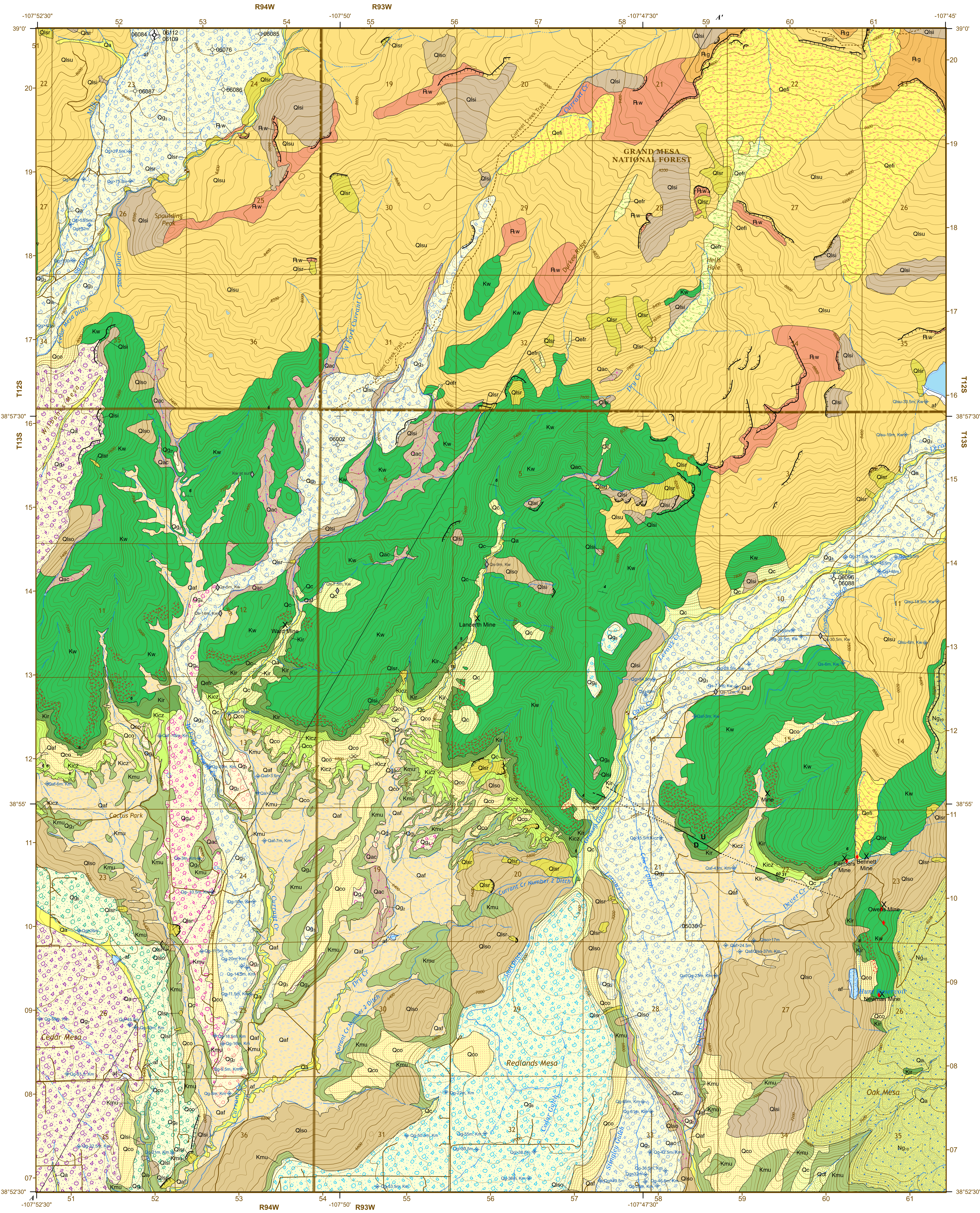
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES
GOLDEN, COLORADO

GEOLOGIC MAP OF THE DRY CREEK QUADRANGLE, DELTA COUNTY, COLORADO
OPEN-FILE REPORT 21-03
PLATE 1 OF 2
DOI: https://10.58783/cgs.of2103.ovbr9253



Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983

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Roads..U.S. Census Bureau, 2016
Names..GNIS, 1978-2019
Hydrography.....National Hydrography Dataset, 2002-2017
Contours.............National Elevation Dataset, 2006-2017
Boundaries......Multiple sources; see metadata file, 2017-2018
Public Land Survey System...............................BLM, 2018

SCALE 1:24,000

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CONTOUR INTERVAL 40 FEET

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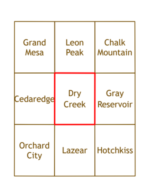
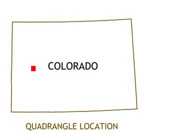
Geology mapped in 2020
GIS and cartography by Pangaea Geospatial



ADJOINING QUADRANGLES



QUADRANGLE LOCATION

GEOLOGIC MAP OF THE DRY CREEK QUADRANGLE, DELTA COUNTY, COLORADO

By Jonathan L. White
2024

DESCRIPTION OF MAP UNITS

Maps units are described using the following classifications: grain sizes chart modified from Wentworth (1922); bedding thickness terms codified in the current classification of the Society for Sedimentary Geology (SEPM); and degree of calcareousness in rock and soils judged by intensity of effervescence (fizz or bubbling in a liquid) that resulted from the introduction of 10% hydrochloric acid (HCl) to a rock or soil sample in the field. Development stages of calcic soils are from Machette (1985).

