KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

# SURFICIAL GEOLOGY OF PAWNEE COUNTY, KANSAS


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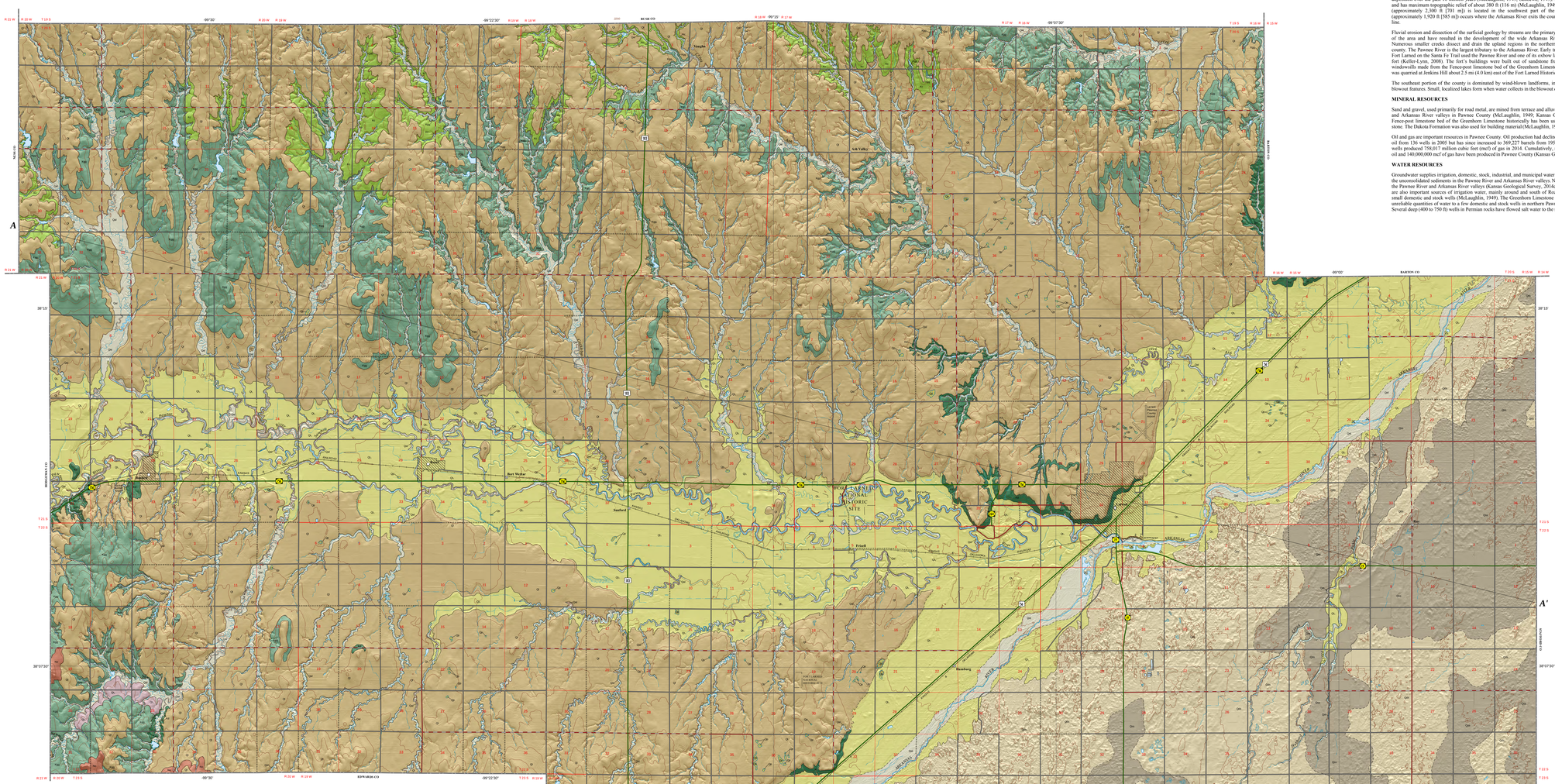
**Text, unit descriptions, and cross section by Charity M. Phillips-Lander**


**2015**


Computer compilation and cartography by John W. Dunham, Christopher R. Bieker, Hillary C. Crabb, Scott T. Klopfenstein, Charity M. Phillips-Lander, R. Zane Price, Jorgina A. Ross, and Gerald Wright III


## MAP M-114


Funded in part by the USGS National Cooperative Mapping Program and by the National Park Service


## LOCATION DIAGRAM

SCALE 1:8,000,000

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 Fm
- CRETACEOUS SYSTEM
- JURASSIC SYSTEM
- PERMIAN SYSTEM
- CARBONIFEROUS SYSTEM
  - Pennsylvanian Subsystem
  - Mississippian Subsystem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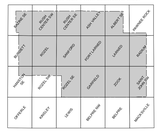
Index to 1:24,000 scale USGS quadrangle maps




Map shows the locations of the 24 quadrangles used in the digital compilation of the Pawnee County map. The index shows the names of each individual 7.5 - minute quadrangle map.

