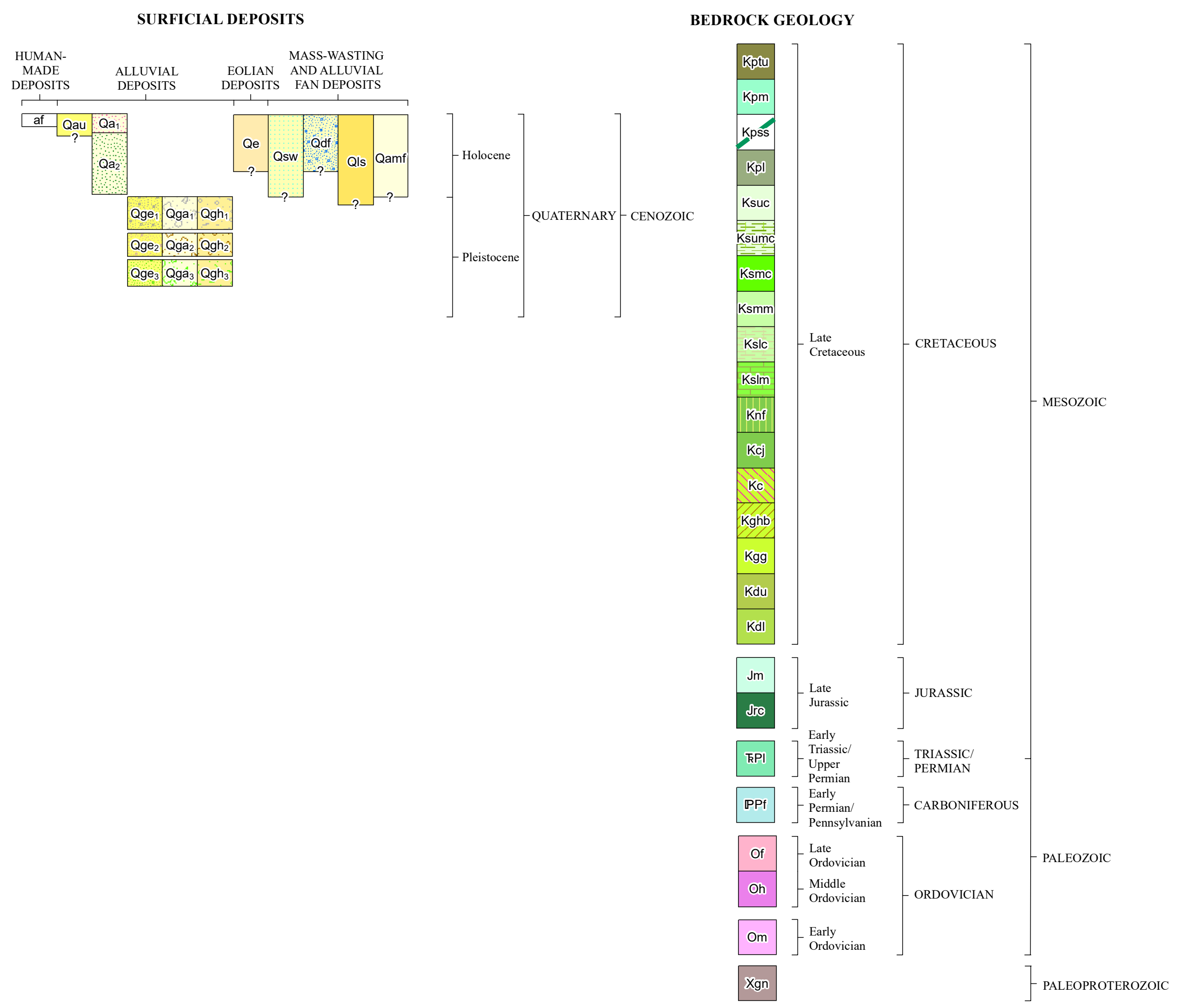
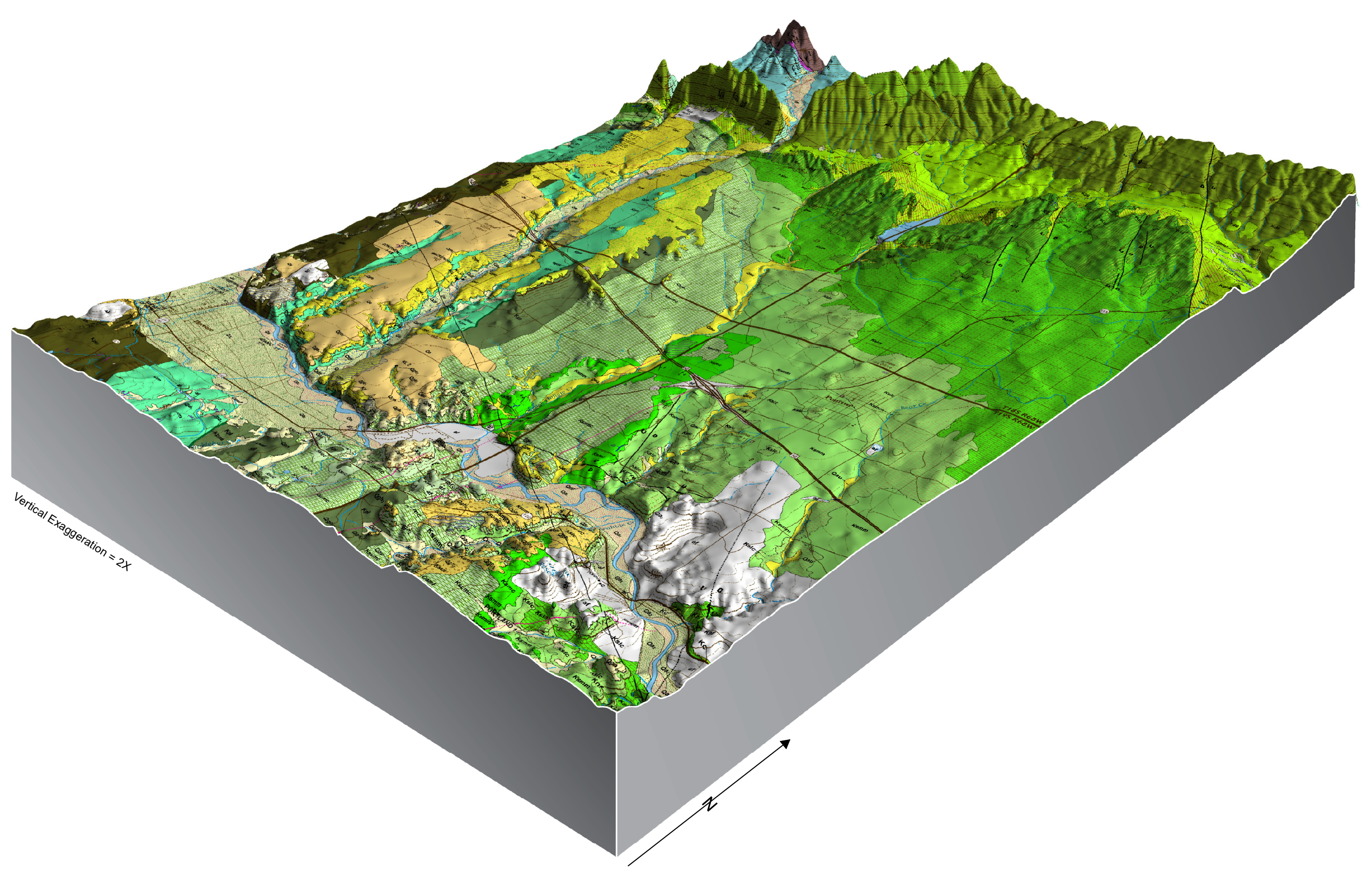
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES
GOLDEN, COLORADO

