MAP M-124

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SURFICIAL GEOLOGY OF DICKINSON COUNTY, KANSAS

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GENERAL GEOLOGY

Dickinson County covers an area of approximately 852 mi^2 (2,207 km^2) (Jantz and Saffry, 1980), of which about 4.2 mi^2 (11 km^2), or 0.49%, is surface water. Surficial sedimentary rocks in the county are Permian to Cretaceous in age and are dominated by limestones and shales. The oldest rocks (Barneston Limestone) lie along streambeds in the eastern part of the county. The youngest rocks (Dakota Formation) are most commonly found capping the hilltops in the northwest and southwest parts of the county.

During the Pleistocene Epoch, streams fed by glacial meltwater drove erosion and deposition of sediments. Terraces composed of unconsolidated silt, sand, and gravel—preserved in the uplands in west-central Dickinson County near Solomon—represent the level of older (Pleistocene) fluvial floodplains of the Smoky Hill River (Latta, 1949). Prior to glaciation in Kansas, the Smoky Hill River flowed south to the Arkansas River. Glacial isostatic adjustments caused the Smoky Hill River to change course and flow northward, joining the Saline and Solomon rivers in Saline County, before draining eastward across Dickinson County (Frye and Leonard, 1952). Holocene sediments (clay, silt, sand, and gravel) occur as terrace and alluvial valley fill along the Smoky Hill River and other streams in the county. Dune deposits along the north bank of the river between Abilene and Solomon and near Detroit were derived from the river's terrace and alluvial valley fill.

Dickinson County is famous for the insect fossil beds in the Permian Wellington Formation (Carlton Limestone Member) near the town of Elmo (Beckemeyer and Hall, 2007; Beckemeyer, 2000). The Elmo locality, discovered in 1899, has yielded thousands of insect fossils and provides significant insight into the diversification of insects throughout time. Among the discoveries from the site is the largest insect fossil ever found—a giant dragonfly-like insect with a 29-inch wingspan (Beckemeyer, 2000; Kansas Geological Survey, 2014a).

GEOMORPHOLOGY

Most of Dickinson County lies within the Flint Hills physiographic region, known for its rolling prairie uplands and wooded stream valleys (Schoewe, 1949). The Flint Hills get their name from the flint (also called chert) found within some of the Permian limestones that form the hills. Some limestone beds contain bands of chert that are harder and more chemically resistant than the surrounding rocks. Differential erosion of these beds has created soils littered with chert, which make good pastureland but are poorly suited for farming (Kansas Geological Survey, 2014b; Schoewe, 1949). The southwest and northwest corners of the county are in the Smoky Hills physiographic region.

The topographic relief of Dickinson County is about 510 ft (155 m), with the lowest area (approximately 1,080 ft; 329 m) along the Smoky Hill River at the boundary between Dickinson and Geary counties and the highest point (approximately 1,590 ft; 485 m) near the southern edge of the county in the southwest corner. The Smoky Hill River flows west to east through the county. Important tributaries to the Smoky Hill River include Chapman Creek, Mud Creek, Holland Creek, Turkey Creek, and Lyon Creek. The creek valleys are surrounded by rolling hills dissected by numerous small streams. Hills in the southwest and northwest parts of the county, especially those capped by sandstones in the Dakota Formation, have noticeably higher relief.

STRUCTURAL GEOLOGY

Dickinson County lies on the east flank of the Salina basin, a post-Mississippian structural feature in north-central Kansas whose axis extends northwest from Saline County (Lee et al., 1948; Jewett, 1951; Lee, 1956). The general strike of the surficial units is north-south, with regional dip slightly to the west. The younger Cretaceous units have a northwest regional dip (Walters and Bayne, 1959).

The Abilene anticline (Jewett, 1951) is a southwest plunging fold on the east flank of the Salina basin that extends from north of Abilene nearly 70 miles (113 km) to Marysville, Kansas (Shenkel, 1959). This asymmetric anticline, which dips more steeply on its east flank and more gently on its west flank, deformed Permian-age and older rocks in the county. Immediately east and parallel to the Abilene anticline is the Irving syncline (Shenkel, 1959).

