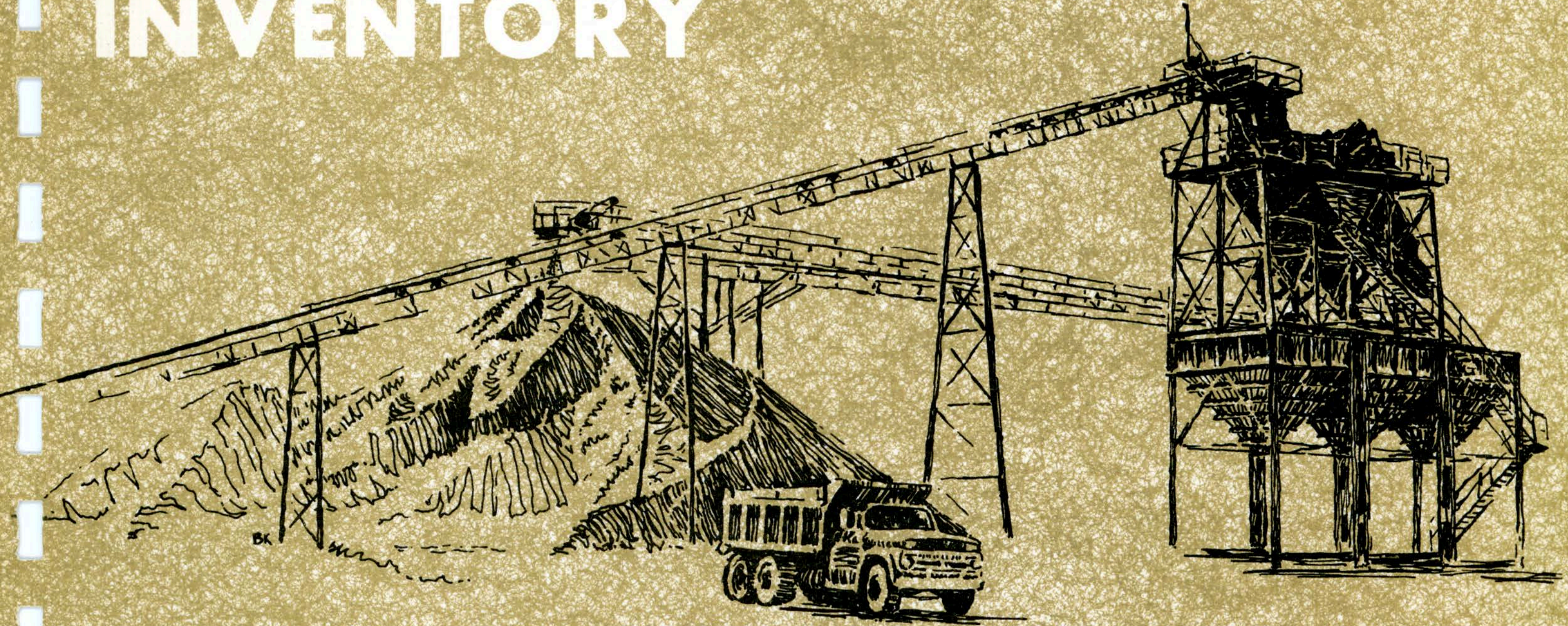
REPORT NO. 22

CONSTRUCTION MATERIALS INVENTORY



DONIPHAN COUNTY, KANSAS

STATE HIGHWAY COMMISSION OF KANSAS

State Highway Commission of Kansas
Location and Design Concepts Department
Planning and Development Department

CONSTRUCTION MATERIALS INVENTORY OF DONIPHAN COUNTY, KANSAS

by

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Prepared in Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

1974

Construction Materials Inventory Report No. 22

Copies are available from the Planning & Development Department
State Highway Commission

the **WHY?**

WHAT?

and **HOW?**

of This REPORT

This report was compiled for use as a guide for locating construction material in Doniphan County.

> ***Construction material includes all granular material, consolidated rock, and mineral filler suitable for use in highway construction.***

Known open and prospective sites, both sampled and unsampled, and all geologic deposits considered to be a source of construction material are described and mapped.

> ***Prospective sites are select geologic locations where construction materials may be found.***

The diagram opposite shows how the MATERIALS INVENTORY SECTION may be used to evaluate and locate ***mapped sites.***

The individually mapped sites certainly do not constitute the total construction materials resources of the county. And, the data outlined in the diagram may be used for purposes other than the evaluation and location of these sites.

Beginning on page 5 is a section explaining the geology of the county. This information (along with the maps, descriptions, and test data) provides the means of evaluating and locating additional construction materials sources in the geologic units throughout Doniphan County.

TO LOCATE AND EVALUATE

A MAPPED SITE OF CONSTRUCTION MATERIAL IN DONIPHAN COUNTY

TURN TO THE MATERIALS INVENTORY SECTION
See
TABULATION OF CONSTRUCTION MATERIALS
Figure 7, Page 15

for material
BY TYPE
USE COLUMN 1

For Quality Data
See Figure 14
Page 25

for material
BY INTENDED USE
USE COLUMN 2

for **DESCRIPTION** of material

Column 3 gives page of DESCRIPTION which includes engineering characteristics, approximate locations, and references to materials map.

for **AVAILABILITY** of material

Column 4 gives relative amounts available, general location, and references to materials map.

MATERIALS MAP

SEE PINK SHEET, PAGE 27

Material source units, as well as all open sites, are mapped. Each site is referenced to an individual data form.

SITE DATA FORMS

OPEN SITES; SAMPLED	GREEN SHEET, PAGE 30
OPEN SITES; NOT SAMPLED	GREEN SHEET, PAGE 44

Each site data form includes a map for site location and provides information concerning landownership, material quality (if available), geologic age, and site accessibility.

CONTENTS

PREFACE

This report is one of a series compiled for the Highway Planning and Research Program, 'Materials Inventory by Photo Interpretation'. The program is a cooperative effort of the Federal Highway Administration and the State Highway Commission of Kansas, financed by highway planning and research funds. The objective of the project is to ***provide a statewide inventory of construction materials,*** on a county basis, to help meet the demands of present and future construction needs.

Several publications issued by the State Geological Survey of Kansas, concerning Doniphan and surrounding counties, provided the basic geologic information used in this investigation. Detailed geologic and soil data were obtained from soil surveys and centerline geologic profiles prepared for design of major highways in the county by the State Highway Commission.

Appreciation is extended to Raymond Neely, Doniphan County Road Supervisor, John Griffith, First Division Materials Engineer, Jim Able, First Division Materials Dept., and Richard McReynolds, Soils Section, Location and Design Concepts for verbal information concerning construction materials discussed in this report.

This report was prepared under the guidance of R. R. Biege, Jr., P.E., Engineer of Location and Design Concepts; and A. H. Stallard, Chief, Remote Sensing Section, Location and Design Concepts Department.

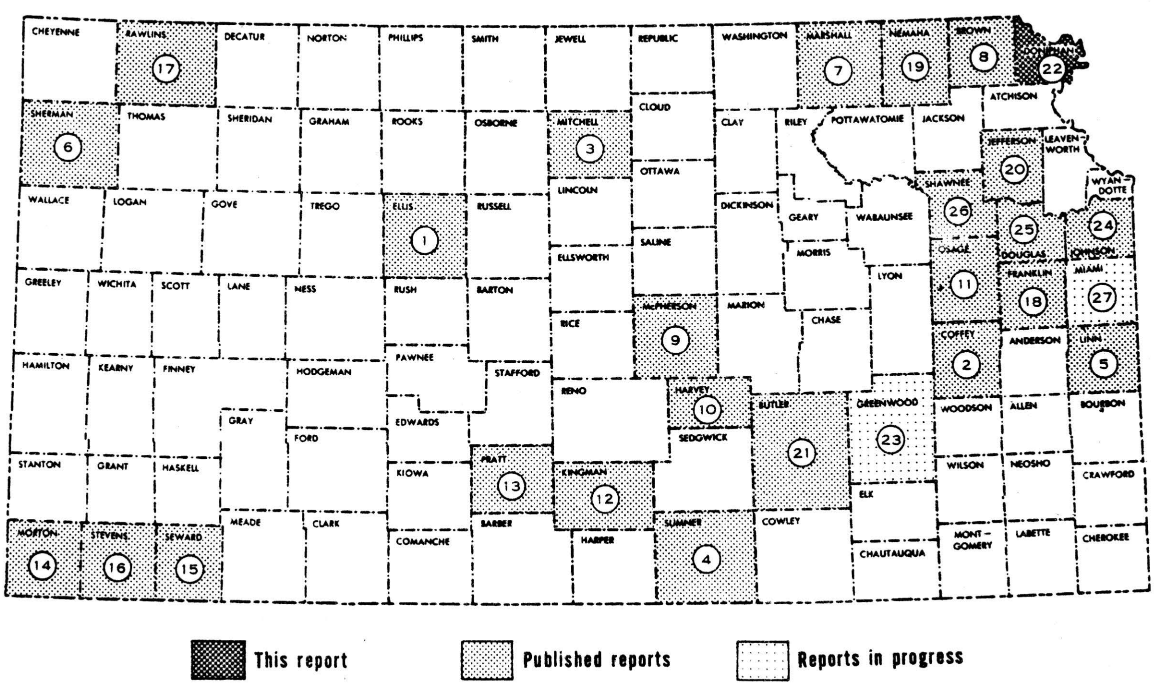


Figure 1. Index map of Kansas showing the location of Doniphan County along with the report numbers and locations of counties for which reports have been or are being completed.