GEOLOGIC MAP OF THE FLORENCE QUADRANGLE
FREMONT COUNTY, COLORADO
CORRELATION OF MAP UNITS, 3-D OBLIQUE VIEW,
GEOLOGIC HISTORY, STRATIGRAPHY, AND CROSS SECTIONS
OPEN-FILE REPORT 18-04
PLATE 2 OF 2

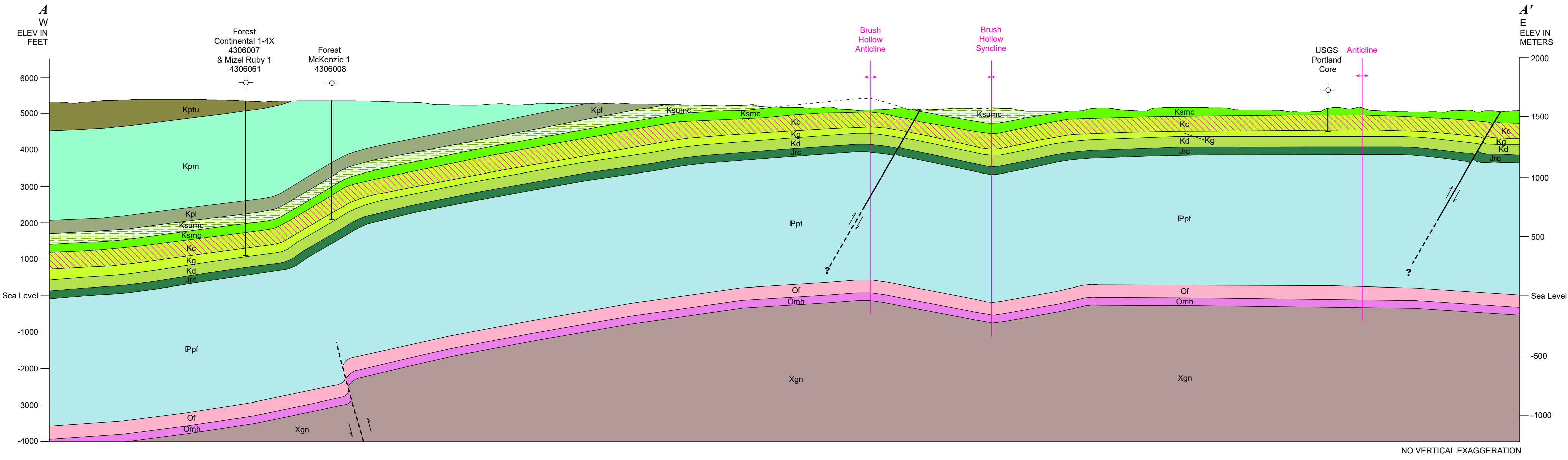
CORRELATION OF MAP UNITS



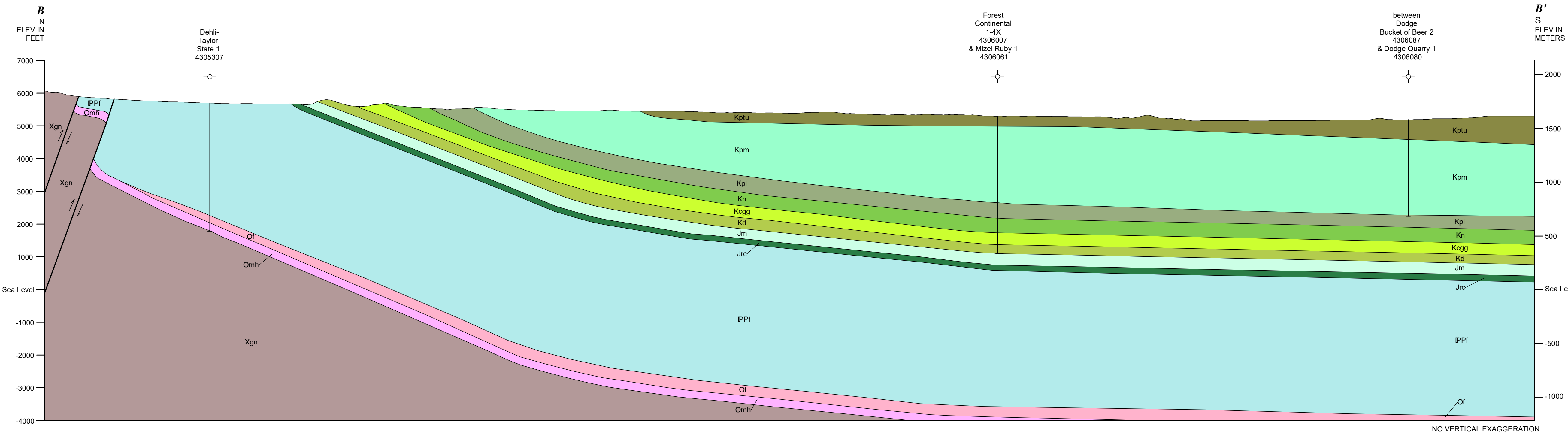
3-D OBLIQUE VIEW



CROSS SECTION A-A'



