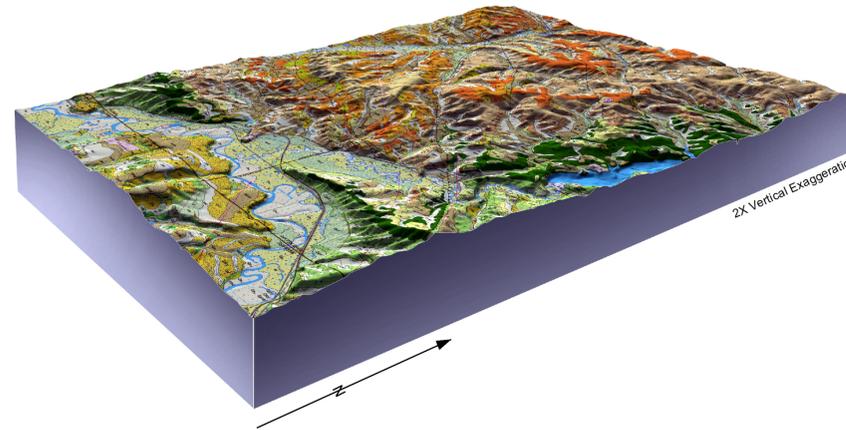
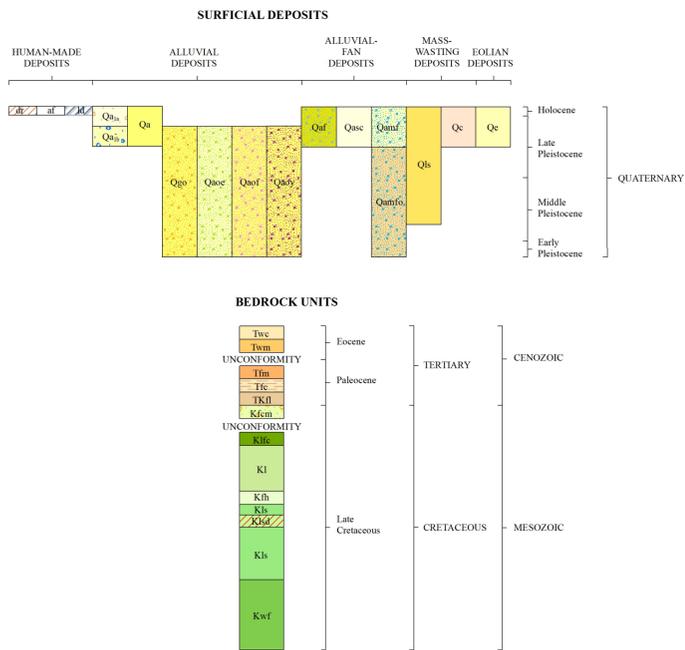


CORRELATION OF MAP UNITS

3-D OBLIQUE VIEW

GEOLOGIC SETTING



Stratigraphy

The Ralph White Lake quadrangle straddles the axial center of the northwest-trending Sand Wash Basin. This setting exposes a stratigraphic succession that records the final eastward retreat of the broad regional Late Cretaceous Interior Seaway, followed by Laramide fragmentation of the region into a series of uplifted ranges separated by downwarped basins. Marine and shoreline barrier island environments are represented by the Lewis Shale (Kls) and Fox Hills Sandstone (Kfh). The Dad Sandstone Member (Ksd) of the Lewis Shale is interpreted to represent delta-front deposits from the Sheridan delta located some distance to the northwest in central Wyoming (Perman, 1987).

Retreat of the Interior Seaway to the east replaced the marine and shoreline environment with that of a broad coastal plain, characterized by brackish estuaries, broad meandering rivers and streams, and swamps. This brought on an upward transition from marine shale, siltstone and sandstone to an assemblage of sandstone, shale, and coal of the Lance Formation (Kl). The sandstone of Fortification Creek (Kfcm) as informally named on the adjacent Craig quadrangle (Morgan and others, 2014), at the top of the Lance Formation has been interpreted to have been deposited by a low sinuosity fluvial system with a north-flowing axial channel complex northwest of Craig (Tyler and McMurtry, 1994). It corresponds to the lower part of the unnamed Cretaceous and Tertiary sandstone mapped in the subsurface by Honey and Hettinger (1989), but was also called the massive K/T sandstone by Tyler and McMurtry (1994). This setting implies a general northwest direction of transport through this quadrangle with a distant source to the south.

