SURFICIAL GEOLOGY OF LINCOLN COUNTY, KANSAS

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Map M-127

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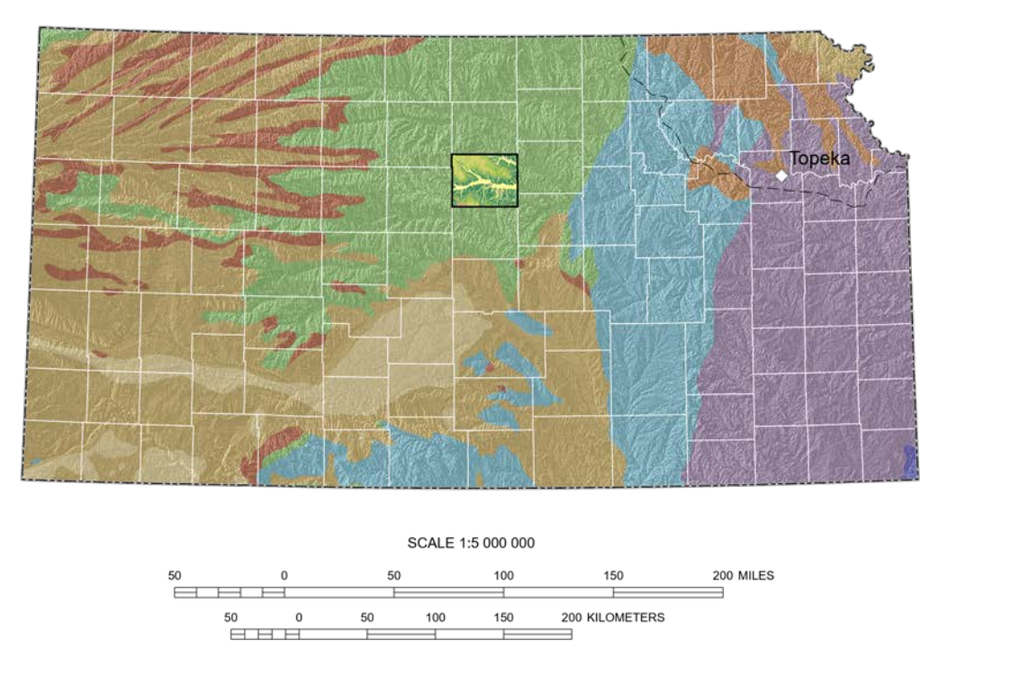
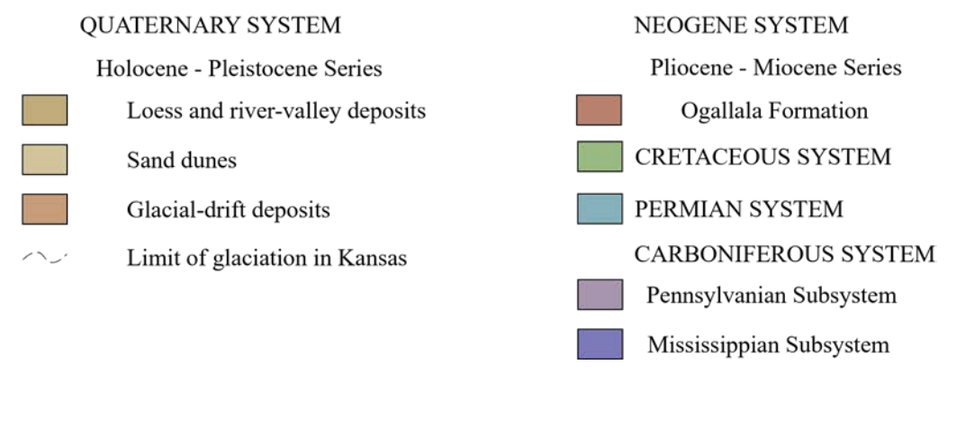
MAP LOCATION



GENERALIZED GEOLOGY OF KANSAS

QUATERNARY SYSTEM
Holocene - Pleistocene Series
Loess and river-valley deposits
Sand dunes
Glacial-drift deposits
Limit of glaciation in Kansas

NEOGENE SYSTEM
Pliocene - Miocene Series
Ogallala Formation
CRETACEOUS SYSTEM
PERMIAN SYSTEM
CARBONIFEROUS SYSTEM
Pennsylvanian Subsystem
Mississippian Subsystem



GEOGRAPHY

Lincoln County is in the Smoky Hills physiographic region. Broad alluvial valleys are associated with the major drainages, and the uplands are deeply dissected and form a prominent escarpment.

