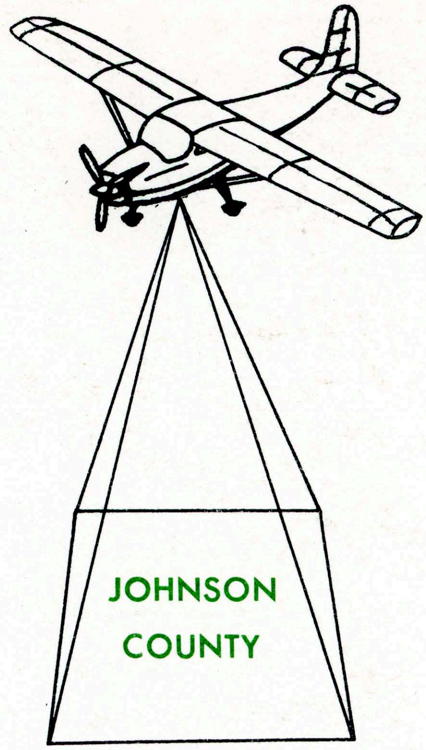

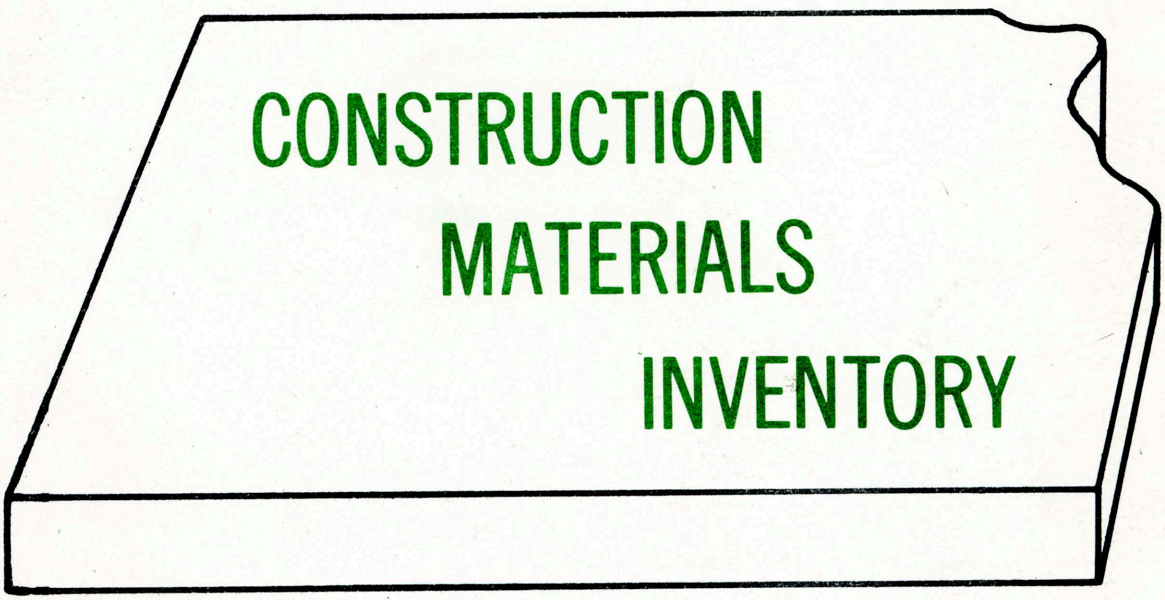

CONSTRUCTION MATERIALS INVENTORY

Report No. 24

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

CONSTRUCTION MATERIALS INVENTORY OF JOHNSON COUNTY, KANSAS

by

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assisted by
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Photo Interpretation Section

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

1970

Construction Materials Inventory Report No. 24

the **Why ?**

What ?

& How ?

of this Report

This report was compiled for use as a guide when prospecting for construction material in Johnson 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 material may be found.*

The diagram opposite shows how the MATERIALS INVENTORY SECTION may be used to evaluate and locate <u>mapped sites</u>.

The individually mapped sites certainly do not constitute the total construction material 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   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 material sources in the geologic units throughout Johnson County.

TO LOCATE AND EVALUATE

A MAPPED SITE OF CONSTRUCTION MATERIAL IN JOHNSON COUNTY

TURN TO THE MATERIALS INVENTORY SECTION

See

TABULATION OF CONSTRUCTION MATERIALS
Figure 7, Page 19

for material
BY TYPE
USE COLUMN 1

For Quality Data
See Figure 18
Page 36

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 MAPS

SEE PINK SHEET, PAGE 39

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 40
OPEN SITES; NOT SAMPLED	GREEN SHEET, PAGE 64
PROSPECTIVE SITES; NOT SAMPLED	GREEN SHEET, PAGE 90

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 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.

Basic geologic data used in this report were derived from the following Kansas Geological Survey bulletins: "The Geology of Johnson, Miami, and Wyandotte Counties, Kansas" by Newell and Jewett; "Quaternary Geology and Ground-water Resources of the Kansas River valley" by Dufford; and the forthcoming report "Geology and Ground-water Resources of Johnson County, Kansas" by Howard G. O'Connor. The Materials Department, State Highway Commission of Kansas, provided construction material quality data. Detailed soil and geologic information was obtained from preliminary soil surveys and centerline geologic profiles prepared by the State Highway Commission.

Appreciation is extended to Mr. Virgil A. Holdredge, Johnson County Engineer and Mr. John Griffith, First Division Materials Engineer for verbal information concerning construction materials discussed in this report.

This report was prepared under the guidance of R. R. Biege, Jr., Engineer of Location and Design Concepts Department; and G. M. Koontz and A. H. Stallard of the Location and Design Concepts Department.

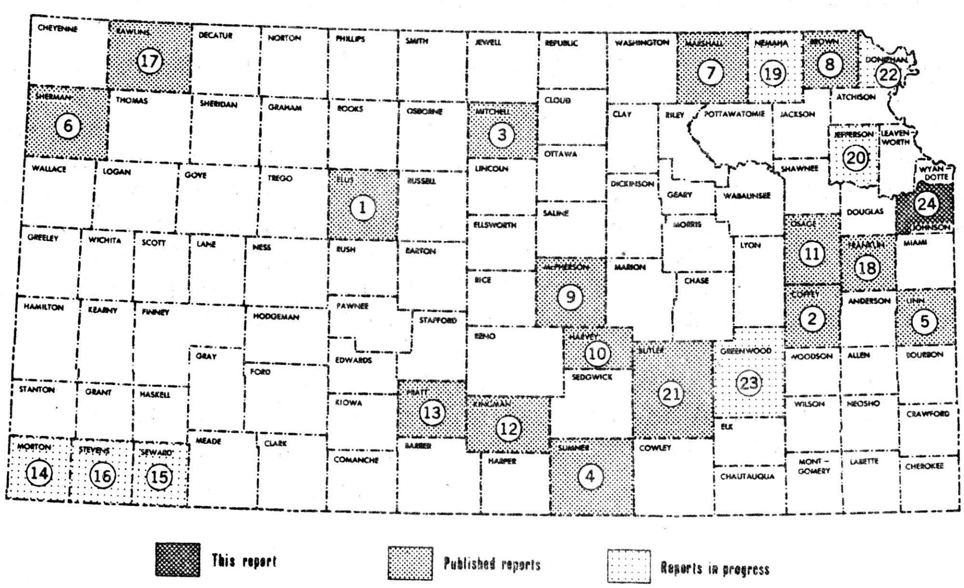


Figure 1. Index map of Kansas showing the location of Johnson County along with the report number and location of other counties for which reports have been or are being completed.

ABSTRACT

Johnson County is located in northeast Kansas and lies partly within the Dissected Till Plains and the Osage Cuestas physiographic divisions. Much of the area is characterized by alternating beds of limestone, shale, and sandstone which give rise to gently rolling uplands with hilly areas along streams. Most of the county is drained by north-flowing tributaries of the Kansas River. The extreme southwest corner of the county is drained by south-flowing tributaries of the Marais des Cygnes River.

Primary sources of construction material in Johnson County are Pennsylvanian limestones and unconsolidated deposits of Pleistocene age. Pennsylvanian sandstones are limited in quantity and (or) quality.

Good quality construction material can be produced from thick limestone beds exposed predominantly in the northern one-third and eastern two-thirds of the county. The more abundant volumes of limestone are located in the Aubry-Stilwell area, the new Olathe Lake area, and along Mill Creek west and northwest of Lenexa.

A limited supply of fine sand is available along the southwestern edge of Johnson County in Ireland Sandstone. Weston Shale, which is exposed in local areas, may be a source of raw material for lightweight aggregate. Sand and gravel deposits are extensive in alluvium within the Kansas River valley. Several pits located in the Alluvium produce sand and gravel by dredging operations. Limited quantities of this type construction material are present within other stream valleys and glacial deposits in Johnson County.

Water is produced in large quantities from Alluvium of the Kansas River by several large municipal systems. Kansas River alluvium is the best aquifer in the county, but water produced from this source may be high in iron and manganese and contamination is a possibility in areas of heavy industry. Low yields may be locally present in alluvium of minor streams and bedrock. Water produced from bedrock normally contains high dissolved solids, sulfate and chloride. Caution should be exercised when obtaining concrete mix water from Pennsylvanian and older rock formations.

Surface water is utilized for municipal use by most of the small communities in Johnson County and should be considered as a possible source for concrete mix.

