Interim Geologic Map of the East Part of the Duchesne 30′ x 60′ Quadrangle, Duchesne and Wasatch Counties, Utah (Year 3)

by

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Disclaimer

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ABSTRACT

This interim geologic map of the east half of the Duchesne 30' x 60' quadrangle is the result of the third year of a multi-year project to map and compile the geology of this quadrangle. The Duchesne 30' x 60' quadrangle is located mostly in the western Uinta Basin, and the northwest corner is located on the southwest flank of the Uinta Mountains. Four 7.5-minute quadrangles were mapped from July 2014 to June 2015 and now eighteen are completed in the eastern half of the 30' x 60' quadrangle.

The map area includes a variety of surficial deposits that range from historical to lower Pleistocene. These deposits include piedmont alluvium and stream alluvium that provide clues to the erosional history of the Uinta Basin and mountain-front retreat of the south flank of the Uinta Mountains. The map area also contains glacial deposits that include till and outwash from three well-documented glacial events. Bedrock map units include members of the Duchesne River Formation, the upper two members of the Uinta Formation, and the upper two members of the Green River Formation. Members of the Duchesne River Formation are (in descending order) Starr Flat, Lapoint, Dry Gulch Creek, and Brennan Basin. Members of the Uinta Formation are (in descending order) C and B. Member A of the Uinta Formation is not present in the Duchesne 30' x 60' quadrangle because it intertongues with and grades to the informal sandstone and limestone facies of the Green River Formation east of this quadrangle. Similarly, most of member B also intertongues with and grades to the informal sandstone and limestone facies of the Green River Formation within this quadrangle. Informal members of the Green River Formation are (in descending order) the sandstone and limestone facies and the saline facies.

Structural features include the east-northeast-trending axis of the Uinta Basin syncline (and associated folds), the basin boundary fault zone located in the northern part of the map area, and the Duchesne fault zone located in the southern part of the map area. A series of fault scarps cut glacial outwash of Blacks Fork age (upper to middle Pleistocene) and pre-Blacks Fork age (middle to early[?] Pleistocene) on Towanta Flat, northwest of Mountain Home, and generally align with exposed faults that may be surface traces of the basin boundary fault. Apparent offset of Blacks Fork-age outwash along the basin boundary fault system near Pigeon Water Creek (NE¼NE¼ section 9, T. 1 S., R. 5 W., UBLM) suggest that displacement occurred less than about 160,000 years ago. The Duchesne 30' x 60' quadrangle also contains an array of geologic resources including phosphate, sand and gravel, and gilsonite, but energy resources within the quadrangle are the most significant as it contains the prolific Altamont-Bluebell and Monument Butte oil and gas fields.

GEOLOGIC SUMMARY

This interim geologic map is the result of the third year of a multi-year project to map and compile the geology of the Duchesne 30' x 60' quadrangle. The Duchesne 30' x 60' quadrangle is located mostly in the western Uinta Basin, and the northwest corner is located on the southwest flank of the Uinta Mountains (figure 1). The area mapped includes eighteen 7.5-minute quadrangles in the east part of the 30'x 60' quadrangle (figure 2) and includes the towns of Altamont, Altonah, Bridgeland, Duchesne (Duchesne County seat), Mountain Home, and Talmage. The Duchesne 30' x 60' quadrangle was previously mapped as part of a study in the southwestern part of the Uinta Basin (Ray and others, 1956) and as part of the Salt Lake City 1° x 2° quadrangle (Bryant, 1992) (figure 2). This map is a continuation of mapping of the Duchesne 30' x 60' quadrangle that began in 2013 (Sprinkel, 2013, 2014).

The map area includes a variety of surficial deposits that range from historical to lower Pleistocene (figure 3). These deposits include piedmont alluvium and stream alluvium that provide clues to the erosional history of the Uinta Basin and mountain-front retreat of the south flank of the Uinta Mountains. The map area also includes glacial deposits (till and outwash) from three well-documented glacial events (Atwood, 1909; Munroe, 2001; Laabs and Carson, 2005; Laabs and others, 2009; Munroe and Laabs, 2009). The glacial till and associated features (moraine, moraine crest, and ice-margin channels) are in the Lake Fork and Yellowstone drainages in the northern part of the map area. Outwash deposits along the south flank of the Uinta Mountains are on successively lower topographic surfaces with the oldest deposit on the highest surface. The elevation differences between the outwash deposits along the south flank of the Uinta Mountains are greater than the elevation differences between the same ages of outwash deposits on the north flank of the Uinta Mountains, suggesting that down cutting and erosion between glacial events were greater along the south flank than the north flank.

Bedrock map units include members of the Duchesne River Formation, the upper two members of the Uinta Formation, and the upper two member of the Green River Formation (figure 4). The uppermost Starr Flat Member of the Duchesne River Formation is coarse-grained to conglomeratic sandstone with some interbedded siltstone, mudstone, and tuff beds, and the member's stratigraphic relation with the underlying Lapoint Member of the Duchesne River Formation and the overlying Bishop Conglomerate is complicated because of limited outcrop areas and poorly exposed contacts. Andersen and Picard (1972) defined the Starr Flat Member as conglomeratic beds that conformably overlie the Lapoint Member on John Starr Flat in the Duchesne 30' x 60' quadrangle. They described the conformable and intertonguing stratigraphic relations between the Lapoint and Starr Flat Members but did not discuss the stratigraphic relations with the overlying Bishop Conglomerate (Andersen and Picard, 1972, 1974). The Starr

Flat Member conformably overlies the Lapoint Member in the eastern part of the Duchesne 30' x 60' quadrangle, but it was mapped as unconformably overlying older members of the Duchesne River Formation and older formations (Mesozoic through Neoproterozoic) in the western part of the quadrangle (Bryant and others, 1989; Bryant, 1992). The Bishop Conglomerate overlies the Starr Flat Member in the southeastern part of the Kings Peak 30' x 60' quadrangle (figure 1), but its stratigraphic relationship is unclear (Bryant and others, 1989). It was not mapped by Bryant (1992) in the Duchesne 30' x 60' quadrangle but was mapped (with a query) by previous geologists (Huddle and McCann, 1947; Huddle and others, 1951). In most places along the south flank of the Uinta Mountains, the Bishop Conglomerate is known to rest unconformably on a variety of more steeply dipping formations, including the Duchesne River Formation. The unconformable boundary at the base of the Bishop Conglomerate is the Gilbert Peak erosion surface, which was cut across the flanks of the Uinta Mountains and which Hansen (1986) interpreted as the end of the Laramide uplift of the Uinta Mountains. On the south side of Little Mountain (in the Vernal 30' x 60' quadrangle), I mapped both the Bishop Conglomerate and underlying Starr Flat Member (Sprinkel, 2007). Because the contact was obscured and I was influenced by the map relationships of Bryant (1992) in the western Uintas, I considered the two units conformable and above the Gilbert Peak erosion surface. However, in August 2013, I revisited the south side of Little Mountain with Takashi Sato (University of Utah graduate student studying the Duchesne River Formation) and we observed that the Starr Flat Member is conformable and intertongues with the underlying Lapoint Member. The contact between the Starr Flat Member and Bishop Conglomerate is mostly obscured, but in general, the Starr Flat Member dips more steeply than the nearly flat-lying Bishop Conglomerate, suggesting that the Gilbert Peak erosion surface unconformably separates the Starr Flat Member and Bishop Conglomerate at Little Mountain. I now suspect that beds mapped by Bryant (1992) as Starr Flat may be Bishop Conglomerate. Future mapping to complete the Duchesne 30' x 60' quadrangle may help resolve this conundrum.

The age of the Starr Flat Member of the Duchesne River Formation is problematic, further complicating its regional stratigraphic relationship with the Bishop Conglomerate. $^{40}Ar/^{39}Ar$ ages of sanidine from near the base of the Bishop Conglomerate on the Diamond Mountain Plateau and the Yampa Plateau range from 30.54 ± 0.22 Ma to 34.03 ± 0.04 Ma (Kowallis and others, 2005). Bryant and others (1989) reported fission-track ages of zircons from the near the top and base of the Starr Flat Member as ranging from 30.0 ± 1.5 Ma to 36.7 ± 3.9 Ma. This suggests the Starr Flat Member and the Bishop Conglomerate were deposited at about the same time. However, fission-track analyses are less reliable than U-Pb (zircon) and $^{40}Ar/^{39}Ar$ (sanidine, biotite) analyses, and some of Bryant and others (1989) samples may have come from the Bishop Conglomerate. More isotopic analysis and mapping for this project should help resolve the problem. On this map, I show the Starr Flat Member conformably overlying the Lapoint Member and note that continued mapping in the Duchesne 30' x 60' quadrangle will show that it is unconformably overlain by the Bishop Conglomerate (figure 3).

Beds of the Duchesne River Formation were deposited in a mostly fluvial to fluvial-lacustrine environment capped by mostly fluvial deposition (Andersen and Picard, 1972, 1974; Sato, 2014). Beds of the underlying Uinta Formation were also deposited in a mostly fluvial-lacustrine environment but have a stronger lacustrine influence. The Uinta Formation represents a transition from the predominately lacustrine deposition of the underlying and intertonguing Green River Formation to the fluvial deposition of the Duchesne River Formation (Fouch, 1975; Bryant and others, 1989; Sandau, 2005). Both the Uinta and Duchesne River Formations are generally fining upward successions of sandstone, siltstone, and mudstone beds. Within the map area, the contact between these two formations is placed at the top of slope-forming siltstone and mudstone of member C of the Uinta Formation and at the base of the first cliff-forming sandstone of the Brennan Basin Member of the Duchesne River Formation, although regionally the contact is problematic because it is gradational and intertonguing. Isotopic ages obtained from ash and bentonitic claystone beds indicate that the Duchesne River Formation below the Gilbert Peak erosion surface is middle Eocene in age (figures 3, 4, and 5). The Uinta Formation is also middle Eocene based on isotopic ages of laterally equivalent ash beds in the upper Green River Formation (Dane, 1954, 1955; Smith and others, 2008).