APPROXIMATE MEAN DECLINATION, 2015


Computer compilation and cartography by the Kansas Geological Survey's Cartographic Services unit. For purchase information, or for information about other KGS maps or publications, please call

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## Explanation

**Boundaries and Locations**
- County line
- Township/range line
- Section line
- National historic site boundary
- County seat
- City
- Locality
- Built-up area

**Transportation**
- U.S. highway
- State highway
- Medium-duty primary road
- Medium-duty secondary road
- Light-duty road
- Unimproved road
- Railroad
- Paved airport runway
- Unpaved airport runway

**Geologic Unit Boundaries**
- Observed contact
- Inferred contact

**Hydrology and Topography**
- Perennial stream
- Intermittent stream
- Perennial water body
- Perennial water body, manmade shoreline
- Intermittent water body
- Elevation contour (100-foot interval)
- Elevation contour (20-foot interval)
- Depression contour (100-foot interval)
- Depression contour (20-foot interval)

**Resource Development**
- Open sand or gravel pit

SCALE 1:50 000

1 0.5 0 1 2 3 4 MILES
1 0.5 0 1 2 3 4 5 KILOMETERS

LAMBERT CONFORMAL CONIC PROJECTION
WITH STANDARD PARALLELS 37 1/2° AND 40°
NORTH AMERICAN DATUM OF 1983

Elevation contours, from the USGS US Topo dataset, are presented for general reference. They were generated from 1/3 arc-second National Elevation Dataset (NED) digital elevation models (DEMs), filtered to smooth the arcs. The NED data were modified by the National Hydrography Dataset (NHD) features for better integration between hypsography and hydrography. 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.

The geology was mapped in the field using USGS 7.5' 1:24,000-scale topographic maps.

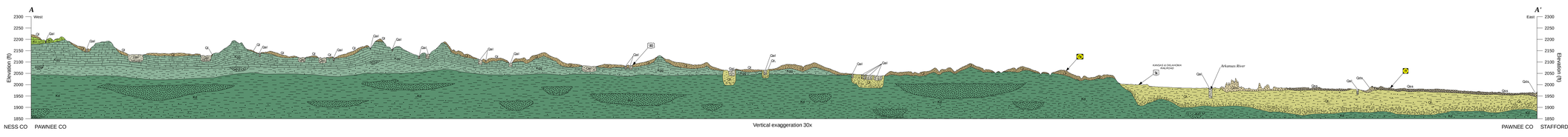
Roads and highways shown on the base map as represented by data from the Kansas Department of Transportation (KDOT) and other sources. U.S. Department of Agriculture – Farm Services Agency (USDA-FSA) National Agriculture Imagery Program (NAIP) imagery also was used to check road locations.

Shaded relief is based on 1-meter hydroflattened bare-earth DEMs from the State of Kansas LiDAR Database. The DEM images, in Erdas Imagine (.img) format, were mosacked into a single output DEM in Esri file geodatabase raster format. That DEM was then downsampled to 2-meter resolution and subsequently converted to geographic coordinates. The output DEM was then converted to a hillshade, a multidirectional shaded-relief image using angles of illumination from 0°, 225°, 270°, and 315° azimuths, each 45° above the horizon, with a 4x vertical exaggeration.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program and by the National Park Service.

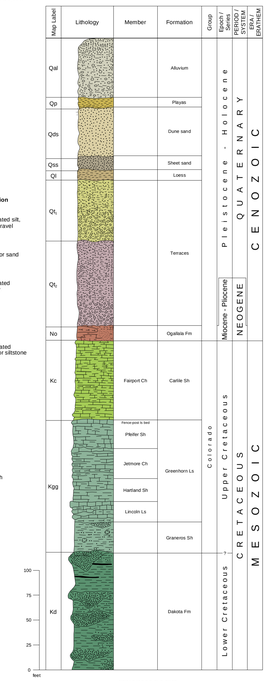
This map was produced using the ArcGIS system developed by ESRI (Environmental Systems Research Institute, Inc.).






