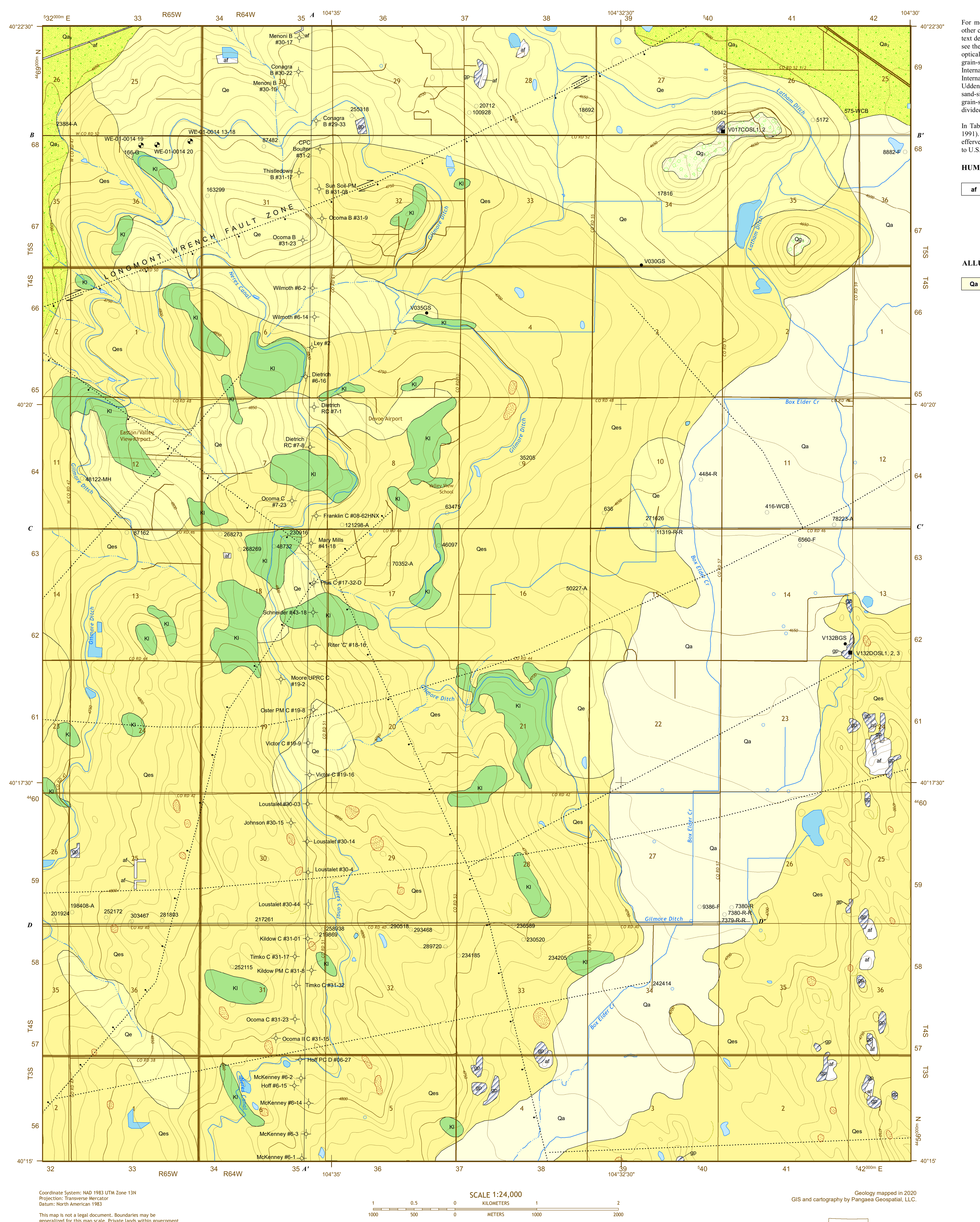
DOI: https://doi.org/10.58783/cgs.of2102.laoi7286



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

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Roads.......................................U.S. Census Bureau, 2017
Names...GNIS, 1978
Hydrography.........National Hydrography Dataset, 2004-2019
Contours...............National Elevation Dataset, 2007-2015
Boundaries.....Multiple sources, see metadata file, 2017-2018
Public Land Survey System................................BLM, 2018

SCALE 1:24,000

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METERS 1000 500 0 1000 2000
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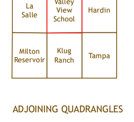
CONTOUR INTERVAL 10 FEET

Geology mapped in 2020
GIS and cartography by Pangaea Geospatial, LLC.



QUADRANGLE LOCATION

Greeley	Kersey	Barnesville
La Salle	Valley View School	Hardin
Milton Reservoir	Klug Ranch	Tampa

ADJOINING QUADRANGLES

This mapping project was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey through the National Cooperative Mapping Program under STATEMAP agreement G20AC00245.

GEOLOGIC MAP OF THE VALLEY VIEW SCHOOL QUADRANGLE
WELD COUNTY, COLORADO

By Stephen M. Keller and Alexander E. Marr
2021

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

For more detailed information on grain size, sorting, color, secondary calcium carbonate, and other characteristics of surficial map units see Table 1; general characteristics are presented in the text describing the map units. For details on geologic hazards (e.g., flood potential) of map units, see the Plate 2 section on Mineral Resources, Groundwater Resources, and Geologic Hazards. For optically stimulated luminescence (OSL) ages of select map units see Table 2, and for results of grain-size analyses of select units see Table 3. Subdivision of the Quaternary follows the International Chronostratigraphic Chart, v 2020/01 (International Commission on Stratigraphy, International Union of Geological Sciences, 2020). Particle-size designation is according to the Udden-Wentworth grain-size scale (see Nichols, 2009), but (in Table 1) modified such that each sand-size category is divided into a coarser (U) and a finer (L) sub-category with the aid of a sand grain-size card (US GeoSupply, Incorporated, 2020). For example, very coarse (vc) sand is divided into the categories vcU (very coarse – coarser) and vcL (very coarse – finer).

In Table 1 the colors are designated with the aid of Munsell soil color charts (Munsell Color, 1991). Description of soil-carbonate morphology is after Machette (1985), and the type of effervescence of sediment or soil observed when treated with dilute hydrochloric acid is according to U.S. Department of Agriculture (2018).

HUMAN-MADE DEPOSITS

af

Artificial fill (Upper Holocene) — Mostly riprap, fill material, and, locally, refuse placed during construction of roads, railroads, buildings, dams, and landfills. Includes waste piles composed of excavated sediment adjacent to sand or gravel pits. The fill deposits generally consist of unsorted clay, silt, sand, and rock fragments. Typically, the unit is less than 6 m thick. Some deposits of artificial fill are not mapped because they are too small to show at map scale. Artificial fill may be subject to settlement, slumping, and erosion if not adequately compacted and (or) if placed on unstable slopes.