ABSTRACT

Doniphan County lies within the Dissected Till Plains of the Central Lowlands physiographic province. The topography of this section is well drained, moderately fine textured, mature, and has a well rounded rolling surface. For the most part it is developed in glacial till with Pennsylvanian rocks exposed in the lower parts of the deeper valleys. In northeastern Doniphan County, thick loess deposits impart a distinctive character to the topography, but elsewhere in the section, the thin loess deposits veneer rather than modify the surface developed on Kansan till.

Wolf River, Independence Creek, Peters Creek, and their tributaries drain Doniphan County into the Missouri River which forms the northern and eastern boundary of the county.

The primary sources of construction material in Doniphan County are the Pennsylvanian limestones and limited quantities of unconsolidated Pliocene and Pleistocene deposits of sand and gravel. Due to the extremely thick overburden of loess and glacial drift over most of the county, only a limited number of suitable limestone outcrops are available for production. Primary areas of limestone production in Doniphan County include the bluffs adjoining the floodplain of the Missouri River and those along other major drainage channels. Very limited amounts of sand and gravel are produced from alluvial and glacial deposits in the county. High percentages of silt and clay cause difficulties in processing to desired gradation. Groundwater may cause construction problems where the base of limestone units are encountered, at the soil mantle-bedrock contact, and in isolated sand and gravel deposits in areas where glacial drift is encountered.

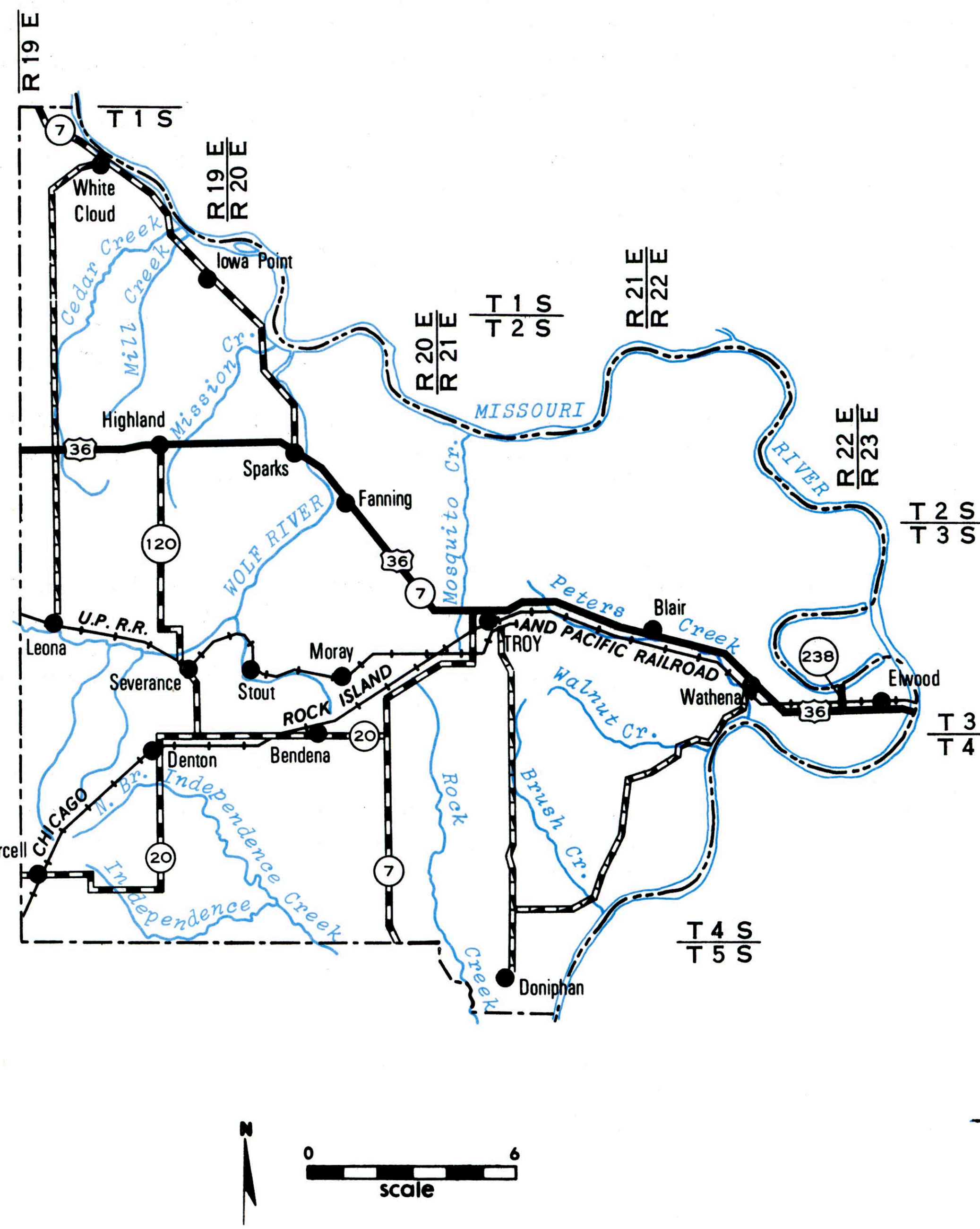


Figure 2. Drainage and major transportation facilities in Doniphan County.

FACTS ABOUT DONIPHAN COUNTY

Doniphan County has an area of approximately 394 square miles and a population of 10,134 in 1973, according to the Kansas State Board of Agriculture. It lies in the Glaciated physiographic division of Kansas. The county falls within an area bounded approximately by parallels 39° 37′ and 40° 00′ north latitude and meridians 94° 54′ and 95° 21′ west longitude. Doniphan County is located in the northeastern corner of Kansas. It is bounded on the north by the Missouri River and Richardson County, Nebraska, on the west by Brown County, on the south by Atchison County, and on the east by the Missouri River. Figure 1 is a state map of Kansas showing the location of Doniphan and other counties currently included in the materials inventory program. Figure 2 shows the major drainage and transportation facilities in Doniphan County.

METHODS OF INVESTIGATION

Investigation and preparation of this report consisted of three phases: (1) research and review of available information, (2) photo interpretation, and (3) field reconnaissance.

Phase One: Relevant information concerning geology, soils, and construction materials of the county was reviewed and the general geology was determined. Quality test results of samples taken in Doniphan County were then correlated with the various geologic units and unconsolidated deposits.

Phase Two: A study and interpretation of aerial photographs taken by the Kansas Highway Commission at the scale of one inch equals 1,000 feet. Figure 3 illustrates aerial photographic coverage of Doniphan County. Geologic source beds and all open materials sites were mapped and classified on aerial photographs. All materials sites were then correlated with the geology of the county.

Phase Three: This phase was conducted after initial study of aerial photographs. A field reconnaissance was conducted by the author to examine construction materials, to verify doubtful mapping situations, and to acquire supplemental geologic information. Geologic classification of open sites was confirmed.

