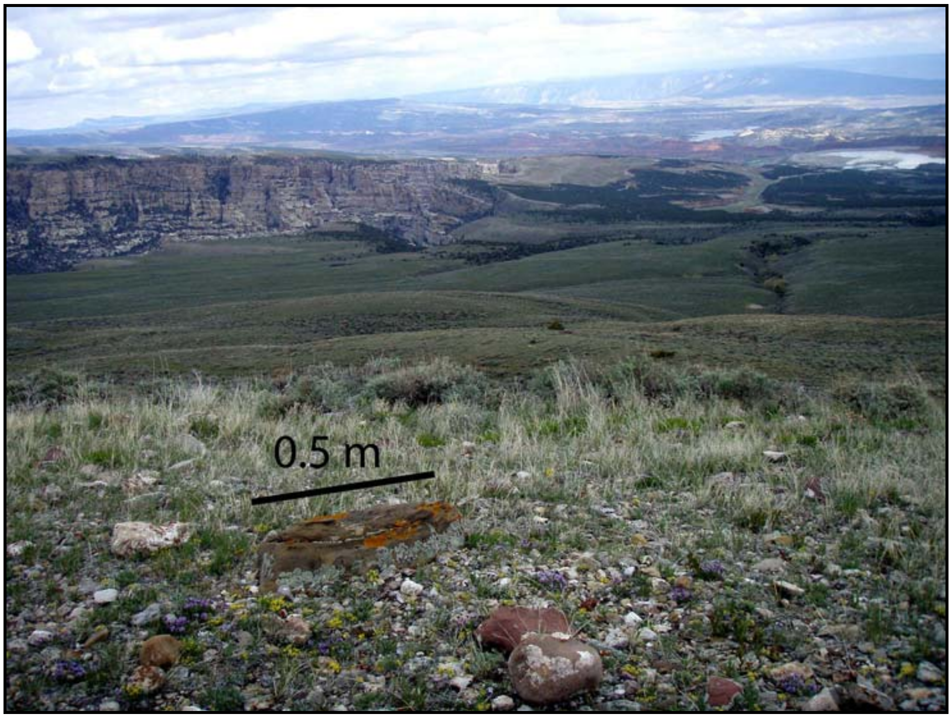
The stratigraphic boundaries between units used in the Dyer Mountain quadrangle are consistent with well established definitions, such as those from Sprinkel (2006). Because terrain, vegetation, and soil cover varied significantly within the quadrangle, different criteria were necessary to place the location of the contact lines on the geologic map (Plate 1). In the southern portions of the quadrangle, especially at the rim and tributaries of Big Brush Gorge, units were well exposed and aerial orthophotos, georeferenced in GIS software, were often utilized for drawing contact locations once field-checking confirmed the unit identity. Units such as the Meade Peak Member of the Phosphoria Formation were easily distinguishable in these areas; it is the slope-forming unit directly above the cliff-forming Weber Sandstone and directly below the lowest cliff-forming limestone of the Franson Member of the Park City Formation.

In the northern portions of the quadrangle, where units are covered by soil and vegetation in many places, topographic characteristics and more intensive field checking was necessary to locate contact locations. In many instances where a unit boundary was located on a slope, the uppermost occurrence of clasts of the underlying unit were mapped as the unit top, such as the contact between the Uinta Mountain Group and the Lodore or Madison, on the north slope of Dyer Mountain. Changes in slope, which are a function of unit hardness, could also be used to map contacts. The soft Lodore Formation shows a distinctly gentle slope beneath the steeper outcrops of the hard Madison Limestone on the north slope of Dyer Mountain. This principle was also applied to the location of contacts between the Madison and the Doughnut and Humbug Formation. Rocks of the Doughnut and Humbug are easily eroded and form many relatively flat areas south of Dyer Mountain. The contact between the Doughnut and Humbug and the Madison was inferred to be between these flat areas and the dip-slope of the Madison.

Finding contacts between the Uinta Mountain Group and the Tertiary and Quaternary gravels is difficult on the ground. Areas of Uinta Mountain Group show more angular and tabular boulders ( Figure 3.1), whereas the Quaternary and Tertiary gravels show more rounded clasts, indicative of stream transport (Figure 3.2).

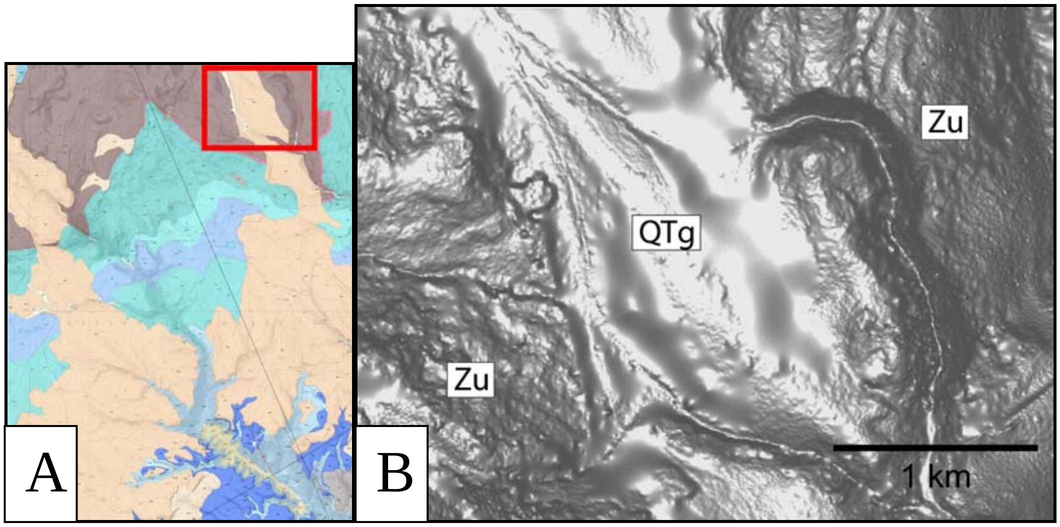
**Figure 3.1 Area of vegetated Uinta Mountain Group in the vicinity of 0617500 E, 4509500 N. The Aspen tree growing from beneath the boulder is approximately 20 cm in diameter.**