Located in north-central Kansas, Lincoln County has an area of about 720 mi^2 (1,865 km^2), measuring about 30 mi (48 km) in the east-west direction and 24 mi (39 km) north-south.

The Saline River runs from west to east through the center of the county, eventually joining the Smoky Hill River in neighboring Saline County. Salt Creek is joined by Rattlesnake Creek near Barnard, then flows southeasterly across the northeast corner of the county to the Solomon River in Ottawa County.

Topographic relief in Lincoln County is 550 ft (168 m). The highest point is about 1,830 ft (558 m) in the southwest corner, and the lowest elevation, about 1,280 ft (390 m), is where Salt Creek enters Ottawa County. Maximum local relief, found in the uplands, is about 300 ft (91 m) (Berry, 1952).

GENERAL GEOLOGY

The surficial sedimentary rocks—beds of limestone, chalky limestone, sandstone, and mudrocks—are all Cretaceous in age (Zeller, [1968] 2022). The oldest rocks in Lincoln County, the Kiowa Formation, occur only in the southeast corner of the county. The Dakota Formation borders the major drainages and represents a major portion of the surface area. Above the Dakota, the Graneros Shale, Greenhorn Limestone, and the lower part of the Carlile Shale occupy the uplands.

Unconsolidated Quaternary deposits include Holocene alluvium and terrace valley fill associated with present-day drainages and mixed colluvial and alluvial deposits along the margins of the floodplains of major streams. Pleistocene deposits of mixed alluvial and eolian (loess) sediments are associated with isolated terraces along the margins of major stream valleys and in an upland position in the southwestern part of the county. These upland deposits extend southward into Ellsworth County and are referred to as the "Wilson valley." The channel fill was deposited by the ancestral Saline River when it flowed through the area to the Smoky Hill River during the Pleistocene.

STRUCTURAL GEOLOGY

The regional dip of the Cretaceous strata in Lincoln County is generally to the west, but locally, the rocks are mostly flat lying. Areas of fairly complex dip occur in the Shady Bend and Wilson NE quadrangles; however, they do not appear to be related to any regional structural trends.

MINERAL RESOURCES

Hard, concentric sandstone bodies occur in the Dakota and Kiowa Formations in central Kansas (Swineford, 1947). This calcite-cemented sandstone is found within the Dakota Formation in Lincoln County and is mined extensively near Lincoln. This sandstone is a high-quality aggregate and is in high demand in central Kansas. It is locally referred to as "Lincoln quartzite" because of its proximity to Lincoln and its exceptional hardness. Geologically, it is not a true quartzite (the grains in sedimentary quartzite are cemented with silica rather than calcite), but the name is entrenched locally and in the literature. Calcite-cemented sandstone was also mined about 5 mi (8 km) west of Sylvan Grove. Numerous outcrops of these concentric sandstone bodies are found within the county. The Sylvan Grove mine was developed in the top of the Dakota in the Janssen Clay Member (Swineford, 1947), while the Lincoln quarry is stratigraphically lower in the Terra Cotta Clay Member (McBride and Milliken, 2006). Surface occurrences of calcite-cemented sandstone in the Dakota Formation are shown on the map.

Lincoln County is in the heart of Fence-post limestone country. Historically, the Fence-post limestone bed at the top of the Greenhorn Limestone was quarried for building stone and fence posts. Settlers on the treeless plains in north-central Kansas used the limestone bed starting in the mid-1870s. Later, during the late 1800s and early 1900s, it became an important building material in the area (Muilenburg and Swineford, 1975). Fresh exposures of the bed are soft and easily split or sawed into blocks or long lengths. Exposure to air then causes the limestone to harden. Although the Fence-post limestone bed is the main source of building stone from the Greenhorn, two other beds below the Fence-post limestone bed also have been quarried (Bayne et al., 1971). Abandoned post rock quarries are easily recognized in the field and on photos, making them a valuable marker for mapping the top of the Greenhorn/base of the Carlile contact and beds below the Fence-post limestone bed that have also been quarried.