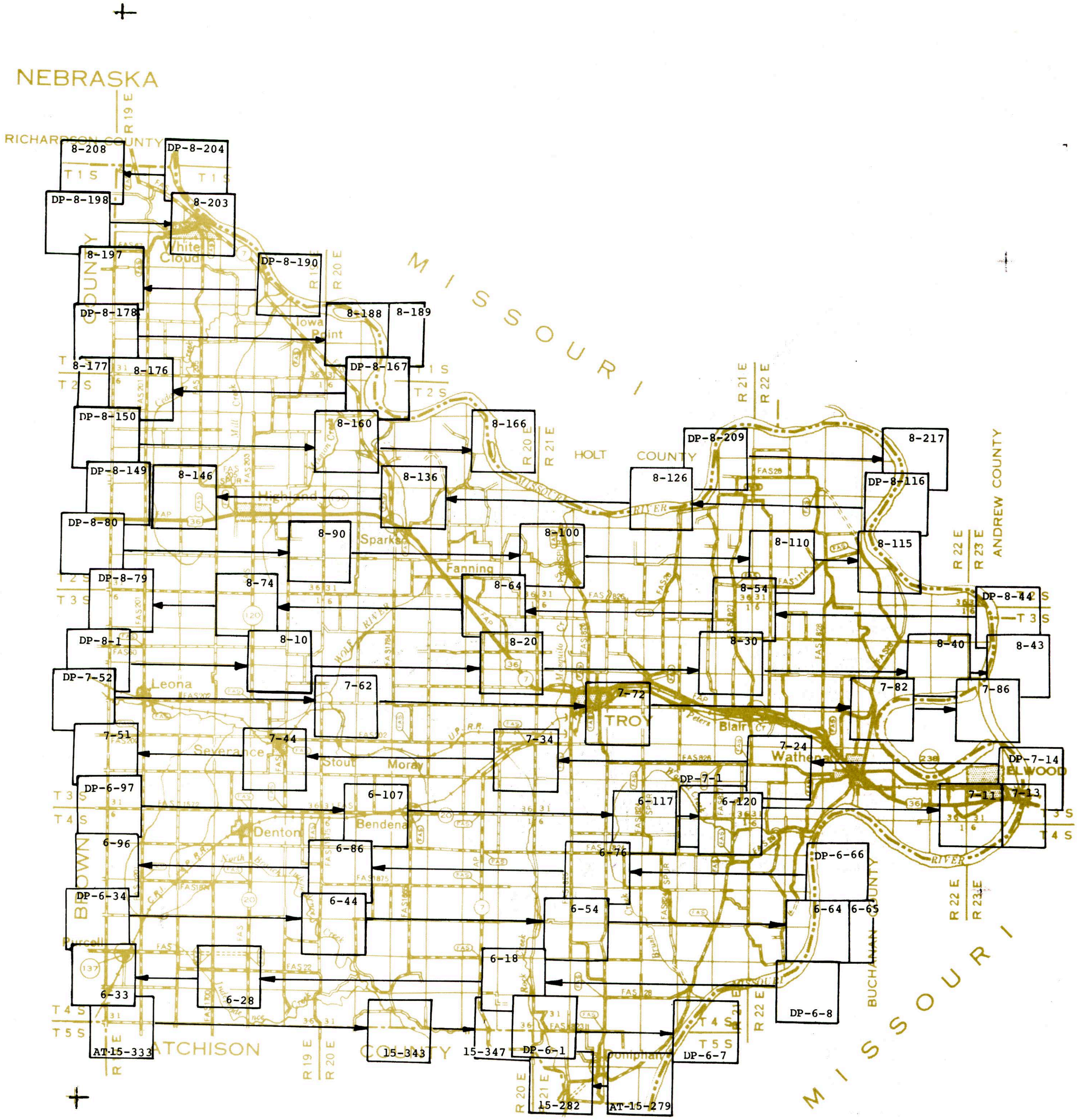
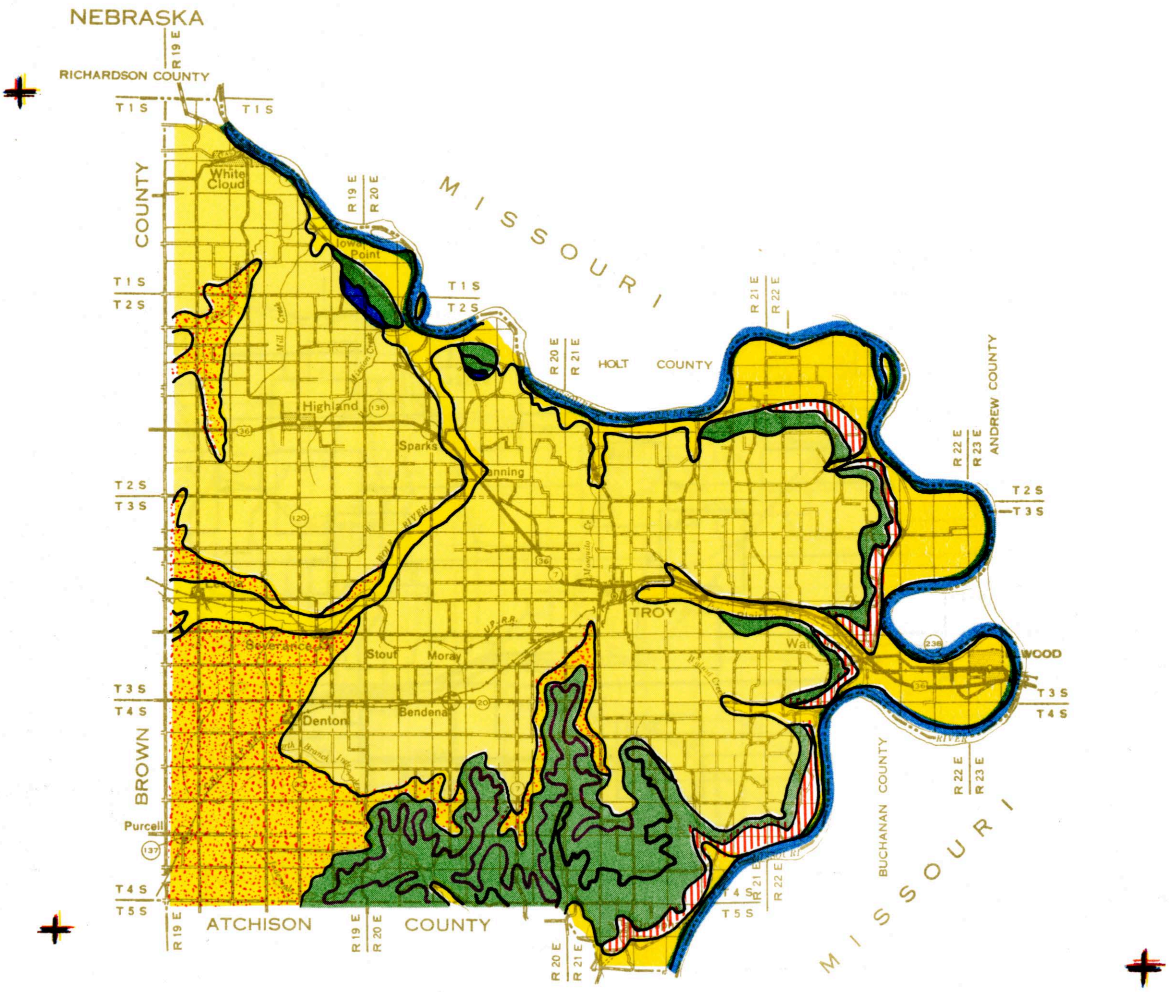


Figure 3. AERIAL PHOTOGRAPHIC COVERAGE MAP for Doniphan County. The numbers refer to photographs taken by the State Highway Commission of Kansas. The county was photographed at 6,000 feet (scale one inch = 1,000 feet) in July, August and September, 1966. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

GEOLOGY SECTION



LEGEND

- *Loess*
- *Alluvium*
- *Glacial Drift*
- *Wabaunsee Group*
- *Shawnee Group*
- *Deer Creek Limestone Base*
- *Lecompton Limestone Base*
- *Douglas Group*

GENERAL GEOLOGY

GEOLOGY is the basis for this materials inventory. Knowledge of the geology makes it possible to: (1) ascertain the general properties of the material source, (2) identify and classify each source according to current geologic nomenclature, and (3) establish a uniform system of material-source-bed classification. By knowing the geologic age, origin, land form, and quality information of the source units, one can derive general information for untested materials sites and prospective locations.

It is important to note that the quality of material from a given source may vary from one location to another, especially in unconsolidated deposits.

Because material source units are exposed or near the surface, most of this discussion pertains to surface geology in Doniphan County. The geologic timetable, Figure 4, page 6 shows in graphic form the major time periods and the approximate duration of each. Figure 5 is a generalized geologic column of the surface geology of Doniphan County illustrating the relative stratigraphic position of each geologic unit.

Rocks which occur in the subsurface but do not outcrop in Doniphan County range from Precambrian to late Pennsylvanian age. Most Precambrian rocks are believed to be of a granitic type. Approximately 2,500 feet of Paleozoic sediments overlie the older Precambrian rocks and are composed of limestones, dolomites, sandstones, and shales. Marine deposits of late Pennsylvanian age are the oldest rocks found at the surface in Doniphan County.

No Mesozoic sediments are found in the county. It is part of an area which was probably a land mass during most of the Mesozoic Era. It is assumed that during this time large amounts of older Paleozoic rocks were removed by erosion.

