SURFICIAL GEOLOGY OF MORRIS COUNTY, KANSAS

MAP M-125

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2016

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KANSAS GEOLOGICAL SURVEY
The University of Kansas

GENERAL GEOLOGY

Morris County has an area of about 707 mi^2 (1,831 km^2) of which approximately 57 percent is in native grass (Barker, 1974). The largest impoundment of water in the county, Council Grove Lake, occupies about 5 mi^2 (13 km^2) when at conservation pool level (U.S. Army Corps of Engineers, 2015).

The surficial sedimentary rocks—alternating beds of limestone, cherty limestone, and varicolored mudrocks—are Permian (Wolfcampian and lowermost Leonardian) in age (Zeller, [1968] 2013) except for a small area of Carboniferous rocks in the extreme southeastern corner of the county. Below the Permian-Carboniferous boundary (Sawin et al., 2006) only the Carboniferous Glenrock Limestone Member of the Red Eagle Limestone and the upper part of the Johnson Shale are exposed. The youngest bedrock unit, the Wellington Formation, crops out along the southwestern edge of the county.

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. Thick Pleistocene deposits of mixed alluvial and eolian (loess) sediments found in the uplands are prevalent in the northeastern and southwestern parts of the county.

GEOMORPHOLOGY

Morris County is in the Flint Hills physiographic region, an area of rolling prairie uplands and wooded stream valleys. The name Flint Hills comes from the flint (chert) in some of the limestone units that is left on the surface as the limestones weather. Mudrocks weather faster than limestones, and this differential erosion results in the prominent limestone-capped hills that characterize the county. While the mudrocks erode to become tillable soils, chert-bearing limestones weather into gravel-sized pieces resulting in very rocky soils. Some of the limestones form prominent topographic features; the most conspicuous is the "rimrock" in the lower part of the Fort Riley Limestone Member, which consistently crops out on hillsides wherever present. The Cottonwood Limestone Member also forms a prominent bench in the southeastern part of the county.

Topographic relief in Morris County is 406 ft (123 m). The lowest point (1,159 ft, 353 m) is in the Neosho River floodplain where the river exits the southeastern corner of the county, and the highest point (1,565 ft, 477 m) is in the south-central part of the county near the southern boundary.

The headwaters of the Neosho River, the only major river in the county, are located in Morris County. The Neosho River and its tributaries flow southeast to drain much of the county. Other major streams include Clarks Creek, which flows north to drain the northwestern part of the county, and Diamond Creek, which flows south to drain the southwestern portion.

STRUCTURAL GEOLOGY

The dip of the Permian strata in Morris County is generally to the west except in the area of the Nemaha uplift, where steep easterly dip is evident, and locally, where strike and dip directions can vary significantly. The Nemaha uplift crosses the county diagonally from the northeastern part of the county to the south-central portion. Evidence of this subsurface feature is expressed at the surface as monoclines, faults, sinkholes, and areas of unusual and steep dip.

MINERAL RESOURCES

The rocky residual soils and steep slopes of the uplands support an abundance of native grasses and forbs that make these areas valuable for cattle and other livestock grazing. Residual soils on the floodplains of the rivers and smaller streams and transported soils (from glacial sources) in some places in the uplands are important for cultivated crops.

The abundance of limestone is important because of its use as an aggregate for concrete and road material, riprap, agricultural lime, and building stone. The limestones most commonly used for aggregate are the non-cherty part of the Threemile Limestone Member, the Funston Limestone, the Fort Riley Limestone Member, and the Cresswell Limestone Member. The Cottonwood, Threemile, and Fort Riley are the main sources of building stone in the county.

Extensive alluvial sand and gravel deposits are not found in Morris County. Pleistocene deposits of chert gravel occur in the uplands and have been used locally, mostly for road material.

Oil and gas are of minor importance in Morris County. In 2014, 79 wells produced 62,767 barrels of oil and no gas (Kansas Geological Survey, 2015). Total cumulative production for the county (through November 2015) is 12,387,336 barrels of oil and 5,729,375 million cubic feet of gas. Most of the oil (more than 10 million barrels) has come from John Creek field (Ordovician Viola Limestone) located along the eastern edge of the county, and nearly all of the gas can be attributed to the Wilde field (Pennsylvanian Lansing, Douglas, and Admire groups) in the south-central part of the county (Smith, 1960). The Wilde field, located on the crest of the Nemaha uplift, last produced gas in 1998.

