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DESCRIPTION OF MAP UNITS
SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

- Artificial fill (uppermost Holocene)** — Earth materials (sand, silt, clay, and rock debris) employed or shaped to construct highways, railroad beds, irrigation works, parking lots, athletic fields, residential and commercial buildings, landfills, and earthen dams. Unit is 3–100 ft thick.
- Wetland deposit (uppermost Holocene)** — Dark gray silty and clayey sand in a small poorly drained area adjacent to the low scarp bounding unit Qa₁ in the southeastern part of the map area. Unit is estimated to be 3–5 ft thick.

ALLUVIAL DEPOSITS

- Valley-floor alluvium (upper and middle Holocene)** — Dark grayish-brown poorly sorted silty clayey sand underlying the channels and adjacent low terraces (height 2–4 ft) of major streams (St. Vrain Creek, Boulder Creek, and to a lesser extent Lefthand Creek). The unit includes alluvial deposits of three different ages that are mapped as a single unit because they (1) consist of similar material, (2) occupy similar positions in the landscape, and (3) are too intermingled to show separately at the scale of this map. The youngest alluvium consists of channel and flood-plain deposits of historic and protohistoric age, which in eastern Colorado encompasses the past 550 yr B.P. (Hunt, 1954) or about 350 yr B.P. (J.B. Benedict, Center for Mountain Archeology, in Madole et al., 2005). The youngest alluvium is present in tracts large enough to easily distinguish only near the confluence of the St. Vrain and Boulder Creeks in the southeastern part of the map area. Soil development in protohistoric alluvium is weak, consisting only of an A/C-horizon sequence in which the A-horizon is 2–4 inches thick. The other two alluvial deposits have organic-rich A-horizons that are 6–20 inches thick. These two alluvial deposits are distinguished primarily by the fact that the oldest alluvium contains secondary CaCO₃ and the middle alluvium does not. Eight radiocarbon ages from gravel pits just west of the map area (Madole, unpublished data 1972–1979) suggest that deposition of the oldest alluvium began in the later part of middle Holocene time (defined here as 8000–4000 yr ago) and continued into late Holocene time. Although the radiocarbon ages do not clearly identify the beginning and end dates of deposition of either alluvium, they suggest that they likely correlate with two intervals during which stream discharge and energy increased greatly (causing a ten-fold increase in channel width in some places) in glaciated drainage basins in the Front Range (Madole, 2012). It is likely that most of the oldest alluvium in unit Qa was deposited between about 5000 and 2000 cal yr B.P. and most of the middle alluvium was deposited between about 1850 and 1100 cal yr B.P. Unit Qa is typically 3–5 ft thick.
- Post-Broadway alluvium (Upper Pleistocene and lower Holocene)** — Chiefly dark grayish-brown to pale brown silty sand 7–10 ft thick overlying 2–4 ft of gray clast-supported gravel. The gravel overlies an undulating surface cut on Pierre Shale (unit Kpt). In the map area, unit Qpb underlies a terrace that is 10–15 ft higher than St. Vrain Creek. Soil-profile development in unit Qpb consists of an A/Bv/C-horizon sequence in which the A-horizon is unusually thick (3–4 ft), and the Bv horizon is weakly developed and only slightly oxidized. The exceptionally thick A-horizons developed in unit Qpb are attributed to a lengthy period of aggradation that occurred at rates equal to or slower than the rate of soil formation. Radiocarbon ages (Table 1) indicate that unit Qpb was deposited sometime after 15,500 cal yr B.P. Unit thickness is 7–15 ft.