MINERAL RESOURCES

Limestone from the Fort Riley limestone and Florence limestone members of the Barneston Limestone and from the Cresswell Limestone Member of the Winfield Limestone have been used for building stone, road aggregate, and riprap (Byrne et al., 1959; Mudge et al., 1958). Sand and gravel, readily available throughout the county, are used mainly for road aggregate (Kansas Geological Survey, 2014c). The Florence limestone, Fort Riley limestone, Towanda Limestone, Cresswell Limestone, Herington limestone, Carlton limestone, and sandstones in the Dakota and Kiowa formations are also used as road metal (Byrne et al., 1959).

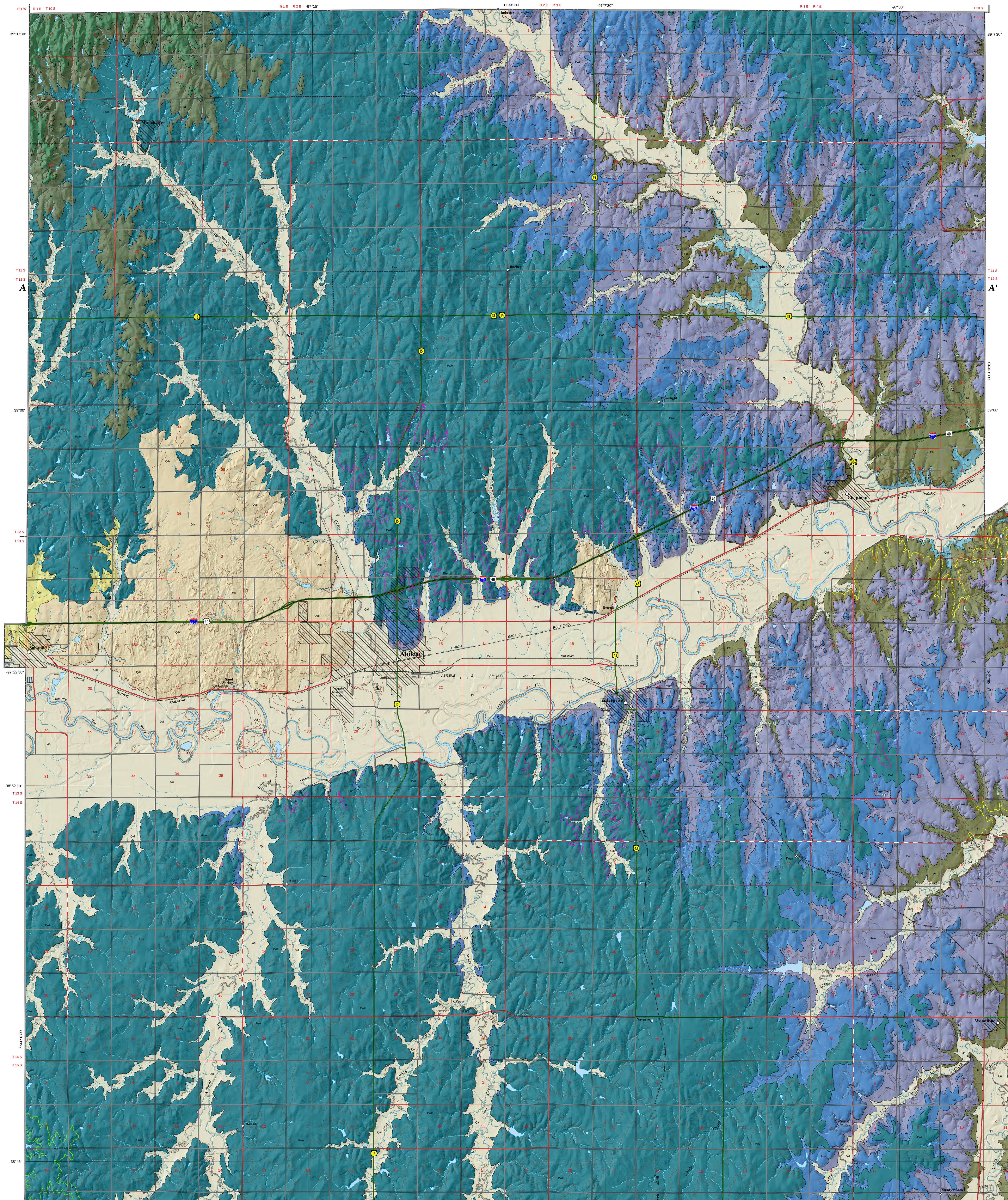
Historically, gypsum from the Wellington Formation was mined in Dickinson County. One of the first gypsum mines in central Kansas was a strip mine operated in 1887 near the town of Hope (Kulstad et al., 1956). Other operations included the surficial exploitation of gypsite near the town of Dillon from about 1896 to 1912 and the St. Joe mine southwest of Dillon, which operated from about 1899 to 1908 (Kulstad et al., 1956). Gypsum is used to make drywall and plaster and as a retarder in Portland cement. Gypsum deposits are not currently being exploited in Dickinson County.