Explanation

Boundaries and Locations

- County line
- Township/range line
- Section line
- A — A′ Geologic cross section
- Council Grove — County seat
- White City — Other incorporated city
- Helmick — Unincorporated city or locality
- Built-up area

Transportation

- U.S. highway
- State highway
- Medium-duty primary road
- Medium-duty secondary road
- Light-duty road
- Unimproved road
- Railroad
- Unpaved landing strip
- Airport

Resource Development

- Open gravel pit
- Quarry
- Disturbed area or fill material

Geologic Unit Boundaries

- Observed contact
- Concealed contact

Geologic Structure

- Fault — identity and existence certain, location accurate
- Fault — identity and existence certain, location approximate
- Fault — identity or existence questionable, location approximate
- Monocline — identity and existence certain, location accurate. Arrow shows direction of dip.
- Monocline — identity and existence certain, location approximate. Arrow shows direction of dip.
- U/D Fault block — "U" = upthrown, "D" = downthrown

Hydrology and Topography

- Perennial stream
- Intermittent stream
- Perennial water body
- Perennial water body; manmade shoreline
- Spring
- Sinkhole
- Elevation contour (100-foot interval)
- Elevation contour (20-foot interval)
- Depression contour (100-foot interval)
- Depression contour (20-foot interval)

Index to 1:24,000-scale USGS quadrangle maps

Index shows the names and locations of the 17 USGS 7.5-minute 1:24,000-scale quadrangles used in the digital compilation of the Morris County map. The geology was mapped in the field using these topographic maps.

APPROXIMATE MEAN DECLINATION, 2016

CITED REFERENCES

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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/Chart/index.html.

SUPPLEMENTAL REFERENCE

Sawin, R. S., and West, R. R., 2015, Data control points used to construct the surficial geology map (M-125) of Morris County, Kansas: Kansas Geological Survey, Open-file Report 2016-2 (revised 27 July 2022), 25 p.

SUGGESTED REFERENCE TO THIS MAP

Sawin, R. S., and West, R. R., 2016, Surficial geology of Morris County, Kansas: Kansas Geological Survey, Map M-125, scale 1:50,000.

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.

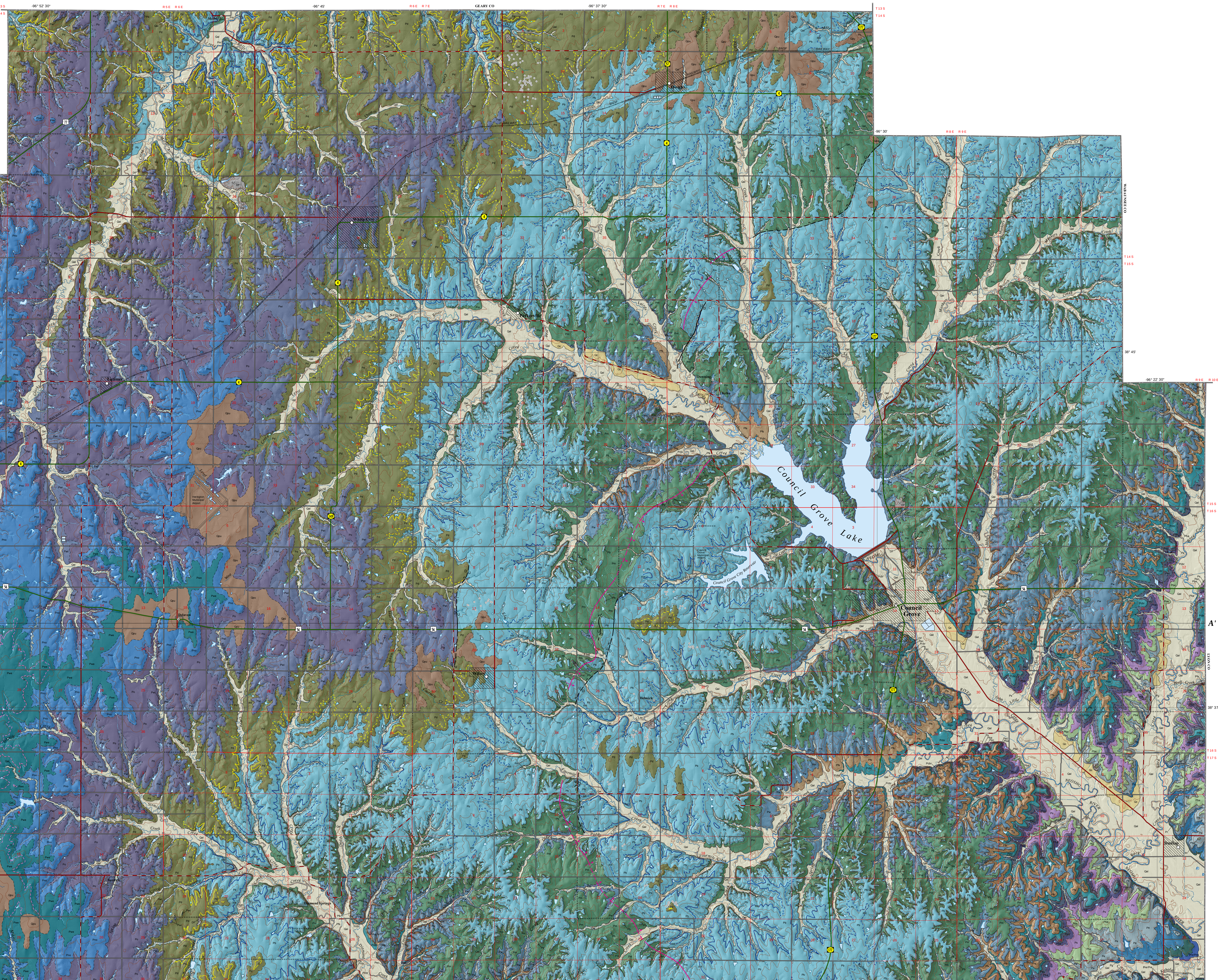
The geology was mapped using a combination of field measurements and observations and subsequent digital mapping using Esri ArcGIS.