**Figure 3.2 Gravel and boulders of Uinta Mountain Group clasts in the Tertiary and Quaternary gravels (seen in the for- and mid-ground), viewed looking southeast from 0620400 E, 4500750 N.**




The topographically rough texture of the Uinta Mountain Group in the digital elevation model (DEM)contrasts with the smoother, rounded features of the Quaternary and Tertiary gravels (Figure 3.3). This was used in conjunction with fieldwork to locate the contact between these two units.

**Figure 3.3 A) Plate 1, the geologic map of Dyer Mountain quadrangle. Red square shows location of: B), the topographic texture difference between the Quaternary and Tertiary Gravels (QTg) and the Uinta Mountain Group (Zu) seen in a digital elevation model (DEM).**




The geologic contact between the Morgan and Round Valley limestones is difficult to see in air photos or by examining topographic features. It is also difficult on the ground because each of these units is composed of multiple beds of differing lithologies, and a hand sample from one unit may look identical to a sample from the other. It is necessary to establish a broad set of general characteristics of each by examining them over large areas. The area where these generalities change was mapped as the inferred contact between the units. For instance, each unit contains beds of limestone with crinoids and brachiopods, beds devoid of fossils, beds of calcareous sandstone, and variously colored chert; but the Morgan typically has more abundant fossils, red chert, and sandstone, wheras fewer fossils are found in the Round Valley and bluish-gray chert is common.

Geologic contacts can be drawn with high precision in the southern portions of the quadrangle where little soil and vegetation conceal units. However, many contacts must be inferred in the middle and northern portions of the quadrangle where units are either rarely exposed or have lithologies that are similar to adjoining units.

# CHAPTER 4 - Structure

The uplift of the Uinta Mountains occurred as an east-west trending anticline during the Laramide orogeny in the Cretaceous Period. Since the Dyer Mountain quadrangle lies on the south flank of this anticline, the Proterozoic and Paleozoic rocks within the study area dip 7-15 degrees to the south and southeast from (Plate 2). Evidence suggests that minor deformation has occurred more recently; the Gilbert Peak erosion surface is distorted and is found at an orientation inconsistent with its drainage history.

An anticline-syncline pair trend northwest-southeast in the southeast portion of the study area. The orientation of these structures is consistent with the direction of shortening modeled by Ashby et al. (2005) that described bending of the eastern Uinta Mountains from an east-west trend to a northwest-southeast trend. Depictions of these structures are seen in Hansen (1965), but have not been included in geologic maps of the area. The numerous fractures that parallel these structures are responsible for many springs in the area, including Brush Creek Spring in the southeast corner of the quadrangle (Spangler 2005).

A number of significant unconformities are found between the geologic units within the Dyer Mountain quadrangle. The first of these, chronologically, is between the Precambrian Uinta Mountain Group and the Cambrian Lodore Formation. This erosion surface represents at least 220 Myr of missing rock record (Sprinkel, 2006). Another unconformity is found between the Cambrian Lodore Formation and the Mississippian Madison Limestone. In the western part of the quadrangle, this unconformity cuts the Lodore Formation and the Madison Limestone is seen overlying the Uinta Mountain Group. The absence of Ordovician and Silurian rocks is attributed to periods of non-deposition, and short periods of uplift during the Mississippian Period have eroded rocks of Devonian age (Haun and Kent, 1965). The unconformity beneath the Madison Limestone on the south flank of the Uinta Mountains represents approximately 136 Myr of missing rock record (Sprinkel, 2006).

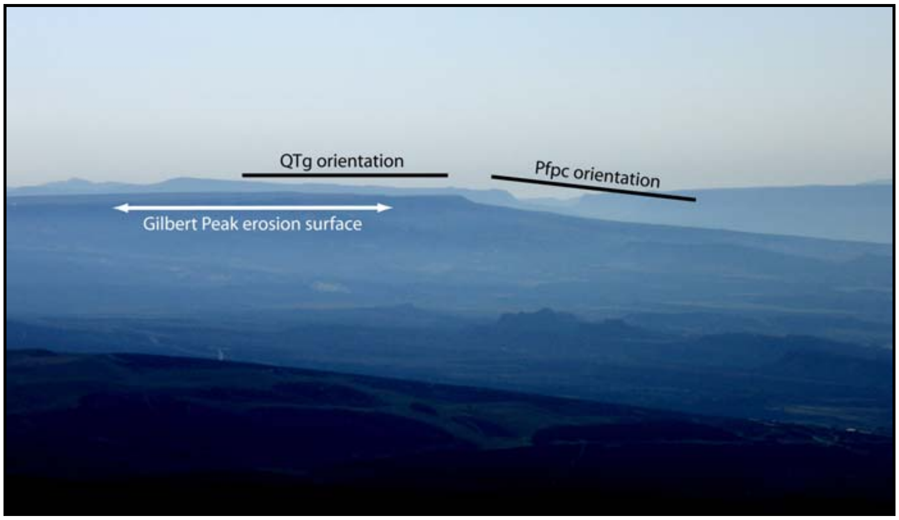
Unconformities have been reported beneath the Morgan Limestone in surrounding areas. In Colorado, this unconformity has deleted the Round Valley Limestone and the

Morgan lies directly on the Doughnut Shale (Johnson, 2006). No evidence was found to indicate an unconformity beneath the Morgan in the Dyer Mountain quadrangle, and Sprinkel (2006) does not identify such a feature in the Dutch John 30x60-minute quadrangle.