The oldest bedrock unit in the map area is the Green River Formation, consisting of the uppermost sandstone and limestone facies and underlying saline facies. The sandstone and limestone facies is composed of mostly light-colored, interbedded sandstone and limestone (as the name implies), but it also contains interbeds of greenish-gray and grayish red siltstone and shale. This unit intertongues with and grades into most of member B of the Uinta Formation in the western part of the map area near Coyote and Cottonwood Canyons. The contact on the map is shown as gradational to reflect the intertonguing relationship. The underlying saline facies is composed of light- to moderate-brownish gray and greenish-gray limestone with some chert, shale, claystone, dolomite, and sandstone (some cross-bedded). It also contains oil shale and saline minerals in subsurface sections, but surface sections commonly have dissolution molds where the saline minerals are leached. The saline facies intertongues with and laterally grades to the sandstone and limestone facies in the quadrangle. Older units of the Green River Formation are exposed to the south in the Price 30' x 60' quadrangle (Weiss and others, 1990) and west in the Provo 30' x 60' quadrangle (Constenius and others, 2011).

Structural features in the map area include the axis of the Uinta Basin syncline and associated folds, the basin boundary fault zone, and the Duchesne fault zone. The Uinta Basin is an asymmetric basin with a steep north limb and a gently dipping south limb. The syncline axis is located near the north margin of the basin and is related to the basin boundary fault zone. The basin boundary fault zone is generally not exposed, but its location can be inferred from surface fault segments mapped within the Duchesne River Formation and from seismic reflection profiles or well data. The location of the basin boundary fault is not fully shown on the map because my study of well data and seismic reflection profiles will be done after more mapping is completed. Part of the fault zone may be exposed on the slopes of John Starr Flat in the northern part of the map area where beds of the upper two members of the Duchesne River Formation are offset and between Bald and Twin Knolls (west edge of Towanta Flat) in the western part of the map area where beds of the Brennan Basin Member are offset. A series of fault scarps cut glacial outwash of pre-Blacks Fork age (middle to early[?] Pleistocene) on Towanta Flat, northwest of Mountain Home, and generally align with exposed faults that I believe are surface traces of the basin boundary fault. Displacement of Pleistocene deposits along the basin boundary fault system shows that segments of the fault have been active in the Quaternary. To the east, Mesozoic and middle Eocene rocks are juxtaposed across the fault zone (Sprinkel, 2006, 2007). Movement along the basin boundary fault zone is partly responsible for uplift of the Uinta Mountains.

The Duchesne River fault zone is exposed in the southern part of the map area, and faults form an east-west-trending, discontinuous graben that cuts beds of the Uinta Formation and underlying Green River Formation. Graben-forming faults are not mapped in some areas because of poor exposures and difficulty in recognizing offset of beds.

The Duchesne 30' x 60' quadrangle contains an array of geologic resources (figure 6) including phosphate, sand and gravel, and gilsonite, but energy resources are the most important (for more information see Utah Geological Survey website; Doelling and Graham, 1972; Verbeek and Grout, 1993; Longman and Morgan, 2008; Boden and Tripp, 2012). Energy resources include oil and gas production, oil shale, some tar sand, and coal. The giant Altamont-Bluebell field and Monument Butte oil and gas fields are the largest in the quadrangle and are among the most productive in the Uinta Basin (for more information see Utah Division of Oil; Fouch and others, 1992; Hill and Bereskin, 1993; Longman and Morgan, 2008).

DESCRIPTION OF MAP UNITS

Quaternary Surficial Map Units

Human Disturbances

Qh Human disturbances, undivided (Historical) – Engineered fill or disturbed areas resulting from construction, such as sewage lagoons, that obscures the original geology; variable thickness.

Qhd Earthen dams (Historical) – Materials used in these structures may include clay, sand, gravel, and boulders derived from local sources; variable thickness.

Qhg Gravel pit (Historical) – Disturbed areas left after extracting borrow materials, mostly for dams, roads, and building pads; gravel pits are located in the various levels of the Quaternary Duchesne River deposits (Qat2, Qat3, and Qat4) and older piedmont alluvium (Qa_3); only the larger gravel pits are mapped; pit depth varies depending on thickness of the gravel deposit, which may be as much as 10 m.

Alluvial Deposits

Qal Stream alluvium (upper Holocene) – Unconsolidated silt, sand, and gravel (pebble-size to small boulder-size clasts) in floodplains of the Duchesne River, Cottonwood Creek, Dry Gulch Creek, and other perennial creeks and in drainages that are downstream of large springs; locally grades into Qac, Qae, and Qace; 1 to 30 m thick.

Qat Alluvial terrace deposits, undivided (Holocene and Pleistocene[?]) – Unconsolidated to locally cemented silt, sand, and gravel (pebbles, cobbles, and boulders); well to moderately sorted mixed-clast deposits that are remnants of stream and fan alluvium 2 to 5 m above Big Draw, Cottonwood, and Dry Gulch Creeks; less than a few tens of meters thick.

Qat_2 Level 2 terrace deposits (Holocene[?] to upper Pleistocene) – Unconsolidated silt, sand, and gravel (pebble-size to small boulder-size clasts) 46 to 76 m above the Duchesne River (average 61 m); finer grained compared to piedmont alluvial deposits; clasts (estimate 10% Mesozoic, 60% Paleozoic, and 30% Neoproterozoic clasts) were derived from Mesozoic sandstone units (Nugget Sandstone and Gartra Member of Chinle Formation), Paleozoic carbonate and sandstone units (Weber Sandstone, Round Valley Limestone, Deseret Limestone, and Madison Limestone), and Neoproterozoic sandstone units (Uinta Mountain Group); forms prominent gravel-capped mesas at elevations of about 1600 to 1615 m in map area; source of gravel deposits mapped as Qhg; 1 to 10 m thick.

Qat_3 Level 3 terrace deposits (upper Pleistocene) – Unconsolidated silt, sand, and gravel (pebble-size to small boulder-size clasts) 58 to 88 m above the Duchesne River (average 73 m); sorting, clast size, and clast composition are similar to Qat_2 with a minor increase in Paleozoic clasts at the expense of Neoproterozoic clasts; forms prominent gravel-capped mesas, including South Myton Bench, at elevations of about 1612 to 1628 m in map area (table 1); source of gravel deposits mapped as Qhg; 1 to 10 m thick.

Qat$_4$ Level 4 terrace deposits (middle Pleistocene) – Unconsolidated silt, sand, and gravel (pebble-size to small boulder-size clasts) about 76 to 85 m above the Duchesne River in the Myton area (average 81 m); sorting, clast size, and clast composition are similar to Qat$_2$ and Qat$_3$ with a minor increase in Paleozoic clasts at the expense of Neoproterozoic clasts; forms prominent gravel-capped mesas, including South Myton Bench, at elevations of about 1609 to 1646 m in map area (table 1); source of gravel pits mapped as Qhg; 1 to 10 m thick.

Qat$_5$ Level 5 terrace deposit (middle to lower[?] Pleistocene) – Unconsolidated silt, sand, and gravel (pebble-size to small boulder-size clasts) about 88 to 146 m above the Duchesne River in the Duchesne area (average 117 m); forms prominent gravel-capped mesas, including Blue Bench, at elevations of about 1768 to 1881 m in map area (table 1).

Qa$_2$ Level 2 piedmont alluvium (Holocene[?] to upper Pleistocene) – Unconsolidated to consolidated pebble to boulder clast-supported gravel in a sand matrix; calcium carbonate coats the underside of some clasts in top 3 m; calcium carbonate coating becomes more pervasive in the underlying 3 m and interval is more consolidated; well-rounded and moderately sorted; deposit has less mixed clasts (estimated 5% Mesozoic, 40% Paleozoic, and 55% Neoproterozoic clasts) and coarser grained compared to lowest terrace deposits (Qat$_2$); clasts were derived from Mesozoic sandstone units (Nugget Sandstone and Gartra Member of Chinle Formation), Paleozoic carbonate and sandstone units (Weber Sandstone, Round Valley Limestone, Deseret Limestone, and Madison Limestone), and Neoproterozoic sandstone units (Uinta Mountain Group); forms the lowest prominent gravel-capped mesas that generally slope south from 1737 to 1585 m elevation and average 40 m above Cottonwood Creek in map area (table 1); deposited on broad alluvial surfaces that have been dissected; deposit may have graded downslope to Qat$_2$; 6 to 6.5 m thick.

Qa$_3$ Level 3 piedmont alluvium (upper Pleistocene) – Unconsolidated to poorly consolidated pebble to boulder clast-supported gravel in a sand matrix; calcium carbonate coatings on the underside of clasts; sorting and clast size are similar to Qa$_2$, but clasts are predominately derived from the Uinta Mountain Group (estimated at about 30% Paleozoic clasts and 70% Uinta Mountains Group clasts); forms prominent gravel-capped mesas that generally slope gently southward from 1981 to 1600 m elevation and average 53 m above Cottonwood Creek in map area (table 1); deposited on broad alluvial surfaces that have been dissected; deposit may have graded downslope to Qat$_3$; 1 to 3 m thick.