CROSS SECTION B-B'



GEOLOGIC MAP OF THE FLORENCE QUADRANGLE, FREMONT COUNTY, COLORADO
CORRELATION OF MAP UNITS, 3-D OBLIQUE VIEW, GEOLOGIC HISTORY, STRATIGRAPHY, AND CROSS SECTIONS

By Kassandra O. Lindsey, David Sawyer, and Jay Temple
2018

STRATIGRAPHY

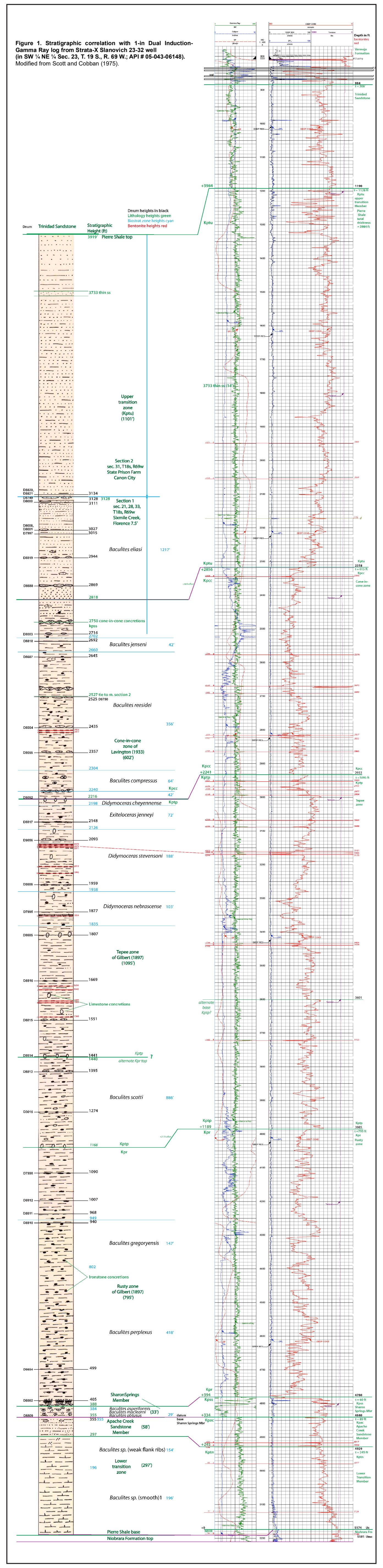
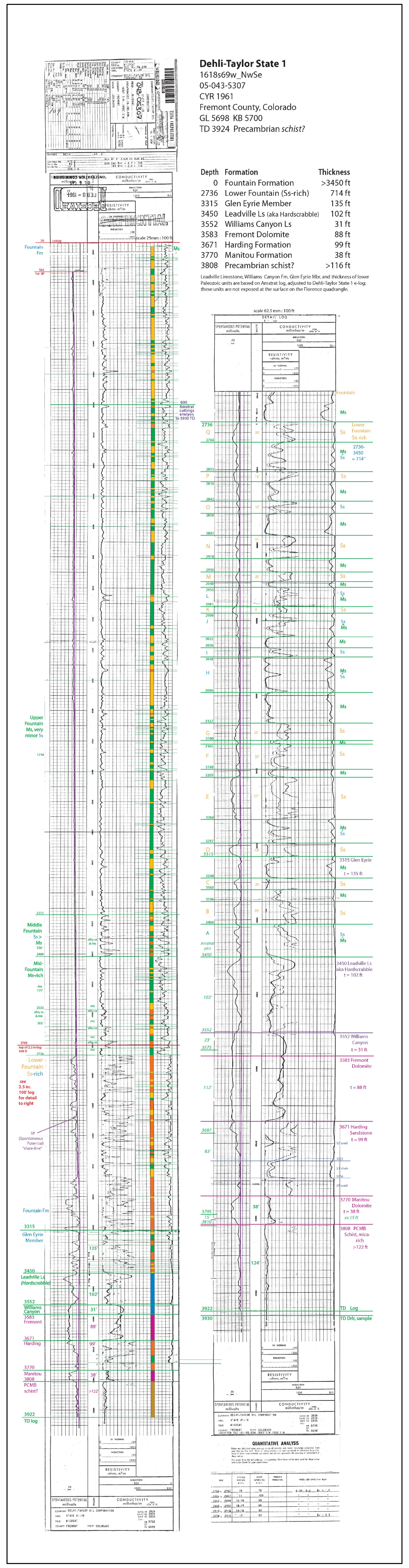