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (uppermost Holocene) —** Gravel, sand, silt, and clay emplaced by human activities, predominantly for road embankments and reservoir dams. Unit may include controlled engineered fill, uncontrolled unsorted rocky fill, and locally disturbed ground. Thickness is variable, with embankment fills measured up to 15 m thick.

ALLUVIAL DEPOSITS

Qa — **Alluvial deposits (Upper Holocene) —** Tan-gray, poorly sorted, boulder to pebbly gravel, sand, silt, and clay that are typically deposited by seasonal flash floods. Clasts are typically subangular to rounded Neogene basaltic rocks of the Grand Mesa Volcanic Field (GMVF) (Cole and others, 2017), reworked from alluvial (Qg) and landslide deposits. In some locations, sandstone clasts are present in the unit where streams flow near exposures of Williams Fork Formation (Kw) and Rollins Sandstone (Kir). Deposits typically occur along the floors of incised creek channels. The unit is typically not mapped if the channel is narrow (<12 m wide). Finer-grained gravelly mud Qa sediments also locally occur in meanders that have been incised into valley-fill deposits (Qaf). Thicknesses are variable. In some locations, unit is limited to bed-load sediments in ravines, but in broader channels likely does not exceed 1.5 to 2 m in thickness. Areas of unit Qa along narrow creek bottoms, ravines, and channels are periodically subject to dangerous flash flooding events.

Qaf — **Alluvium and alluvial-fan deposits (Holocene to Upper Pleistocene) —** Gray to dark-brown to dark reddish-brown, unsorted to poorly sorted, poorly to moderately stratified, sandy to silty clay that locally may contain gravelly lenses and dispersed pebble- to boulder-sized clasts. The unit contains valley-fill deposits of coalesced alluvial fans and may include unmapped alluvial-colluvial (Qac) sediments including slopewash, and mudflows transported from local soil-slip landslides on adjacent hillsides. The typical deposit generally consists of fine-grained sediments transported as sandy mud derived from clay-rich bedrock onto gentle to moderately sloping valley sides and where valley floors widen when underlain by the upper part of the Mancos Shale (Kmu). The unit locally may contain shale and sandstone fragments and can be gravelly with reworked basaltic pebble- to cobble-sized clasts eroded from older and higher landslide deposits (Qlsu) and gravel (Qg) units within the drainage basin. The unit locally may be incised by younger stream alluvium (Qa) in valleys such as Currant and Dry creeks. Unit Qaf is also mapped in broad swales and shallow valleys on the lower flanks of mesa risers, near exposed bedrock, and low-gradient landslide terrain such as slump-block depressions where the unit is more typical of slopewash. Unit thickness is variable but in water-well logs ranges from 6 to 43 m near where an unnamed stream outlets (T13S, R93W, Sec. 22) onto the broadened valley of coalesced alluvial fans above the confluence of Dever Creek to Leroux Creek. In slopewash swales, unit is likely to be thinner. Flash flooding and mud and (or) debris flows locally may occur in and downstream of the many tributary channels that discharge onto and through this unit. In areas where unit Qaf sediments are derived from expansive clay minerals such as in the Mancos Shale, swelling-soil hazards may locally occur.