An unconformity is present above the Weber Sandstone, underlying the Meade Peak Member of the Phosphoria Formation. This is consistent with the terrestrial depositional environment of the Weber; unconsolidated eolian deposits were easily removed before the transgression of the sea during the late Permian Period, which deposited the Meade Peak. This unconformity represents approximately 3 Myr of missing rock record (Sprinkel, 2006).

The Gilbert Peak erosion surface underlies the Bishop Conglomerate as mapped by Sprinkel (2006), or the Quaternary and Tertiary gravels as mapped here. This angular unconformity has been attributed to uplift, exposure, and erosion of the higher peaks of the Uinta Mountains closer to the anticline crest. As streams cut Paleozoic and Precambrian bedrock, they also carried and deposited the Uinta Mountain Group material to the south. It is hypothesized that an arid climate contributed to the high sedimentation of these braided streams; as they lost water from evaporation and infiltration into the ground, they deposited their sediment and formed the Quaternary and Tertiary gravels (Hansen 1986). The base of these deposits within the Dyer Mountain quadrangle decreases in elevation to the south, but it has not been determined whether this is the original slope of the erosion surface or if it has been altered by more recent uplift. The Gilbert Peak erosion surface at other areas along the south flank of the Uinta Mountains has been deformed during the Neogene; the Gilbert Peak erosion surface to the east, near the Utah-Colorado border, once dipped to the south but currently dips nearly 1 degree to the north (Hansen, 1986). The angular nature of the unconformity between the Quaternary and Tertiary gravels and the underlying strata can be seen looking east and west from many vantage points where the two are exposed (Figure 3.1).

**Figure 4.1 The angular unconformity of the Gilbert Peak erosion surface. Difference in dip between the relatively level Quaternary and Tertiary gravels (QTg) and the Franson Member of the Park City Formation (Pfpc) is seen looking east from Military Road (in the southwest portion of the quadrangle). The middle ground, where orientation lines are drawn, is approximately 20 km from the cameral and about 10 km wide.**




# CHAPTER 5 - Hydrology

Drainage in the Dyer Mountain quadrangle is dominated by Big Brush Creek , which trends from northwest to southeast across the Dyer Mountain quadrangle. This stream, and most other streams in the quadrangle, flow down-dip on the Proterozoic and Paleozoic rocks. Big Brush Creek drainage brings acidic water from the Uinta Mountain Group into contact with the Carboniferous limestones; this common scenario seen in the Uinta Mountains has produced extensive cave systems in northeast Utah (Spangler, 2005). Rain, which is usually slightly acidic, falls on the Uinta Mountain Group and percolates through the conifer soils that are common on that unit. Numerous reactions with the soil produce acids and contribute to the further reduction in pH of this water. As it flows south into the limestone terrane, the dissolution of carbonates produces karst topography.

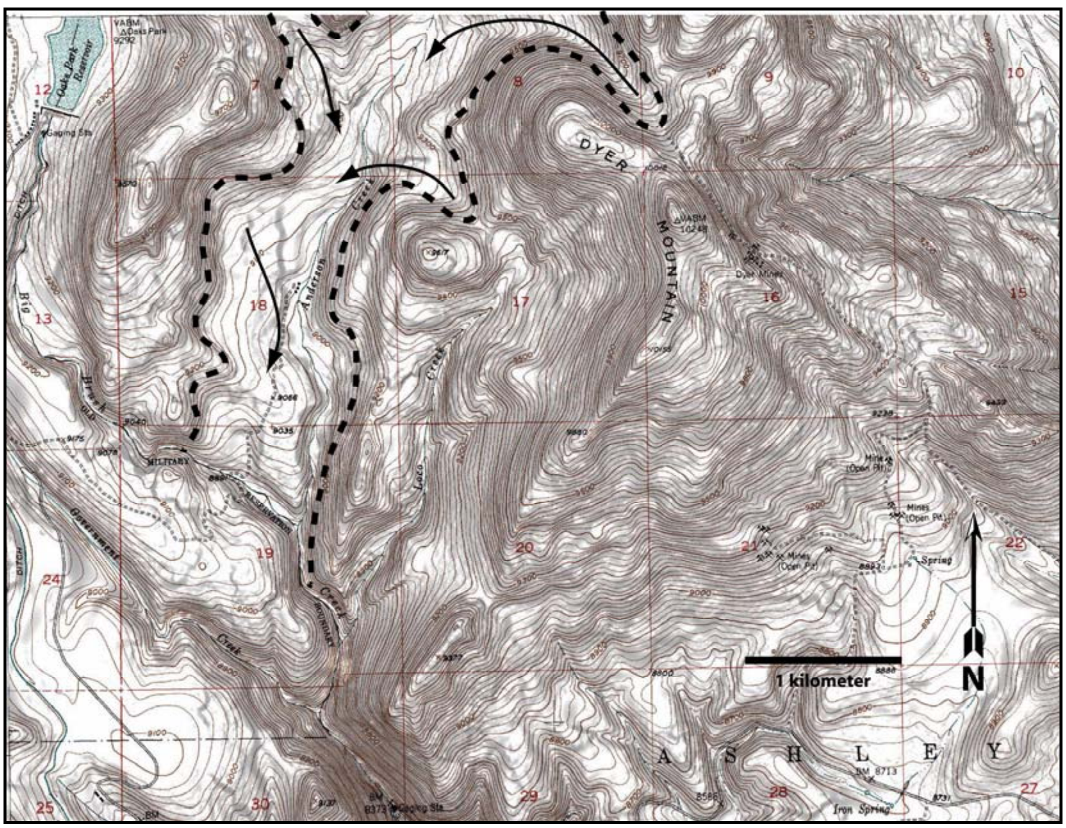
The extensive cave systems in and around the Dyer Mountain quadrangle play a significant role in the groundwater hydrology of the area. Little Brush Cave (located just off the eastern border of the quadrangle, on Route 191) and Big Brush Cave are approximately 9 and 9.5 km long, respectively, and are the longest caves in Utah. Waters entering these caves discharge at Brush Creek Spring, and the travel time is only 2.2 and 2.6 days, respectively (Spangler, 2005). Besides these major cave entrances, numerous sinkholes contribute to the groundwater recharge in the study area. Big Brush Creek rarely flows into Big Brush Cave, yet it is a sizable stream only several hundred meters north at the Brush Creek Bridge on the Red Cloud Loop (0618620 E, 4506590 N). Except during flood stage, Big Brush Creek is dry for most of its length within the quadrangle because its waters percolate into the Carboniferous limestones through small sinkholes. It becomes a large river again at Brush Creek Spring in the southeast corner of the quadrangle.