Sand and gravel are obtained from two main sources in Lincoln County (Berry, 1952). Higher quality quartz sand and gravel come from the channel fill deposits (Wilson valley) in the southwest corner of the county. Locally derived gravel containing more silt and clay is found in terraces along major streams and tributaries throughout the county.

Lignite coal in the upper part of the Dakota Formation was mined in Lincoln County in the late 1800s (Whitla, 1940; Schoewe, 1952).

Volcanic ash crops out at several localities in the southwest corner of Lincoln County and was mined at two pits, now abandoned, where the ash was 6–6.5 ft (2 m) thick (Carey et al., 1952). The volcanic ash occurs in the Pleistocene deposits associated with the Wilson valley and is identified as the Lava Creek B ash bed (formerly Pearlette ash bed; Layzell et al., 2017) (Carey et al., 1952; Izett and Wilcox, 1982).

Lincoln County has no oil and gas production (Kansas Geological Survey, 2023).

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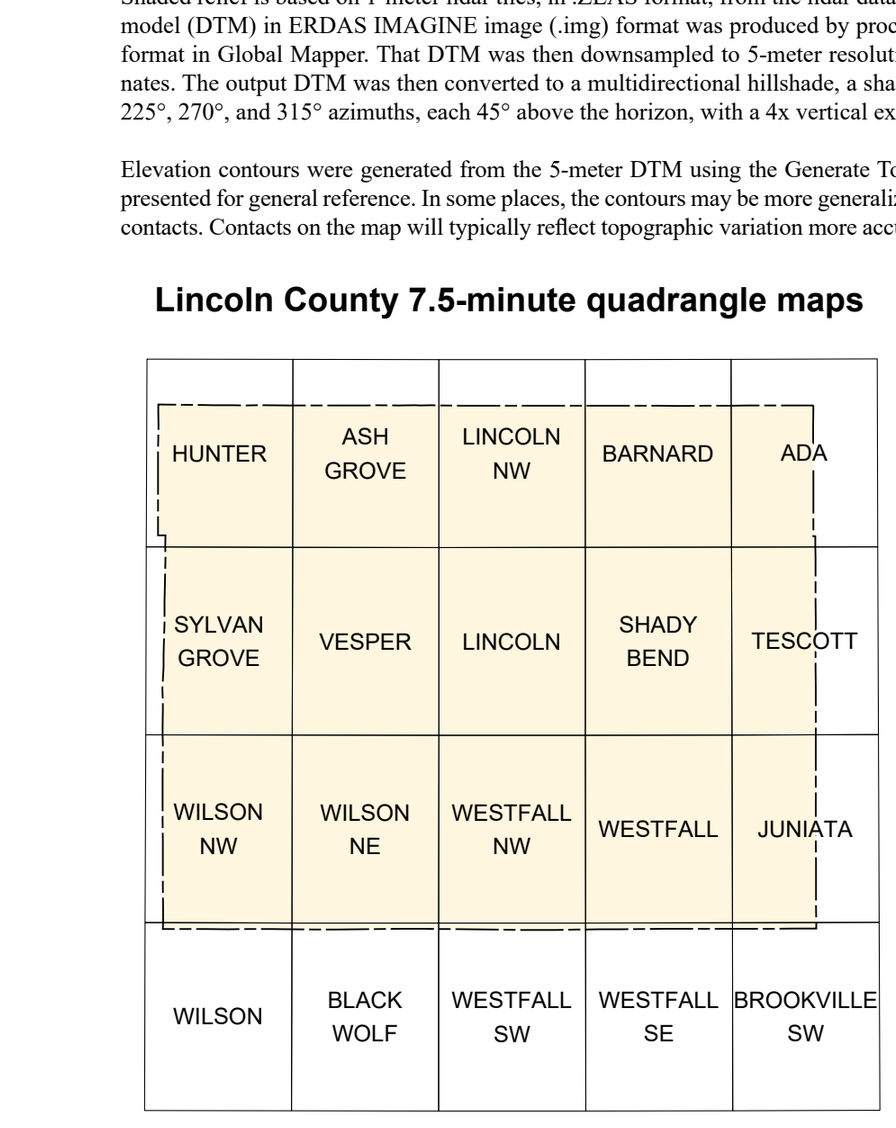
Roads, highways, and municipal areas are shown on the base map as represented by data from the Kansas Department of Transportation (KDOT) and Kansas Next Generation (NG) 911. U.S. Department of Agriculture–Farm Services Agency (USDA-FSA) National Agriculture Imagery Program (NAIP) imagery also was used to check road locations. U.S. Public Land Survey System (PLSS) township-range-section data were provided by the Kansas Data Access and Support Center (DASC). Railroad data were provided by KDOT.