Events of the Cenozoic Era have had a dominant influence on the construction materials resources of Doniphan County; however, most of these events took place during the late Cenozoic (Quaternary Period). During the earlier Tertiary Period, which represents most of Cenozoic time, the surface of Doniphan County was believed to have been eroded. Channels flowing eastward and southward were cut into Pennsylvanian bedrock. Locally derived chert and limestone gravel was deposited in these channels during late Tertiary and early Quaternary time.

The Pleistocene Epoch of the Quaternary Period represents a time of repeated glacial and interglacial cycles. The glacial ages (Nebraskan, Kansan, Illinoisan, and Wisconsinan) represent the advance of glaciers, of which only the Nebraskan and Kansan reached Kansas, while the three interglacial ages (Aftonian, Yarmouthian, and Sangamonian) represent periods of major glacial recession. Figure 6 is a geologic timetable which shows the divisions of the Quaternary Period and the approximate duration of each.

During Aftonian time, a well developed soil was formed on lake sediments which were deposited during late Nebraskan time. Younger deposits covered the soil which has been designated the ***'Afton Buried Soil'.*** It is exposed in several gravel pits along the Missouri River in Doniphan County.

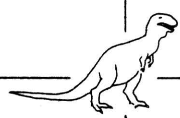
ERAS	PERIODS	ESTIMATED LENGTH IN YEARS	TYPE OF ROCK IN KANSAS	PRINCIPAL MINERAL RESOURCES
CENOZOIC	QUATERNARY (PLEISTOCENE) 	1,000,000	Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.	Sand and gravel; volcanic ash; agricultural soils; water.
	TERTIARY 	59,000,000	Silt, sand, and gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.	Sand and gravel; volcanic ash; diatomaceous marl; water.
MESOZOIC	CRETACEOUS	70,000,000	Chalky shale, dark shale, vari-colored clay, sandstone, conglomerate; outcropping igneous rock.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and building stone; ceramic materials; water.
	JURASSIC	25,000,000	Sandstone and shale, chiefly subsurface.	
	TRIASSIC	30,000,000		
PALEOZOIC	PERMIAN 	25,000,000	Limestone, shale, evaporites (salt, gypsum, anhydrite), red sandstone and siltstone, chert, and some dolomite.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and building stone; natural gas, salt, gypsum, water.
	PENNSYLVANIAN 	25,000,000	Alternating marine and non-marine shale; limestone, sandstone, coal, and chert.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and limestone and shale for cement; ceramic materials; oil, coal, gas, and water.
	MISSISSIPPIAN 	30,000,000	Mostly limestone, predominantly cherty.	Chat and other construction materials; oil, zinc, lead, and gas.
	DEVONIAN	55,000,000	Subsurface only. Limestone and black shale.	Oil.
	SILURIAN	40,000,000	Subsurface only. Limestone.	Oil.
	ORDOVICIAN	80,000,000	Subsurface only. Limestone, dolomite, sandstone, and shale.	Oil, gas, and water.
	CAMBRIAN 	80,000,000	Subsurface only. Dolomite and sandstone.	Oil.
PRE-CAMBRIAN	(Including PROTEROZOIC and ARCHEOZOIC ERAS)	1,600,000,000 +	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.	Oil and gas.

Figure 4. Geologic timetable

System	Series	Stage	Graphic Legend	Thickness	Type of Deposit	Map Symbol	Generalized Description	Construction Material
Quaternary	Pleistocene	Recent and Wisconsinan		0-118'	Alluvium and Terrace Deposits	Qal	Predominantly silt and clay with local accumulation of limestone and siliceous gravel.	Light type surfacing Fine aggregate
		Wisconsinan and Illinoisan		0-130'	Loess	Ql	Wind-deposited brown silt, generally, in an upland position.	
		Kansan and Nebraskan		0-118'	Glacial Drift	Qgd	Consists of clay and silt with concentrations of sand, gravel, and boulders at various horizons.	Light type surfacing
		Nebraskan		0-20'	Terrace Deposits	Qt	Chert Gravel with smaller amounts of siliceous sand highly contaminated with silt and clay.	Light type surfacing

Note: Any Pleistocene deposits may be in contact with any older outcropping rock.

System	Series	Group	Graphic Legend	Formations and Members		Map Symbol	Thickness	Generalized Description	Construction Material
Pennsylvanian	Virgilian	Wabaunsee Group		White Cloud Shale	Scranton Shale		80'±		
				Howard Limestone			11-12'		
				Severy Shale			40'±		
		Shawnee		Topeka Limestone		Pt	23'±	Source units are the middle and basal limestone members. The middle bed is a gray, hard, and dense rock about two feet in thickness. The basal unit is brown mottled limestone that is massive and hard.	Light type surfacing Crushed aggregate Riprap
				Calhoun Shale			9.5'		
				Deer Creek Limestone	Ervine Creek Limestone		14.0'	A gray-tan, wavy-bedded, hard and dense limestone with shale partings.	Light type surfacing Crushed aggregate Riprap Aggregate, when processed is suitable for bituminous and concrete construction.
					Larsh & Burrock Shale		4.5'		
					Rock Bluff Limestone	Pdc	2.0'		
					Oskaloosa Shale		6.0'	Upper unit is brown, shaly limestone which varies from soft to hard. Lower unit is a gray, hard, limestone bed which is a better quality rock than the upper unit.	Light type surfacing Crushed aggregate Riprap
					Ozawkie Limestone		9.0'		
				Tecumseh Shale			29.0'		
				Lecompton Limestone	Avoca Limestone		1.0'	A gray-brown, dense limestone that weathers brown. Wavy-bedded and less dense in upper part.	Light type surfacing
					King Hill Shale		5.0'		
					Beil Limestone		5.3'		
					Queen Hill Shale	Pl	3.3'		
					Big Springs Limestone		2.1'	A hard blue-gray, limestone that contains abundant fusilinids.	Light type surfacing Crushed aggregate Riprap
					Doniphan Shale		10.0'		
					Spring Branch Ls.		2.0'	A gray-brown, hard, limestone that weathers brown.	Light type surfacing Crushed aggregate Riprap
				Kanwaka Shale			72.0'		
				Oread Limestone	Kereford Limestone		4.0'	A gray to brown, hard, dense limestone that weathers yellowish-brown.	Light type surfacing Crushed aggregate Riprap
					Heumader Shale		3.2'		
					Plattsmouth Limestone		22.0'	Upper part is a blue-gray, wavy-bedded, shaly limestone with thin shale partings. Lower part is a gray to tan wavy-bedded, hard limestone which has numerous chert nodules.	Light type surfacing Crushed aggregate Riprap Aggregate, when processed is suitable for bituminous and concrete construction.
					Heebner Shale	Po	5.0'		
					Leavenworth Limestone		1.7'		
					Snyderville Shale		13.8'		
					Toronto Limestone		4.5'	A light brown, massive limestone that weathers brown.	Light type surfacing Crushed aggregate Riprap
		Douglas		Lawrence Formation	Amazonian Limestone	Pla	11.3'	A gray to tan, dense limestone which is wavy-bedded and has thin shale partings. Lower nine feet is brecciated with fractures filled with calcite and limonite.	Light type surfacing Crushed aggregate Riprap Aggregate, when processed is suitable for bituminous and concrete construction.

Figure 5. Generalized geologic column of the surface geology in Doniphan County.

Divisions of the Quaternary Period				
Period	Epoch	Age	Estimated length of age duration in years	Estimated time in years elapsed to present
Quaternary	Pleistocene	Recent		10,000
		Wisconsinan Glacial	45,000	55,000
		Sangamonian Interglacial	135,000	190,000
		Illinoisan Glacial	100,000	290,000
		Yarmouthian Interglacial	310,000	600,000
		Kansan Glacial	100,000	700,000
		Aftonian Interglacial	200,000	900,000
		Nebraskan Glacial	100,000	1,000,000

Figure 6. Geologic timetable of the Quaternary Period

As Kansan ice advanced, outwash was deposited and lacustrine sediments were laid down in pre-glacial lakes. According to Bayne (1968), two glacial tills of Kansan age are present in Doniphan County. The older *(Nickerson Till)* was laid down during the initial advance of the Kansan glacier, overlying the earlier outwash deposits in some areas. The *'Cedar Bluffs Till'* is associated with a second Kansan ice sheet. The combined thickness of the two tills and outwash deposits exceeds 100 feet in western Doniphan County.

During and following the retreat of the Kansan glacier, outwash deposits were laid down. However, during most of Illinoisan time, erosional processes removed large amounts of material in this area.

Erosion continued during early Wisconsinan time and the present stream system was established. Later the valleys were partially filled with alluvium and loess. Most loess deposits found in Doniphan County are early Wisconsinan *(Peoria Formation)* and late Wisconsinan *(Bignell Formation)*. Up to 130 feet of loess has been encountered near the town of White Cloud in extreme northern Doniphan County. Fairly thick deposits cover the county except in the southwestern part.