ALLUVIAL DEPOSITS

Qa

Alluvium, undivided (Upper Holocene) — Unit Qa covers the flat valley floor of Box Elder Creek, a north-flowing minor tributary of the South Platte River. In its physical properties and position in the landscape, unit Qa correlates with the unit Qa of Beebe Draw in the La Salle quadrangle (Palkovic and others, 2019), adjacent to the west. Beebe Draw also is a north-flowing tributary of the river. There are three known exposures of unit Qa in the Valley View School quadrangle and one in the Hardin quadrangle (Palkovic and others, 2021b) adjacent to the east. One of the Valley View School quadrangle exposures is in the bank of Box Elder Creek, where the channel has been routed to run adjacent to the south side of Weld County Road (WCR) 48, 0.2 km east of WCR 57. The other two Valley View School quadrangle exposures are in the north and south ends of a sand pit located at Box Elder Creek and ~0.6 km east of the terminus of WCR 44. The Hardin quadrangle exposure is 0.4 km east of the Valley View School quadrangle's east boundary and on the east side of WCR 61, ~0.4 km north of WCR 50. Unit Qa is not sufficiently incised to form terraces along the Box Elder Creek valley. Within the creek channel there are some fine-grained deposits of alluvium younger than unit Qa. These probably are correlative with alluvium one (Qa_1) of the Greeley quadrangle (Keller and Morgan, 2020) and other northern Colorado Piedmont quadrangles, but are not extensive enough to be shown at map scale.

The WCR 48 exposure of unit Qa is 1.8 m thick and has the following characteristics (from ground surface downward): 0.9 m of pale-brown, very well sorted very fine sand with minor silt; 0.3 m of dark-brown, poorly sorted very fine to medium sand with minor silt and clay; and 0.6 m (exposed – actual thickness is greater) of grayish-brown, moderately sorted fine to medium sand with trace coarse sand. In the sand pit east of WCR 44 there are unit Qa exposures in the south and north ends of the pit. At the south end of the pit, in the east face, unit Qa overlies ~2.5 m of exposed unit Qes (on the geologic map, see sample locations V132DOSL1, V132OSLD2, and V132DOSL3). The unit Qa exposure is ~1.8 m high and has the following characteristics (from ground surface downward): 0.6 m of dark-gray, very cohesive clayey silt with a subordinate amount of fine to very coarse sand, no secondary calcium carbonate; 0.4 m of dark grayish-brown, very cohesive, resistant silty clay or clayey silt with a subordinate amount of fine to very coarse sand, abundant secondary calcium carbonate nodules and filaments; 0.8 m of grayish-brown, very cohesive, resistant clayey silt or silty clay, abundant secondary calcium carbonate nodules 2 to 3 cm in diameter. From the southern sand-pit exposure unit Qa can be traced northward for ~200 m to the northern sand-pit exposure, a cut bank consisting of 1.3 m of massive, very cohesive, medium dark-gray silty clay or clayey silt with abundant white calcium carbonate nodules up to 10 mm. The Hardin quadrangle exposure is a fresh cut-bank along Box Elder Creek. It is 1.9 m high and is described as follows (from ground surface downward): 0.4 m of artificial fill; 0.3 m of brownish-gray, very cohesive clayey silt to very fine sand, minor medium sand; 0.3 m of dark grayish-brown, moderately cohesive sandy clayey silt, with minor very fine sand and coarse sand; 0.7 m of light grayish-brown, weakly cohesive very fine to medium sand, with minor coarse sand to granules at base; and 0.2 m (exposed) grayish-brown fine to coarse sand with fragments of carbonaceous clay.

The above exposures are the most important sources for describing unit Qa, but they are supplemented by many shallow sampling holes in this unit. These were dug with a drain spade, and some were begun at the base of road cuts and thus reached as deep as 1.3 m below undisturbed ground surface. In 40 percent of sample holes, unit Qa is silty clay or clayey silt with a fraction (5 to 35 percent) of fine to medium sand and some coarser sand. In another 40 percent, the material is very fine to medium sand with minor fines (combined silt and clay content) and minor coarse to very coarse sand. In 20 percent, the sediment is fine to very coarse sand with minor fines. In general, unit Qa is poorly to moderately sorted and moderately to very cohesive. Colors mostly are grayish-brown, dark grayish-brown, dark olive-brown, brown, and dark-brown. Secondary calcium carbonate is not prominent: in half the sample holes the alluvium has no visible calcium carbonate and no reaction to dilute hydrochloric acid; in the other half there is weak effervescence, and there are a few locations where calcium carbonate filaments or nodules are visible.

Characterization of unit Qa is assisted by lithologic descriptions in water-well driller's logs (Colorado Division of Water Resources [DWR], 2020). In the water wells used for the Quaternary cross sections (Plate 2), the alluvium is described as clay, clay with streaks of sand, fine sand and clay, and fine to medium sand. In the Box Elder Creek valley, the water-well driller's logs used for the east ends of the Quaternary cross sections indicate that unit Qa thickness ranges between 2.4 and 4.9 m, that the unit is underlain by interbedded sand, gravel, and clay layers of older alluvium considered to be alluvium three (unit Qa_3), and that the bedrock underlies unit Qa_3 at depths of as much as 26 m. In this minor tributary to the South Platte River, unit Qa covers unit Qa_3. Unit Qa does not occupy an incised flood plain flanked by unit Qa_3 terraces, as does unit Qa_2 (coeval with unit Qa) in the valleys of the South Platte River and major tributaries such as the Cache la Poudre River.

In the Valley View School quadrangle, unit Qa is rarely well enough exposed for reliable radiocarbon sampling. Two of the radiocarbon ages used for unit Qa in the present report are from samples taken from the cut bank of Box Elder Creek in the Hardin quadrangle, adjacent to the east. The samples were taken from sediment near the top and near the bottom of the cut bank. The sampling location is ~1.1 km east of the Valley View School quadrangle's east boundary. Details for the samples are given in Palkovic and Morgan (2021b). The sample ages are 1,813-1,616 cal yr BP for sample V028C14-1, in clayey silt to very fine sand 0.4 m below ground surface, near the top of the cut bank; and 2,799-2,740 cal yr BP for sample V028C14-2, in fine to medium sand 1.4 m below ground surface, near the bottom of the cut bank. Within the Valley View School quadrangle samples of unit Qa were collected for OSL age determination at a sand-pit exposure, in the east pit face where unit Qa overlies unit Qes. The sampling location is shown on Plate 1. Sample V132DOSL2 was collected in unit Qa at 0.4 m below ground surface, from the highest of the three layers of unit Qa exposed there; the sample yielded an OSL age estimate of 825 +/- 45 yr. Sample V132DOSL1 was collected at 2.1 m below ground surface, from the lowest of the layers; the sample yielded an OSL age estimate of 3,640 +/- 180 yrs. Sample V132DOSL3 was collected from unit Qes immediately below the contact with unit Qa. It yielded an OSL age estimate of 3,165 +/- 290 yrs, a younger value than the above age for the overlying unit Qa. The younger end of the age range for unit Qes (using the error band) would be 3,455 yr. This is very close to 3,460 yr, which would be the older end of the age range for OSL sample V132DOSL1 in overlying unit Qa near the Qa/Qes contact. Therefore, the contact may have an age of ~3,460 yr, and the OSL ages can be interpreted as indicating that the overlying unit Qa is not much younger than the underlying unit Qes. All the above ages are Late Holocene. The unit Qa OSL ages in the sand-pit face in the Valley View School quadrangle are approximately equivalent to the unit Qa radiocarbon ages in the Box Elder Creek cut bank in the Hardin quadrangle.