Streams that cut the relatively soft Quaternary and Tertiary gravels show a higher density and more dendritic drainage patterns than streams elsewhere in the quadrangle. Two landslides involving this unit were identified within the Dyer Mountain quadrangle. These landslides were probably caused by water percolating through the highly permeable Quaternary and Tertiary gravels and meeting the relatively impermeable shale of the underlying Franson. Failure would have occurred as pore pressure within the Quaternary and Tertiary gravels increased as water pooled above the Franson. The clay-rich Franson would also have provided a plain of weakness for failure. Larger landslides further to the south, where the Bishop Conglomerate overlies clay-rich Mesozoic units, have been attributed a similar scenario (Kowallis and Bradfield, 2005).

# CHAPTER 6 - Possible Glaciation

Extensive glaciation has long been known in the higher elevations of the western Uinta Mountains (Atwood, 1909). Six large glaciers and seven smaller glaciers have been mapped in detail on the south flank of the western Uinta Mountains (Laabs and Carson, 2005), but no glaciation has been reported in the study area. There are, however, landforms that suggest the possibility of small glaciers that once occupied valleys in the northwest parts of the Dyer Mountain quadrangle (Figure 5.1). These valleys are wider and possess a more U-shaped profile than other stream valleys in the quadrangle. This is the only criteria used to suggest possible glaciation within the Dyer Mountain quadrangle; no till, moraines, striated rocks, or cirque headwalls were identified. Terminal moraines, which mark the maximum extent of glaciation, have been found at an elevation of 2743 m (9000 ft) in the Ashley Creek drainage, approximately 5 to 8 km west of the study area (Spangler, 2005). This suggests that glaciation within the Dyer Mountain quadrangle above 2743 m (9000 ft) is possible, which includes the area depicted in Figure 5.1. Whereas the dominant glacial landforms seen in the Uinta Mountains are of late Pleistocene age, the surface features in the Dyer Mountain quadrangle may represent glaciation from an older time. More fieldwork aimed at discovering glacial deposits within the quadrangle would be necessary to determine with certainty the existence and extent of former glaciation within the Dyer Mountain quadrangle.

**Figure 6.1 Hillshade relief of the northwest portion of the U.S. Geological Survey Dyer Mountain 7.5-minute quadrangle. The dotted line depicts extent of possible glaciation based on landforms.**



# CHAPTER 7 - Geologic Hazards

The geologic hazards found within the Dyer Mountain quadrangle relate mostly to the interaction of tourists with the environment. Because nearly the entire area of the quadrangle is within the Ashley National Forest, the region often is visited by motorists, hikers, campers, and cavers. Most of the land within the quadrangle is also frequented by ranchers who lease portions of the National Forest for grazing cattle.

Big Brush Cave, located northwest of the center of the quadrangle and south of the Red Cloud Loop (0619700 E, 4505950), is a popular destination for cavers and hikers. Once past the first constriction, this cave opens to a room with a ceiling approximately 10 m above the floor. Large tabular rocks are calving from of the ceiling and falling to the floor. These falling rocks not only present a danger to the caver, but also represent erosion and thinning of the cave ceiling. Whereas no topsoil is yet exposed, a hole in the limestone about 4 m in diameter and 1 m deep is present on the ceiling. This hole corresponds to a small marsh in the alluvium above the cave. It appears that as water sits in this marsh and percolates into the ground, dissolution and freeze-thaw action is eroding a hole in the cave ceiling. The thickness of the remaining rock of the ceiling was not determined, and an estimate of the possibility of a total ceiling collapse and large sinkhole in the meadow was not reliably made in this study.