## Lithologic Explanation

- Unconsolidated silt, sand, and gravel
- Sandstone or sand
- Unconsolidated silt and clay
- Shale
- Undifferentiated sandstone or siltstone
- Limestone
- Chalk
- Bentonite
- Volcanic ash




## CENOZOIC ROCKS

**Alluvium**—Alluvial sediments of the major rivers and smaller streams are Holocene in age and are composed of sand, gravel, silt, and clay (McLaughlin, 1949). In the Pawnee River valley, the upper part of the alluvium consists primarily of clay with some sand and silt. Thicknesses range from 15 to 50 ft (5 to 15 m) but average about 30 ft (9 m). A thick deposit of sand and gravel lying beneath the upper clay deposits yields large quantities of water to wells in the valley. The total thickness of the Pawnee River alluvium ranges from 65 to 138 ft (20 to 42 m), with an average thickness of 105 ft (32 m) (McLaughlin, 1949). In contrast to the Pawnee River alluvium, the Arkansas River alluvium contains no thick clay deposits, although localized clay layers may occur. The Arkansas River alluvium contains sandy soils overlying thick beds of sand and gravel. As a result, the recharge rate of wells is greater in the Arkansas River valley than in the Pawnee River valley. The Arkansas River alluvium ranges from 18- to 135-ft (6- to 41-m) thick, with an average thickness of about 61 ft (19 m) (McLaughlin, 1949).

Qal

**Upland intermittent lake (playa) deposits**—Shallow basins, also known as playas or buffalo wallows, have developed in the upland loess deposits, mainly south of the Pawnee River. The origin of these features is usually attributed to wind deflation, animal activity, dissolution, or some combination of these processes. The age of the playas probably ranges from late Pleistocene to Holocene. Playa basins range in size from less than an acre to tens of acres. The basin fill consists of re-deposited silt and fine sand from the loess. In the larger basins, a caliche layer typically develops a few feet below the basin floor. The average thickness of the basin fill is approximately 6 ft (2 m).

Qp

**Eolian dune sand**—Inactive sand dunes are present in much of the area south of the Arkansas River in Pawnee County and are Pleistocene to Holocene in age. The dune areas closest to the Arkansas River are grass-covered, moderately steep, irregular hills surrounding relatively small, undrained basins. A few active dunes may occur locally. The dune sand is composed of moderately well-rounded fragments of quartz with lesser amounts of silt and clay and is mostly derived from the Arkansas River valley (McLaughlin, 1949; Arbogast, 1998). The thickness of the dunes ranges up to 50 ft (15 m) (McLaughlin, 1949).

Qds

**Active sand**—Active sand areas are being reworked and re-deposited by wind. Active sand areas are typically expressed as blowouts within the sand dune map unit.

Qas

**Sheet sand**—The sheet sands are older remnants of the sand-dune topography characterized by a much flatter surface of broad, undulating swells and swales. The sheet sands have developed a thick, heavy soil that is extensively cultivated (McLaughlin, 1949). The thickness of the sheet sands is approximately 12 ft (4 m).

Qss

**Loess**—Uplands in the county are mantled by loess composed of wind-deposited silt and minor amounts of clay and fine sand. The loess is calcareous and buff in color. The age of the loess ranges from late Pleistocene to Holocene. It has an average thickness of about 6 to 10 ft (2 to 3 m).

Ql

**Terrace valley fill**—Terrace valley fill is primarily derived from the erosion of sedimentary rocks in and west of Pawnee County and occurs along the Pawnee and Arkansas rivers. The fill consists of light-tan to brown clay and silt containing some caliche and interbedded fine to coarse sand with scattered gravel. Sand and gravel, typically brown, but range in color from white to bright green and blue. Silt is poorly consolidated except where cemented by calcium carbonate. Sand and gravel are poorly sorted, containing fragments of sandstone, limestone, and ironstone derived from weathering of the Greenhorn Limestone, Carlile Shale, and Dakota Formation (McLaughlin, 1949). Two terraces ($Q_t$ and $Q_{t1}$) within the Pawnee River valley have been differentiated and lie 20 ft (6 m) ($Q_{t1}$) and 50 ft (15 m) ($Q_t$) above the valley floor (McLaughlin, 1949; Mandel, 1994).