Mixed Alluvial and Debris-Flow Gravel Deposits — Basaltic gravel deposits at various heights above stream level and of different ages cover extensive areas throughout the map area where they aggraded and formed broad treads of coalesced glacio-fluvial outwash, debris-flow fans, and paleovalley-fill sediments. Through the process of topographic inversion, these deposits now form a series of elevated and dissected, gravel-capped, relatively flat-lying treads along Surface, Currant, and Leroux creeks. The gravel deposits remnants are typically older at progressively higher elevations above the current creek level and where they have alluvial fan-like geometries with surface profiles that slope upward toward sediment source areas high on the southern flank of Grand Mesa. Old landslides (Qlso) typically mantle the flanks of the high mesa. Assigning relative age to the older gravel deposits is complex; the segregation and isolation of alluvial-fan deposition had been separated by paleo-bedrock drainage divides that have been long removed by later Pleistocene erosion, which may locally result in both differing elevations and longitudinal slope profiles of the high mesas. In all Qg units, three major types of deposits are locally present: 1) tan to tan-gray, debris-flow deposits, stratified by individual flow events, containing very poorly sorted, sub-angular pebbles to boulders in an unsorted sandy-mud matrix that contain very large boulder (≤ 2.5 m) trains and levees; 2) gray, riverine, alluvial deposits containing beds of sub-rounded to well-rounded pebbles to small boulders, densely packed and imbricated in a moderate- to well-sorted sand matrix; and 3) olive-gray to tan-gray, fine-grained, thinly bedded to interlaminated sandy mudflow deposits with scattered, matrix-supported pebbles to small boulders. Cut-and-fill channel deposits are typically composed of debris-flow deposits. Gravel clasts in the deposit are composed chiefly of basaltic rocks of the GMVF. Minor amounts (<5% are non-basaltic rock types) of sandstone, siltstone, clinker, chert, carbonate concretions, and well-rounded polylithic pebbles and cobbles are locally present. These minor clasts are eroded from Upper Cretaceous rocks or reworked from Paleogene- to Miocene-aged sedimentary rock within the drainage basin. The thickness of the deposits varies within individually mapped gravel units listed below. The degree of weathering and calcic soil development (Bk horizon) increases with the increasing age of the deposits. Topsoil on the older units is typically reddish-brown to reddish-tan, and significant erosion and weathering of the ground surfaces has occurred. The reddish-brown topsoil has a pinkish-white chalky appearance in many areas because of the erosion of surface soil horizons and exposure of the well-developed Bk calcic soil horizon. This horizon is best exposed along mesa rims. Basaltic boulders, exposed to long-term surface weathering, are heavily stained, fractured, and have weathering pits. With increasing age, sediments are typically more consolidated, and streaks of blue-gray mineral staining are locally common. Locally the basal zones of some of the older deposits have sufficient calcite cement to form conglomerate that outcrop as subtle ledges at the base of the deposits. Side slopes and swales eroded into risers of the older units are typically mantled with deposits of unit Qaf, old colluvial deposits (Qco), and landslide deposits. Terminology for gravel deposits generally follows Noe and Zawaski (2013) and Noe and others (2015a and 2015b). However, at the southern map boundary, this map area differs in the enumeration of Late Pleistocene units. Gravel deposits are present at ten levels in the map area. Point symbols on gravel deposits indicate thicknesses of basaltic gravel taken from water-well log data accessed from the Colorado Division of Water Resources (DWR) map viewer.

Qg_1 — **Gravel deposit one (Lower Holocene) —** Unit underlies lowest terrace level on valley floors. The unit surface is typically 6 to 9 m above the current stream level channel that contains unit Qa. Unit is poorly exposed and typically buried by valley-fill (Qaf) deposits.

Qg_2 — **Gravel deposit two (Lower Holocene to Upper Pleistocene) —** Qg_2 deposits underlie terrace tread remnants that mainly occur along Currant Creek about 20 m above stream level. Water-well logs penetrated 6 to 16 m of Qg_2 basaltic gravel overlying shale bedrock (Kmu).

Qg_3 — **Gravel deposit three (Upper Pleistocene) —** Unit Qg_3 includes extensive terrace treads of the major creeks (Surface, Currant, and Leroux creeks) in the map area. These creeks have extensive drainage basins that extend northward of the map, into Grand Mesa highlands. The unit has a moderately developed, Calcic Stage II, Bk horizon and the topsoil has a reddish-tan to reddish-brown color. Where exposed, clasts are heavily encrusted with chalky-white colored $CaCO_3$. This unit yielded an optically stimulated luminescence (OSL) age estimate of 19,245±1,640 yrs BP within the adjacent Cedaredge quad (White, 2023). The total thickness of the unit varies: water-well borings exceeded 100 m in basaltic gravel along Surface Creek; Leroux Creek terrace treads range from 26 m to 69 m thick, but many water wells with total depths exceeding 50 m terminate in basaltic gravel; and thinner Currant Creek treads range from 5 and 20 m thick. The surface of this deposit above modern stream elevation ranges from 25 to 32 m, except for Leroux Creek at the southern border of the map area, where stream incision into Mancos Shale has increased the height of the Qg_3 surface to about 55 m above the modern stream level. The gravel that underlies this surface were likely deposited as glacio-fluvial outwash during the Pinedale glaciation (Marine Isotope Stage 2 (MIS 2)) on Grand Mesa north of the map area.

Qg_4 — **Gravel deposit four (Upper Pleistocene) —** Deposits of unit Qg_4 underlie terrace remnants and treads along Currant Creek above the confluence with Dry Creek. A sample collected from this unit within the adjacent Cedaredge quad yielded an OSL age estimate of 34,145±2,560 yrs BP (White, 2023). The topsoil of this unit has a reddish-brown color and a well-developed, stage III+, calcrete K soil horizon is present where exposed at a landslide scarp. Water-well logs and measurements at the landslide scarp exposure reveal a thickness of about 11 m. The terrace surface elevation is 38 to 55 m above the modern stream level. Deposits of unit Qg_4 may correlate to the early Pinedale glaciation (MIS 3) (Sturchio and others, 1994).

Qg_5 — **Gravel deposit five (upper Middle Pleistocene) —** The Qg_5 unit underlies one local mesa remnant in the map area above the confluence of Currant and Dry creeks. No water-well data is available, but the thickness of the unit is estimated to be less than 5 m. The surface of this remnant is 75 m above the current level of Currant Creek. Deposits of unit Qg_5 may correlate with the outwash of the Bull Lake glaciation (MIS 6).