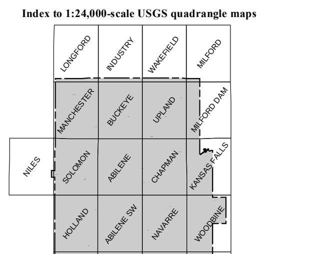
Cumulatively, over 3.2 million barrels of oil and 74,000 million cubic feet of gas have been produced in Dickinson County (Kansas Geological Survey, 2014d). In 2013, 29 wells produced 8,590 barrels of oil and no gas, which is a slight decrease in oil production from 2012 when 9,073 barrels of oil and no gas was produced from 29 wells (Kansas Geological Survey, 2014d). The northern tip of the Lost Springs field extends into the southeast corner of the county, where oil and gas is produced from the Pennsylvanian Wabaunsee and Kansas City groups, the Mississippian, and the Ordovician Viola Limestone. Scattered oil production from the Mississippian and the Pennsylvanian Burgess sandstone (Cherokee Group) occurs along the western edge of the county near Holland.

WATER RESOURCES

Holocene terrace and alluvial valley fill in the Smoky Hill River valley are the main source of groundwater in Dickinson County. Shallow wells (approximately 50 ft; 15 m) in the alluvium provide water for domestic, stock, industrial, irrigation, and public water supplies throughout the county (Kansas Geological Survey, 2014e). The large sand-dune area northwest of Abilene and north of the Smoky Hill River captures rainwater and recharges the alluvium and terrace deposits north of the river. This area provides much of the water for Solomon and Abilene (Kansas Department of Health and Environment, 2003). Sand Spring, just west of Abilene on the north bank of the river, was developed for use in 1881 and then purchased and improved for use as a public water supply by the City of Abilene in 1907 (Latta, 1949). Other tributaries of the Smoky Hill River in the county are important sources of groundwater for smaller wells. Historic Rock Spring supplies about 1,000 gallons per minute of freshwater from the Florence Limestone Member of the Barneston Limestone (Buchanan et al., 2000; Kansas Geological Survey, 2014b).

The deepest wells in the county draw water from the Winfield Limestone, Fort Riley limestone, and Florence limestone (Kansas Geological Survey, 2014c; Latta, 1949). In general, the groundwater in western Dickinson County is hard and, in some places, contains high concentrations of iron and chloride (Latta, 1949). Water from the area around Sand Spring is a notable exception (Latta, 1949).





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

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SUGGESTED REFERENCE TO THIS MAP

McCauley, J. R., 2014, Surficial geology of Dickinson County, Kansas; text, geologic-unit descriptions, and cross section geology by C. M. Phillips-Lander: Kansas Geological Survey, Map M-124, scale 1:50,000.