Figure 1. Stratigraphic correlation with 1-in Dual Induction-Gamma Ray log from Strata-X Slanovich 23-32 well (in SW ¼ NE ¼ Sec. 23, T. 19 S., R. 69 W.; API # 05-043-06148). Modified from Scott and Cobban (1975).



Dehli-Taylor State 1
1618s69w_NwSe
05-043-5307
CYR 1961
Fremont County, Colorado
GL 5698 KB 5700
TD 3924 Precambrian *schist?*

Depth	Formation	Thickness
0	Fountain Formation	>3450 ft
2736	Lower Fountain (Ss-rich)	714 ft
3315	Glen Eyrie Member	135 ft
3450	Leadville Ls (aka Hardscrabble)	102 ft
3552	Williams Canyon Ls	31 ft
3583	Fremont Dolomite	88 ft
3671	Harding Formation	99 ft
3770	Manitou Formation	38 ft
3808	Precambrian schist?	>116 ft

Leadville Limestone, Williams Canyon Fm, Glen Eyrie Mbr, and thickness of lower Paleozoic units are based on Amstrat log, adjusted to Dehli-Taylor State 1 e-log; these units are not exposed at the surface on the Florence quadrangle.

GEOLOGIC SETTING

The Florence quadrangle is located in the northeastern part of the Canon City embayment, a Phanerozoic structural and topographic low at the junction of the Wet Mountains and the Front Range of the Rocky Mountains. High-angle faulting and subsequent erosion in these mountain ranges have exposed Precambrian rocks described by Tweto (1987) as a gneissic complex dated at 1,600 to 1,800 Ma that has been subjected to several episodes of folding.

Early Paleozoic sedimentary rocks were deposited in a shallow marine shelf environment beginning with the Manitou Limestone followed by the Harding and Fremont Formations, each were unconformably succeeded by the other. Cambrian strata were probably present but eroded away prior to deposition of overlying strata. Sedimentation also occurred during the Devonian and Mississippian periods but was eroded during the Late Pennsylvanian coinciding with the uplift of the Ancestral Rocky Mountains. These uplifts were extensive throughout the south central, central, and north central parts of Colorado. These uplifts are fault-bounded blocks with crystalline basement cores. The uplifted rocks were eroded and the resulting coarse detritus was transported by rivers and smaller streams and was deposited along the mountain flanks as thick alluvial-fan deposits that after diagenesis, compaction, and lithifaction became rocks of the Fountain Formation.

Middle Permian through Upper Jurassic strata of the Lykins, Ralston Creek, and Morrison formations suggest transitional conditions from shallow marine to continental environments. The Lower Cretaceous Dakota Group represents the end of the continental depositional cycle and the onset of sedimentation related to the development of the Cretaceous Western Interior Seaway (WIS). Upper Cretaceous rocks of the Greenhorn and Carlile Shale, Niobrara Formation, and Pierre Shale are all WIS basin marine deposits.

The Laramide orogenic episode (Late Cretaceous to middle Eocene) uplifted the basement and overlying sedimentary veneer to create most of the present-day mountainous regions of Colorado. High-angle faults and resulting fault-propagation folds in the overlying sedimentary rocks, especially along the mountain fronts, are typical deformational styles. Deformation of this type is visible in the upturned Ordovician strata in the footwall block of the basement fault along Phantom Canyon Road in the extreme northwest part of the quadrangle. Southeasterly dips in the Lykins Formation, Morrison Formation, and Dakota Group strata near Upper Beaver Creek Road and southerly dips in the same strata between Upper Beaver Creek and Phantom Canyon Roads are strongly suggestive of an underlying basement corner.

Late Cretaceous to early Paleogene sedimentary rocks of the Trinidad and Vermejo formations are primarily continental deposits representing the final stages of the orogenic episode (not mapped on the quadrangle).