Qg_6 — **Gravel deposit six (upper Middle Pleistocene) —** Gravel remnants of unit Qg_6 form a long (4.4 km) curving tread deposited on the eastern flank of the Cedar Mesa gravel deposit (Qg_7). The deposit surface is 120 m above stream base level at Cactus Park, but only 57 m above the modern stream level at the confluence of Currant and Dry creeks. The topsoil is a reddish-brown color, and the deposit has developed a strong K soil horizon (calcic Stage IV+). Water wells on the Qg_6 deposit penetrated 20 m of basaltic gravel. In a recent road excavation for Cedar Mesa Road, the 20 m-thick riverine gravel filled a gullied paleosurface in the Mancos Shale (Kmu). Based on height above current stream levels, soil development, and elevation relationship with other gravel units, Qg_6 unit may correlate with an early phase Bull Lake glaciation (MIS 6).

Qg_7 — **Gravel deposit seven (lower Middle Pleistocene) —** Unit Qg_7 forms an ancient, massive, and prominently high-elevation alluvial fan named Cedar Mesa near the southwest corner of the map area. The center of the mesa is about 120 m above the present stream level of the confluence of Currant and Dry creeks. The topsoil is silty clay, reddish-brown in color, and contains reworked loess at the surface. Below the reddish-brown topsoil is a ~1-m thick, well-developed Km horizon (calcic Stage IV) that forms a chalky-white-colored band in the deposit exposed at landslide scarps. Near and above the mesa rims, the strong K horizon also forms a pinkish-white, well-consolidated calcrete that weathers into abundant angular pebble-sized clasts in a chalky-white matrix. Unit thickness is variable and likely reflects the aggradation of a gravel fan in a topographic low such as a preexisting valley. Water wells penetrated between 32 to 59 m of basaltic bouldery gravel before hitting Mancos Shale (Kmu). The unit is at a higher elevation than Petrie Mesa in the North Delta quadrangle, where Noe and others (2015a) reported the presence of Lava Creek B ash (631 ka, Matthews and others, 2015). However, it is not clear whether the mesa elevations correspond to the same approximate age. The author did not observe the ash in the map area or in the Cedaredge quadrangle (White, 2023).

Qg_8 — **Gravel deposit eight (Lower Pleistocene) —** Unit Qg_8 gravel forms a massive alluvial fan called Redlands Mesa that extends southward beyond the map area. This older bouldery gravel deposit has reddish-brown topsoil (hence its name), a discontinuous mantle of reworked reddish-brown loess, and a thick, ~1 m, well-developed, pedogenic Km horizon (calcic Stage IV-V). This high mesa has a longitudinal profile at its apex that is about 167 m higher than the adjacent apex of the Cedar Mesa alluvial fan. The center of the mesa is about 275 m above the present stream level of the confluence of Currant and Dry creeks. However, the profile gradient is steeper than Cedar Mesa so that, south of the map area, the elevation of Redlands Mesa closely matches the adjacent Cedar Mesa alluvial fan (Qg_7). Noe and others (2015) placed the distal portion of the Redlands Mesa gravel deposit in the Qg_7 gravel deposit. Where measured at canal exposures, the gravel is about 35 m thick along the perimeter of the mesa. However, in the interior of the mesa, water wells penetrated over 80 m of basaltic gravel without encountering the underlying Mancos Shale bedrock, likely reflecting the aggradation of sediments into a paleovalley. At the apex of Redlands Mesa alluvial fan, the deposit surface elevation is 138 m above the base level of Leroux Creek. At the southern map boundary, the deposit surface elevation is 161 m above the base level of Leroux Creek. Gravel deposit nine (QNg_9) does not occur in the map area. A single remnant was previously mapped as Tg_9 just south of the map boundary (Noe and others, 2015b).

QNg_{10} — **Gravel deposit ten (Lower Pleistocene to Upper Pliocene?) —** Basaltic boulder gravel of unit QNg_{10} forms a high-elevation, massive alluvial fan called Oak Mesa; a portion of which lies in the southeast corner of the map area. Deposits of this unit, including subsequent soil development, are very similar to the deposits of Cedar Mesa (Qg_7) and Redlands Mesa (Qg_8). However, at the southern map boundary, the surface of Oak Mesa is 240 m in elevation higher than Redlands Mesa of early Pleistocene age and is 385 m above the base level of Leroux Creek. Thicknesses vary; although no water-well data is available, the deposit was measured about 50 m thick overlying Mancos Shale at the south map boundary. However, bedrock was observed at the surface of unit QNg_{10} in one location where the Rollins Sandstone Member (Kir) is poorly exposed. Although a terrace deposit composed of early North Fork Gunnison River gravel was reported underlying unit QNg_{10} by Noe and others (2015b), in-situ terrace gravel was not observed by the author during geologic mapping of the Dry Creek quadrangle but may have been obscured by poor exposures. Pebbles of granodiorite porphyry of the West Elk Mountains provenance were seen in hillslope colluvium down slope of Oak Mesa within the map area.