- Alluvium three (Upper Pleistocene)** — Gray clast-supported pebble and cobble gravel and some interbedded lenses of stratified silt and sand, which except beneath the flood plains of St. Vrain Creek and Boulder Creek, fine upwards into sandy alluvium. Also, in some places in the southeastern part of the map area the sandy alluvium is covered by collan sand of late Pleistocene age. Along Lefthand Creek, unit Qa₃ is more sand than gravel. Gravel underlying the floors of valleys whose headwaters are in the glaciated part of the Front Range (St. Vrain, Boulder, and Lefthand Creeks) consists chiefly of granitic and gneissic rock, and a small percentage of other resistant materials, such as sandstone and vein quartz. Also, films of glacial flour commonly coat the gravel in unit Qa₃ enhancing its gray color. However, the glacial-flour coatings decrease eastward and are negligible near the eastern edge of the map area. Unit Qa₃ is correlated with the Pinedale glaciation, which began before 31,420 cal yr B.P. (Madole and others, 2010) and likely ended prior to 14,000 cal yr B.P. A lens of organic-rich sediment inset in the top of Qa₃ gravel at locality AG-3 in the southeastern part of the map area has a radiocarbon age of 13,460±15 cal yr B.P. (Beta-441146, Table 1), and charcoal from a similar lens at locality AG-1 has a radiocarbon age of 12,025±45 cal yr B.P. (Beta-441144, Table 1). These ages indicate that deposition of unit Qa₃ had ceased by or before 12,000 cal yr B.P. Unit Qa₃ is about 15 ft thick near the west edge of the map area and thins to about 8–10 ft near the southeastern edge of the map area. The sandy alluvium and collan sand that overlie the clast-supported gravel in the southeastern part of the map area are estimated to be 5–10 ft thick.
- Alluvium four (upper Middle Pleistocene)** — Brown to slightly reddish-brown clast-supported and matrix-supported pebble and cobble gravel. Unit Qa₄ is exposed only in excavations that penetrate the windblown sediment (unit Qe) that covers it nearly everywhere. Clasts of granitic and gneissic rock are common on the surface of unit Qe where it is underlain by unit Qa₄, which combined with the height of unit Qa₄ above the St. Vrain Creek helps establish its boundaries. A stipple pattern is used to indicate the presence of unit Qa₄ beneath unit Qe. The composition of unit Qa₄ is similar to the composition of unit Qa₃. It consists mostly of clasts of granitic and gneissic rock from the core of the Front Range. Soil development in unit Qa₄ is moderate to strong; it includes a clay-enriched subsoil (Bt horizon) and secondary calcium carbonate (Bk horizon). Unit Qa₄ is equivalent to the Louviers Alluvium in the Hygiene quadrangle (Madole and others, 1998) and to unit Qa₂ in quadrangles in the central and southern Colorado Piedmont mapped by the Colorado Geological Survey. Geotechnical reports for residential buildings in the map area indicate that unit Qa₄ is 10–20 ft thick.
- Alluvium five (Middle Pleistocene)** — Brown to reddish-brown clast-supported gravel that consists chiefly of cobbles and pebbles. As with unit Qa₄, except in a few excavations, loess (unit Qe) covers this unit. The unit is present only in the southwestern part of the map area where it caps a narrow ridge (a stream deposit now topographically inverted; that is, a former valley floor is now a ridge). The gravel consists mostly of granitic and gneissic rock derived from the Front Range. The deposit is deeply oxidized and has a clay-enriched subsoil (Bt horizon) and white to light-gray secondary calcium carbonate coats both the clasts and much of the otherwise reddish-brown sandy matrix (particles less than 2 mm in size). Unit thickness is generally 3–10 ft.
- Old alluvium (Middle Pleistocene)** — Sand and clast-supported gravel consisting chiefly of cobbles and pebbles of crystalline rock and some vein quartz derived from the Front Range. The unit is exposed in only two localities (a railroad cut, SW1/4, Sec. 1, T2N, R.69W, and an abandoned gravel pit, SE1/4, NE1/4, Sec. 7, T2N, R.68W). Deposits of Qao clip some of the topographically higher parts in the map area. These deposits are remnants of ancient valley-floors that are topographically inverted (that is, former valley floors are now ridges or high points in the landscape). Topographic inversion and stream piracy, the process that beheaded the Little Thompson River and diverted it eastward, are common in areas where coarse-grained alluvium is transferred from mountains (particularly those that have cores of crystalline rock) into adjacent basins or piedmonts underlain by shale, mudstone, and siltstone. This describes the alluvium and bedrock in the Longmont quadrangle. The gravel is more resistant to erosion than the bedrock that once formed valley walls. Thus, when the base level of the drainage basin was lowered, stream incision occurred along valley margins rather than in the gravel covering the valley floor. Unit is 3–15 ft thick.