Landslides have occurred in the Dyer Mountain quadrangle and in much of the south flank of the Uinta Mountains (Kowallis and Bradfield, 2005). There has probably been no significant change in the geomorphologic processes or the environment of the area since these landslides have occurred, so it is logical to assume that more will occur in the future. These landslides are typically found on the borders of the Quaternary and Tertiary gravels. In most cases, and certainly within the Dyer Mountain quadrangle, these landslide-prone areas are not populated or frequented and pose little danger. It would be prudent to be mindful of the possibility of landslides, especially during periods of very high rainfall.

The Red Cloud Loop in the northeast portion of the quadrangle is a narrow improved dirt road that in many places is built on steep slopes. Some of these areas pose a threat to motorists from rocks becoming dislodged and rolling down the slope into the road.  Other areas where there is little between the road and the steep slopes below may experience erosion and failure of the road itself.  Care must also be taken in these areas not to drive off the road and over the steep bank.  As of the summer of 2008, this road was kept in very good condition by workers of the Ashley National Forest to mitigate the dangers posed by the precarious route.

The cliffs of Big Brush Gorge are easily accessible to motorists and hikers.  The areas near these cliffs provide magnificent views of the canyon, but activity near cliffs poses obvious dangers of falling to one's death.  Caution must be taken when around these areas, and the unstable steep slopes of the Meade Peak that overlie the cliff-forming Weber should probably be avoided.

Few hikers descend into the canyon of Big Gorge since it is relatively inaccessible in the southern portion of the quadrangle.  When in the canyon, hikers must be cognisant of possible rock falls and slides from the canyon walls.  It would be best to travel along Big Brush Creek, away from the base of the canyon cliffs.  This path along the stream is the easiest route through the canyon anyway.

# CHAPTER 8 -  Economic Geology

The past and current methods for extraction of resources within the Dyer Mountain quadrangle are limited to open-pit mining.  The area of Dyer Mines, located 500 meters east-southeast of the peak of Dyer Mountain in the vicinity of 0620950 E, 4510150 N, seems to be the most ambitious attempt to mine copper ore from the Lodore Formation.  An inactive smelting facility, apparently once connected by rail to the Dyer Mines, is located west of Dyer Mountain at 0618420 E, 4510210 N, near the headwaters of Anderson Creek.  Numerous prospect pits are also dug throughout the Lodore outcrop belt.  Since the quadrangle is almost entirely within the Ashley National Forest, these are federal lands and entrepreneurs may stake claims to property with natural resource potential.

There are numerous areas within the study area that are indicated as open pit mines according to the U.S. Geological Survey 7.5-minute topographic map of the Dyer Mountain quadrangle.  Most of these are usually only small holes approximately

6 m in diameter and a 1 m deep, and apparently are small abandoned limestone quarries; others are probably prospect pits.  The Madison Limestone has been used in the desulfurization process at power plants, and the small quarries may have contributed to this need.  Lore has circulated throughout the Uinta Mountains area that various individuals, including American Indians, Spanish explorers, and the members of the Mormon Church, have hidden vast quantities of gold and treasure in the Uinta Mountains.  These myths have led to frequent prospecting, and may be responsible for some of these small pits.

The Meade Peak Member of the Phosphoria Formation contains phosphate ore that is mined in the southeast corner of the Dyer Mountain quadrangle.  Simplot Phosphates, LLC, runs a medium-sized mining operation approximately 2 km southeast of the quadrangle.  The company owns about 6 square kilometers of the southeast corner of the quadrangle.  The area of Camp Canyon and Gompers Canyon are no longer being actively mined due to the low concentration of phosphate ore there, but the land is being held as a reserve for future increases in market price.  The area east of Big Brush Gorge is currently being mined, with the mining face propagating north nearly 100 m per year. The mine pumps phosphate slurry150 km north to Rock Springs, Wyoming and produces about 1.3 tons of raw phosphate every year for the fertilizer industry.  The geologic map (Plate 1) depicts the area of active mining and disturbed land as of July, 2008.

The Weber Sandstone produces petroleum at depth in the Uinta Basin to the south and east.  The clean, porous, and permeable Weber is well suited as a reservoir rock at Rangely Field, Colorado.  The overlying clay-rich Meade Peak member of the Phosphoria Formation acts as a trap for hydrocarbons within the Weber (Johnson, 2005). Depending on lateral continuity of lithology, examination of the Weber within the Dyer Mountain quadrangle may provide data for depositional models that could be useful in petroleum exploration.