Qdf — **Debris-flow deposits (Holocene) —** Brown-gray to tan-gray, clast-supported, poorly sorted, poorly stratified, bouldery deposits formed from transport of rock fragments in a viscous to hyperconcentrated debris-laden flow. The deposit matrix is unsorted sand, silt, and clay. Mancos Shale hillslope morphology suggests soil-slip earth flows may have locally contributed debris to this deposit. Clasts are mostly subangular to rounded basaltic rocks of the GMVF up to 2 m long that have eroded from older Qg deposits. Thickness is unknown, but the deposit contains drainage channels up to 5 m deep.

ALLUVIAL-COLLUVIAL DEPOSITS

Qac — **Alluvial and colluvial deposits, undivided (Holocene) —** Tan-gray to olive-gray to dark-gray, sandy to silty clay with sporadic dispersed pebbly gravel that was deposited in a low-energy alluvial and colluvial environment on low-gradient (typically <15°) slopes. Gravel is composed chiefly of basaltic clasts reworked from older gravel and landslide deposits. The sediments are typically deposited by slope rilling and slopewash processes, but locally includes riverine Qg deposits too small to map. Unit is poorly sorted and poorly stratified and is typically deposited along the lower flanks of hillsides and upland valleys in the Williams Fork Formation. In upland valleys, the unit typically contains shallow drainage channels where GMVF basaltic rocks are locally exposed. Unit thickness is highly variable. Localized areas may include bedrock residuum or thicken where unmapped earth-flow sediments may have been incorporated into the deposit. Swelling-soil hazards may occur in clay-rich deposits of this unit where deposits are derived from the weathering of Mancos Shale.

MASS-WASTING DEPOSITS

Qc — **Colluvial deposits (Holocene) —** Olive-gray to tan-gray rocky sediments on hillsides and swales of mesas and ridgelines, deposited primarily by gravity with limited additions of slopewash sediments. The unconsolidated deposit is typically rocky, poorly sorted, and poorly stratified. Unit is derived from the erosion of upslope bedrock and older gravel units. The boulder- to pebble-sized clasts are dispersed in a sandy clay matrix, but may be locally clast supported where talus forms at the base of steep slopes. Deposit thickness likely does not exceed 3 m, with some deposits ranging from less than 1.5 m to a stony residuum on weathered bedrock slopes at the angle of repose. Swelling-soil hazard may occur where the deposit is clay-rich and derived from Cretaceous shale rocks.

Qco — **Old colluviul deposits (Upper to Middle Pleistocene) —** Old colluvial deposits that mantle hillsides, mesa risers, and swales on slopes with gradients that may steepen up to the angle of repose, from 10° to 34°. The sediments are reworked from Upper to Early Pleistocene gravel units (Qg_4 through QNg_{10}) and exposed bedrock. These deposits are reddish-brown to light tan-gray and moderately consolidated. On flatter slopes, the unit may contain slopewash sediments washed down from exposed bedrock and rocky surficial deposits that cap higher slopes. Unit is unsorted and poorly stratified, containing abundant subangular to subrounded, boulder-sized clasts in a gravelly clay matrix. A well-developed K soil horizon, calic stage III+ - IV, over 1-m thick, forms a chalky-white band exposed in landslide scarps. Where derived from older mesa gravel, weathered basaltic boulders exposed on the surface are heavily stained with desert varnish, fractured, and covered with weathering pits. At the base of near-vertical sandstone outcrops of the Kw and Kir units, the deposit forms aprons of talus and fans of blocky rockslide rubble. Qco deposits are thickest, up to 20 m, on surfaces that include rockslide material. Locally, some deposits are less than 1.5-m thick and may only be a veneer of rocks consolidated within a weathered K-horizon soil matrix that extends into the underlying bedrock. The unit may locally contain unmapped soil-slip landslide deposits. The bouldery deposit armors the slope, and subsequent erosion into softer underlying bedrock has formed triangular-shaped facets on some Qco deposit surfaces.

Qlsr — **Recent landslide deposits (Uppermost to Middle Holocene) —** Variable brown, brown-gray, gray and reddish-gray, unsorted, unstratified, chaotically mixed, deposit of abundant cobble- to boulder-sized basaltic rocks of the GMVF in a matrix of gravelly to silty clay with soft, contorted, plastically deformed, clay-rich sedimentary rock fragments. Recent landslide morphology is commonly observed on hillshaded lidar imagery. Observed landslide forms include relatively fresh and oversteepened scarps and sheared furrows along side slopes, ruptured and fissured ground, rotated slump blocks, pressure ridges, and hummocky to lobate landforms. In the landslide terrain in the northern portion of the map area, Qlsr deposits deform plastically and failed to mobilize as a fluidized flow with extended sinuous runout zones (Qefr). Most of the mapped Qlsr deposits overlie heavily weathered clay-rich Cretaceous and Paleogene rocks. Some Qlsr landslides are historical and were initiated along hillslopes and mesa risers (where shale bedrock is shallow) when lands were developed for agricultural use, and irrigation commenced. Thicknesses are unknown, but likely highly variable depending on the size of the landslide deposit. For land-use purposes, this map unit should be considered to contain potentially active landslides and prone to continuous movement. Where landslide deposits are derived from Cretaceous shales, expansive soils may also occur.