Elevation contours are presented for general reference. They are generated from U.S. Geological Survey National Elevation Dataset (NED) digital elevation models (DEM) with 1/3 arc-second resolution, which are in turn generated from high-resolution elevation data and other USGS DEMs. In some places the contours may be more generalized than the base maps used for compilation of geologic outcrop patterns. Outcrop patterns on the map will typically reflect topographic variation more accurately than the associated contour lines. Repeated fluctuation of an outcrop line across a contour line should be interpreted as an indication that the mapped rock unit is maintaining a relatively constant elevation along a generalized contour.

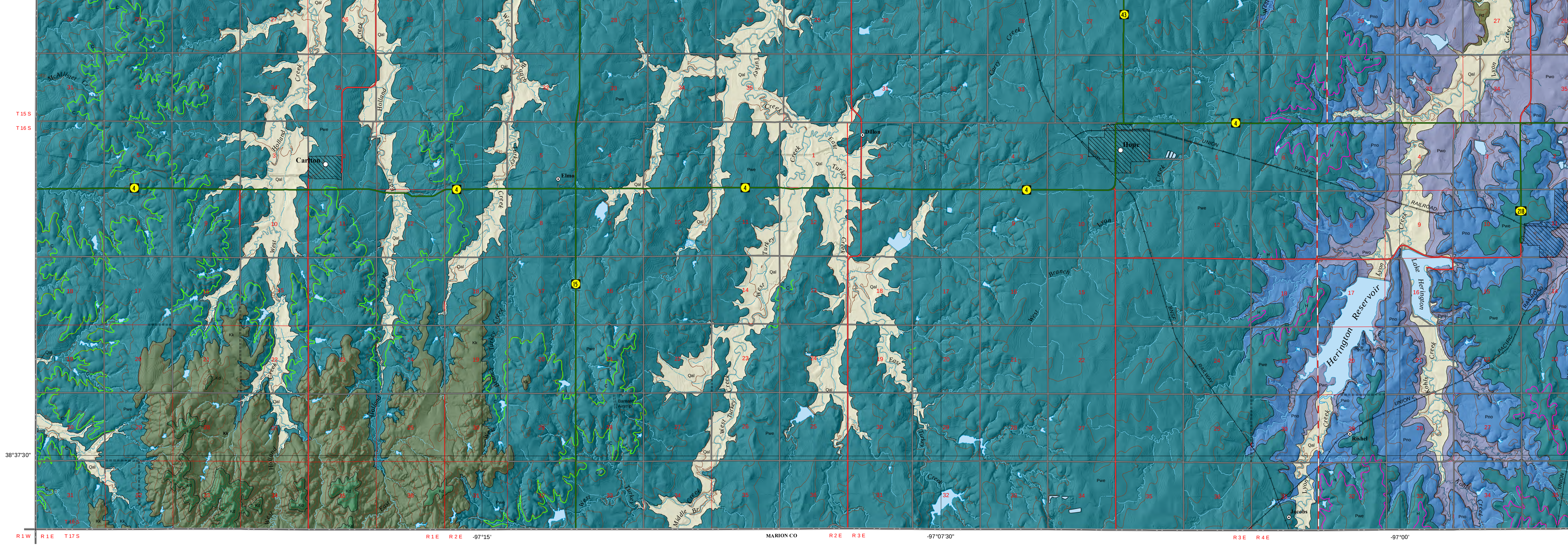
The geology was mapped in the field using USGS 7.5' 1:24,000-scale topographic maps.