The correlation of map units chart (CMU) for the Valley View School quadrangle is presented in Plate 2. Contacts between unit Qa and units Qe and Qa_3 are not exposed in the quadrangle. Based upon relative ages of the geologic units, however, unit Qa possibly is locally incised into unit Qe (eolian sediment) (see cross sections B-B', C-C', and D-D').

On the basis of water-well driller's logs, unit Qa is shown in cross sections as overlying unit Qa_3. Areas mapped as Qa may be prone to flooding (see Mineral Resources, Groundwater Resources, and Geologic Hazards in Plate 2).

Qa_3

Alluvium three (Upper Pleistocene) — Unit Qa_3 (also mapped as Broadway Alluvium by other researchers in the region) is mapped in localized areas of the South Platte River valley near the northwest and northeast corners of the quadrangle. Most of unit Qa_3 in the quadrangle, however, is inferred from subsurface water-well driller's logs (Colorado DWR, 2020). Unit Qa_3 is present in the Box Elder Creek valley, where it underlies unit Qa and overlies Laramie Formation bedrock. Unit Qa_3 in this tributary valley is not incised as it is in the South Platte River valley. Unit Qa_3 is not exposed in the quadrangle, but its subsurface extent is depicted in the cross sections (Plate 2). In the northwest corner of the quadrangle, water-well driller's logs indicate unit Qa_3 thickness as 9 m and depth to bedrock as 12 m. In cross sections B-B', C-C', and D-D' unit Qa_3 occupies a paleovalley coincident with but wider than the present Box Elder Creek valley. Unit Qa_3 thickness ranges from 11 to 26 m and depth to bedrock is between 14 and 31 m. Unit Qa_3 thickness decreases westward away from the valley axis to the (very subdued) valley wall. In cross section C-C' unit Qa_3 extends west ~0.25 km from the west wall of the present valley, and west of the present valley wall it decreases from 13 m to 4 m in thickness. In cross section B-B', west of the hill capped with unit Qg_1, a body of unit Qa_3 occupies a possible reentrant of the South Platte River valley, or a possible paleovalley that could have been a tributary to the South Platte River valley. In this area the unit Qa_3 thickness is from 3 m up to more than 8 m. Unit Qa_3 also is found in the valley of Beebe Draw (see west ends of cross sections B-B' and C-C').

In the Colorado Piedmont north of Denver, unit Qa_3 is areally and volumetrically the largest alluvium in the South Platte River valley and its major tributary valleys. This is evidenced by cross sections in Lindsey and others (2005); by Colorado Geological Survey mapping in the La Salle quadrangle adjoining the Valley View School quadrangle on the west (Palkovic and others, 2019), Greeley quadrangle diagonally adjoining on the northwest (Keller and Morgan, 2020), Kersey quadrangle adjoining on the north (Lindsay and others, 2020); and geologic maps of the Masters quadrangle (Berry and others, 2015a) and Orchard quadrangle (Berry and others, 2015b), 19 to 38 km east along the South Platte River from the Valley View School quadrangle. In the northeast corner of the Valley View School quadrangle the area mapped as unit Qa_3 underlies the Kersey terrace of Bryan and Ray (1940), which flanks the south side of the South Platte River valley. From west to east the terrace extends across parts of the La Salle, Greeley, Kersey, Valley View School, Barnesville, and Hardin quadrangles. The terrace is bounded to the north by the valley floor composed of unit Qa_1 and by a discontinuous incised terrace of unit Qa_2. The top of the unit Qa_2 terrace is ~3 m below the top of the Qa_3 terrace (Kersey terrace).

According to Madole (2016), unit Qa_3 alluvium consists of vertical sequences of superposed, longitudinal bars of sand and gravel deposited by braided streams. These sequences locally contain finer-grained layers that probably are overbank deposits. In the water-well driller's logs (Colorado DWR, 2020) used to construct cross sections B-B', C-C', and D-D', unit Qa_3 consists of interbedded clay, sand, and gravelly sand/sandy gravel layers in approximately equal proportions. Gravel layers typically are present toward the bottom of the unit and clayey layers toward the top. In the Greeley quadrangle (Keller and Morgan, 2020) layers of unit Qa_3 in the valleys of the South Platte River and Cache la Poudre River are typically composed of: 1) gravelly sand and sandy gravel (preponderant); 2) very fine to very coarse sand with little or no gravel (subordinate); and 3) clayey silt or silty clay with minor gravel, possibly overbank deposits (rare). Gravel-pit faces in the Greeley quadrangle expose the following: interbedded sand and gravel layers, as well as gravel-filled channels inset in underlying sand and gravel layers; crossbedding in gravel layers; and large (as much as 0.2 m thick and 1.5 m long) rip-up fragments of sand layers contained in gravel layers (Keller and Morgan, 2020). Also in the Greeley quadrangle, three south-trending tributary paleovalleys join the Cache la Poudre River valley on the north side, and in their shape and size (as seen on hillshaded lidar imagery) and subsurface dimensions they resemble the paleovalley of Box Elder Creek in the Valley View School quadrangle. Based on a Greeley quadrangle cross section through Quaternary units, unit Qa_3 sediments in the tributary Sand Creek paleovalley are continuous and coeval with unit Qa_3 sediments in the Cache la Poudre River valley (Keller and Morgan, 2020). By analogy it is probable that unit Qa_3 in the Box Elder Creek paleovalley is continuous and coeval with unit Qa_3 in the South Platte River valley.

There are no unit Qa_3 exposures in the quadrangle and thus no samples could be obtained for laboratory age determination. Deposits of unit Qa_3 have been dated by the CGS in several nearby quadrangles, such as the Greeley and Gowanda quadrangles (Keller and Morgan, 2020; Keller and others, 2019), and have been assigned to the Late Pleistocene. In the Valley View School quadrangle, unit Qa_3 locally is overlain by Early to Middle Holocene eolian sediment (unit Qe), Late Holocene eolian sand (unit Qes), and Late Holocene alluvium (undivided unit Qa) (see cross sections B-B', C-C', and D-D'). Coal seams recorded in water-well driller's logs indicate that the sandstone bedrock beneath unit Qa_3 is the lower part of the Laramie Formation. In the Box Elder Creek valley unit Qa_3 is an important shallow alluvial aquifer and its sand and gravel layers are possible sources of aggregate resources.