Qa$_4$ Level 4 piedmont alluvium (middle Pleistocene) – Poorly to moderately consolidated pebble to boulder gravel in a sand matrix; calcium carbonate coatings on the underside of clasts; sorting, clast size, and clast composition are similar to Qa$_3$; forms gravel-capped mesa of Pine Ridge (section 36, T. 1 S., R. 3 W., UBLM), an unnamed mesa southeast of Monarch Ridge (sections, 6, 7, 18, 19, T. 1 S., R. 3 W., UBLM), and Flat Top (section 13, T. 2 S., R. 3 W., UBLM) above Dry Gulch Creek; generally slopes gently southward from 2012 to 1875 m elevation and averages about 100 m above lower Dry Gulch Creek in map area (table 1); deposited on broad alluvial surfaces that have been dissected; deposit may have graded downslope to Qat$_4$; 1 to 3 m thick.

Qa$_5$ Level 5 piedmont alluvium (middle to lower[?] Pleistocene) – Poorly to moderately consolidated pebble to boulder gravel in a sand matrix; sorting, clast size, and clast composition are similar to Qa$_3$; forms the gravel-capped mesa of La Mink (section 30, T. 1 S., R. 2 W., UBLM); forms the highest gravel-capped mesa in the map area and generally slopes gently southward from 1942 to 1969 m elevation and averages 113 m above lower Dry Gulch Creek in map area (table 1); 1 to 3 m thick.

Qafy Alluvial-fan deposits (Holocene) – Unconsolidated, mud, silt, sand, and gravel (cobbles to few boulders); poorly sorted; grades to stream alluvial deposits (Qal), a variety of mixed deposits (Qac, Qace, Qae), and colluvial deposits (Qc); forms fan-shape deposit at the mouths of drainages and broad coalescing deposits along the base of highlands that have several drainages along their length; less than 10 m thick.

Qafo Older alluvial-fan deposits (upper Pleistocene) – Unconsolidated, silt, sand, and gravel (cobbles to few boulders); poorly sorted; older alluvial fans are dissected and tend to be larger in area than younger alluvial fans; older fan surfaces are generally several meters above younger alluvial fans and about 12 m below older piedmont deposits (Qa$_3$); mapped above the lower part of Spring Branch Creek (W/2, T. 1 N., R. 2 W., UBLM) to its confluence with Cottonwood Creek; 10 m thick.

Colluvial Deposits

Qc Colluvium (Holocene) – Heterogeneous mixture of silt, sand, and pebble to boulder gravel that is transported downslope mostly by soil creep; locally grades into talus (Qmt), landslide (Qms), alluvial fan (Qaf), stream alluvium (Qal), and mixed deposits (Qac, Qae, Qace); thin on steep-gradient slopes and ridge tops to a few meters thick on low-gradient slopes; mapped as stacked units (Qc/Tdl, for example) where colluvial deposits thinly cover bedrock.

Eolian Deposits

Qe — Eolian deposits (Holocene) – Unconsolidated, well-sorted, fine-grained, windblown sand and silt; mostly accumulated on or near outcrops of the Brennan Basin Member (Tdb) of the Duchesne River Formation in broad low-lying areas; generally stabilized by vegetation; grades to mixed alluvial and eolian deposits (Qae); less than 10 m thick.

Mass-Movement Deposits

Qmf — Debris-flow deposits (Historical to Pleistocene) – Locally derived, poorly sorted, matrix-supported debris of clay to boulders; only well-defined deposits are mapped; generally confined to drainages but can spread at the drainage mouth; a high-intensity rainfall or snowmelt event can trigger a debris flow or a landslide, which can mobilize into a debris flow; debris flows are dangerous events because they are fast moving mixtures of thick mud and large debris (boulders, trees, etc.) that can cause significant damage, injuries, and fatalities, and can be expected in and below any drainage including where not mapped; as much as 10 m thick.

Qms — Landslide deposits (Historical to Pleistocene) – Locally derived, very poorly sorted, mixed clay to boulders and blocks of bedrock that result in rotational slumps, translational slides, and earth flows (larger flows are mapped separately as Qmf); commonly forms hummocky and irregular topography that includes closed depressions and sag ponds, internal scarps, and chaotic bedding attitudes; commonly formed in fine-grained and clay-rich bedrock units such as the Lapoint Member of the Duchesne River Formation (Tdl) and the member C of the Uinta Formation (Tuc); landslides in the map area are commonly triggered by increased (often rapid) soil moisture caused by high-intensity rainfall events, above normal precipitation, rapid snowmelt, or excessive irrigation; relative ages of mass-movement deposits were not mapped because even landslides considered old and inactive actually may continue to move by slow creep, are capable of renewed movement, and pose a risk (Ashland, 2003).

Qmt — Talus (Holocene) – Poorly to moderately sorted, mostly rounded to subangular cobble- to boulder-size material that accumulates on and at the base of steeper slopes; may locally include colluvial deposits (Qc) and grade to mixed alluvium and colluvium (Qac); as much as 5 m thick.

Glacial Deposits

Qgs — Smiths Fork till (upper Pleistocene) – Unconsolidated, poorly sorted, matrix supported, angular to rounded boulders, cobbles, and pebbles mostly of red sandstone and quartzite (Uinta Mountain Group); generally forms lateral and terminal moraines with steep crests, knolls, and kettles with a smooth to hummocky surface and thin soils; lateral moraines and till deposits on steeper bedrock slopes are prone to mass wasting, especially when water-saturated; Smiths Fork till was deposited ca. 32,000 to 14,000 years ago but cosmogenic ^{10}Be surface-exposure dating reveal that terminal moraines were abandoned by retreating glaciers before 16,000 years ago (Laabs and others, 2009); considered correlative to the Pinedale glaciation (Douglass, 2000; Munroe, 2001; Munroe and others, 2006; Laabs and others, 2007; Refsnider and others, 2008); 1 to 50 m thick.

Qgas — Glacial outwash of Smiths Fork age (upper Pleistocene) – Unconsolidated, clast-supported, well-rounded, mostly red sandstone and quartzite (Uinta Mountain Group) boulders to pebbles and sand deposited by meltwaters of the Smiths Fork-age glaciers on the south flank of the Uinta Mountains approximately 12,000 to 17,600 (calendar) years ago (Laabs and Carson, 2005; Munroe and others, 2006; Laabs and others, 2007; Laabs and others, 2009; Munroe and Laabs, 2009); derived from till of the last glacial maximum, which was approximately 16,500 to 18,000 years ago; 1 to 20 m thick (Refsnider and others, 2008).

Qgb — Blacks Fork till (upper to middle Pleistocene) – Unconsolidated, matrix-supported, poorly sorted, angular to subrounded boulders, cobbles, and pebbles mostly of red sandstone and quartzite (Uinta Mountain Group) in a sand matrix; generally forms moderately steep moraine crests, ridges, knolls, and kettles with a smooth to hummocky surface and thin soils; mapped along Yellowstone, Lake Fork, and Dry Gulch Creek drainages; age of Blacks Fork Glaciation has not been directly determined in the Uinta Mountains but is thought to range from 128,000 to 186,000 years (Munroe, 2001; Pierce, 2003; Laabs and Carson, 2005; Munroe and Laabs, 2009), which roughly correlates with Bull Lake Glaciation; less than 50 m thick (Phillips and others, 1997).

Qgab — Glacial outwash of Blacks Fork age (upper to middle Pleistocene) – Unconsolidated, clast-supported, well-rounded, mostly red sandstone and quartzite (Uinta Mountain Group) boulders to pebbles and sand deposited by meltwaters of the Blacks Fork-age glaciers; timing of deglaciation has not been directly determined in the Uinta Mountains but is thought to be roughly correlative with and to follow Bull Lake Glaciation ages, which range from 95,000 to 160,000 years as dated in other mountain ranges in the Rocky Mountains (see Phillips and others, 1997; Munroe, 2001; Laabs and Carson, 2005; Munroe and Laabs, 2009); preserved on high benches (in map area) and upper reaches of drainages (north of map area) along the south flank of the Uinta Mountains; deposits are about 60 m above Smiths Fork outwash deposits (Qgas); less than 1 to 20 m thick.

Qgo Pre-Blacks Fork till (middle to early[?] Pleistocene) – Similar in physical properties and composition to Smiths Fork till; age >245,000 years as dated in other mountain ranges in the Rocky Mountains (Phillips and others, 1997); moraines and till mapped above the Yellowstone and Lake Fork drainages; generally not as thick as Smith Fork or Blacks Fork till but may be as much 100 m thick.

Qgao Glacial outwash of pre-Blacks Fork age (middle to early[?] Pleistocene) – Unconsolidated, clast-supported, well-rounded, mostly red sandstone and quartzite (Uinta Mountain Group) boulders to pebbles and sand deposited by meltwaters of glaciers older than the Blacks Fork Glaciation (Munroe, 2001; Munroe and Laabs, 2009); see Phillips and others (1997) for possible correlation ages; preserved on high benches in map area; deposits are about 120 m above Smiths Fork outwash deposits (Qgas); less than 1 to 20 m thick.