A layer of sandstone containing abundant well-rounded pebbles and small cobbles, herein informally called the Moffat conglomerate (Kfcm), marks the top of the sandstone of Fortification Creek. This mappable unit also marks the base of the lower Fort Union Formation (TKf). Gravel clasts are predominantly Paleozoic chert, Paleozoic or Precambrian quartzite and other metamorphic rocks, and felsic volcanic rocks of unknown age. This distinct conglomerate hints at the uplift and exposure of resilient bedrock formations. The conspicuous absence of igneous and metamorphic clasts further indicates that the uplifted source area had not exposed crystalline Precambrian basement. The source was likely within the central Colorado trough away from the Pennsylvanian ancestral Front Range uplift to the east (DeVoto, 1972). This pulse of gravel signals the first emergence of a Laramide-style uplift in this area, yet it was short-lived and the fluvial sedimentation regime returned to one dominated by fine- to medium-grained sandstone similar to that of the Lance Formation.

The date of the Moffat conglomerate is not well constrained. Pollen analyses indicates that the strata below the gravel have an Upper Cretaceous age and strata above a Paleocene age. Honey and Hettinger (1989) proposed that the conglomerate marks a regional unconformity between Upper Cretaceous and Paleocene strata. This was based on palynological results placing a Cretaceous age for strata 85 feet below the conglomerate and an early Paleocene age for strata approximately 50 feet above. A sample of mudstone collected approximately 60 feet above the conglomerate as part of this mapping effort yielded a pollen date reported as "Base of Zone P1, immediately above the K-Pg boundary" by Morehead State University (J. O'Keefe, MSU-DESS, personal commun., 2015). This suggests that the boundary may lie above the conglomerate. Where exposed in this quadrangle, the base of the gravel does not appear to have a well-defined scoured channel. The sand matrix of the conglomerate is also nearly the same as the sandstone below. Evidence for a regional unconformity at the base of the conglomerate in this area is weak. Based on field relationships and the limited pollen analyses in this quadrangle, the conglomerate is tentatively considered uppermost Cretaceous with the Paleocene boundary just above.

Characteristics of the fluvial deposits transitioned to more widely distributed lenticular sandstone bodies interbedded with overbank siltstone and mudstone along with localized, discontinuous deposits of coal (Tc). Eventually sediment supply diminished, resulting in deposits dominated by mudstone (Tfm). Resumed Laramide uplift of a nearby source, this time cored with Precambrian metamorphic and igneous source rocks, resulted in an influx of arkosic sand and gravel marking the base of the Wasatch Formation. Renewed clastic input was gentle at first with sediments containing micaceous mudstone and siltstone with channels of arkosic sandstone and gravel (Twm) displaying localized variegated coloration. An influx of gravel pointing to higher energy streams and greater sediment supply produced an upper conglomerate (Twc) representing the youngest bedrock formation in this part of the Sand Wash Basin. Bedforms are not well exposed to determine directions of transport, but the clast composition suggests the basement cored Park Range to the east as the likely source.

Quaternary deposits mantle much of the quadrangle recording gradual incision of the modern drainage system into the Sand Wash Basin bedrock landscape. Isolated gravel deposits high on ridges and plateaus (Qgo) represent Early Pleistocene trunk stream systems and tributaries. Terrace deposits stair-step downward toward the modern rivers and tributaries (Qmo, Qsoe, Qsof, and Qsoy), many of which are strand deposits on benches of bedrock disconnected from modern waterways. Modern rivers and tributaries have Late Pleistocene to Holocene deposits hydraulically connected with modern drainage systems (Qa, Qas, and Qao). Deposits from intermittent flash-flood dominated tributary drainage systems can consist primarily of coarse (Qaf) or fine (Qam) sediments depending on watershed bedrock characteristics. Landslide deposits (Qc) and colluvium (Qe) reflect inherent instability of bedrock formations in the semi-arid environment. Many of the protected north- to northeast-facing slopes are gentle and mantled with eolian sand and loess (Qe), reworked by sheetwash. These contrast with the steeper, sun-baked, and often wind-scoured, south- to southwest-facing exposures.