- Valley-floor and sheetwash alluvium, undivided (Holocene and Pleistocene)** — Chiefly brownish-gray and grayish-brown sand and silty clayey sand on the floors and footslopes of small valleys that originate on the plains (Colorado Piedmont). The unit consists chiefly of Holocene alluvium that is locally interbedded with Pleistocene alluvium and in many places is overlapped by loess and by sheetwash alluvium derived from loess (unit Qe). In the uppermost reaches of these small valleys stream incision is typically less than 3 ft. However, incision increases to 10 ft or more where streams approach St. Vrain Creek, which is their local base level. Twice during Holocene time conditions favorable to valley widening and alluviation resulted in the formation of narrow terraces, which subsequently were dissected. The various deposits included in unit Qau are undivided because most are too small to show individually at the scale of this map. Soil development in Holocene alluvium is weak, consisting of simple A/C-horizon profiles. In contrast, soils in alluvium and loess of Pleistocene age have well developed Bt (clay-enriched) horizons. Unit Qau is similar to unit Qe in color and grain-size distribution, presumably because much of it was derived from the extensive deposits of unit Qe that blanket adjacent uplands. Unit Qau is estimated to be 3–15 ft thick.
- Sheetwash alluvium (Holocene)** — Grayish-brown to pale brown, extremely poorly sorted sand, silt, clay, and minor amounts of rock fragments that were transported primarily by sheetwash (unconfined runoff). Unit exists principally in sheets and wedges along valley sides and footslopes. The estimated thickness of the unit is 1–25 ft.
- Fan deposits (Holocene)** — Fan-shaped bodies of pale-brown to brown, extremely poorly sorted sand, silt, clay, and minor amounts of pebble- and cobble-size rock fragments. In some places on the north side of St. Vrain Creek in the southeastern part of the map area the unit includes colluvium. The estimated thickness of the unit is 1–30 ft.
- Eolian sediment (Upper Pleistocene)** — Chiefly pale-brown wind-deposited sandy and clayey silt generally referred to as loess. Typically, loess is 50–70 percent silt and less than 20 percent clay by weight (Pye, 1987). However, loess in the Longmont quadrangle contains more clay than is typical, likely because the Pierre Shale is at the surface over broad areas northwest (direction of prevailing winds) of the map area. The boundaries of unit Qe are commonly difficult to discern because loess lacks topographic expression and is not associated with a specific landform. Instead, it blankets the landscape across a broad range of altitudes. Hence, the distribution of unit Qe is partly inferred from county soil maps (Moreland and Moreland, 1975; Crabb, 1980). Stratigraphic relations and soil development indicate that the unit is of late Pleistocene age. It overlies middle Pleistocene alluvium (areas where this occurs are indicated by stipple patterns) and is crosscut and overlapped in some places by early Holocene alluvium (unit Qpb). The upper part of the soil profile developed in unit Qe is noncalcareous, but the subsoil, besides being oxidized, contains significant concentrations of secondary CaCO₃, some in the form of nodules. In addition, the subsoil is enriched in clay (has a Bt horizon) translocated from higher in the profile. Deposits of alluvium, mostly sheetwash, in swales and small, shallow valleys throughout the map area, are included in unit Qe because they are too small to show at the scale of this map. Unit Qe is generally 3–20 ft thick.