Shaded relief is based on 1-meter lidar tiles, in .ZLAS format, from the lidar database administered by DASC. A hydro-enforced terrain model (DTM) in ERDAS IMAGINE image (.img) format was produced by processing the lidar tiles and breaklines in shapefile (.shp) format in Global Mapper. That DTM was then downsampled to 5-meter resolution and subsequently converted to geographic coordinates. The output DTM was then converted to a multidirectional hillshade, a shaded-relief image using angles of illumination from 0°, 225°, 270°, and 315° azimuths, each 45° above the horizon, with a 4x vertical exaggeration.

Elevation contours were generated from the 5-meter DTM using the Generate Topographic Contours script tool in ArcGIS Pro and are presented for general reference. In some places, the contours may be more generalized than the base maps used for compilation of geologic contacts. Contacts on the map will typically reflect topographic variation more accurately than the associated contour lines. Repeated fluctuation of a contact across a contour line indicates that the mapped rock unit is maintaining a relatively constant elevation along a generalized contour.

Lincoln County 7.5-minute quadrangle maps



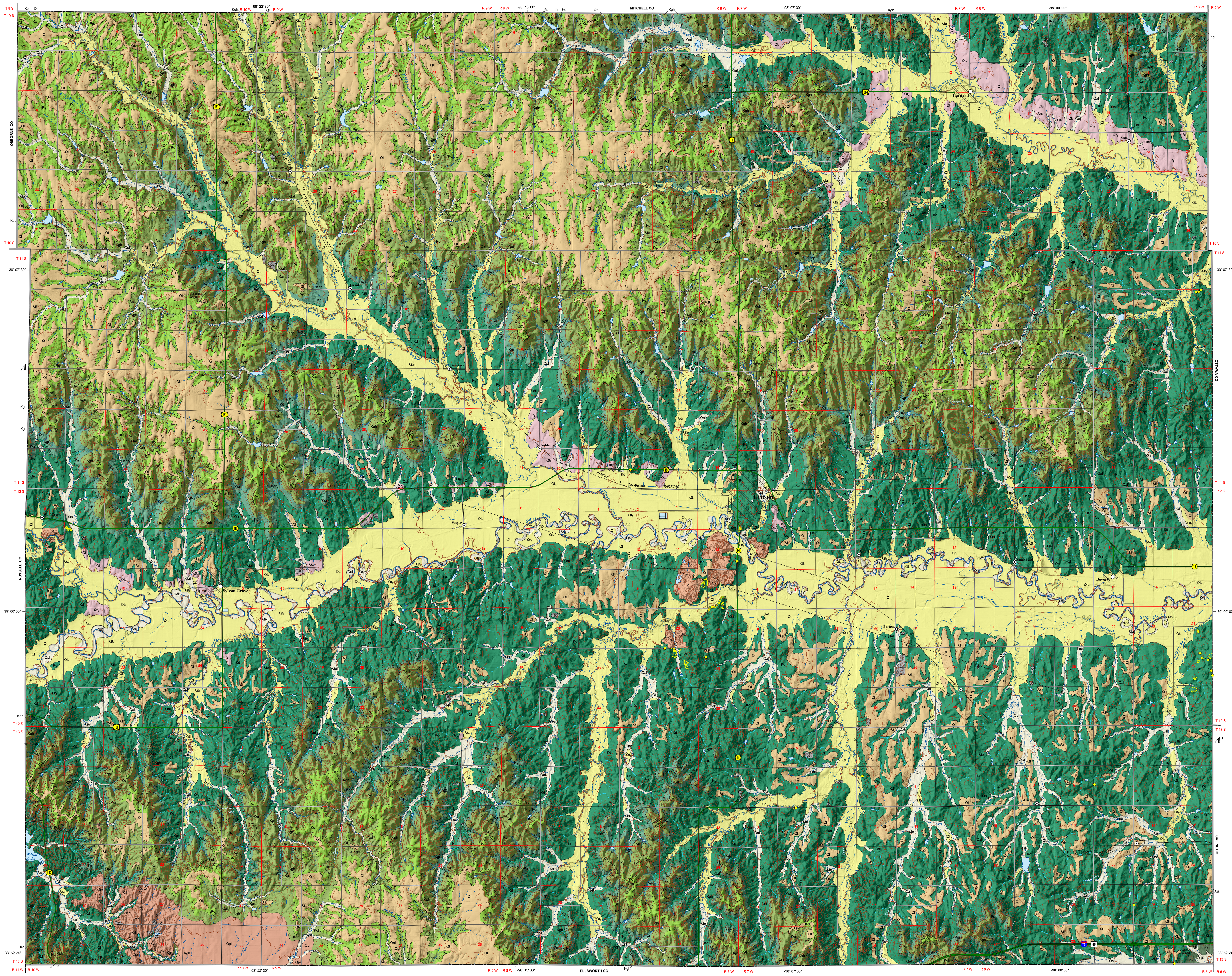
Index shows the names and locations of the 20 USGS 7.5-minute 1:24,000-scale quadrangle maps used in the digital compilation of the Lincoln County map. The geology was mapped in the field using these topographic maps.