Although the Canon City embayment has a rich stratigraphic record of Phanerozoic sedimentary rocks and sediments extending from the Ordovician (485 Ma) through to the Quaternary (<2.6 Ma), the Late Cretaceous (100-66 Ma) rocks stand out as a detailed record of marine sedimentation represented by thick deposits of shale, calcareous shale (marl), chalk, and sandstone. The WIS extended across Colorado beginning about 108-100 Ma, and for most of the following 30 million years, sediments were deposited below sea level, with only limited periods where the sea retreated and marginal marine sediments were deposited nearshore. The final regression of the WIS began about 70 million years ago and led to deposition of non-marine sediments that later became the sandstone, mudstone, and thick coal seams in the Vermejo Formation mined in the Canon City coal field in and adjoining the towns of Rockvale, Williamsburg, Coal Creek, and the ghost town of Chandler.

Marine sedimentary rocks were deposited during the Late Cretaceous during continually changing transgressive and regressive depositional cycles. The cycles include the Kiowa-Skull Creek cycle, Greenhorn and Niobrara cycles, and the Pierre Shale which represents the last transgressive-regressive cycle and culminates with the Bearpaw Cycle signaling the final retreat of the seaway toward the mid-continent. The Glencairn Shale and Dakota Group rocks record the initial advance of the Cretaceous ocean in the area. The Greenhorn cycle represents the highest stand of sea level during the Cretaceous, with the shoreline of the WIS in western Utah. The Graneros Shale, Greenhorn Limestone, and Carlile Shale were deposited during this cyclothem. The Fairport chalky shale, the Blue Hill Shale, and the Codell Sandstone members of the Carlile Shale record the Greenhorn regression of the seaway and eastward migration of the western shoreline. The Niobrara Formation began with deposition of the Fort Hays Limestone member, quarried for Portland cement in the Florence quad. The overlying Smoky Hill Member consists of alternating chalks and marls, and is equivalent to the organic-rich source rock for the prolific Niobrara horizontal-fracture oil play in the Denver Basin. The 4,000 feet (1,219 meters) of the Pierre Shale, deposited over the 12 million-year Campanian stage of the Upper Cretaceous, is comprised of predominantly non-calcareous shale rich in ammonite inoceramid fossils. The lower organic-rich Sharon Springs Member of the Pierre Shale is thought to be the source for oil in the open-fracture reservoirs of the lower part of the Pierre Shale in the Florence Basin, the second oldest oil producing basin in the United States. Finally, the regression of the Cretaceous sea led to deposition of the shoreface sands of the Trinidad Sandstone. The overlying nearshore sandstone, coal, and fluvial deposits of the Vermejo Formation and the Raton Formation record the change to a nonmarine sedimentary environment in the Florence Basin during the latest Cretaceous.

The Cretaceous bedrock in the mapped area is overlain by a variety of Quaternary deposits, predominantly eolian sand, and fluvial gravels. During the Late Pleistocene and into the Early Holocene, gravel was deposited by the eastward-flowing Arkansas River and streams draining south-southeast from the highlands of the southern Front Range and north-northeast from the Wet Mountains. Topographic inversion, caused by differential erosion, left these resistant remnants of former valley floors stranded relatively high in the landscape. A sequence of deposition and erosion of stream deposits is recorded by multiple terrace levels. Fluvial gravels were likely deposited during interglacial periods, when meltwaters were able to transport coarse-grained material. Optically stimulated luminescence (OSL) ages of the gravels dated in the Florence quadrangle fall within the range of the Pinedale Glaciation (30,000-12,000 yrs. BP; Wobus and others, 1976). Continuing through the Holocene, rivers and streams deposited mostly sandy alluvium and cut smaller terraces suggesting a decrease in relative stream power. An alluvial terrace in Eightmile Creek about 5 ft above the modern channel and one in Sixmile Creek roughly 15 to 20 ft above modern drainage were dated by Carbon-14 analysis. The sample near Eightmile Creek dated at 960 ± 30 yrs. BP and the sample near Sixmile Creek yielded an age of 8,260 ± 30 yrs. BP. The most recent alluvial deposit consists of poorly sorted sandy gravelly alluvium in modern channels. Wind-blown silty sand covers some of the landscape along the Arkansas River and areas adjacent to Eightmile Creek. A single Carbon-14 age of 2,080 ± 30 yrs. BP was obtained from tan homogenous silty sand. Other Quaternary deposits include landslide, debris fans, sheetwash, and alluvial mudflow-fan deposits. These deposits were deposited at various times, likely during periods of wetter climate.