Qlsi — **Intermediate landslide deposits (Middle Holocene to Upper Pleistocene) —** Intermediate-aged landslide deposits similar in size and composition to Qlsr landslides that can be discerned in hillshaded lidar imagery. However, they have been smoothed and vegetated during extended exposure to weathering and erosion. These deposits are prehistoric, but they may be susceptible to reactivation during periods of high precipitation or if disturbed by ground modifications such as excavations and (or) fill placements. The stability of intermediate-aged landslide deposits is unknown, but they should not be considered dormant. They will likely be sensitive to ground disturbance and (or) the addition of water. Stability analyses should be completed before land use that includes occupied structures.

Qlso — **Old landslide deposits (Upper to Middle Pleistocene) —** Old landslide deposits typically occur in riser slopes that flank the older mesas (Qg_5 through QNg_{10}) that overlie weak clay-rich bedrock. Red-brown topsoil and ≤ 1-m thick chalky-white Bk and K horizons are present. These landslide deposits contain many weathered and pitted basaltic boulders that armor slopes at the surface. The ground morphology is more eroded and smoother compared to that of the Qlsi unit. However, landslide landform morphology is still discernable in hillshaded lidar imagery. Unit thickness is highly variable but likely exceeds 30 m at the landslides on the flanks of Redlands and Oak mesas. Old landslide deposits are generally stable, but they can be sensitive to ground disturbances and (or) the addition of water.

Qefr — **Recent earthflow deposits (Uppermost to Middle Holocene) —** Recent, variably colored, unsorted landslide deposits composed of very soft, clay-rich, disturbed sedimentary rock, plastically deformed mudstone fragments, and silt and clay. Observed landforms include flow paths, flow banding, hummocks, sinuous lateral side-shear furrows and levees, soil ripples, and lobate toes of the deposit that overthrust (override) and spread over the preexisting ground surface. Boundaries of this unit were predominantly interpreted from hillshaded lidar imagery. Recent earth-flow pathways have undergone little erosion or subsequent ground-movement disturbance. On some of the most recent flows, ruptured, torn, and contorted ground surfaces have not yet been revegetated. Thickness is unknown but likely is highly variable. In the earthflow evacuation zones, weathered and disturbed bedrock may be exposed. A lobate earth-flow toe is up to 10 m above the Dry Creek floor in the Grand Mesa National Forest. These deposits are susceptible to creep and reactivation during periods of high precipitation. Deposits of the Qefr unit are unpredictable, susceptible to continuous movement, and should be considered potentially active when considering land development.

Qefi — **Intermediate earthflow deposits (Lower Holocene to Upper Pleistocene) —** Variably colored, landslide deposits that are mapped where earth-flow pathways are discerned on hillshaded lidar imagery within undivided landslide (Qlsu) deposits. Intermediate earthflow pathways are older than those of unit Qefr, based on a combination of cross-cutting relationships, muting of ground morphology by weathering and erosion, and development of drainage networks on the deposit. Thickness is unknown but likely highly variable. In some upper excavation source areas of earth-flow landslides in the Grand Mesa National Forest, lidar shaded hillside imagery suggests the underlying, potentially disturbed bedrock may be near the surface. These deposits may be susceptible to creep and reactivation during periods of high precipitation and (or) rapid spring snowpack melting.

Qlsu — **Landslides, undivided (Holocene to lower Pleistocene?) —** Undivided landslide deposits that mantle slopes in the northern third of the map area where the underlying bedrock is weak, clay-rich Paleogene (Pɛg and Pɛw) formations, and shale intervals of the upper Williams Fork (Kw) Formation. The deposit is typically unsorted, disturbed, plastically deformed mudstone and earth-flow breccia derived from clay-rich bedrock, which also contains abundant, angular to subrounded, basaltic rocks that were mobilized from talus deposits, glacial till, and blockfield deposits to the north below GMVF basalt exposures (White, 2023). Basaltic rock fragments range in size from cobbles to boulders as much as 2.5-m wide. Unit thickness is highly variable. At landslide scarps, bedrock may be shallow, but it is likely to be disturbed. Water-well logs on file at the Colorado DWR shown on the map indicate thicknesses of landslide deposits with entrained basaltic boulders range from 6 to 33 m thick. Early Pleistocene landslide deposits of this unit were the source materials for younger Pleistocene (Qg_3 through Qg_6) gravel deposits mapped on this quadrangle and adjacent quadrangles (Noe and Zawaski, 2013; Noe and others, 2015a; White and Palkovic, 2019; White, 2023). More recent earth-flow mobilizations and landslide reactivations within this unit, discerned by scarps and ground morphology observed in lidar hillshade imagery, have been mapped separately as units Qefr, Qefi, Qlsr, and Qlsi.