Roads and highways are 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 DEMs, in Erdas Imagine (.img) format, were mosaicked into a single output DEM in Esri file geodatabase raster format. The 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.

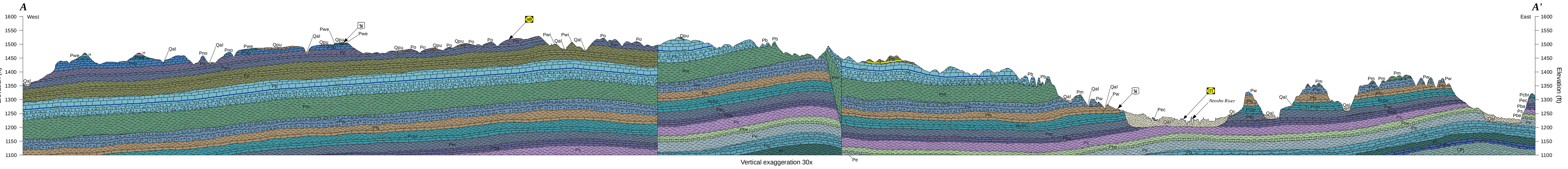
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.

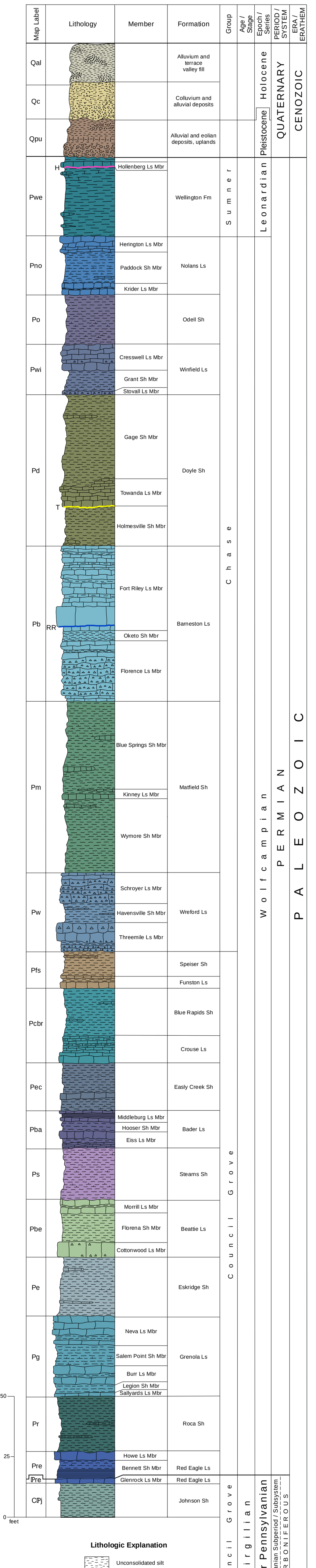
This map was produced using the ArcGIS system developed by Esri (Environmental Systems Research Institute, Inc.).



SCALE 1:50 000

LAMBERT CONFORMAL CONIC PROJECTION WITH STANDARD PARALLELS AT 33° AND 45° NORTH AMERICAN DATUM OF 1983





Lithologic Explanation

- Unconsolidated silt
- Sand
- Unconsolidated silt, sand, and gravel
- Soil
- Limestone
- Mudrock
- Calcareous mudrock
- Cherty limestone
- Argillaceous limestone
- Black shale
- Hollenberg Ls Mbr marker bed
- Towanda Ls Mbr marker bed
- Fort Riley Ls Mbr "rim rock" marker bed

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

Publication Sales
(785) 864-2157

or visit the Kansas Geological Survey website at www.kgs.ku.edu.