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Table 1. Ages for Quaternary deposits in the Florence quadrangle
Radiocarbon dating by Beta Analytic, Inc., Miami, Florida

Map unit	Field Number	UTM Easting [a]	UTM Northing [a]	Latitude	Longitude	Laboratory Number	Material	Conventional 14C age (yr BP)	Depth Below Ground Surface	δ13C(‰)	14C age (14C yr BP)[b]	Calibrated Age (cal yr BP)[c]
Qa$_2$	KL C 1	491771	4252383	38.420	-105.094	Beta - 474336	Silty sand	960 ± 30	4 ft (1.2 m)	-22.6	960 ± 30	930 - 795
Qa$_2$	KL C 2	489506	4258440	38.474	-105.120	Beta - 492439	Silty sand	8260 ± 30	16 (4.9 m)	-24.1	8260 ± 30	9322 - 9128
Qe	KL 2	493262	4250166	38.400	-105.077	Beta - 477468	Sandy silt	2080 ± 30	5 ft (1.5 m)	-16.4	2080 ± 30	2140 - 1987

[a] North American Datum (NAD) 1983, zone 13N

[b] Conventional radiocarbon age, normalized to -25‰, based on 5,568 year half life; uncertainty ± 1 σ

[c] Calibrated age calculated using INTCAL13 (Reimer and others, 2013); 0 yr B.P. = 1950 A.D.

Optically Stimulated Luminescence (OSL) dating by U.S. Geological Survey, Lakewood, Colorado

Map unit	Field Number	UTM Easting [a]	UTM Northing [a]	Latitude	Longitude	Material	Depth Below Ground Surface	% Water Contact [b]	K (%) [c]	U (ppm) [c]	Th (ppm)c	Total Dose (Gy/ka) [d]	Equivalent Dose (Gy)	n [e]	Scatter [f]	OSL Age (yrs) ± 1 σg
Qge$_1$	KL 1	491729	4252315	38.419	-105.095	Sand matrix in gravel unit	5.25 ft (1.6 m)	2 (24)	4.08 ± 0.05	3.34 ± 0.27	13.0 ± 0.36	5.78 ± 0.11	6.9 ± 1.0 or 20 ± 3.4	4 (20) or 17 (20)	69%	3460 ± 560 or 1200 ± 200
Qge$_2$	KL 3	491443	4256376	38.456	-105.098	Fine to coarse sand bed in gravel unit	18 ft (5.5 m)	1 (37)	3.90 ± 0.05	2.89 ± 0.20	9.73 ± 0.57	5.13 ± 0.15	97.2 ± 6.1	15 (15)	21%	18950 ± 1310
Qga$_2$	KL 4	490119	4250489	38.403	-105.113	Silt to coarse sand bed n gravel unit	16 ft (4.9 m)	2 (30)	3.43 ± 0.09	3.59 ± 0.25	11.7 ± 1.05	5.05 ± 0.25	89 ± 7.1	19 (20)	34%	17450 ± 1640

[a] North American Datum (NAD) 1983, zone 13N

[b] Field moisture, with figures in parentheses indicating the complete sample saturation %. Ages calculated using 25% of the saturated moisture (i.e. 0 (25) = 25 * 0.25 = 6).

[c] Analyses obtained using high-resolution gamma spectrometry (high purity Ge detector).

[d] Includes cosmic doses and attenuation with depth calculated using the methods of Prescott and Hutton (1994). Cosmic doses were about 0.20-0.32 Gy/ka.

[e] Number of replicated equivalent dose (DE) estimates used to calculate the total. Figures in parentheses indicate total number of measurements included in calculating the represented DE and age using the central age model (CAM); analyzed via single aliquot regeneration on quartz grains.

[f] Defined as "over-dispersion" of the DE values. Obtained by the "R" factor program. Values >30% are considered to be poorly bleached or mixed sediments.

[g] Dose rate and age for fine-grained 250-90 micron sized quartz. Exponential + linear fit used on DE, errors to one sigma.

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