In Recent time alluvial and colluvial deposits have been deposited in many of the stream valleys. In smaller streams in Doniphan County, the alluvium does not exceed 25 feet. In the Wolf River valley up to 50 feet of alluvium is encountered. Some gravel is found in the Wolf River sediments but most alluvium in the county consists of clay and silt size particles. Clay, silt, sand, and gravel make up the Missouri River alluvium with coarser material in the basal part. Well over 100 feet of alluvial material is present in the Missouri River valley.

GEO-ENGINEERING

This section provides a general appraisal of the geo-engineering problems that may be encountered in Doniphan County during highway construction. Potential groundwater problems and the quality of water available for concrete are briefly reviewed along with engineering soil types present in the area. ***Detailed field investigations may be necessary to ascertain the severity of specific problems and to make recommendations in design and construction procedures.***

Bedrock outcrops in valley walls, alluvial filled stream and river valleys, glacial drift, and thick deposits of loess make up the diverse geology and associated geo-engineering problems of Doniphan County.

Limestone outcrops are found in most of the steeper valley walls along drainage channels. These outcrops vary from the thin limestones of the Lecompton and Topeka Formations to the thick limestones of the Lawrence, Oread, and Deer Creek Formations. Moderate amounts of rock excavation can be expected in areas where the limestones and unweathered shales outcrop. Hydrology problems may be encountered along the base of limestones, and at the soil mantle-bedrock contact. Limited water supplies containing high concentrations of sulfates, nitrates, chlorides, and iron are available from the Pennsylvanian rocks. Quantities of water produced from these sources are generally less than 10 gpm.

The alluvium encountered in the Missouri River valley consists of relatively flat terraces and floodplain deposits composed of silt, sand, and clay with some larger granular material present in the lower part of the alluvium. Numerous abandoned oxbow meanders containing organic material, silts, and clays are also located on the terraces and in the alluvium. Reworked loess, silts, and clays make up the alluvial deposits of the Wolf River and other streams in the county. Abandoned oxbow areas should be avoided where fill sections are contemplated because of differential consolidation of the organic material, silts, and clays.

Hydrology problems may be expected in deep excavation if the water table is encountered in the stream and river valleys. The need for borrow for fill construction may require careful exploration to acquire sufficient material above the water table. Water quantity varies from 10 gpm in the Wolf River and other stream valleys to greater than 100 gpm in the Missouri River floodplain. Water quality should be tested before use because of varying concentrations of sulfates, chlorides, nitrates, and iron.

Glacial drift of varying thickness is exposed over much of the southwest quarter of the county. Except for local sand and gravel deposits, most soil derived from the drift is composed of silty clay, clay loam, and in severe cases, clay. Most of this material is an A-6 or A-7 type of soil according to AASHO standards. Excavation will generally be common except where large quartzite boulders are encountered. Short term hydrology problems may be anticipated where sand and gravel pockets are encountered. Water is available from the drift in amounts ranging from 10 to 100 gpm and containing varying concentrations of chlorides, sulfates, nitrates, and iron.

Thick loess deposits capping high terrain are encountered over all but the stream valleys, Missouri River floodplain, and the southwestern quarter of the county. Laboratory results from tests run on this material found in Brown County and field observations in Brown and Doniphan Counties indicate that the plasticity index will generally exceed the specified maximum for use as a mineral filler; however, the material can provide select borrow for embankment and subgrade construction. Cuts in the loess will be common excavation. Hydrology problems will be encountered in areas where groundwater is induced into the loess deposits. Areas containing high water concentrations are susceptible to slope failures. Limited water supplies, generally less than 10 gpm and having high mineral contents, are available from the deposits.

MATERIALS INVENTORY SECTION

GENERAL INFORMATION

Pennsylvanian limestone makes up the major portion of the construction materials resources of Doniphan County. Limited amounts of chert gravel may be produced from terrace deposits of Tertiary age in the eastern portion of the county. Sand and gravel in limited amounts may be produced from the Quaternary terraces and floodplain of the Missouri River.

The construction materials types, their uses, and availability are tabulated in Figure 7. Test results from a limited amount of sampling and testing are presented in Figure 14 (page 25).

CONTENTS
MATERIALS INVENTORY SECTION

TYPE material and geologic source	USE	page	AVAILABILITY
LIMESTONE			
Amazonia Limestone Member	Construction aggregate, riprap, light type surfacing	16	Very limited source along eastern edge of county. Plates 3 & 5.
Toronto Limestone Member	Light type surfacing	17	Limited to moderate source along southeastern and eastern edge of county. Plates 3 & 5.
Plattsmouth Limestone Member	Construction aggregate, riprap, light type surfacing.	17	Moderate to good source along eastern edge of county. Plates 3 & 5.
Kereford Limestone Member	Light type surfacing	18	Limited source. Plates 3 & 5.
Spring Branch Limestone Member	Light type surfacing	19	Very limited source on eastern and southern edge of county. Plates 3, 4, & 5.
Big Springs Limestone Member	Light type surfacing	19	Very limited source on eastern and southern edge of county. Plates 3, 4, & 5.
Beil Limestone Member	Light type surfacing.	19	Very limited source on eastern and southern edge of county. Plates 3, 4, & 5.
Ozawkie Limestone Member	Light type surfacing	20	Good source in north central, south central and south western part of county. All Plates.
Ervine Creek Limestone Member	Construction aggregate, riprap, light type surfacing.	20	Good source in north central, south central and south western part of county. All Plates.
Hartford Limestone Member	Light type surfacing	22	Limited source in north central, south central and south western part of county. Plates 1, 2, 3, 4.
Curzon Limestone Member	Light type surfacing	22	Limited source in north central, south central and south western part of county. Plates 1, 2, 3, 4.
SAND AND GRAVEL			
Chert Gravel	Light type surfacing	22	Very limited source along northern and eastern edges of county. Plate 5.
Quaternary Alluvium	Light type surfacing	23	Limited source in river alluvium. Plates 1, 2, 3, & 5.

Figure 7. Tabulation of the construction materials types and their availability in Doniphan County.

DESCRIPTION OF CONSTRUCTION MATERIALS

Limestone

Lawrence Formation

The Lawrence Formation in Doniphan County has an approximate thickness of 57 feet. The formation is comprised of two shale members separated by a limestone. These members are, in ascending order, the Robbins Shale, the Amazonia Limestone, and an unnamed upper shale. The Amazonia is a source of construction material and has been produced extensively in Doniphan County.

Amazonia Limestone Member

The Amazonia Limestone Member is a light-gray to tan, hard, dense, fossiliferous, wavy-bedded limestone. The total thickness of this limestone in Doniphan County is approximately 11.5 feet, the lower nine feet of which is brecciated and contains stringers of limonite. Although the Amazonia has been quarried extensively in outcrop areas in eastern Doniphan County, its accessibility is limited by thick overburden and therefore its value as a construction material aggregate is limited. At selected sites this member meets all specifications for construction material aggregate and the outcrop pattern is shown on plates 3 and 5.

Figure 8. The Amazonia Limestone Member exposed in the NE¼ sec. 28, T2S, R22E.

Oread Limestone Formation

The Oread Limestone Formation is the basal formation of the Shawnee Group and is composed of four limestone and three shale members. These members are, in ascending order, the Toronto Limestone, Snyderville Shale, Leavenworth Limestone, Heebner Shale, Plattsmouth Limestone, Heumader Shale, and the Kereford Limestone. The total thickness of the formation in Doniphan County is approximately 51 feet. The Oread is exposed along the bluffs adjacent to the Missouri River in eastern Doniphan County and along some of the tributaries flowing into the Missouri River.

The Plattsmouth Limestone Member is the only important source of construction material in this formation in Doniphan County. The outcrop pattern of the Oread Formation is mapped on plates 3 and 5.

Toronto Limestone Member

The Toronto Limestone Member is a massive, light-gray to brown unit that weathers to a dark brown, is very fossiliferous, and contains prominent bedding planes 2.4 feet from the top. The total thickness of this member in Doniphan County is approximately 4.5 feet.

Although the Toronto has been quarried in other counties in eastern Kansas, it has not been quarried in Doniphan County because a much better quality rock is available in the overlying Plattsmouth Limestone Member. In areas where it has been produced, it exhibits high absorption characteristics and is not suitable for concrete or bituminous aggregate; however, it is suitable for light type surfacing material.

The Toronto is a member of the Oread Formation which is mapped on plates 3 and 5.