Qg_1

Gravel one (Middle Pleistocene) — Unit Qg_1 caps two hills in the northeast corner of the quadrangle. The hills are examples of inverted topography in that the capping gravel is more resistant than the underlying bedrock. Unit Qg_1 characteristics are described mostly from a shallow trench (part of this mapping project) excavated at ground surface near the center of the northernmost hill. The trench includes OSL sampling locations V017COSL1 and V017COSL2, as shown on the Plate 1 geologic map. Other unit Qg_1 data from the hill are from an inactive former gravel pit adjacent to the north of and several meters lower in elevation than the trench, from gravel exhumed at a prairie dog town southwest of the trench, and from a road cut on WCR 57. The mapped areal extent of the unit is inferred based upon landforms visible in the lidar image for the quadrangle, the deposit thickness as estimated using local topography, and the National Resource Conservation Service (NRCS) soils map of the quadrangle (Crabb, 1980). At the hill, the thickness of unit Qg_1 is ~5 m. Approximately 1 m of the base of the unit is exposed in the adjacent former gravel pit and overlies Laramie Formation sandstone. The trench was dug entirely in unit Qg_1 and the exposed trench face was 2.2 m high; the bottom of the face was ~3 m above the Laramie Formation.

In the sampling trench, unit Qg_1 consisted of the following material (from ground surface downward): 0.4 m of weakly cohesive, poorly sorted gravelly sand, clasts up to 6 cm, brown, some secondary calcium carbonate; 0.5 m of moderately cohesive sandy gravel, clasts up to 7 cm with calcium carbonate rinds coating the bottoms of many clasts, white, matrix locally cemented by calcium carbonate; 0.6 m of weakly cohesive, poorly sorted medium to very coarse sand with minor gravel, some secondary calcium carbonate; 0.6 m of strongly cohesive, poorly sorted gravelly sand or sandy gravel, clasts up to 11 cm with calcium carbonate rinds, pinkish-gray, matrix locally cemented by calcium carbonate; and 0.1 m of weakly cohesive, well sorted medium to coarse sand with no fines or gravel, pinkish-gray, no secondary calcium carbonate. In the gravel pit exposure, unit Qg_1 is a poorly sorted, strongly cohesive gravelly sand with clasts up to 17 cm, pale-yellow, and with abundant secondary calcium carbonate (Stage II) both as matrix and nodules.

In the Valley View School quadrangle, the highest surface of unit Qg_1 is ~40 m above the South Platte River, which is ~4 km to the northeast. In the Masters quadrangle (Berry and others, 2015a), ~28 km southeast of the Valley View School quadrangle, three exposures of unit Qai (intermediate alluvium) are in a rough line ~2 km long and parallel to the South Platte River; the river lies 2.5 km to the north, and the tops of the exposures are ~28 m above the river. Unit Qai of the Masters quadrangle and unit Qg_1 in the Valley View School quadrangle both have pervasive secondary calcium carbonate in the matrix and carbonate rinds on clasts. The gravel remnants in the above two quadrangles are at a similar distance southwest of the South Platte River. Based on uranium-series dating, Berry and others (2015a) determined the best unit Qai minimum age estimate as somewhat older than 382 ka. They correlate the unit with older deposits of Slocum Alluvium, per the age range of 320-390 ky for this unit as given in Kellogg and others (2008).

Unit Qg_1 trench sample V017COSL1, from sandy gravel 1.1 m below ground surface, yielded an age of >80,000 yr from conventional OSL analysis; unit Qg_1 trench sample V017COSL2, from sandy gravel 2.0 m below ground surface, yielded an age of >90,000 from conventional OSL analysis (Table 2). Considering the advanced secondary carbonate accumulation in the gravel, and relatively high elevation of the deposit, these ages were unexpectedly young. A second analysis of unit Qg_1 trench sample V017COSL2 yielded an age of 341,080+/-22,840 yr from thermal transfer OSL (TT-OSL) analysis (Table 2). This age is not greatly younger than the 382 ka age for unit Qai and also falls within the Slocum Alluvium age range. Therefore, unit Qg_1 in the Valley View School probably is equivalent to unit Qai in the Masters quadrangle and also correlative with Slocum Alluvium as mapped elsewhere in the Colorado Piedmont.

EOLIAN DEPOSITS

Qes

Eolian sand (Upper Holocene) — Unit Qes covers approximately half the total area and much of the upland in the Valley View School quadrangle. It lies within an eolian sand area named the "South Platte deposit" by Madole and others (2005). This sand body is one of several extensive, eastern Colorado eolian sand deposits mapped and described in that publication. In the field, unit Qes is recognized in road cuts and in sample holes that penetrate below its thin (generally less than 20 cm thick) and poorly developed soil A horizon (for definitions of soil horizons see Birkeland, 1999). Unit Qes eolian sand is distinguishable from unit Qe eolian sediment because the former consists of coarser, well-sorted sand with only a small amount (less than 6%) of fines (silt and clay), whereas the latter consists of finer, less-sorted sand locally containing a large amount (22 to 30%) of fines. More evidence supporting this distinction is presented by Keller and Morgan (2020). Mapping of unit Qes in the Valley View School quadrangle is supported by the following data sources: road cuts, excavations, many shallow sample holes, 121 water-well driller's logs (Colorado DWR, 2020), the extent of eolian sand as mapped by Madole and others (2005), the distinctive northwest-to-southeast-oriented dune topography of unit Qes as recognized in the lidar image for the quadrangle, and the NRCS soils map of the quadrangle (Crabb, 1980). Within the South Platte sand deposit (Madole and others, 2005), on the west side of the Valley View School quadrangle, there is a group of seven "windows" or gaps in the eolian sand cover; these areas are roughly 1 to 3 km in diameter. Water-well driller's logs, sample holes, and the NRCS soils map for the quadrangle indicate that these areas mostly consist of Laramie Formation (see geologic map). Also, west of the Box Elder Creek valley there are some areas included in the eolian sand cover by Madole and others (2005) but which are designated as unit Qe on the present map. This distinction is based on water-well driller's logs, sample holes, and the soils map. (It should be noted that Madole and others (2005) is a small-scale reconnaissance map covering a very large area.) In the northern third and middle third of the quadrangle, represented by cross sections B-B' and C-C' respectively, water-well driller's logs in the cross sections indicate unit Qes thickness to be in the range of 4 to 8 m. In the southern third, cross section D-D' depicts the thickness as mostly 4 to 10 m. All three cross sections show unit Qes to be thicker closer to hilltops and thinner on hillslopes and in valleys. On the basis of lithology and position in the landscape, unit Qes correlates with eolian sand mapped by the CGS in other Colorado Piedmont 7.5' quadrangles, such as Frederick (Keller and Morgan, 2018), La Salle (Palkovic and others, 2019), and Greeley (Keller and Morgan, 2020). In the Valley View School quadrangle there are no exposures of unit Qes in contact with underlying deposits. On the basis of water-well driller's logs (Colorado DWR, 2020), unit Qes locally overlies Laramie Formation bedrock, alluvium of unit Qa_3, and eolian sediment of unit Qe (see cross sections B-B', C-C', and D-D'). In the Frederick quadrangle, 42 km to the southwest of the map area, unit Qes was observed overlying unit Qe in a shallow trench and also in nearby geotechnical boreholes (Keller and Morgan, 2018).