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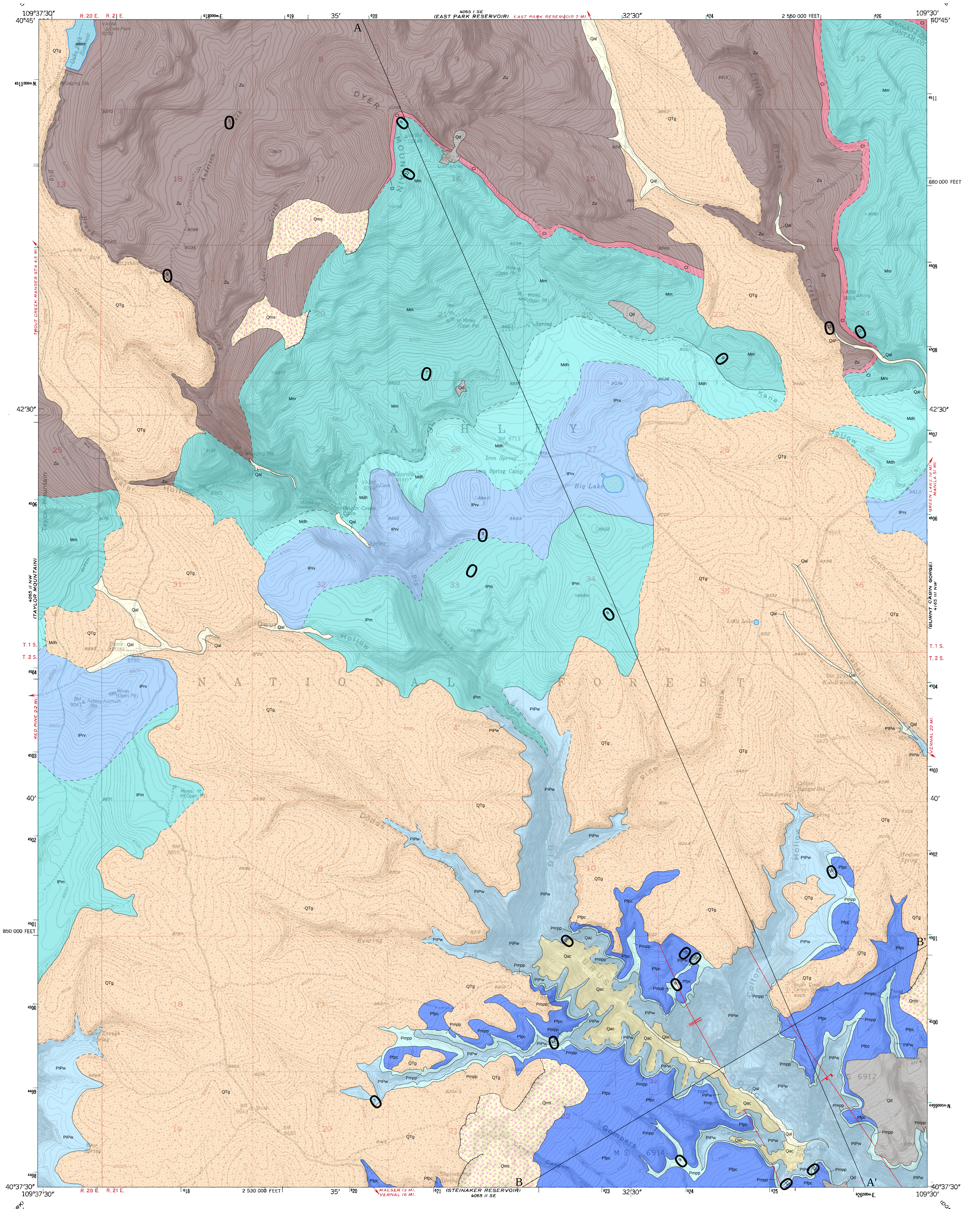
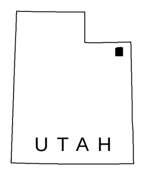
**Plate 1**
**Geology of the Dyer Mountain Quadrangle, Utah**
**M.S. Thesis, Kansas State University, 2009**
**Nickolas L. Patch**




Base map from the U.S. Geological Survey
Dyer Mountain 7.5' Quadrangle, 1950

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET




QUADRANGLE LOCATION

# GEOLOGIC MAP OF THE DYER MOUNTAIN QUADRANGLE, UINTAH COUNTY, UTAH

by

**Nickolas L. Patch**

**2009**

APPROXIMATE MEAN DECLINATION, 2009

Base from USGS Dyer Mountain 7.5' Quadrangle (1950)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

GIS and Cartography: Buck Ehler

**Utah Geological Survey**
1594 West North Temple, Suite 3110
P.O. Box 146100, Salt Lake City, UT 84114-6480
**(801) 537-3300**
geology.utah.gov

This map was created from Geographic Information System (GIS) data.

| 1 | 2 | 3 |
|---|---|---|
| 4 | | 5 |
| 6 | 7 | 8 |

1. Elk Park
2. East Park Reservoir
3. Mount Lena
4. Taylor Mountain
5. Burnt Cabin Gorge
6. Dry Fork
7. Steinaker Reservoir
8. Donkey Flat

ADJOINING 7.5' QUADRANGLE NAMES

## DESCRIPTION OF MAP UNITS

**Qd** — Human-Disturbed Land - *This unit includes the small excavation and tailings piles at Dyer Mines, small quarries on the Madison Limestone, and the Simplot Phosphates mine in the southeast corner of the quadrangle. This phosphorous mine is the only active mining occurring within the quadrangle, and will continue to grow to the north.*

**Qal** — Alluvium - *These areas primarily contain silt and mud and form small flood plains that correspond to areas of relatively low stream gradient. This unit is covered with grasses in most places and may contain pebbles and cobbles in addition to fine sediment.*

**Qac** — Alluvium and Colluvium - *This unconsolidated and poorly sorted sediment in Big Brush Gorge ranges in size from pebbles to boulders. It is derived from rock falls, mass movement, and river transport during flood stage. This is predominately material from the Weber Sandstone, but also contains Franson material and Uinta Mountain Group boulders from the Quaternary and Tertiary deposits.*

**Qms** — Mass Movement, Slide - *Landslides in the southern portion of the quadrangle are composed of displaced material from the Quaternary and Tertiary gravels. Those in the northern portions of the map are composed of displaced Madison Limestone, with perhaps intermixing of the underlying Uinta Mountain Group.*