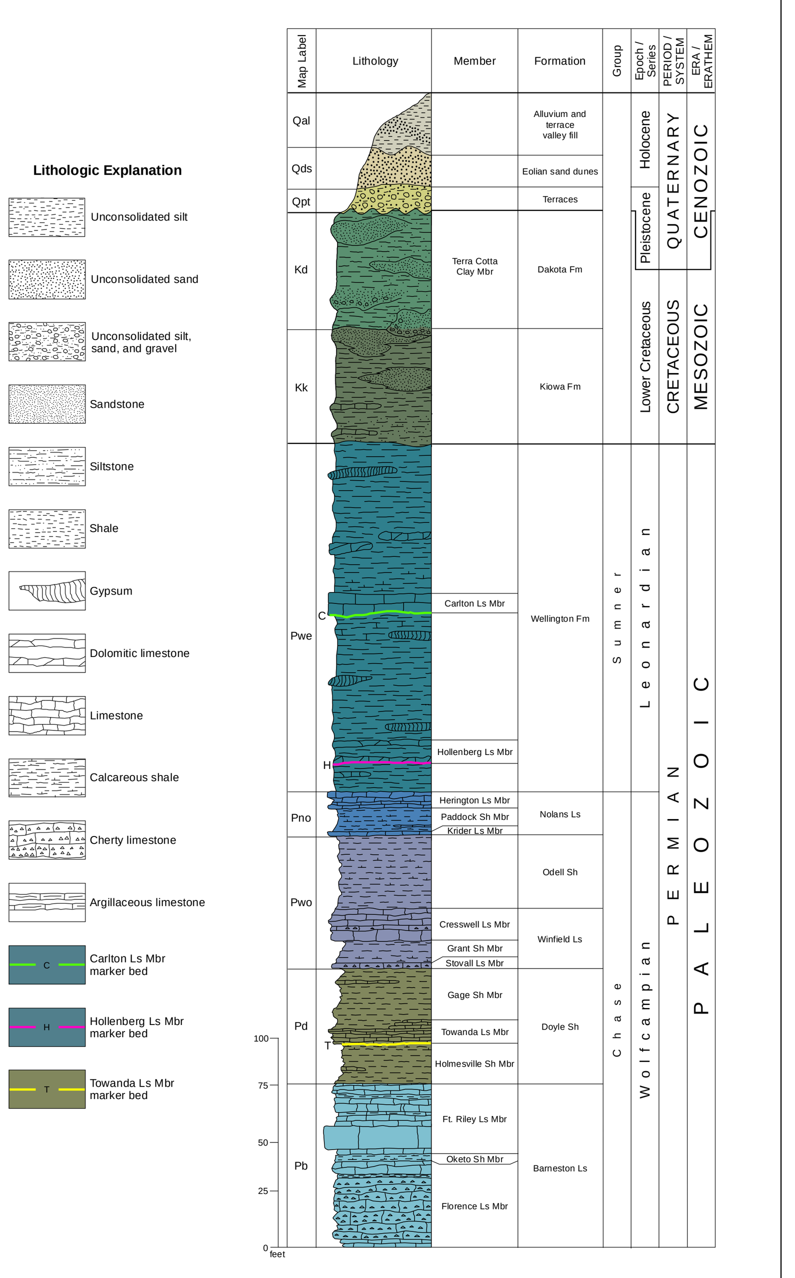
Roads and highways shown on the base map as represented by data from the Kansas Department of Transportation (KDOT) and other sources. U.S. Department of Agriculture – Farm Services Agency (USDA-FSA) National Agriculture Imagery Program (NAIP) imagery also was used to check road locations.

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 mosaicked 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 and a focal mean filter applied. 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.).





GEOLOGIC UNITS

CENOZOIC

Holocene

Qal — **Alluvium and terrace valley fill** – Alluvium and terrace valley fill is found along major rivers and smaller streams. Floodplain deposits associated with the Smoky Hill River contain mostly clay, silt, sand, and gravel (Latta, 1949). The smaller streams draining the uplands contain floodplain sediments primarily derived from weathered shales, sandstones, and loess. As a result, clay and silt dominate these deposits, although sand and gravel are present in varying amounts. In Dickinson County, the thickness of the alluvium and terrace valley fill ranges from 0 to 68 ft (0 to 21 m); the average thickness is approximately 50 ft (15 m) (Latta, 1949).

Qds — **Eolian dune sand –** Holocene sand dunes are found north of the Smoky Hill River between Abilene and Solomon and near Detroit. These fine-grained eolian sands were derived from the Smoky Hill River floodplain and redeposited by prevailing southerly winds. Thickness of the dune sand ranges from 0 to 40 ft (0 to 12 m) (Latta, 1949).