Unit Qes is composed of poorly sorted very fine to coarse or very coarse sand, moderately sorted fine to medium sand with minor coarse to very coarse sand, and poorly sorted fine to coarse sand with minor very coarse sand. Fines are minimal at all locations and rare granules and small pebbles are present at one-third of the sample locations. At location V132BGS (see geologic map) one sample was taken from unit Qes for grain size analysis. The material is composed of 94.4% sand, 2.6% silt, and 3.0% clay (Table 3), which is in accordance with the low content of fines (4 to 9%) reported for eolian sand by Madole and others (2005). The sand is non-cohesive to weakly cohesive, lacks visible secondary carbonate, and has no reaction to dilute hydrochloric acid. Colors are brown, yellowish brown, grayish brown, and pale brown. Unit Qes is best observed in the east and west faces of a sand pit located at Box Elder Creek and ~0.6 km east of the terminus of WCR 44 (location of grain size sample V132BGS, above), and in a smaller sand pit located ~0.5 km to the north. The deposits exposed in these pits are planar bedded at a scale of several millimeters to several centimeters, locally cross-bedded, and have stoss-side dune beds with a northward apparent dip of ~20 degrees. At the sand pit, OSL sample V132DOSL3 was collected at 1.9 m below ground surface, at the top of unit Qes and within a few cm below the contact with overlying unit Qa. This sample yielded an age of 3,165+/-290 yr, which is Late Holocene and accords with the Madole and others (2005) Late Holocene age group for Qes (the youngest of three Qes age groups presented in that publication). Unit Qes sand has been extracted (possibly for borrow material) from small excavations east of the Box Elder Creek Valley. There is abundant, relatively clean eolian sand remaining at these sites and elsewhere in the quadrangle. The area mapped as unit Qes locally may contain collapsible soils.

Qe

Eolian sediment (Lower Holocene to Upper Pleistocene) — Eolian sediment of unit Qe covers approximately one-third of the upland area west of the Box Elder Creek valley. This deposit occupies much of the north part of the Valley View School quadrangle and extends northward into the Kersey quadrangle. Less-extensive deposits are present in the center and south of the quadrangle. Mapping of unit Qe in the Valley View School quadrangle is supported by observations in road cuts, sample holes, grain-size analysis, water-well driller's logs (Colorado DWR, 2020), and the NRCS soils map for the quadrangle (Crabb, 1980). At present, unit Qe occupies much less of the quadrangle's ground surface than does the eolian sand of unit Qes. Cross sections B-B', C-C', and D-D' indicate, however, that unit Qe formerly was aerally extensive, and that at higher elevations it has been covered by the younger eolian sand of unit Qes. Thus, most of unit Qe is now present on hillslopes rather than on hilltops. Per Madole (2016), however, unit Qe is not associated with particular landforms and can be present over a broad range of elevations. On the basis of its position in the landscape, lithologic characteristics, and secondary calcium carbonate development, unit Qe is similar to unit Qe in the Longmont quadrangle (Madole, 2016), Milliken (Palkovic and others, 2018), Greeley (Keller and Morgan, 2020), and other Colorado Piedmont quadrangles mapped by the CGS. In the northern third and middle third of the Valley View School quadrangle, as represented by cross sections B-B' and C-C' respectively, water-well driller's logs indicate that unit Qe thickness is typically 2 to 7 m. In the southwest corner of the quadrangle, the west end of cross section D-D', unit Qe has a thickness range of 9 to 14 m. Unit Qe locally may contain small unmapped bodies of unit Qes.

Unit Qe is composed of poorly sorted, very fine sand to coarse sand, locally with a dominant fines fraction, and poorly to moderately sorted fine to medium sand with minor coarse to very coarse sand, also locally with a dominant fines fraction. At a few locations the deposit contains rare to minor granules and small pebbles. The fines fraction is usually sufficient to impart moderate cohesion, although cohesion locally can be either weak or strong. Unit Qe is massive in the two road cuts where it is exposed (the deposit also is massive in excavations in other piedmont quadrangles mapped by the CGS). Colors are brown, grayish-brown, dark grayish-brown, and dark yellowish-brown. Unlike in other quadrangles mapped by the CGS, unit Qe sampled in the Valley View School quadrangle has no visible secondary calcium carbonate and no reaction to dilute hydrochloric acid. This may be because road cuts and sample holes did not penetrate deep enough to encounter secondary calcium carbonate (e.g., in a soil Bk horizon). Two sediment samples were taken from unit Qe for grain-size analysis; the locations are V030GS and V035GS on the geologic map. Their respective sand fractions are 77.7 and 69.8%, silt fractions 14.4 and 17.5%, and clay fractions 7.5 and 12.7% (Table 3). The total fines in the two samples were 21.9 and 30.2%, respectively, which is in accord with total fines being mostly between 21 and 55% in 19 geotechnical grain size analyses of unit Qe in the Greeley quadrangle, adjacent diagonally to the northwest (Keller and Morgan, 2020). The unit Qe silt fraction in the Valley View School and Greeley quadrangles is too small for the material to be considered sandy loess.

On the basis of water-well driller's logs (Colorado DWR, 2020), unit Qe overlies Laramie Formation bedrock and the alluvium of unit Qa_3; it locally underlies the eolian sand of unit Qes (see cross sections B-B', C-C', and D-D'). Along the west side of the Box Elder Creek valley, unit Qe is interpreted to be incised by a stream that deposited alluvium of unit Qa. In the Frederick quadrangle, 42 km to the southwest, unit Qe was observed underlying unit Qes in a shallow trench and also in nearby geotechnical boreholes (Keller and Morgan, 2018).

In the Valley View School quadrangle, unit Qe is not sufficiently exposed to collect suitable samples for radiocarbon analysis. Radiocarbon ages for unit Qe are ~9 ky and ~21 ky in the Johnstown quadrangle (Palkovic and Morgan, 2017), ~4 ky and ~5 ky in Frederick (Keller and Morgan, 2018), ~5 ky in Gowanda (Keller and others, 2021), and ~9 ky in Greeley (Keller and Morgan, 2020). With one exception (~21 ky age in the Johnstown quad) these ages are Holocene. Within the Valley View School quadrangle, unit Qe is not a likely potential source of clean sand because of its relatively high content of fines. The area mapped as unit Qe locally may contain collapsible soils.

BEDROCK GEOLOGY

Within the Valley View School quadrangle, the only bedrock unit mapped at the ground surface is the Laramie Formation, and its exposure is mostly limited to residuum formed in place by weathering of the formation. Bedrock units beneath the Laramie Formation are shown in cross section A-A' (Plate 2). Descriptions of the Laramie Formation and Fox Hills Formation are from Spencer (1986), who investigated these units in detail in the Frederick and Erie quadrangles, ~46 km southwest of the Valley View School quadrangle. Descriptions of Pierre Shale members are adapted from Scott and Cobban (1965), supplemented by descriptions by Braddock and others (1988). Descriptions of older units are adapted from descriptions in the geologic map of the Carter Lake Reservoir quadrangle, 53 km to the west, where these units are described in outcrop (Braddock and others, 1988). Thickness values for the Laramie Formation and Fox Hills Sandstone are from Spencer (1986). Thickness values for older bedrock units are from cross section A-A', which was prepared with the aid of oil and gas well logs from the Colorado Oil and Gas Conservation Commission (COGCC) (2020).