BEDROCK UNITS

- Fox Hills Sandstone (Upper Cretaceous)** — The upper part of the formation consists of tan crossbedded sandstone that grades downward into brown, fine-grained silty sandstone and gray fissile shale. The Fox Hills Sandstone formed along the shoreline of the Western Interior seaway that occupied this area during the Late Cretaceous (Roberts, 2005). Formation thickness is variable, ranging from about 300 to 500 ft.
- Pierre Shale (Upper Cretaceous)** — The formation consists of marine strata composed chiefly of dark gray shale, siltstone, and fine-grained sandstone. Bentonitic beds are common in the lower part of the formation and calcareous concretions are common throughout. The formation is at or near the surface over a broad area (as much as 20 miles wide) along the east flank of the Front Range. The Longmont quadrangle is in the eastern part of this area. In an area between Denver and Loveland, Colorado, Scott and Cobban (1965) divided the formation into six members. Only the upper two members are present in the Longmont quadrangle.
- Uppermost transition member** — The upper transition member consists of friable sandstone and soft shaly sandstone containing thin beds of sandy shale and large calcareous concretions. This member is about 2000 ft thick.
- Upper shale member** — Gray concretionary silty shale that is about 2800 ft thick.
- Niobrara Formation (Upper Cretaceous)** — Shown only in cross section (A–A'). Unit consists of light-gray to dark-gray fissile calcareous shale and light-gray thinly bedded micritic limestone. Thickness varies from about 210 to 310 ft.
- Benton Group: Carlile Shale, Greenhorn Limestone, and Greenow Shale (Upper Cretaceous)** — Undivided and shown only in cross section (A–A'). Group consists chiefly of olive-gray, dark-gray, and grayish-black siltstone, sandy siltstone, silty claystone, shale, and dark-gray limestone. Thickness varies from about 410 to 470 ft.

Table 1. Radiocarbon ages of alluvial deposits in and near the Longmont quadrangle, Boulder and Weld Counties, Colorado

Map unit	Locality	Laboratory number	Method ¹	Material sampled	Measured ¹⁴ C age ²	6σ ³	Conventional ¹⁴ C age ²	Cal yr BP (1σ)	Cal yr BP (2-σ range)
Unit Qa	AG-2A	Beta-441145	AMS	plant matter	3,580±30	-28.1	3,530±30	3,835±60	3,890±1,715
Unit Qa	AG-2B	Beta-441543	AMS	sediment ⁴	3,940±30	-24.3	3,950±30	4,420±10	4,515±4,300
Unit Qa ₃	ZW-2	Beta-37775	RAD	wood	-----	---	10,260±40	11,980±155	12,380±11,755
Unit Qa ₃	AG-1	Beta-441144	AMS	charcoal	10,280±40	-26.2	10,260±40	12,025±45	12,120±11,935
Unit Qa ₃	ZW-1B	Beta-36211	RAD	wood	-----	---	10,690±100	12,640±70	12,750±12410
Unit Qa ₃	AG-3	Beta-441146	AMS	sediment ⁴	11,630±30	-24.4	11,640±30	13,460±30	13,535±13,430

¹At the sample locality, unit Qa₃ underlies unit Qe.
²AMS—determined by accelerator mass spectrometer as opposed to radiometric decay.
³Conventional ¹⁴C age indicates: (1) the age was calculated using a ¹⁴C half-life of 5,568 yr; (2) 6σ³ was determined and used to correct for isotopic fractionation; and (3) A.D. 1950 is the base (zero) year.
⁴BP—Before Present.
⁵INTCAL 13 is the database used for calibrations.
⁶Organic-rich clayey silty sand
⁷6σ³ unreported; assumed to be <25.0 for purposes of calibration.

GPS coordinates for AG-1: 40°49'40"N, 105°09'25"W. AG-3 is about 30 ft north of AG-1 and AG-2 is about 80 ft north of AG-1. Latitude and longitude for ZW-1B and ZW-2 (gravel pit, Zwick farm, Hygiene quadrangle): 40°10'44"N, 105°09'25"W.

MAP SYMBOLS

- Contact** — Approximately located
- Gravel pit**
- Paleovalley** — Approximate location of gravelly alluvium that was deposited by an ancestral Little Thompson River sometime during the middle Pleistocene (interval between 781,000 and 126,000 yr ago) prior to when the river was intersected and diverted eastward by a stream that originated on the plains. The ancestral valley floor is completely covered by unit Qe. Thus, its limits are based on widely scattered geotechnical data and information from deep excavations just south of Terry Lake that were examined while mapping the Hygiene quadrangle (Madole and others, 1998).
- Strike and dip of inclined bedding** — Showing direction and angle of dip
- Estimated strike and dip of inclined bedding** — Strike based on outcrop trend, dip of strata not exposed
- Numerical age localities** — Showing sample collection number
- Producing oil and gas well**
- Non-producing, abandoned or permitted oil and gas well location**
- Alignment of cross section**

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