GENERAL INFORMATION SECTION

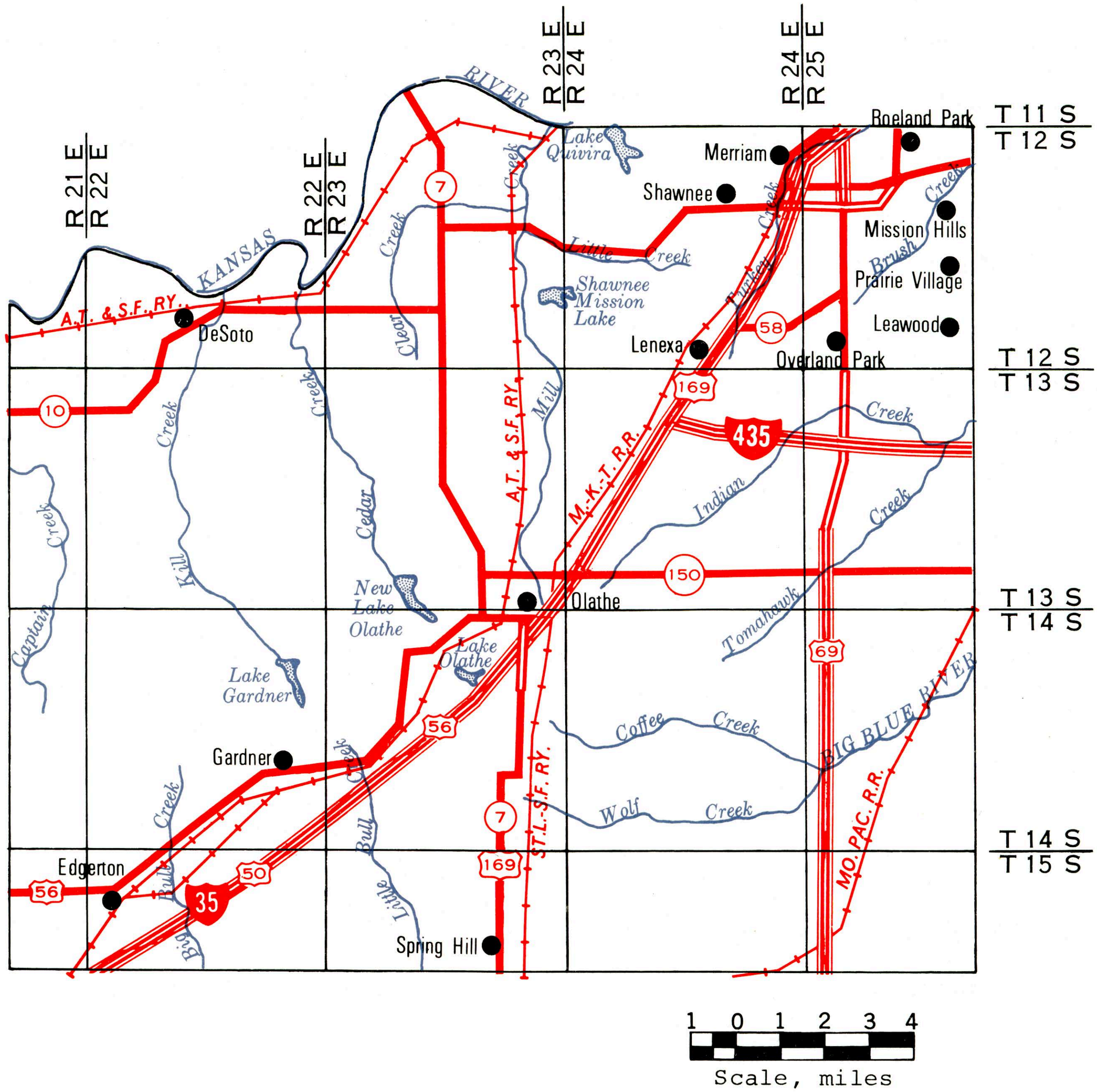


Figure 2. Drainage and major transportation facilities in Johnson County.

FACTS ABOUT JOHNSON COUNTY

Johnson County, located in eastern Kansas, includes all or parts of 21 townships and constitutes an area of about 478 square miles. The northeastern part of the county is primarily an urban area, including about a dozen cities. According to the Kansas State Board of Agriculture, the population of Johnson County was 216,783 in 1969.

The highest point in the county, located in the southeastern part, is approximately 1,135 feet above sea level. The lowest point, about 740 feet, is near the Kansas River where it flows eastward into Wyandotte County. Maximum relief is approximately 395 feet.

Major railroads and highways are present in Johnson County and serve all major cities. A well-developed secondary road system provides good access to nearly all small communities. Figure 2 illustrates drainage, railroads, and major highway locations.

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.

During phase one, relevant information concerning geology, soils, and construction material of the county was reviewed and the general geology was determined. Quality test results of samples taken in Johnson County were then correlated with the various geologic units and unconsolidated deposits.

Phase two consisted of study and interpretation of aerial photographs taken by the Kansas Highway Commission at a scale of one inch equals 2,000 feet. Figure 3 illustrates aerial photographic coverage of Johnson County. Geologic source beds and all open material sites were mapped and classified on aerial photographs. All material sites were then correlated with the geology of the county.

Phase three was conducted after initial study of aerial photographs. A field reconnaissance was conducted by the author to examine construction material, to verify doubtful mapping situations and acquire supplemental geologic information. Geologic classification of open sites was confirmed and prospective sites were observed.

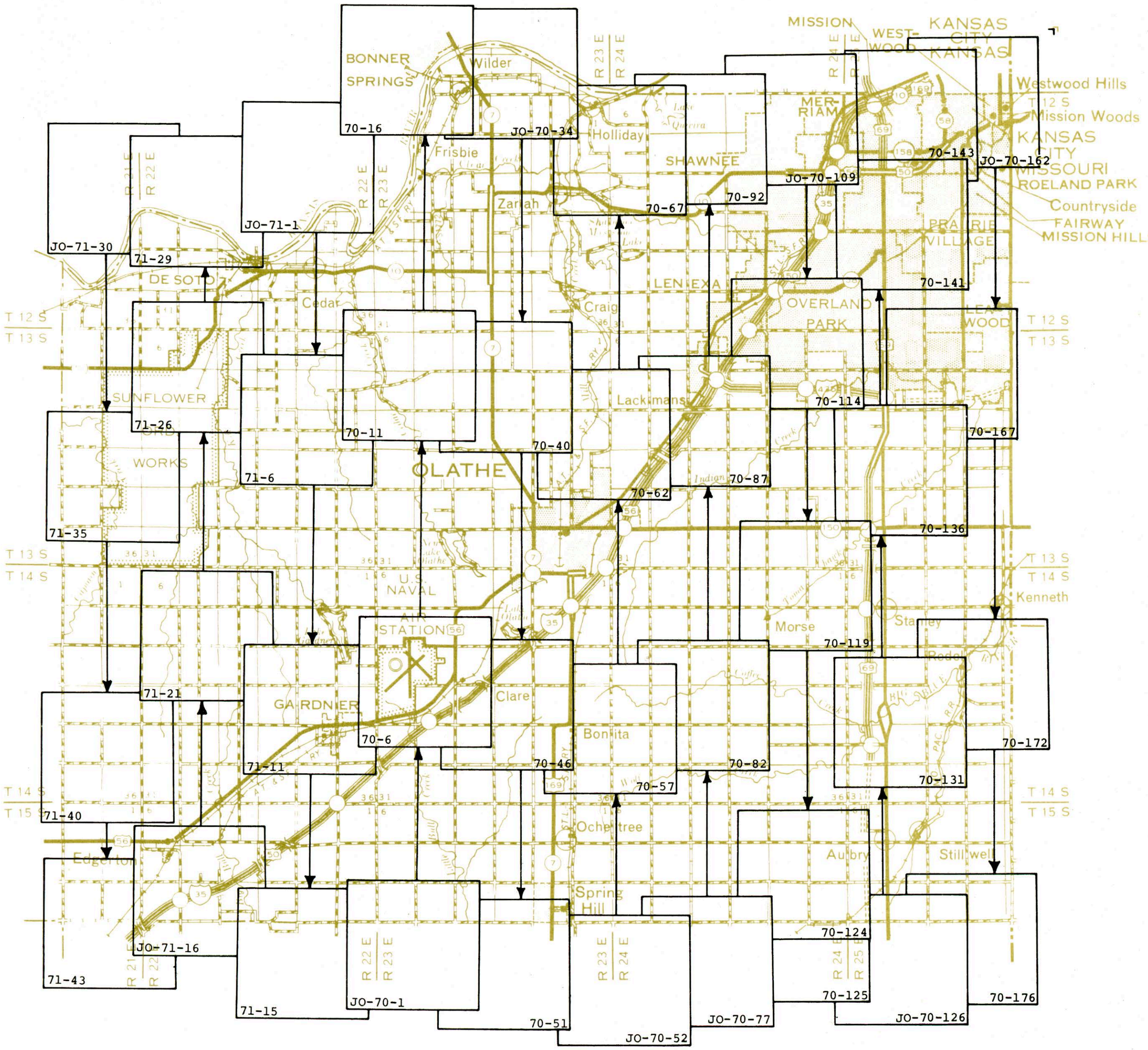
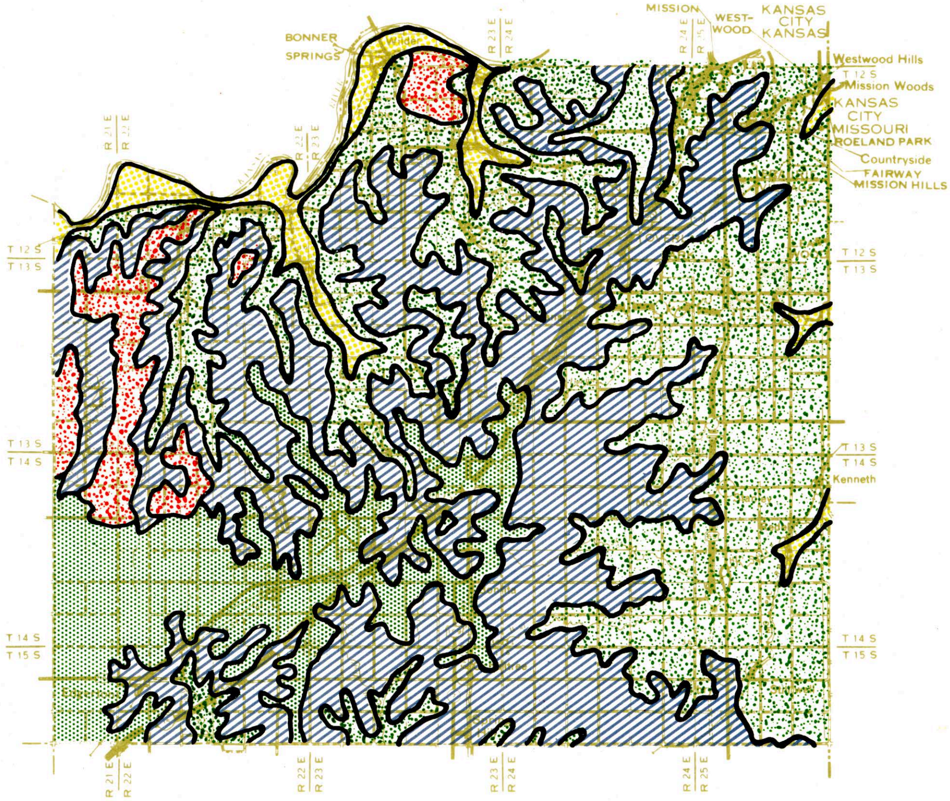