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GEOLOGIC UNITS

These descriptions are a compilation of several sources, including field notes and measured sections, Kansas Department of Transportation geological reports and profiles, and lithologic descriptions in Mudge et al. (1958), Jewett (1941), Moore et al. (1951), O'Connor (1953), and Byrne et al. (1959).

CENOZOIC ROCKS

Holocene

Qal — **Alluvium and terrace valley fill**—Undifferentiated alluvium and terrace valley fill of the Neosho River, Clarks Creek, Diamond Creek, and their tributaries. The alluvium of smaller streams that drain the uplands is derived primarily from weathered limestone, shale, and loess and is dominated by silt- and clay-sized particles with gravel lenses of angular to subangular fragments of limestone and chert. Alluvium along the Neosho River is mostly silt and clay with gravel lenses of rounded to subrounded fragments of limestone and chert. Alluvial deposits along smaller streams range up to 20 ft (6.1 m) in thickness; the maximum thickness in the Neosho River valley is about 30 ft (9.1 m) (Mudge et al., 1958). Terraces were deposited by present-day streams in earlier stages of deposition and occupy positions on the sides of the floodplain and at slightly higher elevations. Their composition is similar to the alluvium—silt- and clay-sized particles with lenses of chert and limestone gravel. Terrace thicknesses range from a few feet along smaller streams to more than 50 ft (15.2 m) in the Neosho River valley (Mudge et al., 1958).

Qc — **Colluvium and alluvial deposits**—Extensive deposits of mixed colluvial aprons and alluvial fans along the margins of the floodplain of the Neosho River and Rock Creek. The colluvium is a poorly sorted mixture of clay, silt, and gravel- to boulder-sized angular fragments of chert, limestone, and shale (Mudge et al., 1958). The alluvial fans form where smaller streams enter the larger valleys. Alluvial deposits are stratified and consist of well-sorted silt and clay and thin, interbedded lenses of chert and limestone gravel. Only extensive areas of these mixed colluvial and alluvial sediments were mapped. These deposits are mostly Holocene in age although portions may be late Pleistocene.

Pleistocene

Qpu — **Alluvial and eolian deposits (uplands)**—Mixed alluvial and eolian (loess) deposits occurring on the uplands. Fluvial clay, silt, sand, and gravel sediments and windblown silt and clay characterize this unit. Loess is windblown silt- and clay-sized particles associated with glacial activity. Originally a component of outwash or floodplain sediments, this material was redeposited in the uplands by wind. A thin mantle of loess covers the high upland ridges, flats, and side slopes in much of the county. Known accumulations of these deposits that are greater than 10 ft (3 m) thick were mapped. These accumulations are generally located in the southwestern part of the county and near White City and Dwight, where they reach a thickness of up to 50 ft (15.2 m) (Mudge et al., 1958).

PALEOZOIC

Pwe — **Wellington Formation**—The lower part of the Wellington Formation crops out along the southwestern edge of Morris County. The **Hollenberg Limestone Member** of the Wellington Formation occurs at or near the top of the Wellington exposure. The Hollenberg is a gray to gray-brown, hard, crystalline limestone that weathers blocky and porous to vuggy. Limonite and iron staining are common. The Hollenberg ranges from 4 to 7 ft (1.2 to 2.1 m) thick. The lower part of the Wellington is a tan-gray to gray-green, silty, thin-bedded mudrock that may contain additional thin limestone beds. Fossils have not been observed. About 30 ft (9.1 m) of the lowermost Wellington Formation is present in Morris County.

Pno — **Nolans Limestone**—The **Krider Limestone Member** at the base of the Nolans Limestone is one or two beds of soft, gray to tan, dolomitic limestone that weathers blocky and with a sugary or sandy texture. Bivalves are common. A thin mudrock bed less than 1 ft (0.3 m) thick may separate the two thin limestone beds. The total thickness of the Krider is 1 to 6 ft (0.3 to 1.8 m). Above the Krider, the **Paddock Shale Member** is tan-gray (upper part) and gray-green (lower part) mudrock that is blocky, argillaceous, and generally noncalcareous. Fossils are abundant in some areas. The Paddock averages 15 ft (4.6 m) in thickness. The uppermost member of the Nolans Limestone, the **Herington Limestone Member**, is a light-gray, tan, and gray-brown, thick- to massive-bedded, medium-hard, slightly dolomitic limestone. The unit contains calcite-lined cavities (geodes) and common to abundant bivalves. It weathers into large blocks. The Herington is about 7 ft (2.1 m) thick and forms a characteristic, prominent bench on hillsides. The Nolans Limestone averages about 25 ft (7.6 m) thick in Morris County.