Qt, Qt1

**Ogallala Formation**—The Ogallala Formation is Miocene and earliest Pliocene in age and is composed of silt, sand, and gravel sediments transported by westward-flowing eastward from the Rocky Mountains. The sediments are variously cemented (ranging from unconsolidated to caliche-type deposits) with calcium carbonate. Throughout the Ogallala, thick caliche beds, referred to regionally as "mortar beds," are irregularly and discontinuously exposed (Moss, 1932). Silt dominates the Ogallala and commonly occurs in poorly sorted and lenticular bodies. Thin, isolated outcrops of Ogallala occur only in the extreme southwest corner of the county.

No

## MESOZOIC ROCKS

**Carlile Shale**—The Cretaceous Carlile Shale is composed of three members, in ascending order: the Fairport Chalk Member, the Blue Hill Shale Member, and the Codell Sandstone Member. The **Blue Hill Shale Member** and the **Codell Sandstone Member** have not been observed in the county (McLaughlin, 1949; Hattin, 1962; McKellar, 1962; Wallace and Nelson, 1988). The **Fairport Chalk Member** is an olive-gray to dark-gray, blocky, fossiliferous, chalky shale with flat concretions intercalated with chalk and chalky limestone beds and a few thin bentonite beds (Moss, 1932; Hattin, 1962). Thicker, more resistant beds of chalky limestone are more common near the base of the Fairport chalk and form small benches. The upper beds erode more easily and form rounded, soil-covered hills (Fishel, 1952). Outcrops occur along stream valleys in the northern part of the county. The total thickness of the Carlile Shale in Pawnee County is hard to determine because of poor exposures, but nowhere is it believed to be more than 100 ft (30 m) thick (McLaughlin, 1949).

Kc

**Graneros Shale and Greenhorn Limestone**—In Pawnee County, the Graneros Shale and Greenhorn Limestone are poorly exposed and undifferentiated. The **Graneros Shale** is a dark-gray to black, fissile, argillaceous shale that may contain sandy shale and sandstone (McLaughlin, 1949). Where the Graneros crops out in north-central and west-central Kansas, the thickness ranges from 24 to 40 ft (7 to 12 m), averaging about 30 ft (9 m) (Hattin, 1965). McLaughlin (1949) believed the thickness does not exceed 35 ft (11 m) in Pawnee County. The overlying **Greenhorn Limestone** has four members, in ascending order: the **Lincoln Limestone Member**, the **Hartland Shale Member**, the **Jetmore Chalk Member**, and the **Pfeifer Shale Member**. Lack of good exposures makes differentiating the members difficult. Generally, the Greenhorn Limestone is composed of alternating beds of thinner (usually less than 1 ft (0.3 m)) beds of chalky to crystalline limestone and thicker beds of gray, chalky shale that contain thin beds of bentonitic clay (McLaughlin, 1949). The Fencepost limestone bed is located at or near the top of the formation (McLaughlin, 1949; Hattin, 1975). The thickness of the Greenhorn averages 100 ft (30 m) in Rush County (McNellis, 1973) and is thought to be of similar thickness in Pawnee County.

Kgg

**Dakota Formation**—Several isolated outcrops of the Dakota Formation occur in Pawnee County, most notably near Burdett, Garfield, and Larned. Based on limited outcrops and cuttings from more than 100 test holes, McLaughlin (1949) described the Dakota as buff, yellow-brown, and brown fine-grained, lenticular sandstone and variegated sandy clay and clay. The sandstone may be thin-bedded to massive but generally is strongly ripple-marked and cross-bedded. Although sandstone dominates the outcrops, the Dakota is predominantly clay and sandy clay (Plummer and Romary, 1942; Fishel, 1952). Topographic expression is variable and depends on cementation. Well-cemented portions of the Dakota form bluffs near Larned, while low, smooth hills are characteristic where the sandstone is poorly cemented. In a few places in the county, zones of hard, calcite-cemented "quartzitic" sandstone weather out as rounded boulders or form resistant ledges (McLaughlin, 1949). The Dakota underlies most of Pawnee County, where the average thickness is thought to be about 200 ft (61 m) (McLaughlin, 1949).

Kd

## CITED REFERENCES


Arbogast, A. F., 1998, Late Quaternary paleoenvironments and landscape evolution on the Great Bend Sand Prairie: Kansas Geological Survey, Bulletin 242, 74 p.