Figure 3. Aerial photographic coverage map for Johnson County. The numbers refer to photographs taken by the Photogrammetry Section of the State Highway Commission of Kansas, on January 27, 1970 and March 5, 1970. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

GEOLOGY SECTION



LEGEND

Alluvium

Glacial Drift

Lansing Group

Douglas Group

Kansas City Group

GENERAL GEOLOGY

Material source units are the product of geologic agents, therefore, GEOLOGY is the basis on which this report was conducted. This makes it possible to ascertain general properties of construction material, to identify and classify each according to current geologic nomenclature, and to establish a uniform system of material source bed classification.

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.

Geologic classification of unconsolidated material generally denotes age rather than material type; therefore, deposits may vary greatly in composition because of the difference in parent material, carrying capacity of the depositing agent, mode of deposition and weathering processes. By obtaining a knowledgeable understanding of the geologic age, origin, landform, and quality test data of source units, apposite information may be obtained concerning untested and prospective construction material sites.

Johnson County geology, as discussed in this report, is presented to provide a general understanding of the geologic events which contributed to deposition of construction material resources. Suitable construction material in Johnson County is available at or near the surface, therefore, emphasis is placed on the geologic time during which these units were deposited. Figure 4, a geologic timetable, illustrates major time periods and their respective durations.

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

Sedimentary deposits from Quaternary to Cambrian ages underlie Johnson County and overlie a basement complex of Pre-Cambrian igneous and metamorphic rock. Deposits of Tertiary, Jurassic, Triassic and Permian age are not present. The thickness of Paleozoic bedrock ranges from about 2,150 feet in the southeast to approximately 2,550 feet in the southwest. These Paleozoic sediments are primarily limestone, dolomite, sandstone, and shale. Figure 5 is a generalized geologic column of the surface geology in Johnson County.

Deposits of upper Pennsylvanian age are the oldest exposed Paleozoic bedrock in the county. Limestone units of this age are the most abundant and significant source of construction material. Most limestone, shale, and discontinuous sandstone beds were deposited in shallow sea environments. Erosion occurred during brief periods of land emergence and perhaps at this time thick sandstone beds (Ireland Sandstone Member) were deposited in existing drainage channels. Intermittent swamp conditions were present as evidenced by thin, discontinuous coal beds. Elevation of the land mass and subsequent sea regression brought a close to the Paleozoic Era.

During the Mesozoic Era (Triassic and Jurassic Periods) erosion was the prominent process. Deposits of these ages are not present in Johnson County. Continued erosion during the period probably removed much pre-existing Pennsylvanian bedrock. A final invasion of the sea occurred in late Mesozoic time (Cretaceous Period) and if sediments of this age were deposited they were removed by erosion during Cenozoic time.

System	Series	Stage or Group	Graphic Legend	Formations & Members		Map Symbol	Thickness	General Description	Construction Materials
Quaternary	Pleistocene	Recent Wisconsinan & Illinoisan		Alluvium & Terrace Deposits		Qal	0' to 80'	Clay, silt, and sand grading downward to coarse gravel in the Kansas River Valley.	Concrete aggregate, bituminous aggregate, light type surfacing material, filler material.
		Kansan		Glacial Drift		Qgd	0' to +100'	Predominantly clay and sandy clay. Contains local concentrations of sand and gravel with some boulders.	Construction aggregate, light type surfacing material.
Pennsylvanian	Upper Pennsylvanian	Douglas Group		Lawrence Formation	Ireland Sandstone Mbr.	Pl	50'	Fine grained quartz-mica sandstone. Contains minor amounts of shale and conglomerates.	Light type surfacing and filler material. Fine aggregate.
				Stranger Formation	Weston Shale Mbr.				
		Lansing Group		Stanton Limestone Formation	South Bend Ls. Mbr.	Ps			
					Rock Lake Sh. Mbr.				
					Stoner Ls. Mbr.		13' to 18'	A light gray, fine-grained, thin to medium bedded limestone with very thin shale partings.	Light type surfacing. Base course aggregate, shoulder material, concrete aggregate, bituminous aggregate.
					Eudora Sh. Mbr.				
					Captain Creek Ls. Mbr.		5' to 10'	Fine to medium grained, gray, medium bedded limestone. Contains scattered chert nodules near middle in some outcrops.	Construction aggregate, light type surfacing material, riprap.
				Vilas Shale Formation					
				Plattsburg Limestone Formation	Spring Hill Ls. Mbr.	Pp	10' to 25'	Light to medium gray, fine grained, thin to medium bedded limestone contains some chert nodules in lower part.	Construction aggregate, riprap, light type surfacing material, shoulder material, base course aggregate.
					Hickory Creek Sh. Mbr.				
					Merriam Ls. Mbr.		1' to 4'	A thick bedded, massive, yellowish, gray limestone.	Light type surfacing material, riprap, construction aggregate, base course material, shoulder material.
		Kansas City Group, Zarah Subgroup		Bonner Springs Shale Formation					
				Wyandotte Limestone Formation	Farley Ls. Mbr.	Pw	0' to 35'	A light gray to medium gray, thin to massive bedded limestone. Shale beds up to 11 feet thick are present in local areas.	Construction aggregate, riprap, light type surfacing material, shoulder material, base course material.
					Island Creek Sh. Mbr.				
					Argentine Ls. Mbr.		2' to 75'	A very light to bluish-gray, thin to medium, wavy bedded limestone, with numerous very thin shale partings.	Construction aggregate, light type surfacing material, riprap, base course aggregate, shoulder material.
					Quindaro Sh. Mbr.				
					Frisbie Ls. Mbr.		1' to 5'	A gray, fine grained, dense, massive-bedded limestone.	Construction aggregate, riprap, light type surfacing, base course aggregate, shoulder material.
				Lane Shale Formation					
		Kansas City Group, Linn Subgroup		Iola Limestone Formation	Raytown Ls. Mbr.	Pli	5' to 15'	A gray, thin to medium bedded, crystalline limestone.	Light type surfacing, shoulder material, base course aggregate.
					Muncie Creek Sh. Mbr.				
					Paola Ls. Mbr.		1' to 2'	Dense, gray to blue-gray, very hard limestone. Generally single-bedded with prominent vertical jointing.	Light type surfacing material, riprap, base course aggregate, shoulder material.
				Chanute Shale Formation		Pcd			
				Drum Limestone Formation				A massive appearing limestone in fresh exposures but weathers to thin medium, wavy beds. Light gray to gray and finely crystalline.	Light type surfacing material, base course aggregate, shoulder material.
				Cherryvale Shale Formation	Quivira Sh. Mbr.	Pcds			
					Westerville Ls. Mbr.		4' to 20'	A light to medium gray, thin to medium bedded limestone. The upper part is generally irregular crossbedded.	Light type surfacing, shoulder material base course aggregate, building stone, riprap.
					Wea Sh. Mbr.				
					Block Ls. Mbr.				
					Fontana Sh. Mbr.				
		Kansas City Group, Bronson Subgroup		Dennis Limestone Formation	Winterset Ls. Mbr.		30'	Dark gray to blue-gray, medium to thick bedded limestone. Scattered gray to black chert nodules are present in the upper beds. Interbedded black shales may be present in upper-middle part of the member.	Base course aggregate, light type surfacing, shoulder material.
					Stark Sh. Mbr.				
				Galesburg Shale Formation					
				Swope Limestone Formation	Bethany Falls Ls. Mbr.		+20'	A light gray, dense, thin bedded limestone.	Base course aggregate, bituminous aggregate, concrete aggregate, shoulder material, light type surfacing, riprap.

Figure 5. Generalized geologic column of the surface geology in Johnson 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.

All unconsolidated construction material located in Johnson County was deposited during the Cenozoic Era. Perhaps during the early part of this era (Tertiary System), simultaneous deposition of Pliocene sediments and erosion of existing Pennsylvanian units occurred. No deposits of Tertiary age are recognized in the county. They were probably removed by Pre-Quaternary erosion.

The Pleistocene Epoch of the Quaternary Period represents times of repeated glacial activity in northeast Kansas. Figure 6 illustrates divisions of the Quaternary System and approximate durations of glacial-interglacial periods. Glacial deposits of Pleistocene age are present in much of northern Johnson County.