Plattsmouth Limestone Member

The Plattsmouth Limestone is a light bluish-gray, hard limestone with flaggy bedding. This member is approximately 21 feet thick in Doniphan County. The upper 13 feet of the unit shows thin, irregular bedding with wavy thin shale partings, while the lower eight feet is more dense and crystalline. Some chert nodules may be found between eight and nine and one half feet from the base of the member. Due to the flaggy characteristics of the upper portion, care must be exercised to avoid mistaking it for the Ervine Creek Member of the Deer Creek Formation.

Material from selected Plattsmouth outcrops will meet specifications for all types of construction aggregate; however, the quality does vary from location to location in Doniphan County, therefore, tests should be run on the source before use. This member is a part of the Oread Formation which is mapped on plates 3 and 5.

Figure 9. Plattsmouth Quarry located in the SE¼ sec. 20, T3S, R22E.

Kereford Limestone Member

The Kereford Limestone is a gray to brown, dense, fossiliferous limestone that has an approximate thickness of six feet in Doniphan County. This unit contains a thin shale parting two feet from the base of the member, and above this shale parting, it exhibits cross bedding characteristics.

To the south of Doniphan County, the unit thickens and contains a higher percentage of shale. In counties where the unit is thicker, a portion of the ledge has been used for light type surfacing aggregate and riprap. No quality test data are available for Doniphan or the surrounding counties; however, due to its soft nature, its use would be limited to light type surfacing aggregate.

The Kereford Member is the uppermost member of the Oread Formation which is mapped on plates 3 and 5.

Lecompton Limestone Formation

The Lecompton Limestone Formation in Doniphan County has an approximate thickness of 29 feet. It consists of four limestone and three shale members, which are, in ascending order; the Spring Branch Limestone, Doniphan Shale, Big Springs Limestone, Queen Hill Shale, Beil Limestone, King Hill Shale, and the Avoca Limestone.

The Spring Branch, Big Springs, and the Beil are the only units considered as sources of construction material in this report. The exposure pattern of the Lecompton Formation in Doniphan County is mapped on plates 3, 4, and 5.

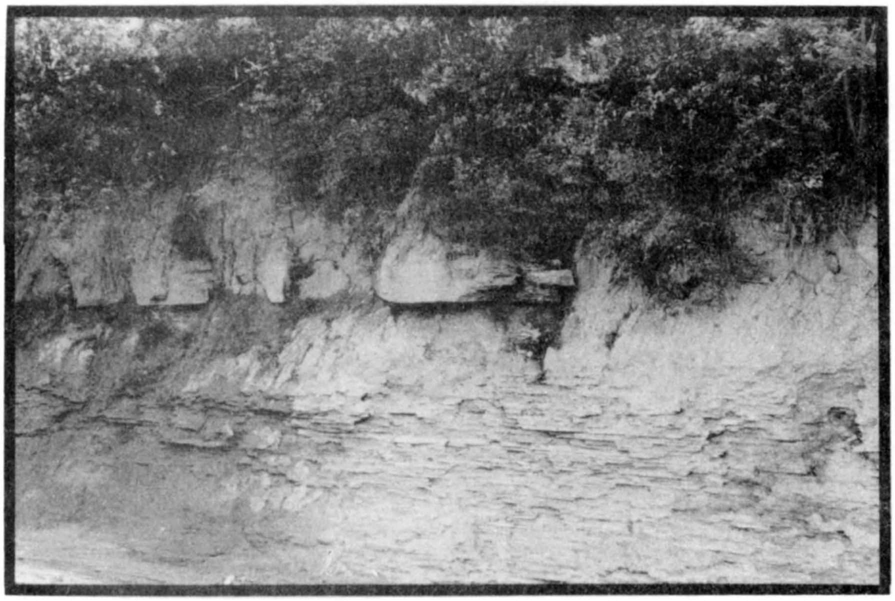


Figure 10. Middle Lecompton S. of Blair NW¼ sec. 19, T3S, R22E.

Spring Branch Limestone Member

The Spring Branch is a massive, light-gray, fossiliferous limestone that weathers to a dark brown and has an average thickness in Doniphan County of two feet. It has not been quarried in Doniphan County and only on a very limited basis elsewhere in eastern Kansas. Due to its limited thickness and the presence of better sources in the Oread and Deer Creek Formations, it is only considered as a limited source of light type surfacing aggregate. The Spring Branch has been shown as a part of the Lecompton Formation which is mapped on plates 3, 4, and 5.

Big Springs Limestone Member

The Big Springs is a dense, fossiliferous, bluish-gray, wavy-bedded limestone. It weathers to a yellowish brown and has an approximate thickness of two to three feet. Quality test data are not available for Doniphan or surrounding counties; however, due to its limited thickness and the availability of good quality aggregate from the Oread and Deer Creek Formations, it is considered only as a limited source of light type surfacing material in the county. It is shown as a part of the Lecompton Formation which is mapped on plates 3, 4, and 5.

Beil Limestone Member

The Beil is a light-gray, wavy-bedded limestone containing numerous shale partings. It has an average thickness of three and one half feet in Doniphan County. No quality test data are available for Doniphan or surrounding counties; however, due to its shaly nature, it may be only suitable for light type surfacing. The Beil is a member of the Lecompton Formation which is mapped on plates 3, 4, and 5.

Deer Creek Limestone Formation

The Deer Creek Limestone Formation is composed of five members. They are in ascending order; the Ozawkie Limestone, the Oskaloosa Shale, the Rock Bluff Limestone, the Larsh and Burroak Shale, and the Ervine Creek Limestone Members. The Deer Creek Formation in Doniphan County has an average thickness of 36 feet. The Ozawkie and the Ervine Creek members are considered as sources of construction material in Doniphan County. The Deer Creek has been mapped as one unit and is shown on all plates.

Ozawkie Limestone Member

The Ozawkie Limestone is gray, massive bedded, and contains a well developed joint system. It weathers to a light brown and contains a dark-gray shale zone midway through the bed. This member has an average thickness of nine feet in Doniphan County.

The Ozawkie has been produced in some eastern Kansas counties for riprap; however, due to its shaly nature and the availability of better quality rock from the overlying Ervine Creek, it is only produced on a limited basis in Doniphan County. Although quality test data are not available in Doniphan County, tests elsewhere in eastern Kansas show the material to be suitable for light type surfacing, and for riprap from selected outcrops. This unit is a member of the Deer Creek Formation which is shown on all plates.

Ervine Creek Limestone Member

The Ervine Creek is a light-gray to white, massive, fine-grained limestone containing scattered chert nodules. It weathers into thinwavy beds, light gray to light brown in color, with small shale seams prominent in the weathered exposures. This unit has an approximate thickness of 14 feet in Doniphan County.

The Ervine Creek Limestone is quarried extensively throughout eastern Kansas. Quality data for Doniphan County show that its characteristics vary from location to location and changes in lithology. Material from selected outcrops is acceptable for concrete and bituminous aggregate as well as riprap and light type surfacing.

The Ervine Creek Limestone Member is a part of the Deer Creek Formation which has been mapped on all plates.

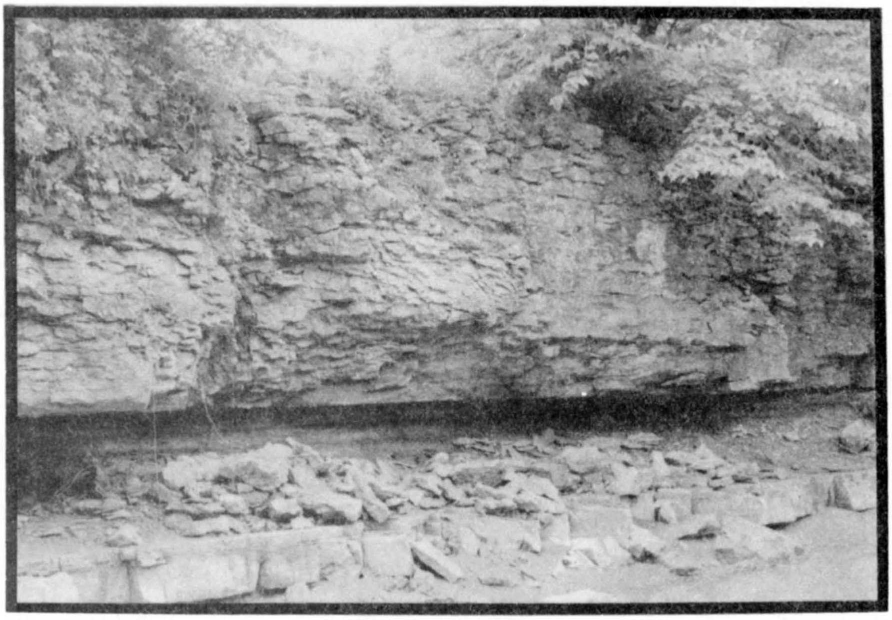


Figure 11. Ervine Creek Limestone exposed in a stream bank in the NE¼ sec. 12, T3S, R19E.