Mixed-environment Deposits

Qac Mixed alluvium and colluvium (Holocene) – Unconsolidated silt, sand, and gravel (pebble to cobble clasts) deposited by streams, sheet wash, and slope creep; moderately sorted with angular to subrounded clasts; locally derived from bedrock units or reworked from other unconsolidated deposits; about 1 m thick.

Qae Mixed alluvium and eolian deposits (Holocene) – Unconsolidated alluvial mud, silt, and sand mixed with windblown sand and silt; many of these deposits are on broad flat surfaces and next to drainages on or near outcrops of Dry Gulch Creek (Tdd) and Brennan Basin (Tdb) Members of Duchesne River Formation; locally grades to other mixed deposits (Qac, Qace), eolian deposits (Qes), and colluvial deposits (Qc); mapped as stacked units (Qae/Tdb, for example) where deposits thinly cover bedrock; generally less than 10 m thick.

Qace Mixed alluvium, colluvium, and eolian deposits (Holocene) – Unconsolidated clay, silt, sand, and some gravel deposited by stream, sheet wash, slope creep, and wind; covers large hollows where it is difficult to map deposits from each process separately; as much as 3 m thick.

Qlam Lacustrine, alluvial, and marsh deposits (Holocene) – Unconsolidated mud, silt, sand, and gravel in abandoned floodplain, oxbow lakes, and marshes in meanders of the Duchesne and Strawberry Rivers; have not determined timing of river and stream abandonment; marsh deposits are also mapped where streams and rivers flow into reservoirs or in low-lying areas along the shores of reservoirs, which may reflect the reservoir's maximum fill elevation; 1-30 m thick.

Stacked Units

Qac/Tds, Qac/Tdl, Qac/Tdd, Qac/Tuc, Qae/Tdd, Qae/Tdb, Qae/Tuc, Qc/Tds, Qc/Tdl, Qc/Tdd, Qc/Tdb, Qc/Tuc, Qgas/Tds (Holocene) – Thin, unconsolidated surficial deposits that cover bedrock; small outcrops of bedrock are common within these stacked map units; thickness of surficial deposits range from a few centimeters to generally less than 30 centimeters.

Bedrock Map Units

Tertiary Duchesne River Formation

Thick reddish-brown to light-gray sandstone to mudstone; descriptions and thicknesses of four formal members given below; combined exposed thickness about 1096 to 1590 m; members defined by Andersen and Picard (1972). Detailed regional setting and sequence stratigraphy of the Duchesne River Formation is discussed by Sato (2014).

Tds Starr Flat Member (upper[?] to middle Eocene) – Reddish-brown, reddish-purple, yellowish-gray, and greenish-gray sandstone (73% at type section), siltstone and mudstone (15% at type section), and conglomerate (12% at type section); sandstone is fine to coarse grained, well to poorly sorted, horizontally to cross-stratified, and very thin to thick bedded (thick beds are generally coarse grained and resistant, and thin beds are generally fine grained); sandstone and fine-grained beds dominate the member and coarsen upward; contact is sharp with underlying Lapoint Member (Sato, 2014) and appears conformable at John Starr Flat as shown by Andersen and Picard (1974); 40 to 230 m thick.

Tdl Lapoint Member (middle Eocene) – Light-reddish-brown and yellowish-gray, fine-grained sandstone, siltstone, and mudstone; contains abundant light-greenish-gray bentonite beds; mostly nonresistant and thin- to very thin bedded; mostly reddish in color in the adjoining Vernal 30'x 60' quadrangle but becomes predominately light gray in the map area possibly due to reduction of iron-rich minerals from microseepage of hydrocarbons from the Altamont-Bluebell field or a gradation to more lacustrine lithofacies; middle Eocene (Duchesnean) age based on vertebrate fossil assemblage and K-Ar age on biotite of 39.3 ± 0.8 Ma from an ashy siltstone bed at the Lapoint-Dry Gulch contact (McDowell and others, 1973); Bart Kowallis (Brigham Young University) and I sampled bentonitic beds near the base of the Lapoint Member in the adjoining Vernal 30' x 60' quadrangle that yielded $^{40}Ar/^{39}Ar$ biotite ages of 41.1 ± 0.3 Ma to 41.5 ± 0.1 Ma (unpublished data); 635 to 1045 m thick.

Tdd Dry Gulch Creek Member (middle Eocene) – Medium-reddish-brown and purplish-gray, fine-grained siltstone, mudstone, sandstone, and conglomerate; dominated by slope-forming siltstone and mudstone with ledge-forming thin-bedded sandstone; generally fines upward; type section was measured east of Dry Gulch Creek; member contains some vertebrate fossils (Andersen and Picard, 1972); Mauger (1977) obtained two K-Ar ages on biotite from near the top of the member but considers them unreliable; 201 m thick at the type section to about 150 m thick to the east in the Vernal 30' x 60' quadrangle (Andersen and Picard, 1972; Sprinkel, 2007).

Tdb Brennan Basin Member (middle Eocene) – Light- to medium-red, light-reddish-brown, and yellowish-gray, fine- to medium-grained lithic sandstone and siltstone with minor amounts of mudstone and conglomerate; contains well-developed paleosols; the exposed basal part of the Brennan Basin Member intertongues with the underlying Uinta Formation in the adjoining Vernal 30' x 60' quadrangle (Sprinkel, 2007). The interval of intertonguing in the Vernal 30' x 60' quadrangle is as much as 60 m thick but is minimal in the map area; the contact is placed at the base of a resistant reddish-brown sandstone bed that lies on the uppermost variegated mudstone bed of the Uinta Formation; member contains a diverse assemblage of vertebrate fossils of middle Eocene age (see Andersen and Picard, 1972); a thin (about 15 cm thick), purplish-gray, biotite-rich ash (sample HC08132012-1) was collected near the middle of the member and yielded a U-Pb zircon age of 40.7 ± 1.9 Ma (figure 5, Appendix A and B)(Utah Geological Survey and Apatite to Zircon Inc., 2014); the reported U-Pb zircon weighted mean age of the Brennan Basin Member is younger than the reported $^{40}Ar/^{39}Ar$ biotite ages of the Lapoint Member, but the 1.9 Ma error margin of the zircon age overlaps the biotite age indicating that age of the Duchesne River Formation is about 41 Ma; exposed thickness 220 to 295 m, but is as much as 1040 m thick in subsurface of Uinta Basin.

Tertiary Uinta Formation

The internal stratigraphy and nomenclature of the Uinta Formation is vexing. Only the upper two of the three members are exposed in the Duchesne 30' x 60' quadrangle; the intervals that comprise the capping member C and underlying member B of the Uinta Formation were originally named Horizon C and Horizon B by Peterson in Osborn (1929) based on the characteristic species of titanotheres in each interval. Subsequently, workers used Horizon C, B, and A of the Uinta Formation interchangeably with Uinta C, B, and A (Peterson, 1931; Peterson and Kay, 1931; Peterson, 1932). Wood (1934) proposed the formal member names, the Myton Member (for Horizon C) and Wagonhound Member (for Horizons B and A), and the names Myton and Wagonhound are continued to be used by some (Townsend and others, 2006; Townsend and others, 2010), whereas the informal names Horizon C (Uinta C or member C), Horizon B (Uinta B or member B), and Horizon A (Uinta A or member A) are used or referred to by others (Stagner, 1941; Cashion, 1967, 1974; Cashion and Donnell, 1974; Cashion, 1982; Sprinkel, 2007, 2009). For now I will use the informal names, member C and member B, to reflect what is more commonly used; member A is not present in this quadrangle because it intertongues and has graded to the informal sandstone and limestone facies of the Green River to the east-southeast in the Seep Ridge 30' x 60' quadrangle (Sprinkel, 2009); unit descriptions and thicknesses shown below; combined exposed thickness is less than 1100 m.

Tuc Member C (middle Eocene) – Soft, light-gray, greenish-gray, white, grayish-purple, red, and pale-yellow shale, mudstone, claystone, and minor sandstone with local tuffaceous interbeds generally east of Starvation Reservoir and Duchesne River but grades to a more sandier lithofacies in the western part of the quadrangle; the base of member C has been placed on the top of the "*Amynodon* Sandstone" of Riggs (1912), but Townsend and others (2006) have shown that the contact is transitional and is about 73 m above the "*Amynodon* Sandstone" in the eastern Uinta Basin; forms badlands topography characteristic of Fantasy Canyon (section 12, T. 9 S., R. 22 E., SLBLM); generally 570 to 650 m thick but may be as much as 1100 m thick in the eastern part of the quadrangle.

Tub Member B (middle Eocene) – Light-gray, light-greenish-gray, light-brown, and light-purple mudstone and claystone with interbeds of greenish-gray, yellow, and brown fine-grained sandstone; contains minor conglomerate and tuffaceous beds; forms nonresistant slopes and thin resistant ledges;

source of gravel in pits mapped as Qhg; most of the unit intertongues with and grades to the sandstone and limestone facies of the Green River Formation; thickness varies from about 300 m east of Duchesne to about 35 m near Starvation Reservoir dam because if intertonguing and grading with the sandstone and limestone facies of the Green River Formation but thickens west and northwest of Starvation Reservoir to about 665 m.