Po — **Odell Shale**—The Odell Shale is composed of silty, calcareous, nonfossiliferous mudrocks. Tan-gray and gray mudrocks characterize the lower part; the upper part is gray-green and maroon. The Odell averages about 20 ft (6.1 m) in thickness.

Pwi — **Winfield Limestone**—The Winfield Limestone crops out in the western third of the county. At the base of the Winfield Limestone is the **Stovall Limestone Member,** a thin (0.3 to 2.7 ft; 0.1 to 0.8 m), light- to medium-gray, dense limestone containing scattered nodules and one or more bands of bluish-gray chert. Fossils are common. Although thin, the Stovall is a reliable marker bed and is easily recognized by the presence of chert; in places, the only clue to its existence is a band of chert rubble. Above the Stovall, the **Grant Shale Member** is commonly about 10 ft (3 m) thick. It is a tan-gray, silty, calcareous, fossiliferous mudrock; *Derbyia* sp., productids, and the bivalve *Myalina* sp. are common. Calcite and siliceous geodes are present. The uppermost **Cresswell Limestone Member** is about 12 ft (3.7 m) thick with thick to massive beds of light-gray limestone. The lower part is a fossiliferous (echinoid spines are characteristic), hard limestone that weathers into irregular blocks. The upper beds consist of a thin-bedded, platy, argillaceous limestone that is medium-hard to soft. Calcite and siliceous geodes are abundant in the upper part and are characteristic of the unit. Chert nodules are scattered throughout the limestone. The lower contact with the Grant is sharp and often exposed; the upper contact is almost always covered. The Winfield Limestone is about 23 ft (7 m) thick and forms a prominent hillside bench.

Pd — **Doyle Shale**—The lower **Holmesville Shale Member** is predominantly a gray and gray-green mudrock with a thin maroon zone in the middle. The upper few feet are characteristically green. The lower part is silty and may contain one or more discontinuous beds of gray, somewhat dense limestone that weathers porous and vuggy. The upper part is argillaceous and calcareous. The Holmesville is nonfossiliferous and typically about 16 ft (4.9 m) thick. Above the Holmesville is the **Towanda Limestone Member**, a thin- to medium-bedded, platy to blocky, hard, nonfossiliferous, gray to tan-brown limestone that characteristically weathers yellow to tan. Weathered surfaces may be pitted, and iron staining is common on bedding and fracture planes. The Towanda averages about 11 ft (3.4 m) in thickness. The base of the Towanda is often exposed along with the green mudrock of the underlying Holmesville; the upper contact is almost always covered. This member forms a prominent bench and is traceable on the landscape. The uppermost **Gage Shale Member** can be divided into two parts; the lower two-thirds is a varicolored (red, green, and purple) silty mudrock. The upper part is a yellowish- to tan-gray, calcareous mudrock that locally contains a thin (less than 1 ft; 0.3 m) bed of tan, crystalline limestone (at some localities, coquinas composed largely of brachiopod shells, mostly *Derbyia* sp., occur). The Gage is rarely exposed in Morris County, where its thickness is about 40 ft (12.2 m). The Doyle Shale is mapped at the surface in the northern, west-central, and southwestern parts of the county. Its total thickness is about 60 to 70 ft (18.3 m to 21.3 m).

Pb — **Barneston Limestone**—The bottom member of the Barneston, the **Florence Limestone Member**, is the uppermost and thickest of the three conspicuous chert-bearing limestones in Morris County. It is a thick-bedded (up to 1 ft; 0.3 m), fossiliferous, yellowish-brown to gray limestone that contains numerous light-gray to dark-gray chert nodules or beds up to 0.5 ft (0.2 m) thick; the lower 5 ft (1.5 m) consists of alternating beds of mudrock and non-cherty limestone; in the upper part, mudrock partings (up to 2 ft; 0.6 m) are common. Fossils are common throughout the unit. Hills capped by the Florence are characteristically rounded and covered with small fragments of chert. The Florence is about 25 ft (7.6 m) thick. Overlying the Florence is the **Oketo Shale Member**, a 5- to 9-ft-thick (1.5 to 2.7 m), gray to yellowish-brown, silty, calcareous, fossiliferous mudrock. A thin limestone bed may be present in the upper part. The uppermost member of the Barneston Limestone, the **Fort Riley Limestone Member**, is a light-gray to yellowish-tan, slightly chalky limestone that averages 35 to 40 ft (10.7 to 12.2 m) in thickness. A 3- to 6-ft-thick (0.9 to 1.8 m) massive limestone bed near the base of this member, the "Fort Riley rimrock," is one of the most conspicuous limestones in Morris County and is an excellent marker bed. It is easily identified by its light-gray color, thickness, vertical bivalve burrows, and prominent outcrop. Springs commonly occur at the base of the rimrock. Beds above and below the rimrock are medium-bedded, argillaceous limestones and calcareous mudrocks that are generally poorly exposed. The upper part of the Fort Riley becomes more thin-bedded and platy. In some parts of the county, a limestone bed in the middle of the member has characteristics similar to the rimrock and may be confused with the more prominent marker bed if both are not exposed. In Morris County, numerous sinkholes have developed in the upper part of the Fort Riley. The Barneston Limestone averages 70 ft (21.3 m) in thickness and is exposed over much of the northeastern and south-central parts of the county.