BEDROCK GEOLOGY

Pɛg — **Green River Formation (Eocene) —** Gray-white to gray, yellow-tan to light-brown, and light green-gray marlstone, mudstone, very fine- to fine-grained sandstone, limestone, and minor oil shale. This thinly bedded to interlaminated unit records the sedimentation in intermountain lakes during the Eocene. The unit contains both lacustrine and nearshore clastic facies. This formation is more indurated and creates steeper slopes between the conformable interfingering contacts with the underlying, less indurated Wasatch (Pɛw) Formation. However, unit Pɛg is also prone to slope failure; it is almost entirely buried by surficial landslide deposits of Quaternary age and is only exposed in landslide scarps at the northeast corner of the map area. Disaggregation and flow of rock debris from this unit can form long pathways of earth-flow deposits (Qefr) that have moved as much as 2.5 km downslope. Unit thickness is estimated at 230 m.

Pɛw — **Wasatch Formation, undivided (Eocene and Paleocene) —** Undivided, variegated reddish-brown, light-gray, gray, lavender, and maroon mudstone, buff to light-gray weakly cemented sandstone, and shale. This color-banded formation was deposited in a terrestrial environment and is clay-rich and poorly indurated. Predominantly a weak rock unit, the Wasatch Formation is disturbed at the ground surface by mass-movement processes and is poorly exposed within the undivided landslide complex (Qlsu). Unit is only locally exposed in landslides scarps and landslide slopes scoured by erosion. Slopes in the Wasatch Formation at high elevations (≥ 2,500 m above mean sea level (AMSL)) and correspondingly higher (>60 cm) annual annual precipitation are prone to instability and landsliding. Unit thins to the southwest. Thickness is estimated at 400 m.

Kw — **Williams Fork Formation (Upper Cretaceous) —** Buff to tan, massive, cross-stratified, non-calcareous sandstone and interbedded gray siltstone, dark-gray shale, carbonaceous shale, and basal coal. This unit was formed from sediments in a terrestrial floodplain environment. The top half of the unit is predominantly massive bedded, laterally extensive, cross-stratified sandstone interbedded with thin- to medium-bedded siltstone and shale. Rare, thin shale beds are locally maroon-red. The sandstone is very coarse- to medium-grained, well-sorted, friable, and locally contains ripple marks and lenses of shale rip-up clasts. There are common pebble- to cobble-sized iron-oxide concretions. Contorted, penecontemporaneous load-deformation structures locally occur. Landslides and colluvial surficial deposits cover many areas underlain by Kw bedrock. However, where sandstone is exposed, the upper part of the unit locally forms bench-like outcrops. Down section, the unit contains more shale beds and forms ledgy slopes, composed of stacked sequences of thick mudstone beds and interbedded, laterally discontinuous, channel sandstone beds. Orange-brown concretions, dinosaur tracks, and fossil plants and wood are locally present. In the lower center part of the map area, the basal Cameo-Wheeler coal zone outcrops along a west-to-east trending belt. This zone contains abandoned and reclaimed mine workings. In the coal zone, ancient coal fires have formed prominent red clinker deposits that locally may be encrusted with white mineral precipitate. Thinner ash beds, formed by the subsurface burning of thicker coal seams, locally underlie deformed strata. Clinker types range from reddish-stained but principally unaltered sandstone to dark red displaced collapse breccia fused to form a porcellanite. As mapped, the Kw unit includes the Paleocene and Upper Cretaceous Ohio Creek Formation. Oil and gas well logs in the northwest corner of the map area indicate the Ohio Creek Formation is present with a thickness range of 261 to 297 m. The unit is composed of sandstone and conglomerate containing polylithic quartzite, chert, and minor igneous and metamorphic pebbles and cobbles. Much of the upper strata of the Kw unit is buried by surficial deposits. The total thickness estimated from oil and gas logs is 850 to 1,000 m.

Kir — **Rollins Sandstone Member of the Iles Formation (Upper Cretaceous) —** Gray-white to tan to pale-orange, fine- to medium-grained, thick- to massive-bedded, cross-stratified sandstone deposited as sandy sediment in a nearshore to shoreface marine environment. Where it is not covered by expansive gravel-capped mesas, the exposed Kir unit weathers to form landforms that range from benchy cliffs to, more commonly, an upper 30.5-m tall continuous vertical cliff that forms a prominent, northward-sloping cuesta. The massive upper section consists of low-angle crossbedded sandstone capped by subhorizontal bedded sandstone. In the top third of the unit, sandstone is commonly bleached gray-white, is increasingly friable, and has a slick-rock appearance that helps make it a prominent marker bed in outcrop. Marine mollusk fossils (*Inoceramid sp.*) and burrow trace fossils are locally present, most common in orange-tan, coarse-grained, calcite-cemented, medium-thick beds. The sandstone unit's upper contact locally may be stained red from ancient coal fires within the Cameo-Wheeler coal zone of the overlying Williams Fork Formation. Lower in the section below the 30-m massive sandstone, sandstone is very fine-grained with hummocky and swaley crossbedding. Bedding is thinner, somewhat bioturbated, and increasingly interbedded with silty marine shale. This basal, thinly bedded interval is thickest and best exposed at the cuesta exposure between Currant and Dry creeks. The basal contact of this unit was mapped at the first sandstone bed that is conformably interbedded with the underlying Mancos Shale tongue of the Kicz member unit. Total thickness ranges from 45 to 70 m.