Tertiary Green River Formation

The Green River Formation is subdivided into a series of formal and informal names across the Uinta Basin that reflect the varying lithofacies changes. Only the upper two informal members of the Green River Formation, the uppermost sandstone and limestone facies of Bryant (1992) and underlying saline facies, are exposed in the current map area; additional informal members are exposed west of the current map area and will be mapped in subsequent years. The sandstone and limestone facies intertongues with and laterally grades into most of the member B of the Uinta Formation in the western part of the map area near Coyote and Cottonwood Canyons; member A of the Uinta Formation is not present in this quadrangle because it also intertongues and grades into the informal sandstone and limestone facies to the east-southeast in the Seep Ridge 30' x 60' quadrangle (Sprinkel, 2009). The underlying saline facies intertongues with and laterally grades into the sandstone and limestone facies within the map area.

Tgsl Sandstone and limestone facies (middle Eocene) – Light-gray to moderate brownish-gray, thin bedded sandstone and dark-gray limestone and interbeds of greenish-gray and reddish-gray siltstone and shale; contains ostracods, gar pike scales, and fossil plants; may contain organic-rich mudstone to thin coaly beds as well as a few thin beds of oil shale; contains tuff beds; the Strawberry tuff is near at the base of the sandstone and limestone facies and has yielded an $^{40}Ar/^{39}Ar$ sanidine age of 44.0 ± 0.92 Ma (Smith and others, 2008); marginal lacustrine depositional environment (Fouch, 1975; Ryder and others, 1976); as much as 300 m thick.

Tgs Saline facies (middle Eocene) – Light- to moderate-brownish gray and greenish-gray limestone with some chert, shale, claystone, dolomite, and sandstone (some cross-bedded); mud cracks are common in fine-grained rocks; contains oil shale; saline minerals are reported in subsurface sections, but mostly beds with dissolution molds are found in surface sections (Dyni and others, 1985); contains tuff beds; the Oily tuff is in the upper saline facies and has yielded an $^{40}Ar/^{39}Ar$ biotite age of 45.58 ± 0.14 Ma; the saline facies grades upward and laterally eastward with the sandstone and limestone facies; the base is not exposed in the quadrangle; open lacustrine depositional environment (Fouch, 1975; Ryder and others, 1976; Dyni and others, 1985; Franczyk and others, 1992), but the interval of saline minerals in the Green River Formation in the Green River Basin of Wyoming is interpreted as a playa depositional environment (Eugster and Surdam, 1973); as much as 350 m thick.

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APPENDICES

Appendix A

Detrital zircon U-Pb data for the Brennan Basin Member of the Duchesne River Formation

- on CD: Duchesne Appendix A_Tdb_FTUPbICP_ 1319-01_#_ZrnUPb_12_10_01.xlsx
- online: http://geology.utah.gov/online/ofr/ofr-635.pdf (This PDF must be downloaded to access the attached spreadsheet of data.)

Appendix B

Detrital zircon U-Pb report and related Excel workbooks: software for calculating U-Pb zircon ages and presenting U-Pb data by LA-ICP-MS

- on CD: Duchesne Appendix B_UPbICP Report.pdf
- online: http://geology.utah.gov/online/ofr/ofr-635.pdf (This PDF must be downloaded to access the attached spreadsheet of data.)

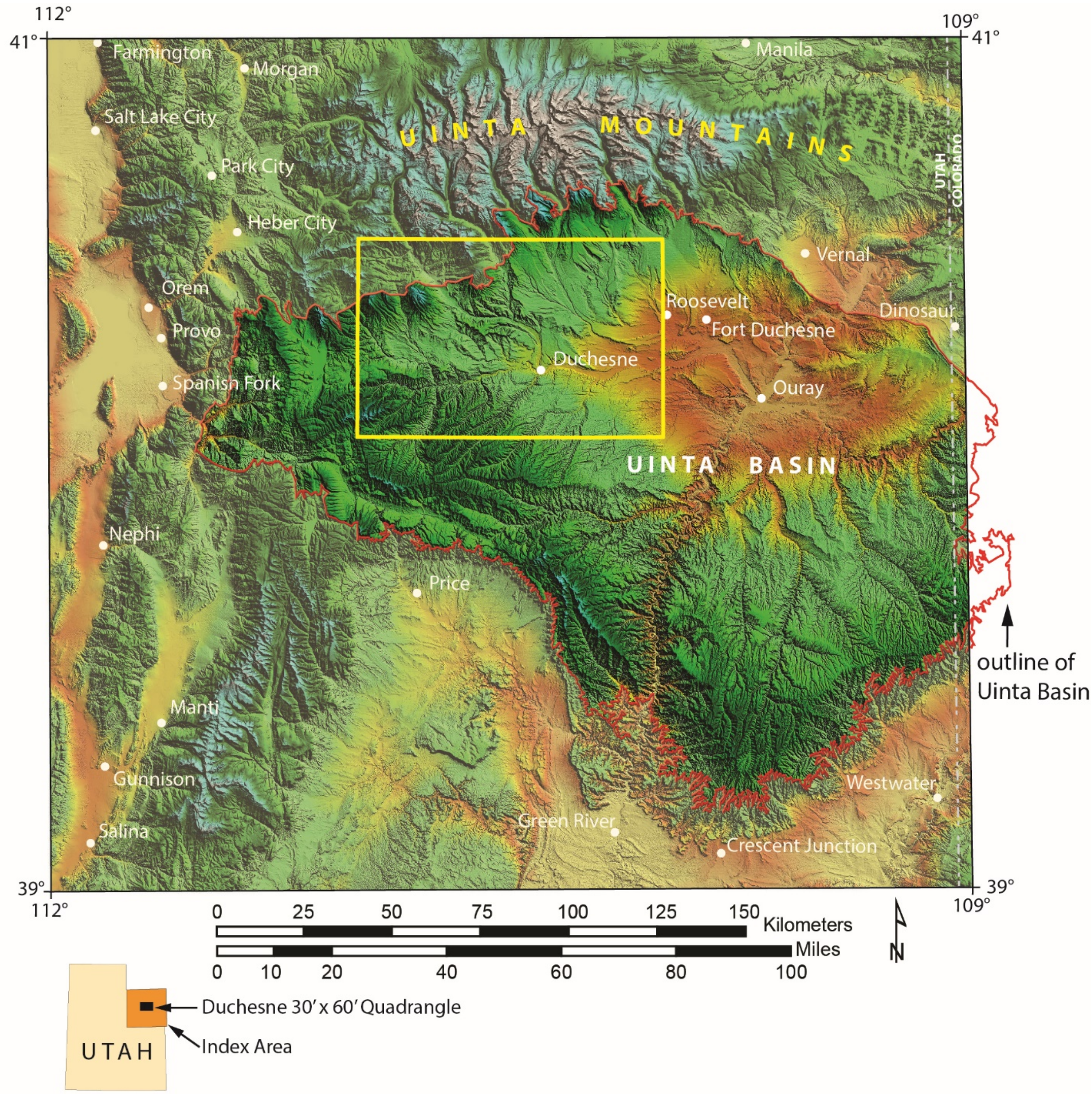
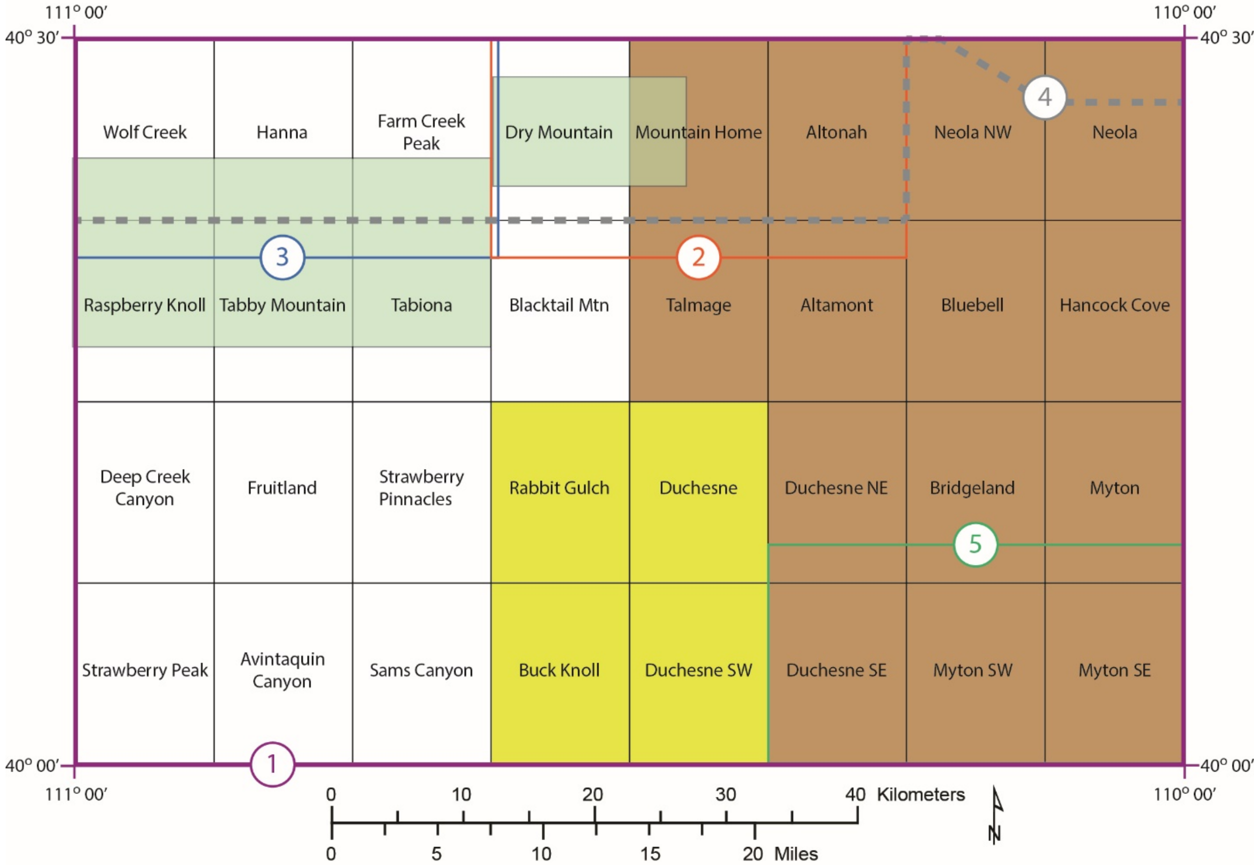


Figure 1. *Colored shaded relief map of the Uinta Basin and surrounding area showing the location of the Duchesne 30′ x 60′ quadrangle.*



(1) Bryant, B., 1992, Geologic and structure maps of the Salt Lake City 1° x 2° quadrangle, Utah and Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1997, 2 plates, scale 1:125,000.