Pm — **Matfield Shale**—The lower **Wymore Shale Member** is a varicolored (gray, green, maroon, red, tan), silty, calcareous mudrock that is rarely exposed. A thin limestone may occur in the upper part. The average thickness of the Wymore is about 30 ft (9.1 m). The middle **Kinney Limestone Member** commonly occurs as two limestones separated by a fossiliferous, calcareous mudrock, but in Morris County, often only the lower limestone is present (Mudge et al., 1958) as a single bed of massive, hard, fossiliferous, gray to tan-brown limestone. The upper limestone, when present, is a thin-bedded, blocky, argillaceous limestone. The Kinney ranges from 1 to 4.5 ft (0.3 to 1.4 m) thick and crops out on hillsides about 35 ft (10.7 m) below the base of the Florence. However, in most places it does not form a discernable bench. The uppermost member of the Matfield Shale is the **Blue Springs Shale Member**. This mudrock member is varicolored (maroon, gray-green, tan, gray, and purple). The lower part is silty and fossiliferous, and the upper part is argillaceous. One or more thin argillaceous limestones can occur near the middle. The Blue Springs Shale Member is about 35 ft (10.7 m) thick. The total thickness of the Matfield Shale ranges from 65 to 70 ft (19.8 to 21.3 m).

Pw — **Wreford Limestone**—The **Threemile Limestone Member**, the lowermost member of the Wreford Limestone, is the lowest of three easily recognized chert-bearing limestones in the county. The lower 2 to 3 ft (0.6 to 0.9 m) of the Threemile is a gray, fossiliferous limestone that contains one to three beds of chert. Overlying the lower limestone is 1 to 2 ft (0.3 to 0.6 m) of gray, calcareous, silty mudrock. The upper light-gray, massive limestone contains several bedded layers and nodules of chert, but in some areas, the chert layers are absent. The upper limestone is normally 8 to 10 ft (2.4 to 3 m) thick and forms the conspicuous, ledge-forming part of the Threemile. Mudge et al. (1958) identified a non-cherty, fossiliferous "biostrome" facies in the upper part of the Threemile that occurs in an area from south of Parkerville to Council Grove and then north along Munkers Creek into Wabaunsee County. The Threemile is typically about 13 ft (4 m) thick but can range up to 30 ft (9.1 m) in Morris County. Above the Threemile, the **Havensville Shale Member** is 6 to 12 ft (1.8 to 3.7 m) of gray, silty, calcareous, fossiliferous mudrock, with thin limestone beds (up to 2 ft; 0.6 m) common throughout the unit. Calcareous geodes and nodules are found in the upper part in many places. The **Schroyer Limestone Member** is the uppermost member of the Wreford Limestone and is the middle of three conspicuous chert-bearing limestones in the area. This light-gray, thick-bedded limestone contains numerous beds of chert and chert nodules. However, the upper 1 ft (0.3 m) is a non-cherty, coated grainstone that is easily recognized where exposed. Fossils are common throughout the unit. The Schroyer ranges in thickness from 8 to 19 ft (2.4 to 5.8 m) but is commonly about 12 ft (3.7 m) thick. The thickness of the Wreford Limestone varies from 30 to 50 ft (9.1 to 15.2 m), but it is usually about 37 ft (11.3 m) thick. Prominent hillside benches and conspicuous outcrops are common in the southeastern portion of the county.