Kl

Laramie Formation (Upper Cretaceous) — The Laramie Formation is mostly overlain by residuum developed mainly from the weathering of sandstone, and most of this residuum is on the upland in the west side of the quadrangle. There is one fresh exposure of Laramie Formation sandstone, in the northeast corner of the quadrangle and in a gravel pit adjacent to the north of OSL sample locations V017COSL1 and V017COSL2. Also, fragments of sandstone with small (<6 cm in diameter) zones of carbonaceous material were found beneath eolian sand of unit Qes, at the base of a shallow trench located near the quadrangle's west boundary and near where the Gilmore Ditch crosses WCR 48. Laramie Formation residuum is mapped from sample holes, water-well driller's logs (Colorado DWR, 2020), the NRCS soils map of the quadrangle (Crabb, 1980), and areas of non-deposition of the South Platte eolian sand area mapped by Madole and others (2005). At the gravel pit mentioned above, the Laramie Formation exposure is ~1 m high and consists of well-sorted, very fine-grained to fine-grained sandstone with trace medium sand and minor fines. The sandstone is weakly to moderately cohesive and pale-yellow, and has planar and flexed bedding at a scale of millimeters to 2 cm. It is overlain by 0.5 m of unit Qg_1 gravelly sand. In the Erie and Frederick quadrangles, ~50 km southwest of the map area, the lower 60 to 90 m of the Laramie Formation consists of light- to medium-gray quartzose sandstone layers separated by clay, fire clay (refractory clay), shale, or coal seams. The upper 123 to 153 m consists of claystone, shale, sandy shale, and lenticular beds of sandstone and lignite. Total thickness is 213 m. Multiple coal beds are present in the lower part of the formation and are as much as 3.7 m thick (Spencer, 1986). Coal seams reported in water-well driller's logs in the Valley View School quadrangle indicate that the lower part of the Laramie Formation underlies the Quaternary deposits in the quadrangle. At the south end of cross section A-A' (Plate 2), limited data for the Laramie Formation indicate that the oil and gas wells penetrate as much as 76 m of the unit (COGCC, 2020). Data used in Quaternary cross sections B-B', C-C', and D-D' (Plate 2) indicate that water wells penetrate up to 79 m of the formation (Colorado DWR, 2020).

Kfh

Fox Hills Sandstone (Upper Cretaceous) — Greenish-tan, fine- to coarse-grained quartzose sandstone; cross bedded in the lower part, grading upward to a light-yellow and white, massive, fine- to medium-grained sandstone. Thickness is 46 to 91 m. The contact of the Fox Hills Sandstone with the underlying Pierre Shale is not depicted on cross section A-A' because data for this contact are not included in the oil and gas well logs used for the cross section.

Pierre Shale (Upper Cretaceous) — Marine strata composed of dark-gray shale, siltstone, and fine-grained sandstone. Bentonite beds, rich in weathered volcanic ash, are common in its lower part and calcareous concretions are common throughout. The various members of the Pierre Shale contain index fossil ammonite species (Scott and Cobban, 1965).

Kpt/Kpu

Uppermost transition member and upper shale member, undivided — These two members are combined in cross section A-A' because they are not distinguished in the oil and gas well data used to prepare the cross section. Both members are observed in outcrop ~45 km southwest of the Valley View School quadrangle (Scott and Cobban, 1965). In general, the members consist of friable sandstone and soft shaly sandstone containing thin-bedded sandy shale and calcareous sandstone concretions. Combined thickness of the two members is ~1,060 m.

Kplr

Larimer and Rocky Ridge Sandstone Members and intervening shale, undivided — The Larimer and Rocky Ridge Sandstone Members are well-indurated, light-gray to light-brown, medium-grained sandstones, composed mostly of quartz with minor feldspar and biotite. Combined thickness is ~46 m.

Kpm

Middle shale member — This unit consists of highly friable, greenish-gray claystone and sandy siltstone, and contains bentonite beds. Thickness is ~120 to ~220 m.

Kph

Hygiene Sandstone member, undivided — The upper part of the unit is well-indurated, light-gray, fine- to medium-grained sandstone composed mostly of quartz, minor feldspar, and minor opaque minerals. The middle part of the unit is medium-gray siltstone; the lower part is a friable, gray concretionary sandstone. Thickness is ~185 to ~200 m.

Kpl

Lower shale member — Dark olive-gray shale and sandy shale containing limestone and ironstone concretions; bentonite beds are common in the lower part of the unit. Thickness is ~470 to ~540 m.

Kn

Niobrara Formation, undivided (Upper Cretaceous) — Very fissile, dark-gray shale containing thin (5 m) micritic limestone layers. Unit is an important oil and gas source in the quadrangle and in much of the Denver Basin (see Plate 2 and section on Mineral Resources, Groundwater Resources, and Geologic Hazards). Thickness is ~60 to ~90 m.

Kcgg

Colorado Group - Carlile Shale, Greenhorn Limestone, Graneros Shale, and Mowry Shale (undivided) (Upper Cretaceous) — Olive-gray silty claystone and sandy claystone; dark-gray limestone and olive-gray, calcareous, silty claystone and siltstone; dark-gray to grayish-black siltstone and claystone and siliceous shale. Combined thickness is ~140 m.

Kd

Dakota Group: South Platte Formation and Lytle Formation (undivided) (Lower Cretaceous) — Unit consists of gray to light-brown, well-sorted, fine- to medium-grained sandstone; dark-gray carbonaceous shale; gray to light-brown, fine-grained sandstone; and gray to light-brown, coarse-grained, conglomeratic sandstone. Combined thickness is ~155 m. A maximum of 36 m of this unit was penetrated in the two oil and gas wells used to prepare cross section A-A'.

MAP SYMBOLS

Contact — Approximately located

Normal fault of Weimer (1996) — Existence certain, location concealed, where known, sense of displacement indicated by ball and bar on downthrown side

Longmont wrench fault zone — Existence certain, location concealed; ball and bar on downthrown side

A|T **Strike-slip fault (in cross section)** — A, away from observer; T, toward observer

Oil and gas wells

Water well

Soil boring for geotechnical investigation

Grain-size analysis sample site

Optically stimulated luminescence (OSL) sample site

Dune crest

Eolian blowout

Gravel pit — Sand or gravel pit - exposed sand or gravel faces

A A' **Alignment of cross section**

REFERENCES

Aleinikoff, J.N., and Muhs, D.R., 2010, Isotopic evidence for South Platte River and bedrock sources for eastern Colorado dune fields: Lunar and Planetary Institute Second International Planetary Dunes Workshop, Alamosa, Colorado, May 18-21, 2010, Program and abstract volume, p. 1-2.