Most construction material in these sediments was deposited in abandoned valleys by glacial meltwater of Kansan age. These outwash deposits are present in local areas along the south bluff and in the subsurface of the Kansas River Valley. As the last glacial ice retreated (Wisconsinan Age), streams alluviated their valleys with Recent sediments.

Deposits of gravel, sand, and silt, which occur as alluvial fills in stream valleys of Johnson County, are predominantly Recent in age. The Kansas River valley comprises most of these sediments. The valley ranges in width from about 1.0 to 2.0 miles, and the thickness of alluvial fill varies from 40 to 80 feet.

GEO-ENGINEERING

This section is a general appraisal of the material available in Johnson County for embankment, shoulder, and subgrade construction. Potential geo-engineering problems and the quality of water available for concrete are briefly discussed. *Detailed field investigation may be necessary to ascertain the severity of specific problems and to make recommendations concerning design and construction procedures.*

Three general physiographic regions are present in Johnson County. Geo-engineering problems in each region may vary; however, some problems are common throughout the county.

Region I

Region I is located in the northwestern one-fourth of the county. This area is characterized by thick alluvial deposits in the Kansas River valley and glacial drift underlain by limestone and shale units. Glacial deposits cap most interstream areas and alternating limestone and shale beds crop out on steep slopes adjacent to major drainage channels.

Deep cuts and high fills may be necessary for highway improvements in this area. Ground-water problems can be anticipated when excavating at or near the base of limestone beds. Slip-outs and slides may occur on backslopes constructed in shale and soil mantle, especially where ground-water is present.

Mantle of Region I includes glacial drift, alluvium, and residual soil. Most residual soils in this area have high plasticity indices and are clay or silty clay, which would be classified A-6 or A-7 according to A.A.S.H.O. Alluvium in the Kansas River valley contains much sand and is generally acceptable for embankment, shoulder, and subgrade construction. Deposits of glacial origin may contain clay, silt, sand, gravel, or combinations thereof. Backslope and subgrade problems can be expected in these deposits when ground-water or perched ground-water is present. The Glacial clays and silty clays have high plasticity indices and should be avoided in subgrade construction.

Ground-water is available in large quantities from shallow wells in Kansas River Alluvium. According to O'Connor (1970) these wells will produce from 150 to 1,000 gallons per minute, but it is a very hard calcium bicarbonate water generally containing much iron.

Region II

Region II comprises upland areas in the south-central and southwest part of the county. Much of the relatively flat upland is underlain by the Stanton Formation and the lower part of the Stranger Formation (Weston Shale). Ground-water problems may exist at the base of limestone units, and in black fissile shale of the Stanton Formation. Stability problems and slides are common in the Weston Shale Member.

Most soil mantle in this region is clayey and highly plastic. With the exception of those derived from Ireland Sandstone, these soils would be classified as silty clay, clay, or clay loam according to Kansas textural classification. Soils derived from the Ireland Sandstone are silty to sandy and usually have a plasticity index of less than ten.

Good quality ground-water is limited to the Ireland Sandstone in this region. Yields of 3 to 25 gallons per minute have been reported but commonly average about 15 gallons per minute from 40 to 60 foot wells. Limited water supplies are available locally in alluvium deposits along Bull Creek and in the Stanton Formation. Reported yields are one to three gallons per minute. Water from the Stanton Formation may be unsuitable for concrete mix because of high dissolved solids and chloride content.

Several small reservoirs are present in this region which may be a possible source for concrete mix water.

Region III

Region III includes the east one-half and those parts of the northwest and southwest one-fourth of Johnson County not previously discussed. The region comprises gentle to moderate relief along stream divides with rugged terrain near major drainage channels. Thin to thick alternating limestone and shale beds crop out over most of the region. Thin residual soil is present in upland, interstream areas.

Deep cuts will be required for most highway improvements and large volume rock excavation will be necessary, especially in the eastern part of the county. Ground-water is usually present at, or near the base of most limestone units, in black fissile shales and sandstone beds. Shales generally have a high clay content with inherent problems of stability, slip-outs and high swell. The Wyandotte Limestone is of particular geo-engineering significance because karst topography and large, clay-filled solution joints have developed in this formation where it is near the surface and relatively thick.

Most soils in this region are residual and have a high clay content except in stream valleys where soils may be silty or sandy. Residual clays and silty clays have plasticity indices ranging from 20 to 45. These would be classified as A-6 or A-7 according to A.A.S.H.O.

Limestones and some sandy shales of the Kansas City-Lansing Groups will yield water locally in varying amounts. Most wells will produce less than ten gallons per minute. Dissolved solids may range up to 5,092 parts per million (O'Connor, 1970) and water from this region should be tested before use for concrete mix.

MATERIALS INVENTORY SECTION

GENERAL INFORMATION

Construction material in Johnson County includes limestone, sand and gravel.

The principal source units of limestone aggregate are the Argentine and Farley Limestone Members of the Wyandotte Formation and the Stoner Limestone Member of the Stanton Formation. Spring Hill and Westerville Limestone Members have been quarried at several localities in past years, primarily for building stone. The Winterset Limestone Member of the Dennis Formation and the Bethany Falls Limestone Member of the Swope Formation are possible source units for construction material. Because of excessive overburden and poor accessibility, these units have not been quarried in Johnson County.

Glacial drift and alluvium are major sources of sand and gravel in the county. Binder soil may be obtained from select locations in Kansas River alluvium.

CONTENTS OF CONSTRUCTION MATERIALS INVENTORY SECTION

TYPE material and geologic source	USE	DESCRIPTION page	AVAILABILITY
LIMESTONE			
Bethany Falls Limestone Member	Light type surfacing. Base course aggregate. Shoulder material Concrete aggregate. Bituminous aggregate. Riprap.	20	Northeast ¼ of the county in the bed of Indian Creek. Plates II & IV.
Winterset Limestone Member	Base course aggregate. Light type surfacing. Shoulder material. Riprap.	20	NE¼ of county along Indian & Tomahawk Creeks near the state line. Plates II & IV.
Westerville Limestone Member	Base course aggregate. Light type surfacing. Shoulder material. Building stone. Riprap.	21	North and East ¼ of county. Along Mill and Tomahawk Creeks, and Big Blue River. Plates II & IV.
Drum Limestone Formation	Base course aggregate. Light type surfacing. Shoulder material.	22	North and East ¼ of county along Mill and Tomahawk Creeks and Big Blue River. Plates II & IV.
Iola Limestone Formation	Base course aggregate. Light type surface. Shoulder material. Concrete aggregate. Bituminous aggregate.	24	North and East 1/3 of county along Mill, Indian, Tomahawk Creeks and Big Blue River. Plates II, IV, & VI.
Wyandotte Limestone Formation	Light type surfacing. Base course aggregate. Shoulder material. Concrete aggregate. Bituminous aggregate. Riprap.	25	All of county except upland areas in Central and Southwest parts of county. Plates III, & V.
Plattsburg Limestone Formation	Light type surfacing. Base course aggregate. Shoulder material. Concrete aggregate. Bituminous aggregate. Riprap.	28	All of county except R25E and upland areas of Central and Southwest parts of county. Plates III & V.
Stanton Limestone Formation	Light type surfacing. Base course aggregate. Shoulder material. Concrete aggregate. Bituminous aggregate. Riprap.	30	All of county except R25E and upland areas of Central and Southwest parts of county. Plates III & V.
SANDSTONE			
Ireland Sandstone Member	Filler. Light type surfacing. Fine aggregate.	32	SW¼ of the county. Plates III & V.
SAND & GRAVEL			
Quaternary Glacial	Light type surfacing material. Fine aggregate.	33	NW¼ of the county. Plates I & II.
Quaternary Alluvium	Fine aggregate. Coarse aggregate. Light type surfacing material. Filler material.	34	NW¼ of the county in Kansas River Valley. Plates I & II.

Figure 7. Tabulation of the construction material types and their availability in Johnson County.

DESCRIPTION OF CONSTRUCTION MATERIAL

Limestone

Swope Limestone Formation, Bethany Falls Limestone Member

The Bethany Falls Limestone is exposed only in Indian Creek in sections 10 and 11, T13S, R25E. It is a light gray, dense, thin to massive-bedded limestone about 25 feet thick.

No quality tests have been performed on the Bethany Falls in this area. It has been sampled, tested, and quarried extensively from mines in nearby Wyandotte County where it is an important source of construction material. The good quality of Bethany Falls aggregate from Wyandotte County is reflected in results listed below:

	Sample No. 1	Sample No. 2
Specific gravity (saturated)	2.61	2.63
Specific gravity (dry)	2.55	2.59
Los Angeles wear	29.70	28.20
Soundness loss ratio	0.97	0.96
Percent absorption	1.97	1.34

Assuming a similiar quality of Bethany Falls is available in Johnson County, the material can be used for most phases of highway construction. Quarry sites would be located in or near the valley floor of Indian Creek of extreme east-central Johnson County.

Because of thick overburden and poor accessibility, the Bethany Falls has not been quarried in the county.

Dennis Limestone Formation, Winterset Limestone Member

The Winterset Member is a light, bluish-gray and light gray limestone containing abundant chert in the upper and middle part.

Black platy shale beds up to 0.5 feet thick are present near the middle of the unit. Individual limestone beds are uneven to wavy-bedded and may contain thin clayey partings.

There are good exposures of Winterset Limestone along Indian and Tomahawk Creeks in eastern Johnson County. Thicknesses of about 30 feet were observed in several outcrops and the limestone probably retains this thickness in the subsurface.

No material has been produced from this unit because thicker limestones, which can be quarried more economically, are available in Johnson County. Chert impurities may also be deleterious in concrete and asphalt mixes.

No quality test results are available from the Winterset Member.