Pleistocene

Qpt — **Terraces –** Pleistocene alluvial terraces underlie the sand dunes north of the Smoky Hill River between Abilene and Solomon and are exposed only in a small area northeast of Solomon. These unconsolidated, poorly sorted sand, gravel, and silt accumulations were probably deposited by the Smoky Hill River when it flowed at a higher level during the Pleistocene. The uppermost reaches of this unit are more than 100 ft (30 m) above the Holocene floodplain. The deposits are thickest (50–65 ft; 15–20 m) near the river and thin northward (Latta, 1949).

MESOZOIC

Kd — **Dakota Formation –** The Dakota Formation consists of two members: in ascending order, the Terra Cotta Clay Member and the Janssen Clay Member (Plummer and Romary, 1947). Probably only the basal **Terra Cotta Clay Member** is present in Dickinson County. The Terra Cotta is composed primarily of red-mottled, light-gray to greenish-gray clay and siltstone and coarse-grained and conglomeratic sandstone. Lenticular, cross-bedded sandstone layers in the Terra Cotta can be locally prominent—the iron-oxide cemented sandstones are resistant to erosion and cap many of the hills and benches—but generally this member is mostly clay and siltstone (Byrne et al., 1959; Walters and Bayne, 1959; Bayne et al., 1971). The maximum exposed thickness of the Dakota Formation in Dickinson County is approximately 50 ft (15 m).

Kk — **Kiowa Formation –** The lower part of the Kiowa Formation consists of medium- to dark-gray and black shales containing scattered thin beds of fine-grained sandstone and siltstone and thin beds of fossiliferous limestone ("shellbeds"). Pyrite, marcasite, gypsum crystals, cone-in-cone structure, siderite (iron-claystone concretions), and marine fossils occur within this horizon (Mack, 1962). Thick (10–100 ft; 3–30 m), lenticular, sheet-like, fine- to medium-grained, cross-bedded sandstones are more common in the upper part of the Kiowa (Franks, 1979), but they are not laterally continuous over long distances (Swineford, 1947). These sandstones are typically very light gray to pale grayish orange, but in places iron-oxide cement colors them reddish brown (Franks, 1979). Locally, calcite-cemented sandstones (colloquially called "quartzite") are found in the Kiowa and Dakota formations. In Dickinson County, calcite-cemented sandstones occur in the "Black Hills" area south of Carlton (Swineford, 1947). The thickness of the Kiowa Formation in Dickinson County ranges from 70 to 120 ft (21 to 37 m). The Kiowa includes the locally mappable "Longford member" (Franks, 1979; Franks, 1966), whose eastern extent is mappable in the southwest and northwest corners of Dickinson County. The Longford, found at the base of the Kiowa, is composed mainly of a white to grayish-orange capping siltstone underlain by red-mottled and gray clay rocks and siltstone, although the lithologies below the capping siltstone can be highly variable (Franks, 1979). Lignite, molds, casts of branching stems and rootlets, and trace fossils preserved in the Longford member may be associated with current and oscillation ripple marks (Franks, 1979).

PALEOZOIC

Pwe — **Wellington Formation –** The Wellington Formation in Dickinson County is predominantly gray and bluish-gray shale with beds of gypsum, anhydrite, and argillaceous limestone. Maroon, red, and green argillaceous shales also occur (Byrne et al., 1959; Walters and Bayne, 1959). The **Hollenberg Limestone Member** crops out in central and eastern Dickinson County and consists of gray to tan, coarsely crystalline, dolomitic limestone with a few tan shale beds (Byrne et al., 1959; Walters and Bayne, 1959). Below the Hollenberg, the Wellington is a thin-bedded, variegated, calcareous shale about 20–40 ft (6–12 m) thick (Byrne et al., 1959; Walters and Bayne, 1959). The **Carlton Limestone Member** is a light-gray to pale-yellow-tan, thin-bedded, platy, argillaceous limestone and interbedded tan-gray, calcareous shale that crops out in the western portion of the county (Byrne et al., 1959). Plant and insect fossils are found at some localities. Below the Carlton, several gypsum/anhydrite beds, ranging up to 20 ft (6 m) thick, are known from outcrops, test holes, and mines (Kulstad et al., 1956). The uppermost member of the Wellington Formation, the Milan Limestone Member, is not known to occur in central Kansas, and the Hutchinson Salt Member is also absent in the county (Byrne et al., 1959). Although the Wellington Formation can be up to 700 ft (213 m) thick in some parts of Kansas, only about 150 ft (46 m) is exposed in Dickinson County. Outcrops of the Wellington Formation in the county are generally poorly exposed.