**QTg** — Quaternary and Tertiary Gravels - *Poorly consolidated conglomerates and unconsolidated gravel deposits composed of rounded Uinta Mountain Group clasts of red sandstone. Grain size ranges from silt to cobbles, but boulders measuring several meters in diameter are seen in the southeast portion of the quadrangle. Weathers and erodes to rounded hills that are covered by red, sandy soil. Uinta Mountain Group cobbles are common on the surface of sparsely vegetated areas because of the erosion and removal of the finer-grained matrix. Vegetation cover is usually sage brush and aspen.*

**Pfpc** — Franson Member of the Park City Formation - *This Lower Permian unit alternates between light gray shale and beds of light tan cherty limestone or dolostone. The base of the formation within the Dyer Mountain quadrangle is defined as the bottom of the lowest cliff-forming bed, which in most cases is a light tan, vuggy, lithic, poorly sorted calcareous sandstone, with fluvial cross bedding in many places.*

**Pmpp** — Meade Peak Phosphatic Shale Member of the Phosphoria Formation - *This Lower Permian light gray to greenish gray soft shale forms slopes at outcrops. The base is composed of cherty gray conglomerate, grading up into a very light gray siltstone with calcareous nodules 1 to 5 cm in diameter and dark gray phosphate nodules approximately 5 mm in diameter. This siltstone grades up into a tan limestone that is probably partially dolomitized, indicated by its mild reaction with hydrochloric acid. Phosphate concentrations in the Meade Peak increase to the east as the unit thins. This unit is seen directly above the Weber Sandstone and below the lowermost limestone of the Franson in Big Brush Gorge.*

**PIPw** — Weber Sandstone - *This Lower Permian to Middle Pennsylvanian unit is predominately a sub-rounded, very well sorted and medium to fine-grained, light to very light tan, quartz arenite. Whereas it typically has silica cement, some outcrops effervesce and indicate that calcium carbonate is present. It contains large cross bedding up to several meters thick. The hardness and thick beds of this formation result in the cliffs seen at Big Brush Gorge and numerous other canyons in the southeast Uinta Mountains. Where exposed to the elements for long periods of time, this unit weathers to medium tan and crumbles easily between the fingers.*

**IPm** — Morgan Formation - *This fossiliferous Middle Pennsylvanian unit is predominately a light gray crystalline limestone with beds of light purple crystalline limestone. Brachiopods are common, and crinoids measuring up to 2 cm in diameter are abundant. Microvugs can be discerned with a hand lens. There are also numerous beds of light tan to orange fine-grained sandstone up to several meters thick, most of which are calcareous. Beds up to 10 cm thick of medium and dark red chert nodules can be found. Chert and fossil occurrence in the Morgan were found to vary laterally within the Dyer Mountain quadrangle.*

**IPrv** — Round Valley Limestone - *This Lower Pennsylvanian unit is up to 150 m thick (Spangler, 2005) and is predominately composed of meter-scale beds of gray limestone and soft red and brown shale. Although crinoids and brachiopods are present in certain beds, they are not common. Red, blue-gray, and yellowish-gray chert nodules and chert beds up to 1 m thick are common. Some beds of tan cross-bedded calcareous sandstone are seen. The Round Valley forms rounded, tall hills, such as those seen north and west of Big Lake in the central part of the quadrangle.*

**Mdh** — Doughnut Shale and Humbug Formation - *These two Upper Mississippian formations are poorly exposed in the Dyer Mountain quadrangle, and have been combined for mapping proposes because they cannot be accurately differentiated. They are composed of gray to brown soft shale that erodes to slopes, valleys, and rounded hills.*

**Mm** — Madison Limestone - *This Mississippian unit, sometimes referenced as the Lodgepole Limestone (Spangler, 2005), is a medium to dark gray, medium to fine grain crystalline limestone with occurrences of light and dark gray chert nodules. Zebra chert, with light and dark bands that form twisting and convoluted designs (Figure 2.1), is found in weathered areas. Outcrops of medium and light gray brecciated limestone with grains approximately 2 mm in diameter are present. Fossils are usually highly altered, with horn corals common in the lower Madison.*