Cherryvale Shale Formation, Westerville Limestone Member

Thickness of the Westerville Limestone is one of the most variable in Johnson County. Outcrop thicknesses vary from about 4 to 20 feet in the eastern part of the county. Drill logs show a greater variation in the subsurface (0 to 35 feet). Maximum observed thickness was in an abandoned quarry located in the NW¼ sec. 35, T12S, R25E (figure 8).

The upper part of the Westerville, highly variable in thickness and distribution, comprises very light gray, cross-bedded, oolitic limestone which has been used for building stone in the Kansas City area. The lower part, more persistent and uniform in thickness, consists of fine-grained, thin to medium-bedded, light gray limestone. A shale zone is present at several exposures between the upper and lower unit. Along the south bluff

Figure 8. Westerville Limestone exposure in an abandoned quarry, NW sec. 35, T12S, R25E.

of the Kansas River (Wyandotte County) this calcareous shale ranges up to six feet in thickness.

Because of poor accessibility, excessive overburden, nearness of more economical limestones, and the presence of detrimental shaly zones, the Westerville Member has not been quarried for highway construction material.

No quality tests have been performed on the limestone, however, if proper precautions were taken to prevent contamination from shale zones, a material of good quality may be produced. The outcrop pattern of this member is shown on plates II and IV.

Drum Limestone Formation

The Drum Limestone is separated from the underlying Cherryvale Formation by two to ten feet of clayey and black, fissile shale. Exposures of the Drum are most prominent along the bluffs of Blue River and Tomahawk Creek in east-central Johnson County.

The Drum Formation normally has two members, which in ascending order are, the Dewey and Corbin City Limestones. In Johnson County, the Dewey Member represents all of the Drum in most outcrops. The formation thickness averages about ten feet in northern and central parts of the county and about five feet in the east central area. In fresh exposures it appears as a medium to light gray, massive limestone. Upon weathering it becomes yellowish-gray and thin to medium-bedded. Scattered chert nodules are present in local areas.

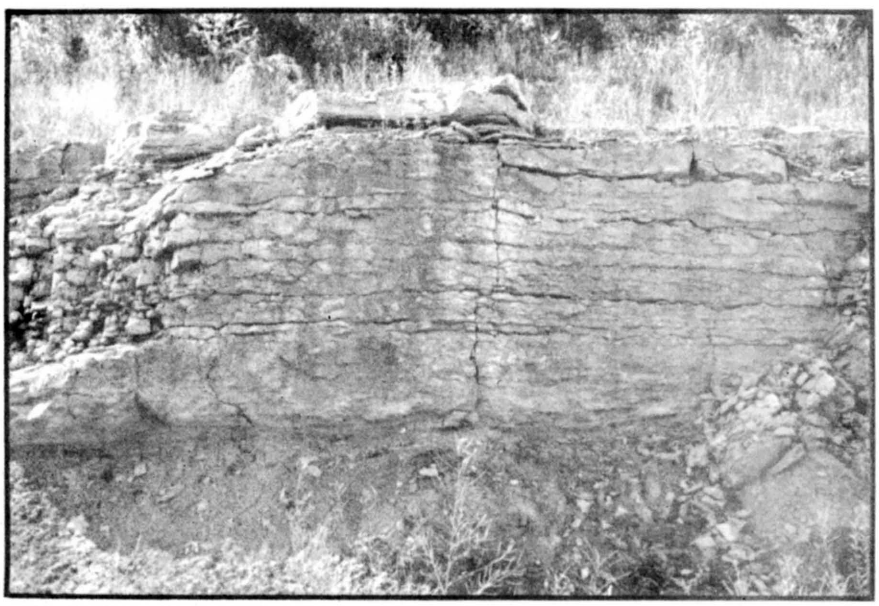


Figure 9. The Drum Limestone Formation in a road cut, NW¼ sec. 5, T12S, R25E.

Presently, no construction material is being produced from the Drum. Much thicker limestones are available in eastern Johnson County and can be quarried more economically. The Drum Formation may be a good source unit if and when these thicker limestones are depleted.

No quality tests have been made on Drum samples. Chemical analyses from one locality in sec. 35, T12S, R25E were conducted by Runnels and Schleicher (1956) which are presented in the following table:

Sample 1

CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	SO_3	S	P_2O_5
51.95	0.66	5.04	0.74	0.66	0.05	0.02	0.11

Drum exposures are shown on plates II, IV and VI.

Iola Limestone Formation, Raytown Limestone Member

Exposures of the Raytown Member are found along the sides of most major streams in eastern and northern Johnson County. This unit is a light gray, fine to medium-textured limestone which appears thin-bedded and flaggy in weathered outcrops. At most sites visited during this investigation, the Raytown appeared to be too thin for economical quarrying. Total thickness was generally five or six feet (figure 10).

The Raytown has not been produced in Johnson County and no quality tests are available from this unit. Good quality aggregate has been produced from the Raytown in Miami County. The results are shown in the following table:

	Sample 1	Sample 2
Specific gravity (saturated)	2.60	2.61
Specific gravity (dry)	2.55	2.55
Los Angeles wear	29.80% (B)	27.00% (B)
Soundness loss ratio	0.95	0.95
Percent absorption	2.15%	2.60%

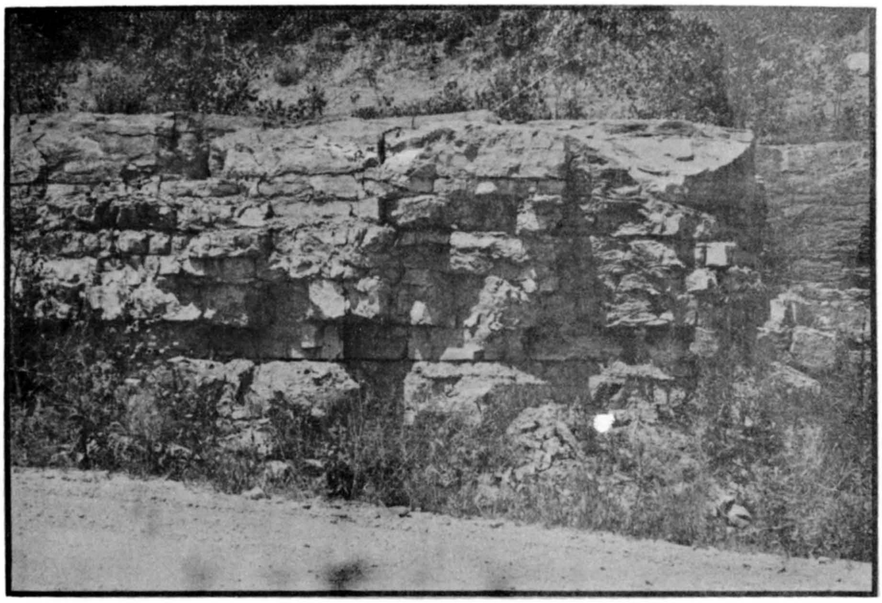


Figure 10. Iola Limestone in roadway cut SE¼ sec. 21, T14S, R25E.

The Raytown Limestone Member could be used for most highway construction purposes if quality is similar to that produced in Miami County. Where the underlying one to two foot thick Paola Limestone member is separated from the Raytown by less than 0.5 feet of Muncie Creek Shale, it may be economical to quarry with the Raytown Member. The outcrop pattern of the Iola Formation can be seen on plates II, IV and VI.

Wyandotte Formation

The Wyandotte Formation comprises five members which in ascending order are: Frisbie Limestone, Quindaro Shale, Argentine Limestone, Island Creek Shale, and Farley Limestone. The Quindaro and Island Creek Shales are commonly two to five feet thick but locally may be very thin or absent. The Wyandotte Formation map unit used in this report includes all limestone members of the formation. The Argentine and Farley are the most important source of commercially minable limestone in Johnson County.

The Wyandotte crops out extensively over much of the county except in the upland area from approximately Olathe, southwest to the Douglas County line.

Generally the Argentine and Farley Members are lithologically quite similar. They consist of light to medium gray, thin to medium wavy-bedded limestones devoid of shale partings (figure 11). Combined thickness of these units is in excess of 90 feet in southeast and central Johnson County. In local areas, mainly the south one-half of T13S, R25E, and the north one-third of T14S, R25E, the Wyandotte is relatively thin. Thicknesses of less than five feet have been found in this general area.

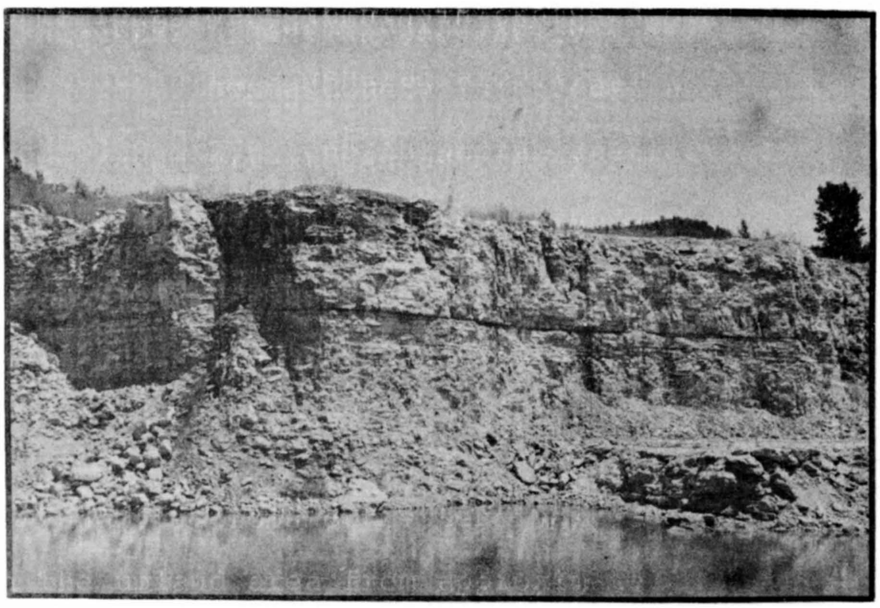


Figure 11. The Argentine-Farley Limestone Members of the Wyandotte Formation in a quarry, SE¼ sec. 31, T14S, R25E.