Kicz — **Cozzette Sandstone and tongue of Mancos Shale members of the Iles Formation (Upper Cretaceous) —** Light orange-brown to tan-brown, coarsening-upward, very fine- to medium-grained, locally bioturbated sandstone with swaley cross-bedding and basal, interlaminated to very thin interbeds of sandy shale. Unit Kicz includes the Mancos Shale tongue interval between the Cozzette and the Rollins (Kir) sandstone members. The Cozzette Sandstone is best exposed where it outcrops in Cactus Park as a 5 m-thick sandstone bed that fines downward to dark-gray siltstone. The sandstone unit thins considerably to the east and becomes a very poorly exposed, <1 m-thick sandstone bed and concretion horizon. Conversely, the Mancos Shale tongue of the Kicz unit thickens to the east (Dunrud, 1989). In the Dry Creek valley, the unit's base is approximated by a prominent light-gray horizon that weathers in the Mancos Shale slope exposures below the Kir unit. Thickness is about 55 m at Cactus Park, thickening to about 105 m in the Dry Creek valley exposure.

Mancos Shale (Upper Cretaceous) — The Mancos Shale is present in the southern part of the quadrangle exposed in valleys and mesa risers and typically capped by Qg gravel deposits or buried by valley-fill deposits (Qaf). Hillslopes of Mancos Shale are susceptible to instability and are locally disturbed by landslides. Twelve members of this marine shale, distinguished on the basis of composition, color, and fossil assemblages were mapped in the bordering Orchard Mesa, North Delta, and Lazear quadrangles (Noe and Zawaski, 2013; Noe and others, 2015a; Noe and others, 2015b). Only the upper Mancos unit (Kmu) and the tongue of Mancos shale included within the Kicz unit occurs within the Dry Creek quadrangle. On mesas risers and ridgelines, the gray to dark-gray shale typically contains an oxidized, yellow-tan stained horizon that is highly fractured with crystalline gypsum fracture filling. This approximately 9- to 15-m thick weathered interval, once subaerially exposed and subsequently buried by Pleistocene surficial deposits, has been informally referred to as the Mancos "blonde" by local Natural Resources Conservation Service soil scientists. In the map cross section (Plate 2), the Mancos Shale is undivided. The Mancos Shale has thin bentonite beds and may locally contain expansive clay minerals; swelling-soil hazards may occur locally.

Kmu — **Mancos Shale, upper part (Upper Cretaceous) —** Dark-gray to olive-gray, non-calcareous, fissile to subblocky, silty to sandy shale. Unit contains scattered, orange-brown concretions up to 3.5 m long along bedding. Many of the concretions are septarian with calcite fracture filling. The unit locally contains thin cream-colored bentonite seams, and marine invertebrate mollusk and gastropod fossils. Unit thickness is about 330 m (Noe and others, 2015b).

Km — **Mancos Shale, undivided (Upper Cretaceous) —** Shown in cross section only.

Kdb — **Dakota Sandstone and Burro Canyon Formation, undivided (Upper to Lower Cretaceous) —** Shown in cross section only

Mz — **Mesozoic Formations, undivided (Jurassic and Triassic) —** Major units include the Morrison Formation, Entrada Sandstone, and Chinle Formation. Shown in cross section only.

p€ — **Precambrian rocks, undivided (Proterozoic) —** Crystalline igneous and metamorphic rocks. Shown in cross section only.

MAP SYMBOLS

13 — **Strike and dip of inclined bedding** — Showing direction and angle of dip.

Quarry/Borrow pit

X — **Coal mine site, abandoned**

Coal-mine spoils and piles

USGS coal exploration borings — Boring locations from Eager (1978, 1979) showing thickness of surficial deposits (Qs) and underlying bedrock penetrated by boring.

Water well — Showing thickness of Quaternary map unit and underlying bedrock if identified (> symbol indicates total depth of well remained within the Quaternary unit). Drill-log data from Colorado DWR online well-permit map viewer.

Oil and (or) gas well — Label is the American Petroleum Institute (API) Unique Well Identifier. Map label does not include preceding State Code (05) and County Codes (029 for Delta County). Well data can be searched on the Colorado Energy and Carbon Management Commission (ECMC) GIS online interactive map.

Contact — Approximately located

Fault — Approximately located, dashed where inferred, dotted where concealed.

Landslide scarp — Crest of a landslide where the ground surface has ruptured, and earth materials have moved downslope and formed the landslide deposit. The slope gradient of landslide scarps are oversteepened and may be vegetated, or bare rock and soil exposed if the landslide is recent. Sub-parallel scarp lines mark secondary ruptures where retrogressive detachment and slump-block failures have occurred. Hachure lines indicate the direction of landslide movement.

A A′ — **Alignment of cross section**

Clinker zones — Outcrops of naturally occurring coal clinker produced by coal-bed fires in the William Fork Formation Cameo-Wheeler coal zone.

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