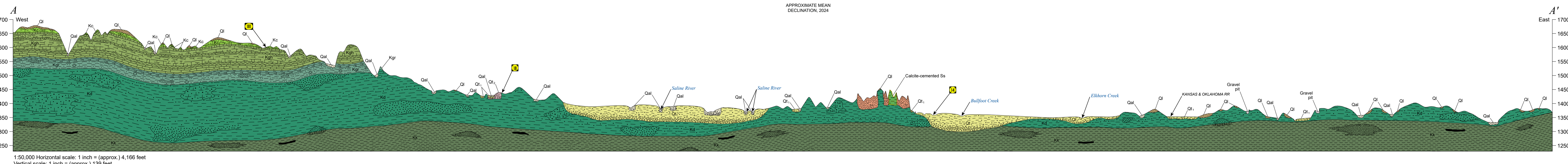
Geology was mapped in the field using U.S. Geological Survey (USGS) 7.5-minute 1:24,000-scale topographic quadrangle maps. Contacts were compiled in GIS format and edited, and attributes were added. These data were then used to generate the mapped-unit GIS data, to which necessary attribution was added.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program (NCGMP) under STATEMAP award number G22AC00574 (FY2022). Preliminary 1:24,000-scale mapping was funded by the NCGMP in part under STATEMAP award numbers G15AC00225 (FY2015) and G16AC00195 (FY2016). The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government.

This map was produced using the ArcGIS system developed by Esri, Global Mapper developed by Blue Marble Geographics, Adobe Creative Cloud Suite (InDesign and Illustrator), and MAPublisher developed by Avenza Systems Inc.

The Kansas Geological Survey does not guarantee this map to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations made from the map or decisions based thereon.





1:50,000 Horizontal scale: 1 inch = (approx.) 4,166 feet
Vertical scale: 1 inch = (approx.) 139 feet
Vertical exaggeration: 30x

SYSTEM	GEOLOGIC UNITS	SERIES

Quaternary

Qal — Floodplain and low terrace deposits (Holocene)

Alluvium beneath floodplain and low terrace surfaces is found along major river valleys and the upper reaches of smaller tributaries in the county. Low terrace surfaces stand 12–18 ft (3.7–5.5 m) above the elevation of the modern channel in the Saline River valley. Floodplain and low terrace deposits are inset against older terrace valley fills (Qt_1) in major river valleys and unconformably overlie Cretaceous bedrock in smaller tributaries. Due to scale, inset Qal deposits are predominantly mapped in the Saline River valley. Deposits mostly comprise silt and clay with some sand. Based on regional studies, valley fills beneath low terrace surfaces are likely younger than 3,000 years old and floodplain deposits are less than 1,000 years old (e.g., Mandel, 1988, 1992; Arbogast and Johnson, 1996; Layzell and Mandel, 2020).