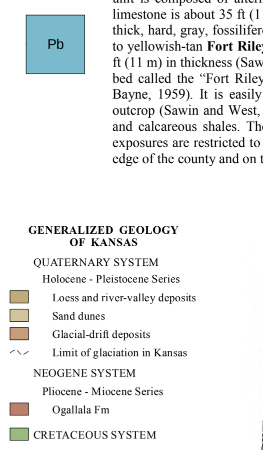
Pno — **Nolans Limestone –** The **Krider Limestone Member** at the base of the Nolans Limestone is one or two beds of hard, gray to yellowish-brown, locally nodular, dolomitic limestone containing bivalves and some brachiopods; a thin shale bed less than 1 ft (0.3 m) thick usually separates the two thin limestone beds (Walters and Bayne, 1959; Mudge et al., 1958). The Krider has a "sugary texture" in weathered outcrops (Mudge et al., 1958). The total thickness of the Krider is 1–2 ft (0.3–0.6 m) (Walters and Bayne, 1959; Sawin and West, 2010). Above the Krider limestone, the **Paddock Shale Member** consists of olive to yellowish-gray, clay-rich, blocky shale that contains a thin bed of gray to grayish brown, dolomitic limestone near its base (West et al., 2010; Mudge et al, 1958). Fossils are locally abundant in some of the shale beds (Sawin and West, 2010; Byrne et al., 1959; Mudge et al., 1958). The Paddock Shale is approximately 10–15 ft (3–5 m) thick (West et al., 2010; Mudge et al., 1958; Byrne et al., 1959; Walters and Bayne, 1959). The uppermost member of the Nolans Limestone, the **Herington Limestone Member**, consists of light gray, tan, and grayish-brown massive, blocky beds of dolomitic limestone. Calcite geodes, siliceous concretions, and bivalve fossils are locally present (Byrne et al., 1959; Walters and Bayne, 1959; Mudge et al., 1958). In Dickinson County, the Herington is approximately 6–8 ft (1.8–2.4 m) thick (Walters and Bayne, 1959). The thickness of the Nolans Limestone in the county is about 20 ft (6 m).

Pwo — **Winfield Limestone and Odell Shale –** The **Winfield Limestone** is composed of three members: in ascending order, the Stovall Limestone Member, the Grant Shale Member, and the Cresswell Limestone Member. The basal **Stovall Limestone Member** is a single, thin (1.5–2.5 ft; 0.5–0.8 m), gray to tan, dense, fossiliferous limestone containing lenses and scattered nodules of bluish-gray chert (Sawin and West, 2010; Mudge et al., 1958). Above the Stovall limestone, the **Grant Shale Member** is a yellowish-gray, fossiliferous shale commonly about 10 ft (3 m) thick (West et al., 2010; Sawin and West, 2010; Mudge et al., 1958). The uppermost member, the **Cresswell Limestone Member,** ranges from 12 to 16 ft (4 to 5 m) in thickness. Thick to massive beds of yellowish-brown to medium-gray limestone make up the lower part of the Cresswell. The lower part is fossiliferous (echinoid spines are characteristic), sometimes vuggy, and locally contains thin lenses or nodules of chert (Sawin and West, 2010; Mudge et al., 1958). The upper part of the Cresswell is composed of thin-bedded, platy, argillaceous, medium-gray to yellowish-brown limestone. Calcite geodes and, less commonly, siliceous concretions are found in the upper part (Sawin and West, 2010; West et al., 2010; Mudge et al., 1958). The average thickness of the Winfield Limestone is about 25 ft (8 m). The lower part of the **Odell Shale** consists of yellow to gray, calcareous shales. The middle and upper parts are variegated (mostly red, but also green, purple, and bluish gray). Typically, the Odell is 20–30 ft (6–9 m) thick (Sawin and West, 2010; Byrne et al., 1959; Mudge et al., 1958).