(green) Doelling, H.H., and Graham, R.L., 1972, Eastern and northern coal fields-Vernal, Henry Mountains, Sego, La Sal-San Juan, Tabby Mountain, Coalville, Henrys Fork, Goose Creek, and Lost Creek: Utah Geological and Mineralogical Survey Monograph 2, 411 p., multiple plates, scale ~1:42,240.

(2) Huddle, J.W., Mapel, W.J., and McCann, F.T., 1951, Geology of the Moon Lake area, Duchesne County, Utah: U.S. Geological Survey Oil and Gas Investigations Map OM 115, 1 plate, scale 1:63,360.

(3) Huddle, J.W., and McCann, F.T., 1947, Geologic map of the Duchesne River area, Wasatch and Duchesne Counties, Utah: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 75, 1 plate, scale 1:63,360.

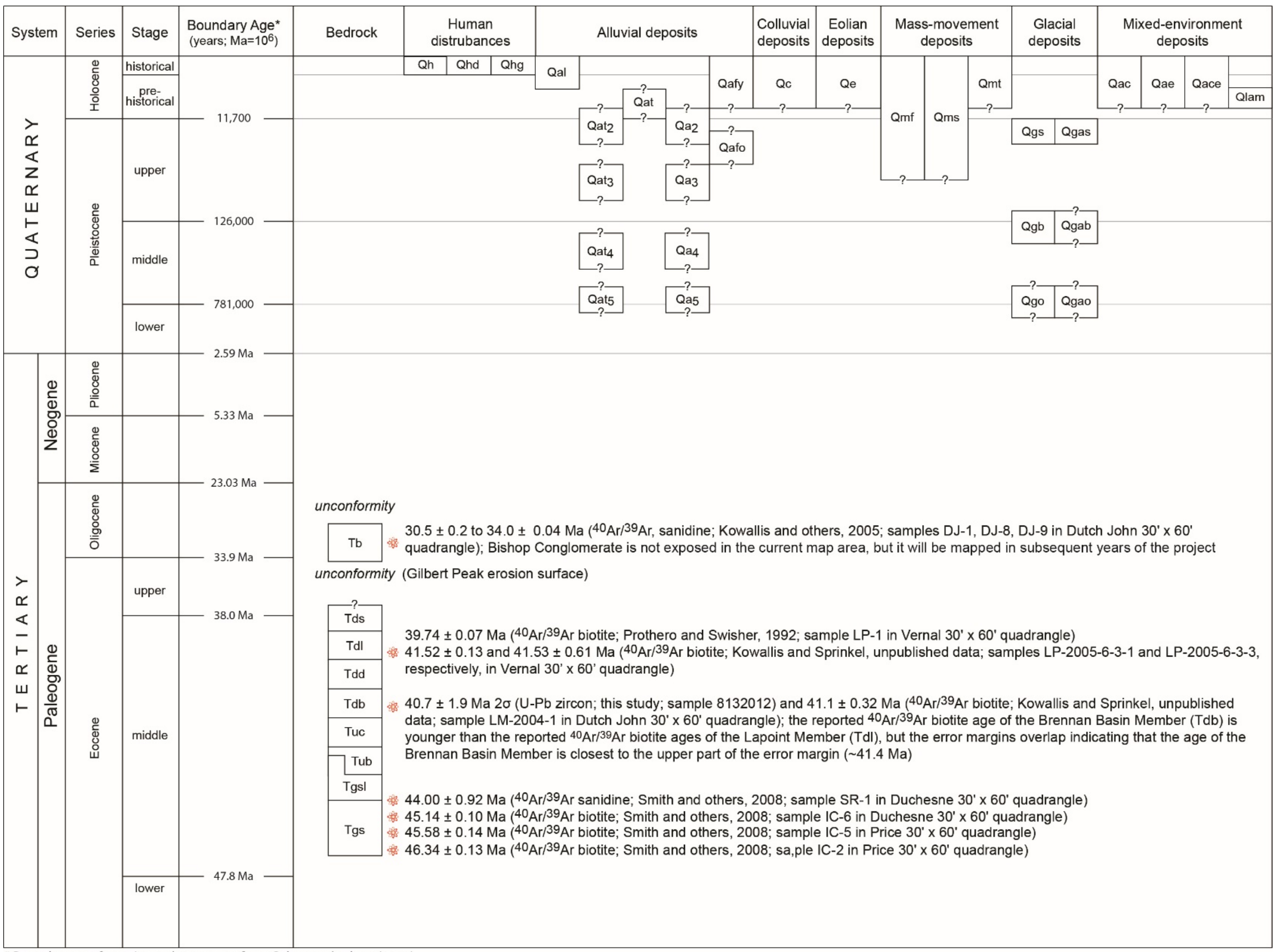
(4) Munroe, J.S., and Laabs, B.J.C., 2009, Glacial geologic map of the Uinta Mountains area, Utah and Wyoming: Utah Geological Survey Miscellaneous Publication 09-4DM, 1 plate, scale 1:100,000.

(5) Ray, R.G., Kent, B.H., and Dane, C.H., 1956, Stratigraphy and photogeology of the southwestern part of the Uinta Basin, Duchesne and Uintah Counties, Utah: U.S. Geological Survey Oil and Gas Investigations Map OM 171, 2 plates, scale 1:63,360.

(brown) Sprinkel, D.A., 2014, Interim geologic map of the eastern part of the Duchesne 30′ x 60′ quadrangle, Duchesne and Wasatch Counties, Utah (Year 2): Utah Geological Survey Open-File Report 634, 19 p., 1 plate, scale 1:62,500.

(yellow) Current Year 3 (07/2014-06/2015) STATEMAP deliverable

Figure 2. *Index of 7.5-minute quadrangles and previous geologic maps within the Duchesne 30′ x 60′ quadrangle that were used to construct this reconnaissance geologic map.*



* Boundary age for series and stages are from Cohen and others (2013)

Figure 3. *Correlation of surficial and bedrock map units.*

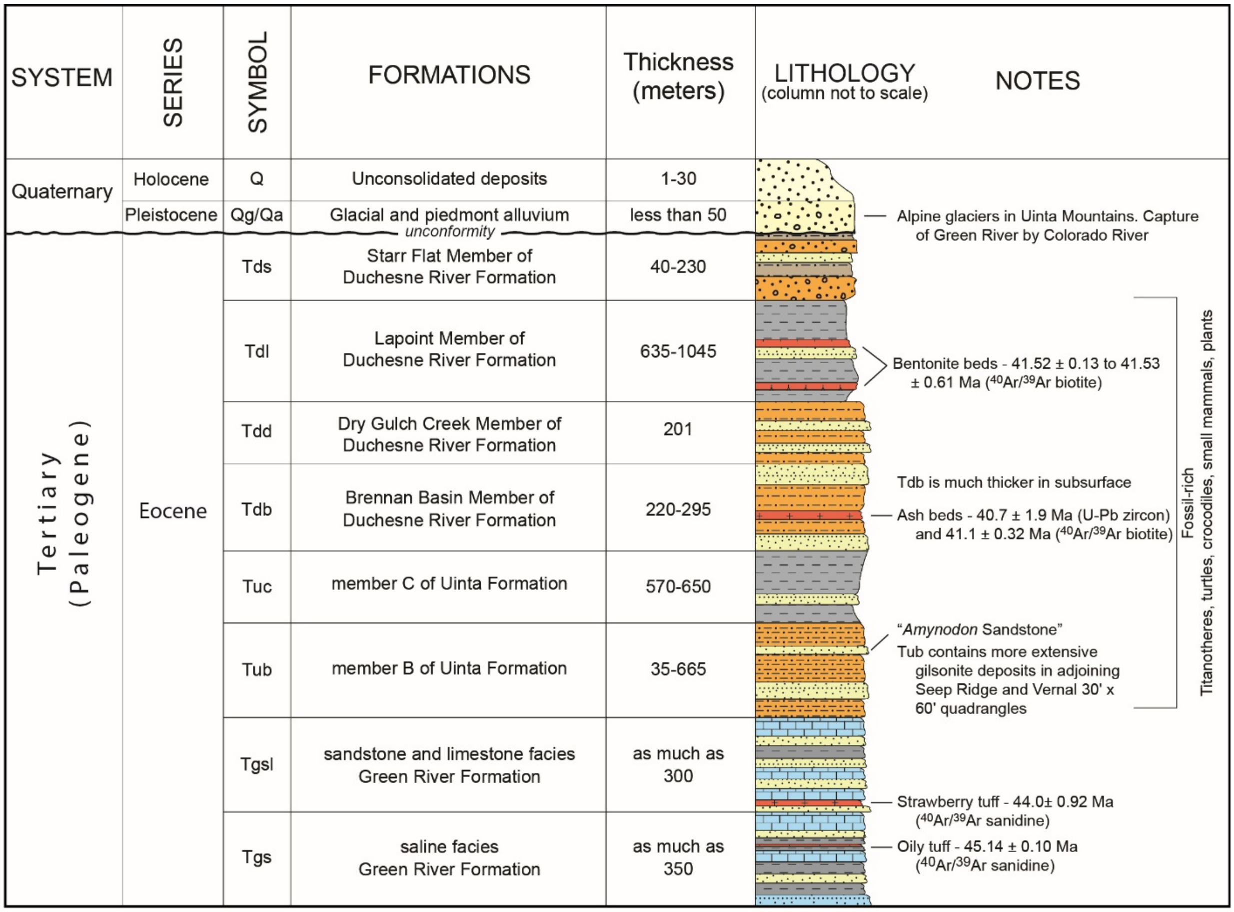


Figure 4. *Stratigraphic column of bedrock units mapped in the east part of the Duchesne 30' x 60' quadrangle.*