Qt_1 — Terrace deposits (Holocene)

Qt_1 terrace deposits comprise valley fills beneath an extensive terrace surface in major stream valleys of the county. In the Saline River valley, the Qt_1 surface stands 25–35 ft (7.6–10.7 m) above the elevation of the modern channel. Qt_1 terrace deposits primarily consist of silt and sand with some clay and gravel beds locally. Based on regional studies, the bulk of the Qt_1 terrace fill in major stream valleys is 4,000 to 11,000 years old but may be mantled by younger alluvium that dates to the late Holocene (e.g., Arbogast and Johnson, 1996; Layzell and Mandel, 2020). In smaller tributaries throughout the county, Qt_1 terrace deposits are thinner and younger, likely dating to between 4,000 and 1,500 years ago (e.g., Mandel, 1988, 1992). Qt_1 terrace deposits overlie older alluvium, comprising primarily sand and gravel, in major river valleys. The total thickness of alluvium beneath Qt_1 surfaces reaches up to 60 ft (18.3 m) in the Saline River valley and up to 25 ft (7.6 m) in other major tributaries in the county.

Ql — Loess (Pleistocene)

Deposits of light yellowish-brown and reddish-brown loess, with predominantly silt loam textures, mantle hilltops and side slopes in portions of Lincoln County. Loess deposits are also commonly found in footslope positions and mantling Pleistocene terrace deposits (Qt_2) but were not differentiated. Mapped loess units are commonly between 6 and 12 ft (1.8–3.7 m) thick but can locally be up to 20 ft (6.1 m) thick. Four loess units have been identified regionally: the Loveland Loess (approximately 160,000–120,000 years old), the Gilman Canyon Formation (44,000–24,000 years old), the Peoria Loess (25,000–12,000 years old), and the Bignell Loess (11,000–9,000 years old) (Bettis et al., 2003).

Qt_2 — Pleistocene terrace deposits (Pleistocene)

Pleistocene terrace deposits are found along the margins of major river valleys in Lincoln County, including the Saline River and Salt Creek. Previously mapped as the Sanborn Formation (nomenclature now abandoned; see Layzell et al., 2017), Pleistocene terrace deposits comprise basal sands and gravel that grade upward into alluvial silt and clay, mantled by undifferentiated loess deposits. Basal sands and gravel are composed of fragments derived locally from Cretaceous rocks and are locally cemented with calcium carbonate (Berry, 1952). Deposits range in thickness from a thin veneer up to 50 ft (15.2 m) thick. In some areas, deposits mantle a strath cut into the Dakota Formation (Kd). The precise age of Pleistocene terrace deposits is unknown; based on stratigraphic position, they are younger than pre-Illinoian valley fills (Qpi) and older than Loveland Loess deposits and, therefore, likely date to between 620,000 and 160,000 years old.

Qpi — Pre-Illinoian fluvial valley fill and loess (Pleistocene)

Early Pleistocene deposits in Lincoln County contain clay, silt, sand, gravel, loess, and volcanic ash. Composed of a basal sand and gravel overlain by undifferentiated loess, and with a total thickness of up to 40 ft (12.2 m) (Berry, 1952), the deposit unconformably overlies Dakota, Graneros, and Greenhorn strata in the southwest corner of the county. This occurrence represents the channel fill remnants of the ancestral Saline River, named the "Wilson valley," that flowed southeasterly to the Smoky Hill River in Ellsworth County during pre-Illinoian time. The term "pre-Illinoian" replaces the classic Pleistocene glaciation terms Nebraskan, Aftonian, Kansan, and Yarmouthian in Kansas (Layzell et al., 2017). An ash bed, formerly known as the Pearlette ash bed (nomenclature now abandoned; see Layzell et al., 2017), occurs in the upper loess unit in Lincoln County (Berry, 1952). Berry (1952) reported the ash to be 3–12 ft (1–3.7 m) thick. It has been identified as the Lava Creek B ash bed whose source is from the last major eruption of the Yellowstone Caldera 620,000 years ago (Izett and Wilcox, 1982).