Pfs — **Funston Limestone and Speiser Shale**—The **Funston Limestone** is generally two limestones separated by 2 to 5 ft (0.6 to 1.5 m) of mudrock, although the number of limestones and intervening mudrocks varies. The lower limestone beds are dark gray, dense, and thin- to thick-bedded. The mudrocks are tan to tan-gray, silty, and calcareous. The upper limestone is light gray to gray and varies from thin-bedded, platy, and argillaceous to thick-bedded and massive. In places, the upper limestone is oolitic and cross-bedded, a facies that Mudge et al. (1958) said areally coincides with the "biostrome" facies in the Threemile. The Funston is fossiliferous and typically is about 12 ft (3.7 m) thick. It may form a slight bench on hillsides. The **Speiser Shale** is a varicolored (gray, red, green, and purple) argillaceous to silty, mostly calcareous mudrock. Near the top, a thin, 0.5 to 1.5 ft (0.2 to 0.5 m) bed of gray to grayish-brown limestone is overlain by 2 to 6 ft (0.6 to 1.8 m) of tan-gray to gray, fossiliferous mudrock. Brachiopods (*Derbyia* sp., *Composita* sp., and productids), bryozoans, fish, and other vertebrate remains are common in this upper limestone and mudrock. The Speiser is about 15 ft (4.6 m) thick.

Pcbr — **Crouse Limestone and Blue Rapids Shale**—The **Crouse Limestone** is most easily recognized by the platy character of the upper limestone. The lower part consists of one to three beds of medium- to thick-bedded, hard limestone that contains a molluscan fossil assemblage. Between these two limestones is a very clayey, platy limestone that, when weathered, has the appearance of a mudrock. Overall, the tan to light-gray Crouse Limestone is consistently about 12 ft (3.7 m) thick. The lower limestones make a prominent hillside bench that is characteristically littered with small, thin plates of light-gray limestone. Crouse exposures are limited to the southeastern corner of the county except for a small area along Diamond Creek near the southern border. **The Blue Rapids Shale** is a varicolored (gray, gray-green, red, and maroon), argillaceous, silty mudrock that may contain thin beds of limestone in the upper part (a 1.3-ft-thick [0.4 m] limestone bed occurs in an area south of Council Grove). The Blue Rapids Shale varies from 15 to 25 ft (4.6 to 7.6 m) thick.

Pec — **Easly Creek Shale**—The dominantly olive-green to gray-green, silty, calcareous mudrock of the Easly Creek Shale contains intervals of maroon, tan, and green mudrock. A persistent limestone 1.5 to 3 ft (0.5 to 0.9 m) thick occurs about 8 ft (2.4 m) below the top of the formation. This gray, somewhat dense, massive limestone and the mudrock above it were considered part of the Crouse Limestone in earlier publications (Moore et al., 1951; O'Connor, 1953; Mudge et al., 1958). The Easly Creek Shale ranges from 20 to 30 ft (6.1 to 9.1 m) thick.

Pba — **Bader Limestone**—The **Eiss Limestone Member**, the lowermost member of the Bader Limestone, is divisible into three distinct units, each about 1 to 3 ft (0.3 to 0.9 m) thick (the middle mudrock is 9 ft [2.7 m] thick at one locality). The basal unit consists of a thin-bedded, gray limestone that weathers to form small irregular plates; the middle unit is a gray, calcareous, blocky mudrock; and the upper unit is a massive, hard, dense, gray limestone that is fossiliferous and characteristically pitted and vuggy when weathered. The upper limestone forms a noticeable bench in places. The total thickness of the Eiss ranges from 7 to 16 ft (2.1 to 4.9 m). Above the Eiss is the **Hooser Shale Member**, a 6 ft (1.8 m) thick bed of varicolored (tan-gray to grayish-green with thinner zones of maroon and purple) mudrock that is silty and calcareous. A boxwork limestone often occurs near the middle. The **Middleburg Limestone Member** is composed of two hard, dense, tan-gray to gray-brown limestones separated by a thin, dark-gray to black shale. The lower limestone weathers platy and the upper limestone blocky. Fossils are common in the limestones. The Middleburg is about 7 ft (2.1 m) thick. Exposures of the Bader Limestone are restricted to the southeast corner of the county, where the total thickness is 15 to 25 ft (4.6 to 7.6 m).

Ps — **Stearns Shale**—The Stearns Shale is a silty, calcareous, predominantly gray-green mudrock with tan, tan-gray, brown, and black zones. Thin, lenticular limestones are scattered throughout the unit, and a thin (less than 0.5 ft; 0.2 m) coal sometimes occurs near the top. The thickness of the Stearns ranges from 8 to 35 ft (2.4 to 10.7 m) in Morris County.

Pbe — **Beattie Limestone**—The lower member of the Beattie Limestone, the **Cottonwood Limestone Member**, is a massive, light-gray to white, fossiliferous limestone that is commonly 5 to 6 ft (1.5 to 1.8 m) thick. Two or three bands of chert nodules are common in the middle and upper parts. Abundant fusulinids in the upper half of the limestone weather in relief and are characteristic. The Cottonwood forms a prominent outcrop and its consistent thickness, abundant fusulinids, and chert nodules make it a good marker bed that is easy to recognize. Immediately above the Cottonwood is the **Florena Shale Member**, a gray-green to tan-gray, platy to blocky, calcareous mudrock that is about 12 ft (3.7 m) thick. Fossils are abundant in the lower few feet; the brachiopod *Neochonetes granulifera* is very abundant and aids in identifying this member. The upper member of the Beattie Limestone, the **Morrill Limestone Member,** is composed of two limestones separated by a thin mudrock. The upper limestone is tan-gray and platy to blocky. The lower limestone is gray to tan-gray and thick-bedded and weathers vuggy. The Morrill is about 5 ft (1.5 m) thick. The Beattie Limestone only occurs in the southeast corner of the county, where the total thickness is about 22 ft (6.7 m).