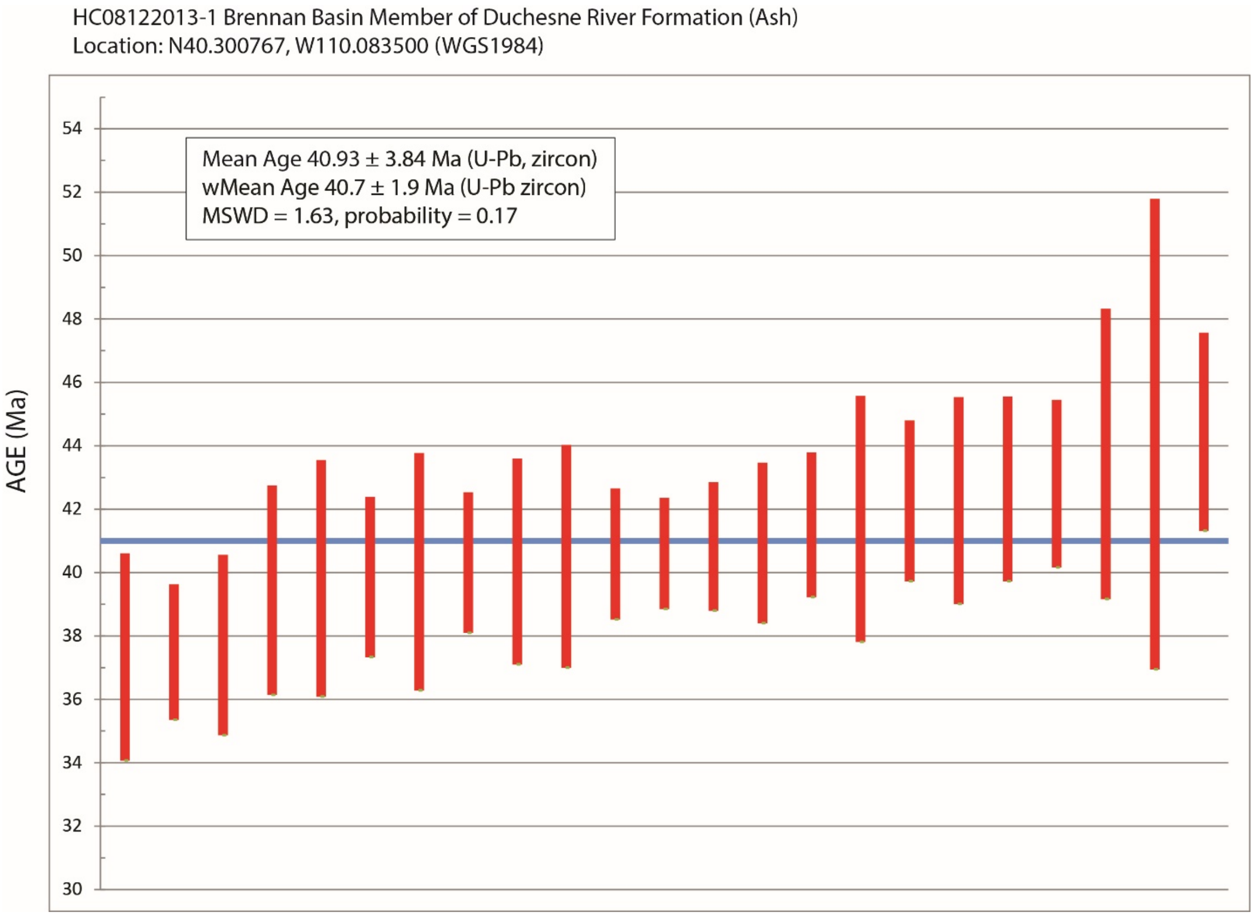


Figure 5. *Age distribution of U-Pb analysis of zircon grains collected from an ash bed located near the middle of the Brennan Basin Member of the Duchesne River Formation. The plot shows the preferred age (blue line) and error range (2σ) for each grain analyzed (red lines).*

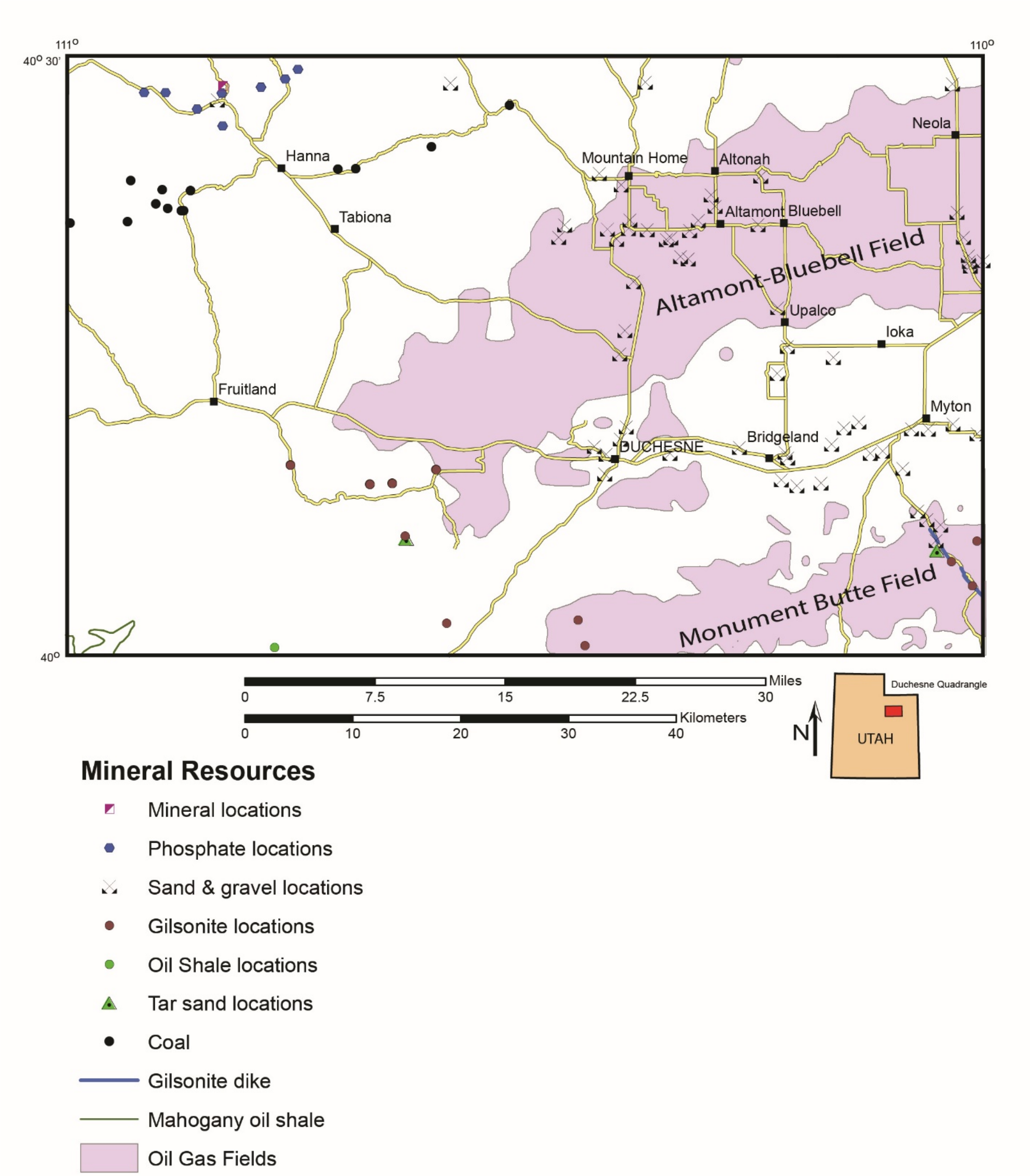


Figure 6. *Location of geologic resources within the Duchesne 30' x 60' quadrangle.*

Table 1. *Elevation and heights of major terrace and piedmont deposits relative to drainages and each other.*