Berry, M.E., Slate, J.L., Paces, J.B., Hanson, P.R., and Brandt, T.R., 2015a, Geologic map of the Masters 7.5' quadrangle, Weld and Morgan Counties, Colorado, U.S. Geological Survey Special Investigations Map 3344, scale 1:24,000

Berry, M.E., Slate, J.L., Hanson, P.R., and Brandt, T.R., 2015b, Geologic map of the Orchard 7.5' quadrangle, Morgan County, Colorado, U.S. Geological Survey Special Investigations Map 3331, scale 1:24,000

Berry, M.E., Slate, J.L., and Taylor, E.M., 2019, Pleistocene and Holocene landscape development of the South Platte River corridor, northeastern Colorado: U.S. Geological Survey Scientific Investigations Report 2019–5020, 22 p. [also available at: https://pubs.er.usgs.gov/search?q=Pleistocene+and+Holocene+landscape+development+of+the+South+Platte+River+corridor%2C+northeastern+Colorado].

Birkeland, P.W., 1999, Soils and geomorphology: New York, Oxford University Press, 430 p.

Braddock, W.A., Nutalaya, P., and Colton, R.B., 1988, Geologic map of the Carter Lake Reservoir quadrangle, Boulder and Larimer Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1628, scale 1:24,000 [also available at: https://pubs.er.usgs.gov/publication/gq1628].

Bryan, Kirk, and Ray, L.L., 1940, Geologic antiquity of the Lindenmeier site in Colorado: Smithsonian Miscellaneous Collections, v. 99, n. 2, p 1-76.

Colorado Department of Natural Resources, Division of Water Resources, 2018, Drillers' logs incorporated with water-well permits [available at: https://gis.colorado.gov/dnrviewer/Index.html?viewer=mapviewer].

Colorado Division of Reclamation, Mining, and Safety, 2020, Reports and Data, GIS Data, AUGER (map of mine permits) [available at: https://gis.colorado.gov/dnrviewer/Index.html?viewer=drms].

Colorado Geological Survey, 2020, Geotechnical boring logs from the Colorado Geological Survey ongoing land use review program: geotechnical logs incorporated with various unpublished site investigation reports, on file at Colorado State Archives, Denver, Colorado.

Colorado Oil and Gas Conservation Commission, 2020, Geologic unit contacts incorporated with oil and gas well data [available at https://cogccmap.state.co.us/cogcc_gis_online/].

Colorado Oil and Gas Conservation Commission, 2021, Oil and gas production data [available at https://cogcc.state.co.us/data.html#/cogis].

Colton, R.B., 1976, Geologic map of the Boulder-Fort Collins-Greeley area, Colorado: U.S. Geological Survey Geologic Investigations Series I-855-G, scale 1:100,000 [also available at: https://pubs.usgs.gov/imap/855/G/i-855-g_v1.1.pdf].

Crabb, J.A., 1980, Soil survey of Weld County, Colorado, southern part: U.S. Department of Agriculture, U.S. Soil Conservation Service, Washington, DC, 135 p., 35 maps, scale 1:24,000.

Dechesne, Marieke, Raynolds, R.G., Barkmann, P.E., and Johnson, K.R., 2011, Notes on the Denver Basin geologic maps - bedrock geology, structure, and isopach maps of the Upper Cretaceous to Paleogene strata between Greeley and Colorado Springs, Colorado: Colorado Geological Survey Open-File Report 11-01, 35 p. [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-stratigraphy-notes-denver-basin-colorado/].

Galbraith, R.F., and Roberts, R.G., 2012, Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations: Quaternary Geochronology, v. 11, p. 1–27.

International Union of Geological Sciences, International Commission on Stratigraphy, 2020, International Chronostratigraphic Chart, v 2020/01.

Keller, S.M., Lindsey, K.O., and Morgan, M.L., 2017, Geologic map of the Berthoud quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 17-03, scale 1:24,000.

Keller, S.M., and Morgan, M.L., 2018, Geologic map of the Frederick quadrangle, Weld and Boulder Counties, Colorado: Colorado Geological Survey Open-File Report 18-01, scale 1:24,000 [also available at: https://coloradogeologicalsurvey.org/publications/geologic-map-frederick-quadrangle-weld-broomfield-colorado/].

Keller, S.M., and Morgan, M.L., 2020, Geologic map of the Greeley quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 20-05, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-greeley-quadrangle-weld-colorado/].

Keller, S.M., Lindsey, K.O., and Morgan, M.L., 2019, Geologic map of the Gowanda quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 19-02, scale 1:24,000.

Kellogg, K.S., Shroba, R.R., Bryant, Bruce, and Premo, W.R., 2008, Geologic map of the Denver West 30′ × 60′ quadrangle, north-central Colorado: U.S. Geological Survey Scientific Investigations Map SIM–3000, scale 1:100,000, 48 p. pamphlet [also available at https://doi.org/10.3133/sim3000].

Lindsey, D.A., Langer, W.H., and Knepper, D.H., Jr., 2005, Stratigraphy, lithology, and sedimentary features of Quaternary alluvial deposits of the South Platte River and some of its tributaries east of the Front Range, Colorado: U.S. Geological Survey Professional Paper 1705, 70 p. [also available at https://pubs.usgs.gov/pp/2005/1705/pdf/PP1705.pdf].

Lindsay, K.O., Palkovic, M.J., and Morgan, M.L., 2020, Geologic map of the Kersey quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 20-06, scale 1:24,000.

Machette, M.N., 1985, Calcic soils of the southwestern United States: Geological Society of America Special Paper 2013, 21 p.

Madole, R.F., 1991, Colorado Piedmont, *in* Wayne, W.J., ed., Quaternary geology of the Northern Great Plains, Chap. 15 of Morrison, R.B., ed., Quaternary nonglacial geology - conterminous United States: Geological Society of America, The geology of North America, v. K-2, p. 456-462.

Madole, R.F., 2016, Geologic map of the Longmont quadrangle, Boulder and Weld Counties, Colorado: Colorado Geological Survey Open-File Report 16-05, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-longmont-quadrangle-boulder-weld-colorado/].

Madole, R.F., VanSistine, D.P., and Michael, J.A., 2005, Distribution of late Quaternary wind-deposited sand in eastern Colorado: U.S. Geological Survey Scientific Investigations Map 2875 (scale 1:700,000) [also available at https://pubs.er.usgs.gov/publication/sim2875].

Matthews, N.E., Vázquez, J.A.; Calvert, A.T., 2015, Age of the Lava Creek supereruption and magma chamber assembly at Yellowstone based on 40Ar/39Ar and U-Pb dating of sanidine and zircon crystals: Geochemistry, Geophysics, Geosystems, v. 16, p. 2508–2528 (also available at https://doi.org/10.1002/2015GC005881].