According to Ives and Runnels (1960) the best probable Wyandotte reserves are located in the Aubry-Stilwell area and west of Olathe within an area beginning near the New Olathe Lake and extending northward along Cedar Creek. They report thicknesses from about 40 to 90 feet at both locations. A third area of probable reserves and where the formation is quite thick, is west and north of Lenexa along the bluffs of Mill Creek. Several quarries and two room and pillar mines (figure 12) are presently producing limestone aggregate from this locality.

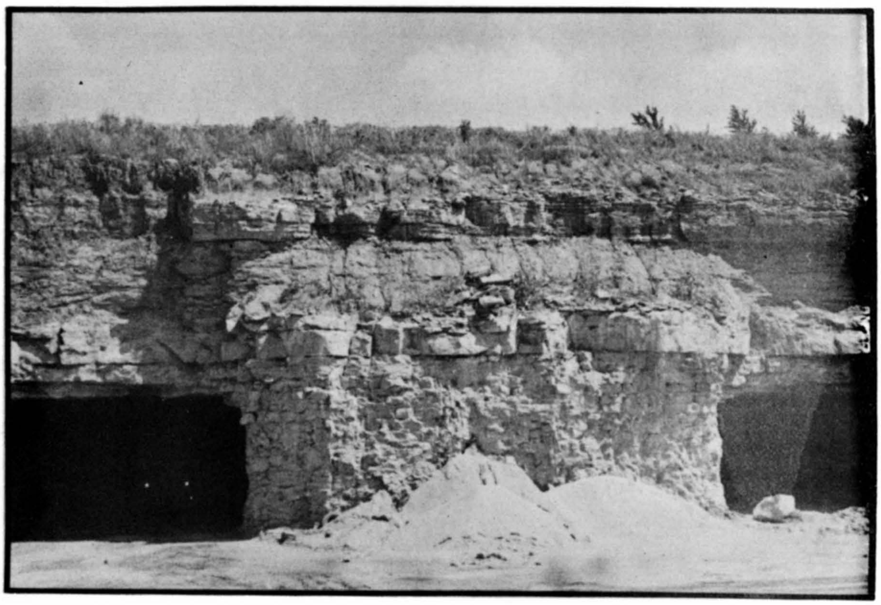


Figure 12. Wyandotte Limestone Mine, SE¼ sec. 6, T13S, R24E.

Karst topography (figure 13) and large solutioned joint cracks have developed in the Wyandotte where it is relatively thick and at or near the land surface. Clay contamination may be a problem when quarrying operations encounter these situations. Abrupt lateral facies changes are also present in the formation and should be considered when prospecting for material sites.

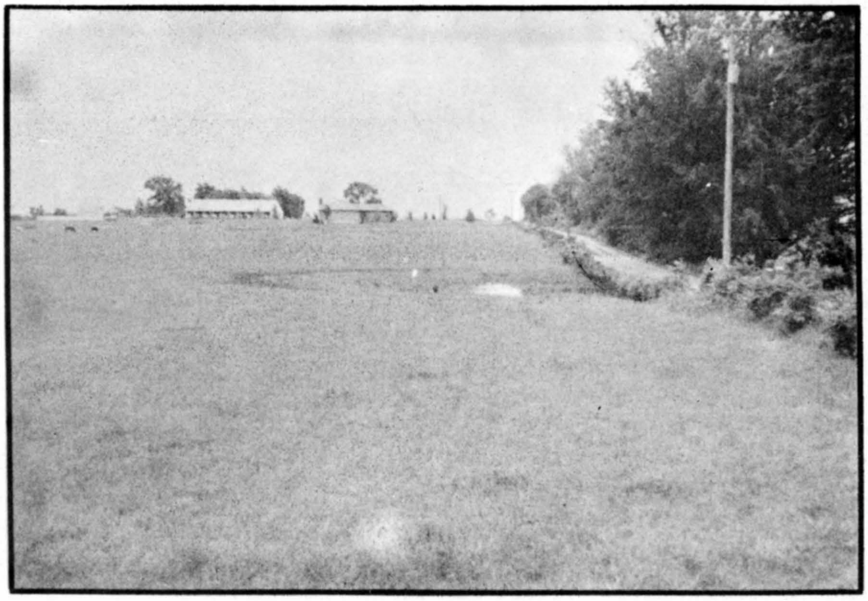


Figure 13. Sinkhole in Karst topography SE¼ SE¼ sec. 30, T14S, R25E.

Quality test results are available on Argentine and Farley samples from several quarries in Johnson County. Representative test data show a specific gravity (saturated) of 2.61, a specific gravity (dry) of 2.55, a Los Angeles wear of 27.5, a soundness loss ratio of 0.97, and an absorption of 1.83%. It is noted that in local areas the Farley Member may have high absorption properties.

Based on quality test results, material from the Argentine and Farley Members in Johnson County can be used for most phases of highway construction. Outcrop patterns of the Wyandotte Formation are shown on all plates of the county materials map.

Plattsburg Limestone Formation

The Plattsburg Limestone overlies the Bonner Springs Formation and is divided into three members: the Merriam Limestone, Hickory Creek Shale, and Spring Hill Limestone.

The formation ranges in thickness from about 15 to 25 feet with an average of 20 feet. Hickory Creek Shale, which separates the Spring Hill and Merriam Limestones, is generally less than one foot thick. Locally where the shale unit is absent, both limestone members have been quarried for construction material. In Johnson County the Spring Hill is the most important source unit in the Plattsburg Formation.

The Merriam is a gray to bluish-gray, massive to blocky limestone with varying thicknesses from one to six feet. The Spring Hill Limestone, comprises three lithologic zones with an aggregate thickness range of 10 to 22 feet. The lower and upper part of the unit are commonly massive appearing in fresh exposures. Upon weathering, thin shaly partings separating the thin to medium-even beds become evident. Scattered, light gray chert nodules are present in the lower beds, but locally the Spring Hill may contain abundant chert. These upper and lower fine-grained, gray limestone beds are separated by a light gray limestone containing abundant broken fossil detritus.

Numerous abandoned Plattsburg quarries are present in northern Johnson County where rock was produced primarily for building stone and riprap. Only the weathered outcrop edge, which could be removed by ripping or dozing was quarried. Several of these abandoned quarries contain large volumes of limestone that could be used for construction purposes if blasting were used. One active Plattsburg quarry (figure 14) was located during the study. Rock was being produced for use as building material.

Two abandoned quarries located in southern Johnson County have been sampled and tested by the State Highway Commission.

Figure 14. The Plattsburg Limestone Formation in a quarry, SE¼ sec. 31, T12S, R24E.

Quality test results show the Plattsburg Limestone to be acceptable for most phases and types of highway construction.

Plattsburg exposures are extensive except in the extreme eastern part of the county. The outcrop pattern is illustrated on all six plates of the county materials map.

Stanton Limestone Formation

The Stanton Formation, consisting of three limestone and two shale beds, is exposed over much of the upland area in the western two-thrids of Johnson County. The formation comprises an average thickness of approximately 40 feet.

The most important source units of the formation are the Captain Creek and Stoner Limestone Members. Both beds have been quarried extensively in eastern Kansas. Locally when the interbedded Eudora Shale is thin, both units are produced at the same sites.

In Johnson County, the Stoner is a more important source than the Captain Creek. Because of the relatively thin shale member between these beds, they have been mapped as one unit and represent the Stanton Formation in this report.

The Captain Creek Member is a medium gray, fine-grained limestone characterized by thin to medium-even beds. Thickness is about five feet in most outcrops. A maximum thickness of 11 feet was observed along I-35 in southwestern Johnson County.

The Stoner is a light, gray, fine-grained limestone containing thin to medium-wavy beds. It has an average thickness of approximately 16 feet and makes a prominent bench along the Stanton outcrop. The Stoner has been quarried in central and western parts of the county due mainly to its extensive surface exposure.

Three active and several abandoned Stoner quarries are present in Johnson County.

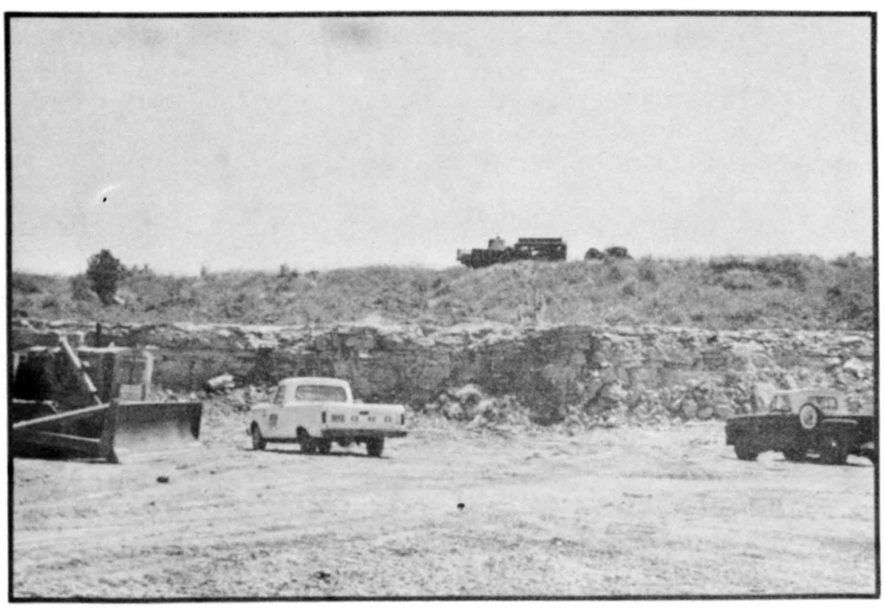


Figure 15. A view of the Stoner Limestone Member of the Stanton Formation in a quarry, NW¼ sec. 8, T15S, R22E.