Elevation/Height (meters)	Qat2	Qat3	Qat4	Qat5	Qa2	Qa3	Qa3	Qa4	Qa5	Duchesne River[1]	Duchesne River[2]	Cottonwood Creek at Qa2	Cottonwood Creek at Qa3	Middle Dry Gulch Creek	Dry Gulch Creek
Upper Reaches (in map area)	1615	1628	1646	1881	1737	1981	1908	2012	1969	1829	1570	1719	1951	1859	1935
Lower Reaches (in map area)	1600	1612	1609	1768	1585	1600	1881	1875	1942	1622	1524	1524	1524	1798	1737
Height Above Drainage (upper reaches)	46	58	76	88	18	30	49	61	34						
Height Above Drainage (lower reaches)	76	88	85	146	61	76	82	137	204						
Height Above Drainage (average)	61	73	81	117	40	53	66	99	119						
Height Above Younger Unit (average)		12	8	37		14	26	46	20						
Drainage	DR	DR	DR		CC	CC	MDGC	DGC	DGC						

DR = Duchesne River[1] (Duchesne area)
DR = Duchesne River[2] (Myton area)
CC = Cottonwood Creek
DGC = Dry Gulch Creek
MDGC = middle Dry Gulch Creek

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

INTERIM GEOLOGIC MAP OF THE EAST PART OF THE DUCHESNE 30′ x 60′ QUADRANGLE, DUCHESNE AND WASATCH COUNTIES, UTAH (YEAR 3)

by
Douglas A. Sprinkel
2015

Map Symbols

Point Data

- Bedding, horizontal, field measured
- Bedding, inclined, field measured
- Bedding, inclined, photogrammetric (3-point)
- Fault, dip
- Paleocurrent, field measured
- Sample, isotopic

Gilsonite

- Gilsonite, concealed
- Gilsonite, well located

Folds

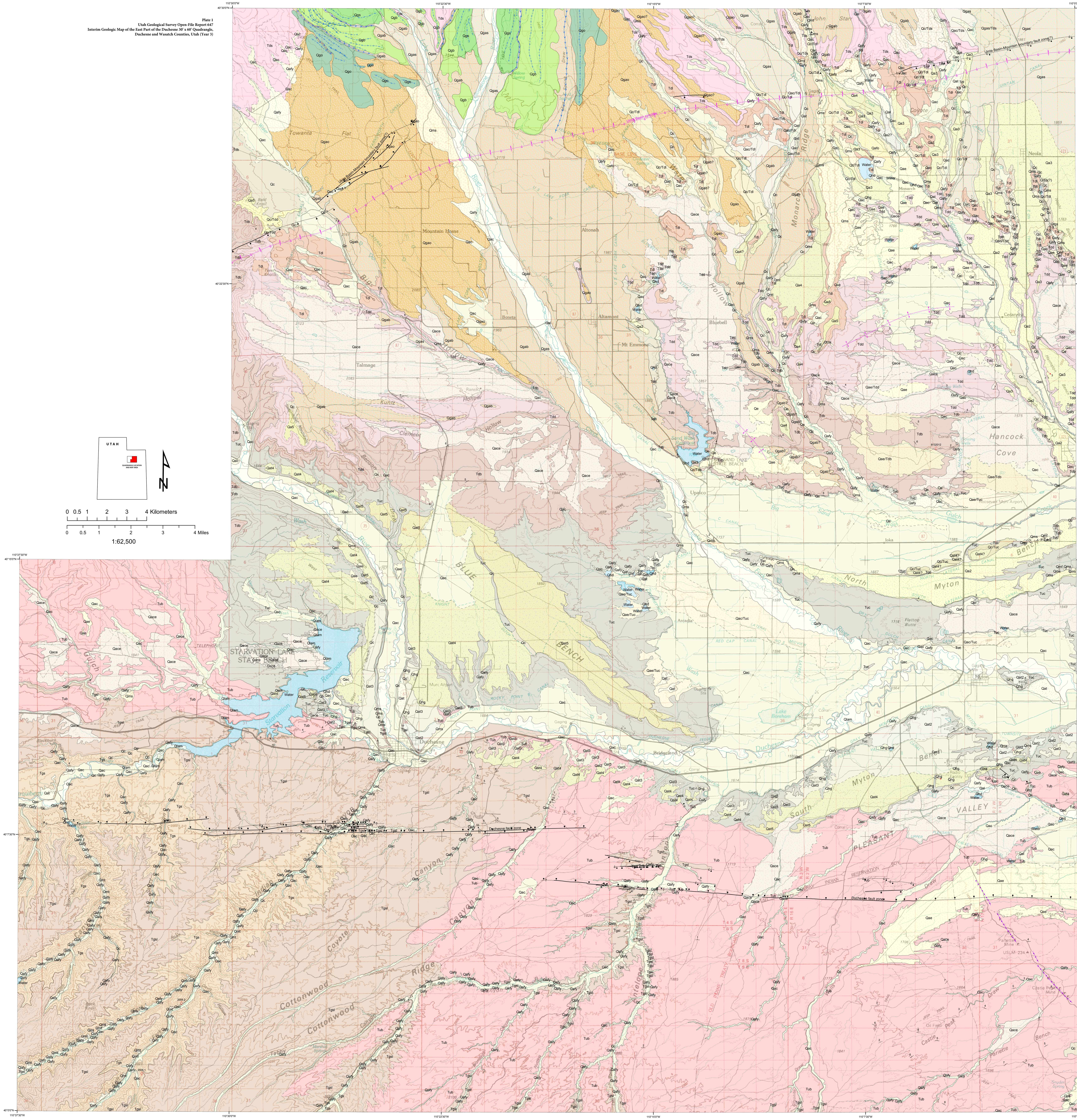
- Anticline, upright, concealed
- Anticline, upright, well located
- Syncline, asymmetrical, concealed, queried

Contacts, Faults, Scarps, and Glacial Features

- Contact, approximately located
- Contact, gradational, approximately located
- Contact, well located
- Fault, normal, approximately located, queried
- Fault, normal, concealed
- Fault, normal, concealed, queried
- Fault, normal, well located
- Fault, oblique-slip, left-lateral, well located
- Fault, oblique-slip, right-lateral, approximately located
- Fault, oblique-slip, right-lateral, concealed
- Fault, offset unknown, well located
- Ice-margin channel
- Moraine crest, symmetrical
- Scarp, landslide, well located
- Map boundary

Unit Symbol

- Qh - Human disturbances, undivided
- Qhd - Eathern dams
- Qhg - Gravel pit
- Qal - Stream alluvium
- Qat - Alluvial terrace deposits
- Qat2 - Level 2 terrace deposits
- Qat3 - Level 3 terrace deposits
- Qat4 - Level 4 terrace deposits
- Qat4? - Level 4 terrace deposits, queried
- Qat5 - Level 5 terrace deposit
- Qa2 - Level 2 piedmont alluvium
- Qa2? - Level 2 piedmont alluvium, queried
- Qa3 - Level 3 piedmont alluvium
- Qa4 - Level 4 piedmont alluvium
- Qa4? - Level 4 piedmont alluvium, queried
- Qa5 - Level 5 piedmont alluvium
- Qafy - Alluvial-fan deposits
- Qafo - Older Alluvial-fan deposits
- Qc - Colluvium
- Qe - Eolian deposits
- Qmf - Debris-flow deposits
- Qms - Landslide deposits
- Qms(?) - Landslide deposits, uncertain
- Qmt - Talus
- Qgs - Smiths Fork till
- Qgas - Glacial outwash of Smiths Fork age
- Qgb - Blacks Fork till
- Qgab - Glacial outwash of Blacks Fork age
- Qgab? - Glacial outwash of Blacks Fork age, queried
- Qgo - pre-Blacks Fork till
- Qgao - Glacial outwash of pre-Blacks Fork age
- Qgao? - Glacial outwash of pre-Blacks Fork age, queried
- Qac - Mixed alluvium and colluvium
- Qae- Mixed alluvium and eolian deposits
- Qace - Mixed alluvium, colluvium, and eolian deposits
- Qlam - Oxbow lake and marsh deposits
- Qac/Tds - Mixed alluvium and colluvium on Starr Flat Member
- Qac/Tdl - Mixed allvium and colluvium on Lapoint Member
- Qac/Tdd - Mixed alluvium and colluvium on Dry Gulch Creek Member
- Qac/Tuc - Mixed alluvium and colluvium on Horizon C member
- Qae/Tdd - Mixed alluvium and eolian deposits on Dry Gulch Creek Member
- Qae/Tdb - Mixed alluvium and eolian deposits on Brennan Basin Member
- Qae/Tuc - Mixed alluvium and eolian deposits on Horizon C member
- Qc/Tds - Colluvium on Starr Flat Member
- Qc/Tdl - Colluvium on Lapoint Member
- Qc/Tdd - Colluvium on Dry Gulch Creek Member
- Qc/Tdb - Colluvium on Brennan Basin Member
- Qc/Tuc - Colluvium on Horizon C member
- Qgas/Tds - Outwash of Smiths Fork age on Starr Flat Member
- Tds - Starr Flat Member of Duchesne River Formation
- Tdl - Lapoint Member of Duchesne River Formation
- Tdd - Dry Gulch Creek Member of Duchesne River Formation
- Tdb - Brennan Basin Member of Duchesne River Formation
- Tuc - Horizon C member of Uinta Formation
- Tub - Horizon B member of Uinta Formation
- Tgsl - Sandstone and limestone facies of Green River Formation
- Tgs
- Water



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