Topeka Limestone Formation

The Topeka Limestone Formation is composed of nine members, which are, in ascending order, the Hartford Limestone, the Iowa Point Shale, the Curzon Limestone, the Jones Point Shale, the Sheldon Limestone, the Turner Creek Shale, the Du Bois Limestone, the Holt Shale, and the Coal Creek Limestone. The thickness of the Topeka Formation varies from 25 feet in the northern part of the county to 33 feet in the southern part. The Hartford and Curzon Limestones are the main source units of construction materials in the Topeka Formation. The Topeka Formation has been mapped on plates 1, 2, and 4.

Figure 12. Hartford and Curzon Members of Topeka Limestone in quarry NE¼ sec. 19, T3S, R20E.

Hartford Limestone Member

The Hartford Limestone is a fossiliferous, light-gray to tan, massive unit that weathers to a yellow-brown color with an average total thickness in Doniphan County of four feet. Quality test data are not available for Doniphan County; however, in counties where it has been tested it has shown a variable nature. It is generally acceptable as riprap and light type surfacing material.

The Hartford Member is a part of the Topeka Formation mapped on plates 1, 2, and 4.

Curzon Limestone Member

The Curzon is a light-gray limestone containing a shale parting near the middle of the unit and chert nodules present in some outcrops. It commonly weathers to a dark yellowish-brown to yellowish orange and has an average thickness of five and one half feet in Doniphan County.

The Curzon Member has been produced throughout eastern Kansas but not as extensively as the Ervine Creek or Plattsmouth. Quality test data are not available for the county; however, tests run in Jefferson County show the material to be marginal for bituminous and concrete aggregate and suitable for riprap and light type surfacing.

The Curzon Member is a part of the Topeka Formation mapped on plates 1, 2, and 4.

Sand and Gravel

Chert Gravel Deposits

Chert gravels are found in high terrace deposits along the southeastern edge of Doniphan County. These gravels were deposited during early Pleistocene time and are very limited in extent. Small amounts of construction material have been produced from sites located in the bluffs along the Missouri River (Plate 5) and used for light type surfacing. In counties where quality tests have been run, the chert gravels will generally meet specifications for concrete and bituminous aggregate after processing. However, limited quantities and a heavy clay matrix make the chert gravels generally uneconomical to produce in Doniphan County. Past experience has shown that when chert gravel is used in concrete, the extreme hardness of the chert makes it very difficult to saw joints.

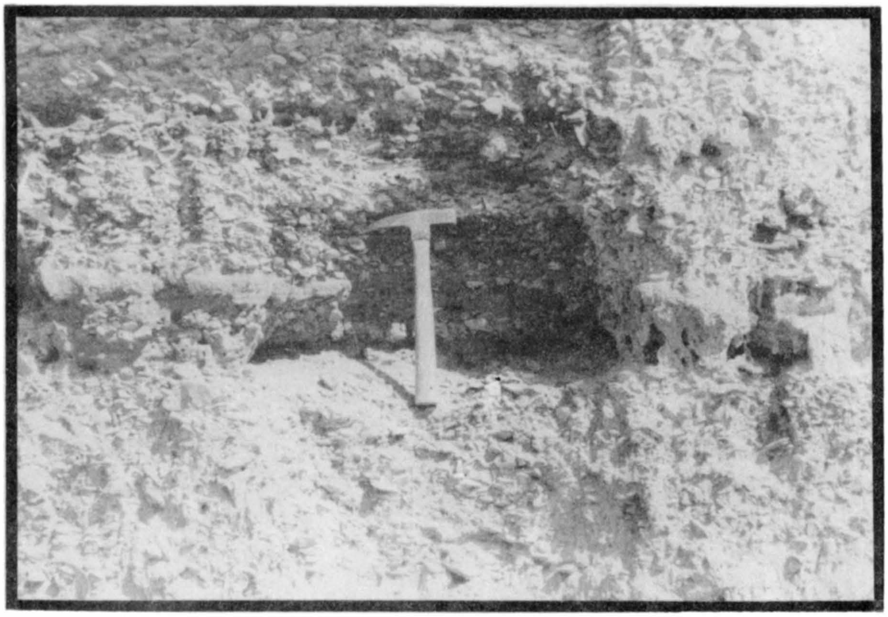


Figure 13. Pre-glacial chert gravel in pit NE¼ sec. 26, T4S, R21E.

Quaternary Alluvium

The Missouri River alluvium is a limited source of siliceous sand and gravel; however, clay lumps are present which are very difficult to remove from the sand. Sand and gravel used in Doniphan County is presently obtained from sand pumping operations located across the river in Missouri.

The alluvium of the Wolf River and other small streams in Doniphan County is composed primarily of silt and clay with small quantities of interbedded sand and gravel. No material is presently being produced from these alluvial deposits which are shown on all plates.