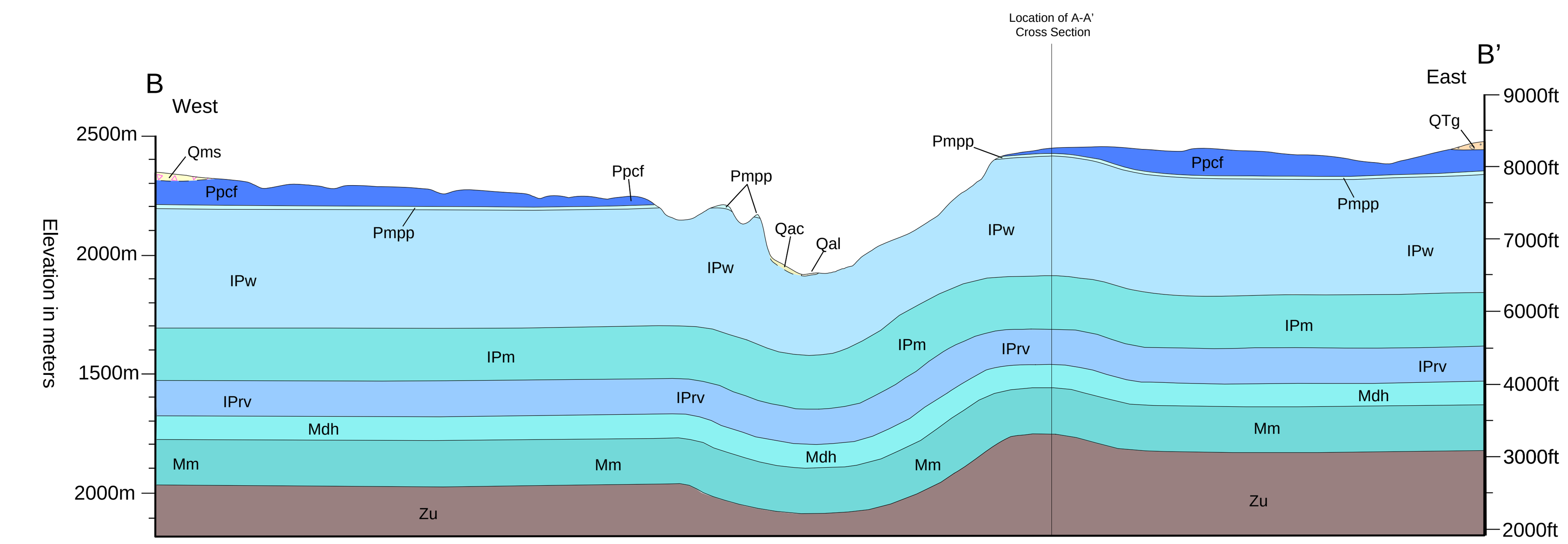
**Cl** — Lodore Formation - *This Cambrian unit unconformably overlies the Uinta Mountain Group and is typically a red or green shaley siltstone and sandstone with metallic nodules. Some areas may be a tan calcareous shaley limestone. This unit is commonly covered by soil and colluvium from the overlying Madison Limestone, and is mostly characterized by a distinct shallowing in slope as the hard Madison meets the soft Lodore.*

**Zu** — Uinta Mountain Group, Undivided - *This Precambrian unit is predominately a red to brown, poorly sorted feldspathic and lithic sandstone and conglomerate interbedded with soft green shale up to four centimeters thick. Within the Dyer Mountain quadrangle, the top of the unit that lies beneath the unconformity with the Madison Limestone is a matrix-supported pebbly conglomerate containing sub-rounded quartz pebbles up to 3 mm in diameter. Most areas of the Uinta Mountain Group display large, angular, and in some places tabular boulders of this conglomerate. These characteristics distinguish the Uinta Mountain Group from the smaller, rounded, and finer-grain boulders usually seen in the Quaternary and Tertiary gravels. Highly weathered areas show sub-angular boulders which may be bleached to medium tan, probably as a result of water movement through the permeable rock that carries away iron oxide pigments.*

## MAP SYMBOLS

- CONTACT
- CONTACT, APPROX. LOCATED
- ANTICLINE AXIS
- ANTICLINE AXIS, CONCEALED
- SYNCLINE AXIS
- SYNCLINE AXIS, CONCEALED
- LANDSLIDE SCARP
- ORIENTATION AND DIP ANGLE OF BEDDING (9)

| AGE | UNIT | THICKNESS meters (feet) |
|---|---|---|
| Cenozoic | Quaternary and Tertierary gravels | 0-100 (0-330) |
| Permian | Franson | 0-115 (0-380) |
| | Meade Peak | 3-5 (10-17) |
| Pennsylvanian | Weber | 490 (1600) |
| | Morgan | 220 (730) |
| | Round Valley | 150 (500) |
| Mississippian | Doughnut and Humbug | 95 (310) |
| | Madison | 195 (640) |
| Cambrian | Lodore | 0-25 (0-80) |
| Precambrian | Uinta Mountain Group | >5000 (>16400) |



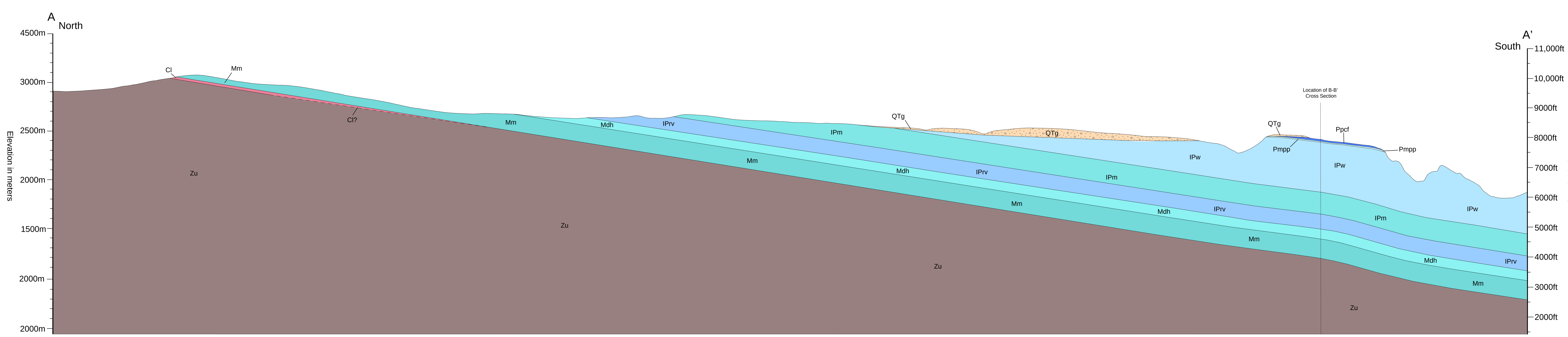




Plate 2
Geology of the Dyer Mountain Quadrangle, Utah
M.S. Thesis, Kansas State University, 2009
Nickolas L. Patch