Structural Features

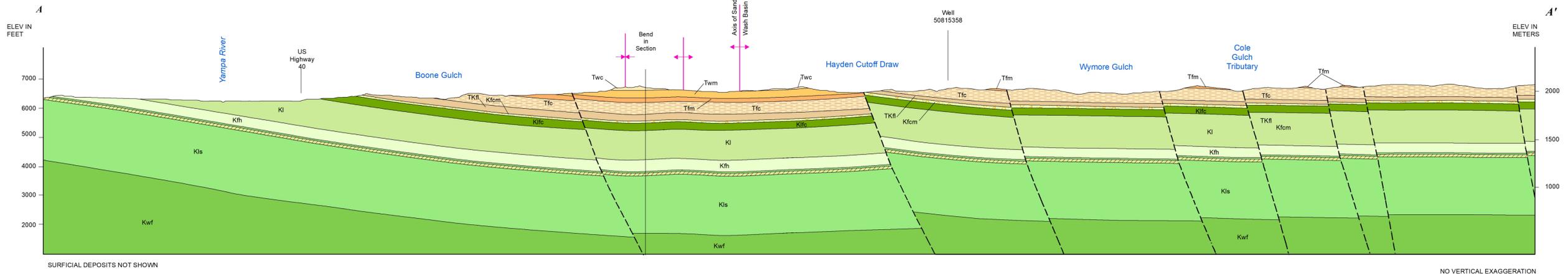
Regional outcrop patterns form an arc around the northwest-plunging axis of the Sand Wash Basin, with the youngest strata heading to the northwest (Tweto, 1979). Attitude measurements and detailed bedrock outcrop patterns within this quadrangle hint at a much more complex structural fabric within the basin center. Bedding attitudes of the Eocene Wasatch Formation within the adjoining Craig quadrangle to the west define a northwest-trending syncline axis (Morgan and others, 2014) that extends into this quadrangle southwest of Hayden Cutoff Draw. In this area, the Wasatch Formation conglomerate (Twc) caps the rough-patterned hills in an arc around the syncline axis. The northeast flank of this syncline is truncated by a northwest-trending fault closely following Hayden Cutoff Draw that displaces the northeast side up. Alignment of this fault, herein named the "Hayden Cutoff fault", suggests that it is a reverse fault dipping to the northeast. Nearly all of the Fort Union Formation is truncated by the fault near the saddle at the head of Hayden Cutoff Draw indicating a displacement of up to 600 feet. Several other similar trending faults, also displacing the northeast side up, can be interpreted from outcrop patterns and attitude measurements north of the "Hayden Cutoff fault". In this area prevailing bedding attitudes strike northwest with a very gentle northeast dip, even though the outcrop pattern gently rises to the northeast. This contradiction suggests a series of northwest-trending faults, with displacements in the range of 30 to 60 feet, effectively stair-stepping northeast dipping strata up to the northeast. This pattern suggests compressional crowding within the central region of the Sand Wash Basin. Outcrop patterns and attitude measurements on the east side of the quadrangle, in the vicinity of Elkhead Reservoir, reveal a series of northeast-trending faults, southeast side down. These faults, which appear to be small normal faults with displacements typically less than 50 feet, tend to stair-step strata down to the southeast. Attitude measurements along Elkhead River also indicate the presence of a southwest- to northeast-trending structural feature transecting the primary Sand Wash Basin alignment. This feature may be a gentle monocline similar to the features described in the nearby Breeze Mountain and Castor Gulch quadrangles (Barkmann and others, 2015a, b).

It is generally thought that the Sand Wash Basin and related features are Laramide structures formed from Late Cretaceous into early Eocene. Differences in composition of the basal conglomerate of the Fort Union Formation and the conglomerates in the Wasatch Formation point to an evolution of the Laramide event from early uplift and denudation to the south and west followed by uplift and denudation to the east. Deformation of the Eocene Wasatch Formation by faulting further hints at late Eocene or younger deformation. Evidence of Neogene deformation is evident in adjoining quadrangles (Morgan and others 2014, Barkmann and others, 2015a) but has not been observed within this quadrangle.

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CROSS SECTION A-A'



GEOLOGIC MAP OF THE RALPH WHITE LAKE QUADRANGLE, MOFFAT AND ROUTT COUNTIES, COLORADO  
 CORRELATION OF MAP UNITS, 3-D OBLIQUE VIEW, GEOLOGIC SETTING AND CROSS SECTION

By Peter E. Barkmann, Erinn P. Johnson, and William Curtiss  
 2016