Pe — **Eskridge Shale**—The Eskridge Shale is an argillaceous, calcareous, varicolored mudrock that is mostly tan-gray to gray-green mudrock but with zones of maroon, green, and purple. A 1-ft-thick (0.3 m) argillaceous limestone often occurs in the upper part of the Eskridge, and one or more thinner, fossiliferous limestones are present in the lower part. The Eskridge is about 25 ft (7.6 m) thick in Morris County.

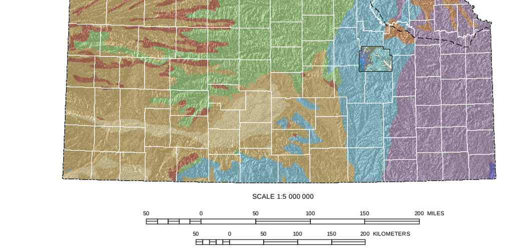
Pg — **Grenola Limestone**—The five members of the Grenola Limestone, in ascending order, are the Sallyards, Legion, Burr, Salem Point, and Neva. The **Sallyards Limestone Member** is a thin (0.5 to 1.5 ft; 0.2 to 0.5 m) fossiliferous, gray limestone that weathers blocky to platy. The **Legion Shale Member** is a thin-bedded, nonfossiliferous, gray, tan-gray, and olive mudrock with a few tenths of a foot of black shale at the base. The Legion is about 7 ft (2.1 m) thick. The **Burr Limestone Member** consists of two limestones separated by a thin mudrock. The upper limestone is tan-gray and weathers platy, and the lower limestone is gray-brown and soft. The Burr is about 8 ft (2.4 m) thick. The **Salem Point Shale Member** is an argillaceous to silty, calcareous, nonfossiliferous mudrock. The upper part is olive to dark gray and the lower part is tan-gray. The thickness ranges from 7 to 12 ft (2.1 to 3.7 m). The **Neva Limestone Member**, the most conspicuous member of the Grenola Limestone, contains several persistent zones. The upper layers are hard, gray, thick-bedded, fossiliferous limestones. The middle, or "main ledge," of the Neva is a massive, fossiliferous, gray limestone that characteristically weathers pitted and brecciated. The mudrock below this zone is gray-green to tan-gray and thin-bedded but becomes dark gray and fissile near its base. The tan limestone at the base of the Neva is hard and blocky. The Neva is about 13 ft (4 m) thick. The total thickness of the Grenola Limestone in Morris County is 35 to 40 ft (10.7 to 12.2 m).

Pr — **Roca Shale**—The Roca Shale is a varicolored (tan-gray, tan-brown, gray-green, green, red, and purple), thin-bedded, argillaceous, calcareous mudrock. Thin, lenticular limestones occur in the middle and lower parts. The Roca is about 23 ft (7 m) thick.

Pre/Pre — **Red Eagle Limestone**—The three members of the Red Eagle Limestone, in ascending order, are the Glenrock, Bennett, and Howe. The **Glenrock Limestone Member** is a light-gray to tan limestone that weathers blocky. Small fusulinids are characteristic. The Glenrock is about 1 ft (0.3 m) thick. The **Bennett Shale Member** consists of a silty, thin-bedded, calcareous, olive to gray mudrock and black fissile shale. Fossils are abundant in the upper part. The Bennett is 5 to 9 ft (1.5 to 2.7 m) thick. The **Howe Limestone Member** is a massive, earthy, fossiliferous, gray to tan-brown limestone that is about 3 ft (0.9 m) thick. The Red Eagle is exposed in one small area in the extreme southeastern corner of the county, where it is about 13 ft (4 m) thick.

CPj — **Johnson Shale**—Only the upper 6 ft (1.8 m) of the Johnson Shale is exposed in Morris County, where it is a silty, calcareous, tan-gray mudrock containing several thin, calcareous lenses and nodules.

LOCATION DIAGRAM



GENERALIZED GEOLOGY OF KANSAS

QUATERNARY SYSTEM

Holocene - Pleistocene Series

- Loess and river-valley deposits
- Sand dunes
- Glacial-drift deposits