Fishel, V. C., 1952, Ground-water resources of Pawnee Valley, Kansas: Kansas Geological Survey, Bulletin 94, 144 p.; http://www.kgs.ku.edu/Publications/Bulletins/94/index.html

Hattin, D. E., 1962, Stratigraphy of the Carlile Shale (Upper Cretaceous) in Kansas: Kansas Geological Survey, Bulletin 156, 155 p.; http://www.kgs.ku.edu/Publications/Bulletins/156/index.html

Hattin, D. E., 1965, Stratigraphy of the Graneros Shale (Upper Cretaceous) in central Kansas: Kansas Geological Survey, Bulletin 178, 83 p.

Hattin, D. E., 1975, Stratigraphy and depositional environment of the Greenhorn Limestone (Upper Cretaceous) of Kansas: Kansas Geological Survey, Bulletin 209, 128 p; http://www.kgs.ku.edu/Publications/Bulletins/209/index.html

Kansas Geological Survey, 2014a, Smoky Hills; *in*, GeoKansas: Kansas Geological Survey, http://www.kgs.ku.edu/Extension/smoky/smoky.html

Kansas Geological Survey, 2014b, Pawnee County; *in*, KGS Directory of Kansas Industrial Mineral Producers http://www.kgs.ku.edu/Magellan/Minerals/index.html

Kansas Geological Survey, 2014c, Pawnee County—Oil and gas production; http://www.kgs.ku.edu/PRS/County/nop/pawnee.html.

Kansas Geological Survey, 2014d, Pawnee County—Water well completion records (WWC5) Database: http://www.kgs.ku.edu/Magellan/WaterWell/index.html

Keller-Lynn, K., 2008, Geologic resource evaluation scoping summary Fort Larned National Historic Site, Kansas: National Park Service, http://www.nature.nps.gov/geology/inventory/publications/s_summaries/FOLS_GRE_scoping_summary_20060919.pdf

Mandel, R. D., 1994, Holocene landscape evolution in the Pawnee River valley, southwestern Kansas: Kansas Geological Survey and Kansas State Historical Society, Bulletin 236, 117 p.

McKellar, T. R., 1962, The Codell sandstone (Upper Cretaceous) of Kansas: Unpublished M.S. thesis, University of Kansas, 92 p.

McLaughlin, T. G., 1949, Geology and groundwater resources of Pawnee and Edwards counties, Kansas: Kansas Geological Survey, Bulletin 80, 189 p.; http://www.kgs.ku.edu/General/Geology/Pawnee/index.html.

McNellis, J. M., 1973, Geology and groundwater resources of Rush County, central Kansas: Kansas Geological Survey, Bulletin 207, 45 p.; http://www.kgs.ku.edu/General/Geology/Rush/index.html

Moss, B. G., 1932, The geology of Ness and Hodgeman counties, Kansas:Kansas Geological Survey, Bulletin 19, 48 p.

Plummer, N., and Romary, J. F., 1942, Stratigraphy of the proGreenhorn cretaceous beds of Kansas: Kansas Geological Survey, Bulletin 41, pt. 9, p. 313-348.

Schoewe, W. H., 1949, The geography of Kansas, pt. 2, physical geography: Kansas Academy of Science Transactions, v. 52, no. 3, p. 261-333.

Wallace, K. C., and Nelson, M. E., 1988, Depositional history of the Codell Sandstone Member, Carlile Shale, (Upper Cretaceous), Kansas: Fort Hays Studies, Science, Third Series, no. 10, p 102–116.


## ADDITIONAL SOURCE


Zeller, D. E., ed., [1968] 2013, Classification of rocks in Kansas, revised by Kansas Geological Survey Stratigraphic Nomenclature Committee; *in*, The Stratigraphic Succession in Kansas: Kansas Geological Survey, Bulletin 189, 81 p., 1 plate; http://www.kgs.ku.edu/General/Strat/index.html.


## SUPPLEMENTAL REFERENCE


Bowen, M. W., Johnson, W. C., Klopfenstein, S. T., and Dunham, J. W., 2009,Developing a geospatial database of playas within the High Plains of Kansas: Current Research in the Pleistocene, v. 26, p. 191193.


## SUGGESTED REFERENCE TO THIS MAP


Johnson, W. C., and Woodburn, T. L., 2015, Surficial geology of Pawnee County, Kansas; text, geologicunit descriptions, and cross section geology by C. M. PhillipsLander: Kansas Geological Survey, Map M-114, scale 1:50,000.