Available test data from the Stoner Member shows the specific gravity (saturated) ranges from 2.59 to 2.75, the specific gravity (dry) from 2.50 to 2.56, the Los Angeles wear from 27.8 to 37.7, the soundness loss ratio from 0.80 to 0.99, and the absorption from 0.66 to 2.50.

Material from the Stanton Formation (Captain Creek and Stoner Members) is suitable for most highway construction purposes; however, the Stoner is known to have high absorption percentages in some areas of eastern Kansas. Outcrop pattern of the Stanton Formation is shown on all plates of the county materials map.

Sandstone

Lawrence Shale Formation, Ireland Sandstone Member

The Ireland comprises fine and very fine-grained quartzose and micaceous sandstone with minor amounts of shale, coal, and silt. Subangular to subrounded quartz grains, silt particles, and mica flakes are cemented by silica and calcium carbonate. Exposures of the sandstone generally are poorly cemented because cementing agents have been leached away.

Sandstone from the Ireland has been quarried in nearby counties for light type surfacing material and fine hot mix aggregate. The Ireland has not been produced in Johnson County, but is a potential source of sandstone for construction purposes.

The sandstone lies on an irregular erosional surface cut in the Weston Shale. Upper and lower contacts are highly irregular. Exposures of the Ireland are in southwest Johnson County. Its outcrop pattern is shown on plate V.

Glacial Drift

Glacial drift deposits consisting of clay, silt, sand, and gravel and combinations of these are on or near the surface over much of northern Johnson County. Locally these deposits are composed of sand, gravel, and scattered boulders commonly bound by a red-brown clay matrix. Dufford (1958, p. 46), reported more than 100 feet of this material in the Holiday Area. Sand and gravel has been produced from these deposits; however, all known pits have been exhausted or abandoned (figure 16), because of the availability of a more suitable and economical material in the Kansas River valley.

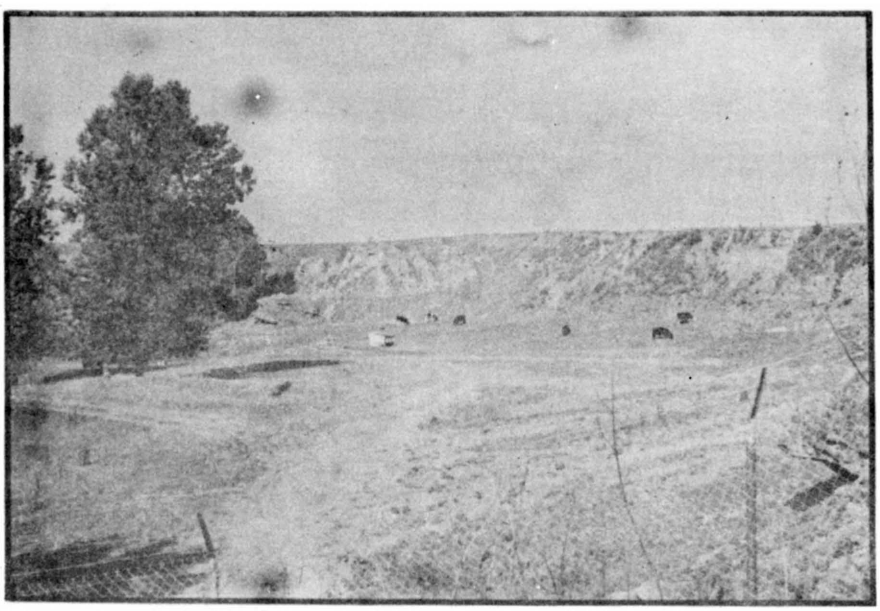


Figure 16. An abandoned sand and gravel pit in glacial till, NW¼ sec. 11, T12S, R23E.

Several northeast trending linear ridges in sections 26 and 35, T13S, R21E, are of glacial origin and may contain possible sand and (or) gravel deposits. The ridge in section 26, T13S, R21E, is shown as a prospective material site on plate III. Other potential material sources were observed within the mapped glacial drift boundaries but they appeared too limited in volume and are quite inaccessible. Detailed field studies and test drilling would be necessary to determine their extent. Glacial Drift areas are mapped on plates I, II and III.

Alluvium and Terrace Deposits

Deposits of gravel, sand, silt, and clay, which occur as undifferentiated terrace and alluvial sediments are predominantly Wisconsinan and Recent in age. These deposits are included in the Alluvium map unit in this report. Although sand and gravel is found in the Kansas River valley, similar age deposits found in other stream valleys in the county are composed primarily of silt and silty clay.

Very fine, fine, and medium size sand with interbedded silt lenses comprise much of the upper part of Kansas River alluvium. Sediments become coarser in the middle and lower part, grading from medium sand downward to coarse sand and gravel. The basal part of the alluvium contains gravel ranging from cobble to boulder size and is probably of glacial origin. Alluvial fill within the Kansas River valley ranges from about 40 to 80 feet in thickness.

Construction material has been produced from several pits located within the valley. Most was produced from near surface deposits and consisted of fine to medium-grained sand. Dredging and pumping operations are presently used to obtain alluvial deposits from the Kansas River and from pits in the valley alluvium.

By using these methods a better graded, medium size gravel to fine sand material can be produced (figure 17).

Quality test results show Kansas River alluvium to be suitable for most types of material used in highway construction. Alluvium deposits are depicted on all six plates of the county materials maps.

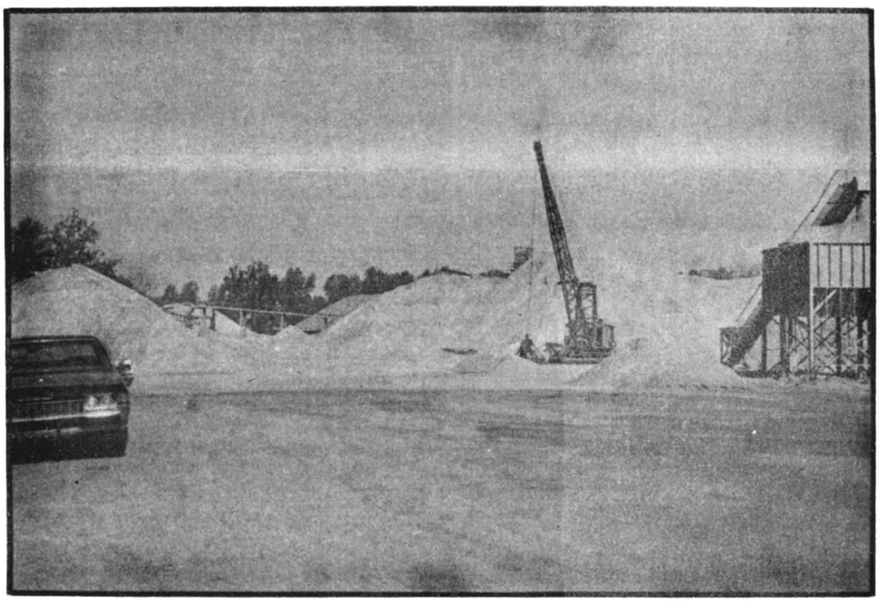


Figure 17. Sand and gravel being produced from Kansas River alluvium.