Cretaceous

Kc — Carlile Shale (Upper Cretaceous)

The Carlile Shale contains three members. In ascending order, they are the Fairport Chalk Member, the Blue Hill Shale Member, and the Codell Sandstone Member. Only the lower part of the Fairport Chalk Member is present in Lincoln County, where it is up to 20 ft (6.1 m) thick and very similar to the upper beds of the Greenhorn Limestone (Berry, 1952). It consists of alternating beds of thin, concretionary limestone and chalky mudrocks, as well as thin bentonite layers. The Carlile Shale caps the high hills in the northern and southwestern parts of the county.

Kgh — Greenhorn Limestone (Upper Cretaceous)

The Greenhorn Limestone contains the following four members, in ascending order: the Lincoln Limestone Member, the Hartland Shale Member, the Jetmore Chalk Member, and the Pfeifer Shale Member. Each member is 15 to 20 ft (4.6 to 6.1 m) thick. The contacts between the members are gradational and not easily recognized in the field. In general, the Greenhorn is light gray to yellowish-gray chalky limestone, chalky mudrock, and chalk. Several limestone beds contain the fossil clam *Inoceramus* sp. that is characteristic of the formation. The lower part of the Greenhorn (Lincoln Member) is interbedded layers of chalky mudrock, chalky limestones, and a hard, dark gray crystalline limestone near the base that has a strong petroliferous odor when freshly broken. The middle part (Hartland and Jetmore Members) is chalky mudrock with interbedded layers of nodular limestone, chalky limestone, and bentonite. The upper part of the formation (Pfeifer Member) is interbedded thin chalky limestones and chalky mudrocks containing bentonite seams and is capped by the Fence-post limestone bed, a 0.7 ft (0.2 m) thick limestone that weathers light tan with a rust-colored line in the middle. The Fence-post bed has been quarried extensively in Lincoln County. The Greenhorn is 65 to 90 ft (19.8 to 27.4 m) thick in Lincoln County (Berry, 1952) and forms the prominent escarpments of the upland areas in the northern, southwest, and south-central parts of the county.

Kgr — Graneros Shale (Upper Cretaceous)

The Graneros Shale is a gray to dark gray, noncalcareous, fissile shale that weathers to light gray and yellow-brown. Small flakes of the light gray fissile shale are characteristic in weathered outcrops. Interbedded layers of fossiliferous (predominantly *Inoceramus* sp. and *Ostrea* sp.) sandstone and limestone (up to 2 ft [0.6 m] thick) occur in the middle to lower part of the formation in Lincoln County, and thin (0.3 ft [0.1 m]) beds of limestone often occur near the top. A 1 ft (0.3 m) bentonite bed may be present near the top. Disseminated gypsum and selenite crystals also occur in the Graneros. In Lincoln County, the thickness of the Graneros Shale ranges from 20 to 45 ft (6.1 to 13.7 m). The Graneros Shale forms low hills above the Dakota Formation adjacent to the valleys and gentle slopes between the Dakota and the Greenhorn Limestone in the uplands. Landslides characterize the Graneros horizon.