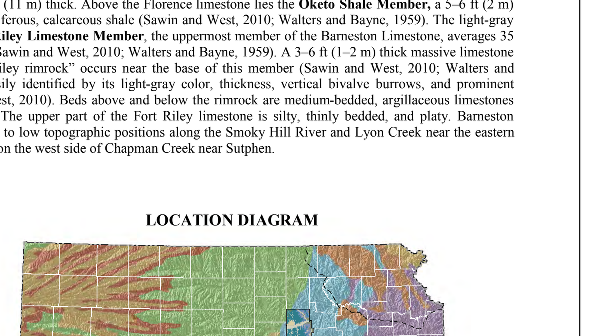
Pd — **Doyle Shale –** The Doyle Shale is divided into three members: in ascending order, the Holmesville Shale Member, Towanda Limestone Member, and Gage Shale Member. The **Holmesville Shale Member** is predominantly a gray, but also yellow, red, maroon, and green shale; beds of limestone or calcareous shale can occur throughout. The thickness of the Holmesville is 15–20 ft (5–6 m) (Sawin and West, 2010; Walters and Bayne, 1959; Mudge et al., 1958). The **Towanda Limestone Member** is a thin- to medium-bedded, platy to blocky, gray to yellow-brown limestone that is approximately 10 ft (3 m) thick (Sawin and West, 2010; Walters and Bayne, 1959; Mudge et al., 1958). The Towanda crops out along drainages in the east-central portion of the county. The upper part of the **Gage Shale Member** is a gray to buff, calcareous, fossiliferous shale; near the top, a thin (less than 1 ft; 0.3 m), calcareous shale or limestone may occur. The lower two-thirds is a variegated (red, green, purple, and dark brown) to dull grayish-yellow shale (Mudge et al., 1958; Sawin and West, 2010). The thickness of the Doyle Shale may range from 35 to 65 ft (11 to 20 m).

Pb — **Barneston Limestone –** The bottom member of the Barneston, the **Florence Limestone Member**, is a thick-bedded (up to 1 ft; 0.3 m), fossiliferous, blocky, yellowish-brown to gray limestone that contains numerous bluish-gray chert nodules or beds up to 0.5 ft (0.2 m) thick (Sawin and West, 2010; Byrne et al., 1959). Shale partings (up to 2 ft [0.6 m] thick) are common in the upper part of the Florence limestone. In contrast, the lower 5 ft (2 m) of the unit is composed of alternating beds of shale and non-cherty limestone (Sawin and West, 2010). The Florence limestone is about 35 ft (11 m) thick. Above the Florence limestone lies the **Oketo Shale Member,** a 5–6 ft (2 m) thick, hard, gray, fossiliferous, calcareous shale (Sawin and West, 2010; Walters and Bayne, 1959). The light-gray to yellowish-tan **Fort Riley Limestone Member**, the uppermost member of the Barneston Limestone, averages 35 ft (11 m) in thickness (Sawin and West, 2010; Walters and Bayne, 1959). A 3–6 ft (1–2 m) thick massive limestone bed called the "Fort Riley rimrock" occurs near the base of this member (Sawin and West, 2010; Walters and Bayne, 1959). It is easily identified by its light-gray color, thickness, vertical bivalve burrows, and prominent outcrop (Sawin and West, 2010). Beds above and below the rimrock are medium-bedded, argillaceous limestones and calcareous shales. The upper part of the Fort Riley limestone is silty, thinly bedded, and platy. Barneston exposures are restricted to low topographic positions along the Smoky Hill River and Lyon Creek near the eastern edge of the county and on the west side of Chapman Creek near Sutphen.

GENERALIZED GEOLOGY OF KANSAS



LOCATION DIAGRAM



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