Site No.	Material Type	Sp.Gr. Sat.	Sp.Gr. Dry	Wt./Cu.Ft.	% Wear	Soundness	% Absorption	Source of Data
Source of Material: Ervine Creek Member - Pdc (Deer Creek Formation)								
LS+1	Limestone	2.59	2.53		27.8(B)	0.96	2.30	One sample SHC form 619, No. 22-13, Lab. No. 23720
		2.54	2.47		32.3(B)	0.97	2.73	One sample SHC form 619, No. 22-13, Lab. No. 36057
		2.53	2.44		31.8(B)	0.95	3.74	One sample SHC form 619, No. 22-13, Lab. No. 65-907
		2.51	2.43		31.8(B)	0.96	3.65	One sample SHC form 619, No. 22-13, Lab. No. 66-343
		2.49	2.37		39.1(B)	0.92	4.98	One sample SHC form 619, No. 22-13, Lab. No. 68-603
		2.52	2.41		38.1(B)	0.94	4.24	One sample SHC form 619, No. 22-13, Lab. No. 68-879
LS+2	Limestone	2.46	2.37		39.5(A)	0.97	4.10	One sample SHC form 619, No. 22-7, Lab. No. 65269
		2.40		92.2	38.8(A)	0.94	4.15	One sample SHC form 619, No. 22-7, Lab. No. 69261
		2.40		90.6	36.7(B)	0.94	4.05	One sample SHC form 619, No. 22-7, Lab. No. 69262
		2.54			43.8(B)	0.85	4.00	One sample SHC form 619, No. 22-7, Lab. No. 82165
		2.53			32.6(B)	0.94	2.61	One sample SHC form 619, No. 22-7, Lab. No. 82669
		2.47	2.35			0.94	5.14	One sample SHC form 619, No. 22-7, Lab. No. 24450
		2.51	2.40		43.7(B)		4.76	Av.3 samples SHC form 619,No.22-7, Lab. No. 29376
		2.52	2.41		41.6(B)	0.92	4.67	One sample SHC form 619, No. 22-7, Lab. No. 29375
		2.50	2.38		44.0(B)	0.91	5.16	One sample SHC form 619, No. 22-7, Lab. No. 29718
		2.47	2.35		38.4(B)	0.90	5.16	One sample SHC form 619, No. 22-10, Lab. No. 6439
		2.48	2.36		43.3(B)	0.91	4.94	One sample SHC form 619, No. 22-10, Lab. No. 14664
		2.52	2.42		32.7(B)	0.94	4.07	One sample SHC form 619, No. 22-10, Lab. No. 17162
LS+3	Limestone	2.65			23.0(A)	0.98	1.72	*One sample SHC form 619, No. 22-9, Lab. No. 81331
		2.54			43.8(B)	0.85	4.00	One sample SHC form 619, No. 22-9, Lab. No. 82452
		2.49			39.8(B)	0.90	4.91	One sample SHC form 619, No. 22-9, Lab. No. 94023
		2.46	2.33		44.1(B)	0.91	5.77	One sample SHC form 619, No. 22-9, Lab. No. 96608
		2.48	2.36		35.6(B)	0.91	5.02	One sample SHC form 619, No. 22-9, Lab. No. 96606
		2.47	2.34		41.6(B)	0.87	5.52	One sample SHC form 619, No. 22-9, Lab. No. 5868
		2.49	2.37		26.4(B)	0.87	5.07	One sample SHC form 619, No. 22-9, Lab. No. 6500
		2.48	2.39		34.7(B)	0.94	4.15	One sample SHC form 619, No. 22-9, Lab. No. 14666
		2.56	2.48		34.5(B)	0.91	3.31	One sample SHC form 619, No. 22-9, Lab. No. 19979
		2.55			32.0(D)	0.94		One sample SHC form 619, No. 22-9, Lab. No. 21927
		2.66			32.0(B)	0.96		One sample SHC form 619, No. 22-9, Lab. No. 21987
		2.45	2.31		47.1(D)	0.89	6.06	One sample SHC form 619, No. 22-9, Lab. No. 23636
		2.43	2.28		45.3(B)	0.92	6.36	One sample SHC form 619, No. 22-9, Lab. No. 25558
		2.50	2.39		38.4(B)	0.91	4.78	One sample SHC form 619, No. 22-9, Lab. No. 26269
		2.54	2.44		32.0(B)	0.91	4.08	One sample SHC form 619, No. 22-9, Lab. No. 27785
		2.53	2.42		39.6(B)	0.90	4.61	One sample SHC form 619, No. 22-9, Lab. No. 28303
		2.57	2.48		33.2(B)		3.50	Av.3 samples SHC form 619,No. 22-9, Lab. No. 28672
		2.44	2.30		53.3(B)	0.90	6.39	One sample SHC form 619, No. 22-9, Lab. No. 30357
		2.47	2.33		46.6(B)	0.88	5.76	One sample SHC form 619, No. 22-9, Lab. No. 30624
		2.51	2.40		43.4(B)	0.90	4.57	One sample SHC form 619, No. 22-9, Lab. No. 31223
		2.52	2.41		37.0(B)	0.89	4.24	One sample SHC form 619, No. 22-9, Lab. No. 31462
		2.50	2.38		40.8(B)	0.85	5.02	One sample SHC form 619, No. 22-9, Lab. No. 31537
		2.53	2.43		35.9(C)	0.87	4.13	One sample SHC form 619, No. 22-9, Lab. No. 31983
		2.51	2.42		32.4(B)	0.91	4.05	One sample SHC form 619, No. 22-9, Lab. No. 33106
		2.52	2.41		35.6(B)	0.87	4.39	One sample SHC form 619, No. 22-9, Lab. No. 33438
		2.55	2.46		33.7(C)	0.90	3.57	One sample SHC form 619, No. 22-9, Lab. No. 33742
		2.55	2.46		32.6(C)	0.90	3.48	One sample SHC form 619, No. 22-9, Lab. No. 33920
		2.55	2.46		38.7(C)	0.96	3.61	One sample SHC form 619, No. 22-9, Lab. No. 34751
		2.55	2.47		35.3(C)	0.92	3.31	One sample SHC form 619, No. 22-9, Lab. No. 34750
		2.54	2.44		37.9(C)	0.94	3.98	One sample SHC form 619, No. 22-9, Lab. No. 35217
		2.50	2.39		39.8(B)	0.94	4.77	One sample SHC form 619, No. 22-9, Lab. No. 35138
		2.47	2.34		46.9(B)	0.86	5.72	One sample SHC form 619, No. 22-9, Lab. No. 35813
		2.65	2.59		29.2(C)	0.96	2.42	One sample SHC form 619, No. 22-9, Lab. No. 36058
		2.65	2.58		26.1(B)	0.97	2.51	One sample SHC form 619, No. 22-9, Lab. No. 36189
		2.50	2.38		37.5(B)	0.89	5.00	One sample SHC form 619, No. 22-9, Lab. No. 65-1021
		2.52	2.41		41.3(C)	0.96	4.45	One sample SHC form 619, No. 22-9, Lab. No. 65-1830
		2.60	2.51		33.9(C)	0.96	3.53	One sample SHC form 619, No. 22-9, Lab. No. 65-2366
		2.46	2.33		50.8(B)	0.95	5.74	One sample SHC form 619, No. 22-9, Lab. No. 66-540
		2.56	2.47		34.6(C)	0.94	3.67	One sample SHC form 619, No. 22-9, Lab. No. 66-1557
		2.50	2.38		42.9(B)	0.92	4.78	One sample SHC form 619, No. 22-9, Lab. No. 66-1729
		2.53	2.42		37.9(B)	0.94	4.30	One sample SHC form 619, No. 22-9, Lab. No. 67-1957
		2.63	2.56		24.8(B)	0.97	2.61	One sample SHC form 619, No. 22-9, Lab. No. 67-1956
		2.58	2.48		37.3(B)	0.95	4.01	One sample SHC form 619, No. 22-9, Lab. No. 68-1307
LS+4	Limestone	2.63			27.4(A)	0.97	1.55	*One sample SHC form 619, DP. Co. #1, Lab. No. 48929
		2.61			27.7(A)	0.96	1.32	*One sample SHC form 619, DP. Co. #1, Lab. No. 48930
		2.57			31.4(A)	0.97	2.09	*One sample SHC form 619, DP. Co. #1, Lab. No. 48931
LS+8	Limestone	2.57	2.47		37.6(B)	0.90	3.80	One sample SHC form 619, No. 22-15, Lab. No. 66-541
		2.53	2.43		37.0(B)	0.84	4.29	One sample SHC form 619, No. 22-15, Lab. No. 68-967
Source of Material: Plattsmouth Member - Po (Oread Formation)								
LS+5	Limestone	2.64		110.47	36.3(C)	0.95	2.87	One sample Lab. No. 31362
		2.62		111.25	28.6(D)	0.99	3.68	One sample Lab. No. 65-5215
LS+6	Limestone	2.53	2.45		26.4(B)	0.94	3.10	One sample, SHC form 619, No. 22-11, Lab. No. 97943
		2.55	2.47		29.2(B)	0.95	3.10	One sample, SHC form 619, No. 22-11, Lab. No. 98614
		2.51	2.42		28.0(B)	0.95	3.79	One sample, SHC form 619, No. 22-11, Lab. No. 6914
		2.52	2.45		26.9(B)	0.96	3.19	One sample, SHC form 619, No. 22-11, Lab. No. 13600
		2.53	2.46		25.0(B)	0.96	3.13	One sample, SHC form 619, No. 22-11, Lab. No. 14665
LS+7	Limestone	2.59	2.55		29.5(A)	0.92	1.86	*One sample, SHC form 619, No. 22-8, Lab. No. 50703
		2.59	2.54		29.7(A)	0.90	1.76	*One sample, SHC form 619, No. 22-8, Lab. No. 50701
		2.51	2.42		33.4(A)	0.82	3.68	*One sample, SHC form 619, No. 22-8, Lab. No. 50702
		2.58			31.6(B)	0.94	2.72	One sample, SHC form 619, No. 22-8, Lab. No. 75698
		2.58		97.2	30.2(B)	0.97	2.70	One sample, SHC form 619, No. 22-8, Lab. No. 75772
		2.54			31.4(B)	0.88	3.61	One sample, SHC form 619, No. 22-8, Lab. No. 82164
		2.53	2.46		32.6(B)	0.92	2.84	One sample, SHC form 619, No. 22-8, Lab. No. 82799
		2.51			29.6(C)	0.92	3.81	One sample, SHC form 619, No. 22-8, Lab. No. 87913
		2.51	2.42		31.2(B)	0.90	3.86	One sample, SHC form 619, No. 22-8, Lab. No. 96607
		2.49	2.39		32.5(B)	0.89	4.32	One sample, SHC form 619, No. 22-8, Lab. No. 15966
		2.50	2.40		31.7(B)	0.92	4.20	One sample, SHC form 619, No. 22-8, Lab. No. 17161
		2.49	2.38		35.3(B)	0.85	4.64	One sample, SHC form 619, No. 22-8, Lab. No. 17451
		2.50			35.1(B)	0.87		One sample, SHC form 619, No. 22-8, Lab. No. 22602
		2.50	2.38		34.1(B)	0.87	4.93	One sample, SHC form 619, No. 22-8, Lab. No. 27644
		2.53	2.43		33.5(B)	0.83	4.15	One sample, SHC form 619, No. 22-8, Lab. No. 66-538
Source of Material Amazonian Member - Pla (Lawrence Shale Formation)								
LS+9	Limestone	2.58	2.51		30.4(B)	0.97	2.63	One sample Lab. No. 68-804
LS+10	Limestone	2.64			30.3(A)	0.97	1.41	*One sample Lab. No. 48932
		2.58			37.8(A)	0.96	3.19	*One sample Lab. No. 48933
		2.64			29.2(A)	0.97	1.35	*One sample Lab. No. 64096
LS+11	Limestone	2.66	2.62		24.0(B)	0.98	1.41	One sample, SHC form 619, No. 22-14, Lab. No. 28920
		2.65	2.61		26.1(B)	0.98	1.52	One sample, SHC form 619, No. 22-14, Lab. No. 33166
* Sample taken from Limestone Ledge								

Figure 14. Results of tests completed on samples of material from the various geologic source beds in Doniphan County.