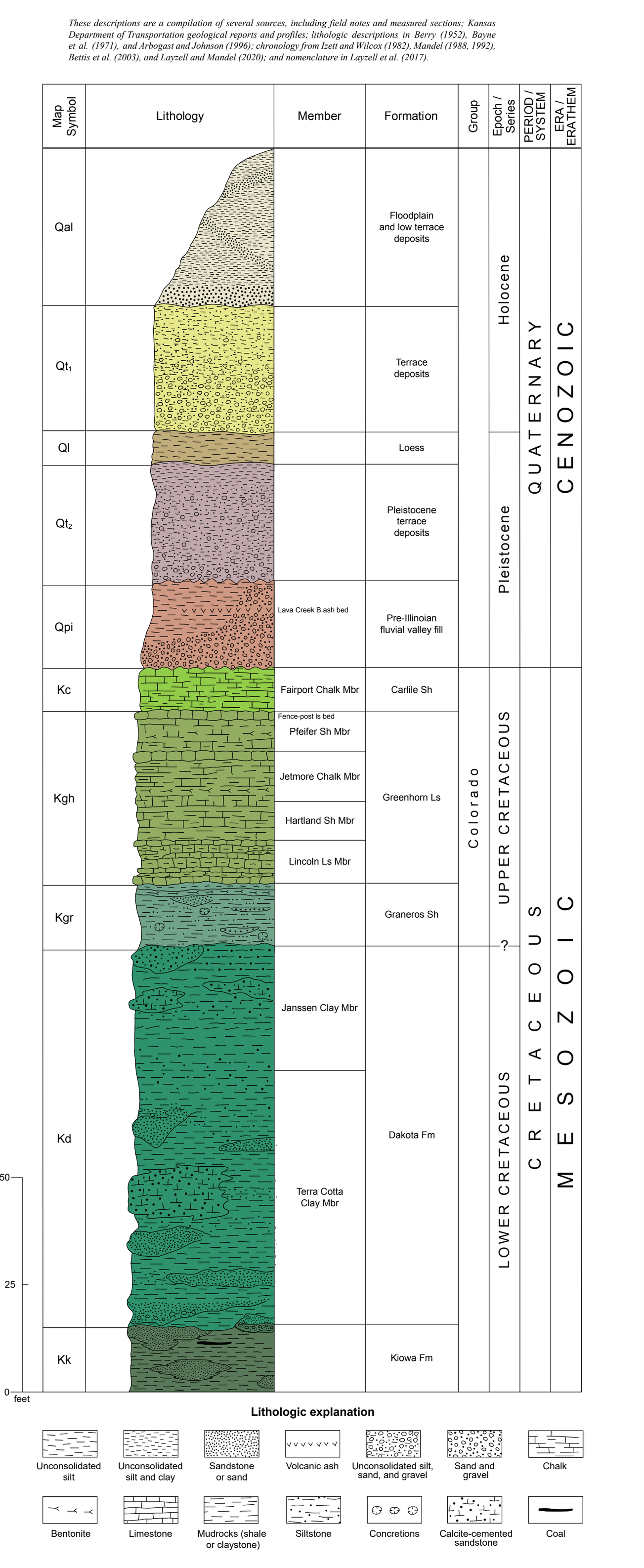
Kd — Dakota Formation (Lower Cretaceous)

The Dakota Formation is composed of two members: the lower Terra Cotta Clay Member and the upper Janssen Clay Member. The Dakota comprises varicolored clay, claystone, and shale with irregular and sometimes massive lenses of siltstone and sandstone. The mudrocks are red-mottled pale-gray, tan to brown clay and silt. The interbedded sandstone lenses are fine to medium grained, very light gray to orange-tan to dark red-brown, and commonly poorly cemented. Concretions and thick layers of hard, gray, calcite-cemented sandstone (locally referred to as "Lincoln quartzite") are found in Lincoln County in small, isolated areas, but extensive deposits near the town of Lincoln are mined for aggregate. The Dakota often contains lignite and carbonaceous fragments, and small concretions and thin beds of limonite, siderite, and hematite occur as scattered fragments on eroded mudrock surfaces. The Dakota Formation ranges from about 140 ft (42.7 m) thick in eastern Lincoln County to about 200 ft (61 m) in the western part (Berry, 1952) and is an important source of water in Lincoln County and elsewhere in Kansas. In Lincoln County, the Dakota is exposed in much of the central and southeastern parts of the county in areas adjacent to the Saline River and its tributaries.

Kk — Kiowa Formation (Lower Cretaceous)

The upper part of the Kiowa Formation is present at the surface only in the extreme southeast corner of Lincoln County, where gray to dark gray shale and siltstone and fine-grained orange-tan sandstones crop out near the boundaries with Ellsworth and Saline counties.

These descriptions are a compilation of several sources, including field notes and measured sections; Kansas Department of Transportation geological reports and profiles; lithologic descriptions in Berry (1952), Bayne et al. (1971), and Arbogast and Johnson (1996); chronology from Izett and Wilcox (1982), Mandel (1988, 1992), Bettis et al. (2003), and Layzell and Mandel (2020); and nomenclature in Layzell et al. (2017).



Lithologic explanation