Muhs, D.R., Aleinikoff, J.N., Stafford, T.W., Jr., Been, Josh, Mahan, S.A., and Cowherd, Scott, 1999, Late Quaternary loess in northeastern Colorado, Part I - age and paleoclimatic significance: Geological Society of America Bulletin, v. 111, n. 12, p. 1861-1875.

Munsell Color, 1991, Munsell soil color charts, 1990 edition revised: Newburgh, NY, Macbeth Division of Kollmorgen Instruments Corp., 14 p.

Murray, Andrew and Wintle, A. G., 2003, The single aliquot regenerative dose protocol: Potential for improvements in reliability: Radiation Measurements, v. 37, p. 377-381.

Myers, A.R., Hansen, J.B., Lindvall, R.A., Ivey, J.B., and Hynes, J.L., 1975, Coal mine subsidence and land use in the Boulder-Weld coalfield, Boulder and Weld Counties, Colorado: prepared by Amuedo and Ivey (consulting firm) for Colorado Geological Survey, Environmental Geology 9, 98 p. [also available at https://coloradogeologicalsurvey.org/publications/coal-mine-subsidence-land-use-boulder-weld-colorado/].

Nichols, G., 2009, Sedimentology and stratigraphy (second edition): Wiley-Blackwell, Chichester (United Kingdom), 419 p.

Palkovic, M.J., and Morgan, M.L., 2017, Geologic map of the Johnstown quadrangle, Larimer and Weld Counties, Colorado: Colorado Geological Survey Open-File Report 17-02, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-johnstown-quadrangle-larimer-weld-colorado/].

Palkovic, M.J., Lindsay, K.O., and Morgan, M.L., 2018, Geologic map of the Milliken quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 18-02, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-milliken-quadrangle-weld-colorado/].

Palkovic, M.J., Lindsey, K.L., and Morgan, M.L., 2019, Geologic map of the LaSalle quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 19-03, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/2020/47517-geologic-map-la-salle-quadrangle-weld-colorado/].

Palkovic, M.J., and Morgan, M.L., 2020, Geologic map of the Bracewell quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 20-03, scale 1:24,000 [also available at https://coloradogeologicalsurvey.org/publications/geologic-map-bracewell-quadrangle-weld-colorado/].

Palkovic, M.J., and Morgan, M.L., 2021b, Geologic map of the Hardin quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 21-02, scale 1:24,000.

Peng, Liang, and Forman, S.L., 2019, LDAC: An Excel-based program for luminescence equivalent dose and burial age calculations: Ancient TL, v. 37, p. 21–40.

Prescott, J.R., and Hutton, J.T., 1994, Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations: Radiation Measurements, v. 23, p. 497-500.

Riihimaki, C.A., Anderson, R.S., Safran, E.B., Dethier, D.P., Finkel, R.C., and Bierman, P.R., 2006, Longevity and progressive abandonment of the Rocky Flats surface, Front Range, Colorado: Geomorphology, v. 78, p. 265-278.

Roberts, S.B., 2005, Coal in the Front Range urban corridor – an overview of coal geology, coal production, and coal-bed methane potential in selected areas of the Denver Basin, Colorado, and the potential effects of historical coal mining on development and land-use planning: Chap. F *in* Fishman, N.S., ed., Overview of studies related to energy resources, northern Front Range of Colorado, U.S. Geological Survey Professional Paper 1698, 170 p. [also available at: https://pubs.usgs.gov/pp/2005/1698/pdf/P1698.pdf (report), https://pubs.usgs.gov/pp/2005/1698/pdf/P1698_Plate01.pdf (plate)].

Schwochow, S.D., Shroba, R.R., and Wicklein, P.C., 1974, Sand, gravel, and quarry aggregate resources, Colorado Front Range Counties: Colorado Geological Survey Special Publication 5B, Plate 1 [also available at https://coloradogeologicalsurvey.org/publications/atlas-sand-gravel-quarry-aggregate-colorado-front-range/].

Scott, G.R., and Cobban, W.A., 1965, Geologic and biostratigraphic map of the Pierre Shale between Jarre Creek and Loveland, Colorado: U.S. Geological Survey Miscellaneous Geological Investigations Map I-439, scale 1:48,000 [also available at https://pubs.usgs.gov/imap/0439/report.pdf (report), https://pubs.usgs.gov/imap/0439/plate-1.pdf (map)].

Spencer, F.D., 1986, Coal geology and coal, oil, and gas resources of the Erie and Frederick quadrangles, Boulder and Weld Counties, Colorado: U.S. Geological Survey Bulletin 1619, 58 p. [also available at https://pubs.usgs.gov/bul/1619/report.pdf].

Topper, Ralf, Spray, K.L., Bellis, W.H., Hamilton, J.L., and Barkmann, P.E., 2003, Ground water atlas of Colorado: Colorado Geological Survey Special Publication 53, 210 p.

Turney, J.E., and Murray-Williams, L., 1983, Colorado Front Range inactive coal mine data and subsidence information, Weld County, Plate 12 of 12: Colorado Geological Survey unpublished map prepared in 1983, scale 1:50,000.

U.S. Department of Agriculture, Natural Resources Conservation Service, 2018, Assessing carbonates in the field with a dilute hydrochloric acid solution: Soil Survey Technical Note 5, 7 p. [also available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053572].

U.S. Energy Information Administration, 2021, Colorado state profile and energy estimates, https://www.eia.gov/state/analysis.php?sid=CO

U.S. Geological Survey, 2021, USGS master seismic catalog (Valley View School quadrangle, Weld County, Colorado seismic events from June 2014 to March 2021) [available at https://www.usgs.gov/science-explorer-results?es=earthquakes].

US GeoSupply, 2020, Grain size card comparator: Grand Junction, Colorado, view at https://www.usgeosupply.com/collections/reference-charts.

Weimer, R.J., 1996, Guide to the petroleum geology and Laramide orogeny, Denver Basin and Front Range, Colorado: Colorado Geological Survey Bulletin 51, 133 p. [also available at https://coloradogeologicalsurvey.org/publications/denver-basin-front-range-colorado-petroleum-geology-laramide-orogeny/].

Weld County (Colorado), 2021, FEMA January 2016 flood plain mapping update for Weld County: Weld County web site, Planning and Zoning, Floodplain Management [available at https://www.co.weld.co.us/maps/propertyportal/].

White, J.L., and Greenman, C., 2008, Collapsible soils in Colorado: Colorado Geological Survey Engineering Geology 14, 108 p. [also available at: https://coloradogeologicalsurvey.org/2018/28848-collapsible-soils/].

Wintle, A.G., and Murray, Andrew, 2006, A review of optically stimulated luminescence characteristic and their relevance in single-aliquot regeneration dating protocols: Radiation Measurements, v. 41. p. 369-391.

Yeck, W.L., Benz, H.M., Weingarten, M., and Nakai, J., 2016, Rapid response, monitoring, and mitigation of induced seismicity near Greeley, Colorado: Seismological Research Letters, v. 87, n. 4, p. 837-847.

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