Site Data Form No.	Type of Material	Date of Test	SP. GR. Wet	SP. GR. Dry	L.A. Wear	% Absorption	% Soundness	Source of Data	Type of Sample
Source of Data: Alluvium - Qal									
SG+1	Sand & Gravel	12-10-68	2.60		35.9(D)		0.98	SHC Lab No. 68-4200	Unknown
		4-25-68	2.60					SHC Lab No. 68-1174	Unknown
		8-23-67	2.60					SHC Lab No. 67-3148	Unknown
		12-30-66	2.60		35.4(D)		0.98	SHC Lab No. 66-5750	Unknown
SG+2	Sand & Gravel	Feb. 1961	2.61			0.5		SHC 619 No. 46-32	Unknown
		Feb. 1961	2.62		36.2	0.6	0.98	SHC 619 No. 46-32	Unknown
Source of Data: Stanton Formation (Stoner) -Ᵽs									
LS-9	Limestone	Feb. 1961	2.60	2.54	27.2	2.54	0.93	SHC 619 No. 46-30	Unknown
		Feb. 1961	2.60	2.55	24.6	1.90	0.96	SHC 619 No. 46-30	Unknown
LS+11	Limestone	2-21-69	2.61	2.55	29.6(B)	2.29	0.93	SHC Lab No. 69-195	Crushed
			2.60	2.54		2.27		SHC Lab No. 69-195	Crushed
		2-19-68	2.61	2.55	30.1(B)	2.19	0.94	SHC Lab No. 68-329	Crushed
		4-25-67	2.61	2.55	29.1(B)	2.14	0.93	SHC Lab No. 67-1360	Crushed
		12-20-65	2.61	2.56	26.0(B)	1.98	0.98	SHC Lab No. 65-5599	Crushed
		10-1-64	2.63	2.58	26.8(B)	1.87	0.96	SHC Lab No. 36765	Crushed
		4-29-63	2.62	2.53	27.5(B)	3.81	0.98	SHC Lab No. 27894	Crushed
		2-8-61	2.59	2.53	29.1(B)	2.30	0.92	SHC Lab No. 15132	Crushed
					31.5(C)				
LS+12	Limestone	Feb. 1961	2.57	2.47	33.2	3.87	0.88	SHC 619 No. 46-31	Unknown
		Feb. 1961	2.55	2.45	33.4	3.84	0.88	SHC 619 No. 46-31	Unknown
LS+13	Limestone	3-18-63	2.62	2.56	28.7(B)	2.27	0.96	SHC Lab No. 27248	Crushed
		2-8-61	2.58	2.52	27.5(B)	2.70	0.91	SHC Lab No. 15130	Crushed
LS+14	Limestone	8-9-65	2.62	2.56	28.8(B)	2.20	0.94	SHC Lab No. 65-2934	Crushed
		7-12-65	2.59	2.52	29.3(B)	2.61	0.95	SHC Lab No. 65-2298	Crushed
		7-20-64	2.56	2.51	36.1(B)	2.00	0.92	SHC Lab No. 35335	Crushed
		4-6-64	2.60	2.54	27.2(B)	2.42	0.94	SHC Lab No. 33436	Crushed
		8-9-63	2.62	2.55	30.6(C)	2.59	0.96	SHC Lab No. 29793	Crushed
		8-1-63	2.61	2.54	32.5(B)	2.49	0.93	SHC Lab No. 29690	Crushed
		8-5-63	2.61	2.54	28.3(B)	2.64	0.94	SHC Lab No. 29717	Crushed
		2-1-61	2.57	2.50	30.8(B)	2.76	0.90	SHC Lab No. 15132	Crushed
					33.8(C)				
LS+15	Limestone	3-1-59	2.59		31.0(A)	2.08	0.80	SHC 619 No. 46-1	Unknown
		3-1-59	2.65		32.2(A)	1.14	0.88	SHC 619 No. 46-1	Unknown
		3-1-59	2.64		29.6(A)	0.66	0.98	SHC 619 No. 46-1	Unknown
		3-1-59	2.63		37.7(A)	1.13	0.99	SHC 619 No. 46-1	Unknown
Source of Data: Plattsburg Formation - Ᵽp									
LS+3	Limestone	3-1-59	2.62		20.2(A)	1.72	0.92	SHC 619 No. 46-21	Unknown
		3-1-59	2.60		32.8(A)	1.90	0.89	SHC 619 No. 46-21	Unknown
		3-1-59	2.63		29.8(A)	1.14	0.90	SHC 619 No. 46-21	Unknown
LS+16	Limestone	3-1-59	2.64		27.8(A)	0.97	0.97	SHC 619 No. 46-9	Unknown
		3-1-59	2.60		30.6(A)	1.23	0.98	SHC 619 No. 46-9	Unknown
LS+17	Limestone	3-1-59	2.60		29.6(A)	1.29	0.97	SHC 619 No. 46-6	Unknown
		3-1-59	2.62		29.8(A)	1.36	0.97	SHC 619 No. 46-6	Unknown

Figure 18. Results of tests completed on samples of material from the various geologic source beds in Johnson County.

Continued

Site Data Form No.	Type of Material	Date of Test	SP. GR. Wet	SP. GR. Dry	L.A. Wear	% Absorption	% Soundness	Source of Data	Type of Sample
Source of Data: Wyandotte Formation - Pw									
LS+4	Limestone	Feb. 1961	2.55	2.48		2.78	0.97	SHC 619 No. 46-35	Unknown
LS+5	Limestone	10-12-61	2.59	2.51	29.6(B)	2.96	0.89	SHC Lab No. 19503	Crushed
					28.7(C)				
		8-15-61	2.63	2.59	25.7(B)	1.60	0.97	SHC Lab No. 18377	Crushed
					25.0(C)				
		8-8-61	2.60	2.55	29.7(B)	2.09	0.95	SHC Lab No. 18191	Crushed
					29.3(C)				
		6-20-61	2.61	2.55	27.5(B)	1.97	0.97	SHC Lab No. 17273	Crushed
LS+6	Limestone	11-24-69	2.61	2.54	29.6(B)	2.89	0.91	SHC Lab No. 69-3515	Crushed
			2.62	2.55		2.46			
		11-12-69	2.58	2.51	31.5(B)	2.67	0.97	SHC Lab No. 69-3391	Crushed
			2.58	2.52		2.75			
		10-21-69	2.59	2.52	31.8(B)	2.56	0.98	SHC Lab No. 69-3157	Crushed
			2.58	2.51		2.88			
		12-23-68	2.60	2.54	29.0(B)	2.41	0.96	SHC Lab No. 68-4310	Crushed
		5-10-68	2.61	2.55	28.8(B)	2.21	0.97	SHC Lab No. 68-1626	Crushed
		8-4-65	2.64	2.60	26.5(B)	1.57	0.96	SHC Lab No. 65-2933	Crushed
		4-6-64	2.61	2.55	24.8(B)	2.41	0.95	SHC Lab No. 33454	Crushed
		5-5-65	2.59	2.49	28.9(B)	4.08	0.83	SHC Lab No. 65-705	Crushed
		12-20-65	2.61	2.56	25.7(B)	1.98	0.97	SHC Lab No. 65-5600	Crushed
		9-27-65	2.64	2.60	27.7(B)	1.61	0.97	SHC Lab No. 65-4055	Crushed
		8-16-65	2.59	2.51	32.1(B)	3.35	0.88	SHC Lab No. 65-3057	Crushed
		7-19-65	2.59	2.51	32.5(B)	3.14	0.91	SHC Lab No. 65-2609	Crushed
		6-2-65	2.60	2.55	29.1(B)	2.16	0.95	SHC Lab No. 65-1603	Crushed
		5-5-65	2.59	2.49	28.9(B)	4.08	0.83	SHC Lab No. 65-705	Crushed
		12-21-64	2.60	2.54	26.5(B)	2.31	0.95	SHC Lab No. 38078	Crushed
		6-3-64	2.61	2.56	28.3(B)	2.01	0.97	SHC Lab No. 34410	Crushed
		12-18-63	2.62	2.57	25.8(B)	1.84	0.95	SHC Lab No. 31923	Crushed
		7-23-63	2.61	2.55	26.3(B)	2.08	0.98	SHC Lab No. 29472	Crushed
		5-28-63	2.65	2.62	23.2(B)	1.02	0.98	SHC Lab No. 28416	Crushed
		5-28-63	2.64	2.60	24.3(B)	1.45	0.99	SHC Lab No. 28414	Crushed
		4-29-63	2.59	2.54	27.0(B)	2.25	0.98	SHC Lab No. 27893	Crushed
		2-8-61	2.58	2.53	26.9(B)	1.98	0.97	SHC Lab No. 15135	Crushed
LS+7	Limestone	5-2-69	2.60	2.55	30.5(B)	2.18	0.97	SHC Lab No. 69-967	Crushed
			2.61	2.55		2.27			
		2-21-69	2.60	2.54	29.4(B)	2.49	0.96	SHC Lab No. 69-194	Crushed
			2.61	2.55		2.15			
		2-6-69	2.59	2.52	30.2(B)	2.77	0.94	SHC Lab No. 69-127	Crushed
			2.62	2.57		2.08			
		9-30-68	2.61	2.55	31.3(B)	2.26	0.95	SHC Lab No. 68-3236	Crushed
		2-19-68		2.55		2.22		SHC Lab No. 68-326	Crushed
		2-20-68	2.61	2.56	30.1(B)	2.06	0.96	SHC Lab No. 68-325	Crushed
		8-18-67	2.61	2.56	30.9(B)	2.13	0.96	SHC Lab No. 67-3087	Crushed
		2-2-67	2.61	2.56	28.4(B)			SHC Lab No. 67-186	Crushed
		2-2-67	2.60	2.54	29.2(B)			SHC Lab No. 67-185	Crushed
		6-8-66	2.61	2.57	28.6(B)	1.70	0.98	SHC Lab No. 66-2126	Crushed
		12-20-65	2.57	2.62	29.0(B)	1.89	0.97	SHC Lab No. 65-5596	Crushed
		6-3-65	2.61	2.56	28.4(B)	2.02	0.97	SHC Lab No. 65-1618	Crushed
		5-20-65	2.62	2.57	29.2(B)	1.91	0.98	SHC Lab No. 65-1404	Crushed
		12-21-64	2.61	2.55	26.9(B)	2.26	0.97	SHC Lab No. 38077	Crushed
		12-17-63	2.63	2.58	26.5(B)	1.79	0.98	SHC Lab No. 31925	Crushed
		10-4-63	2.62	2.57	27.7(B)	1.87	0.98	SHC Lab No. 30845	Crushed
		4-29-63	2.59	2.53	27.2(B)	2.25	0.98	SHC Lab No. 27895	Crushed
LS+8	Limestone	2-17-69	2.59	2.52	33.0(B)	2.63	0.96	SHC Lab No. 69-196	Crushed
			2.57	2.49		3.11			
		3-27-68	2.58	2.51	33.6(B)	2.65	0.97	SHC Lab No. 68-835	Crushed
		2-2-67	2.60	2.54	30.2(B)			SHC Lab No. 67-215	Crushed
		8-3-66	2.59	2.53	33.1(B)	2.45	0.99	SHC Lab No. 66-3220	Crushed
		10-27-65	2.57	2.51	33.1(B)	2.51	0.97	SHC Lab No. 65-4662	Crushed
		9-1-65	2.60	2.55	31.9(B)	2.15	0.98	SHC Lab No. 65-3515	Crushed
LS+10	Limestone	1-25-57	2.58		30.7(B)	2.43	0.96	SHC 619 No. 46-25	Crushed
		1-25-57	2.56		31.7(B)	2.80	0.96	SHC 619 No. 46-25	Crushed
		1-25-57			31.5(C)			SHC 619 No. 46-25	Crushed
LS+18	Limestone	3-1-59	2.57		34.4(A)	2.82	0.95	SHC 619 No. 46-23	Crushed
LS+19	Limestone	4-15-66	2.64	2.59	27.2(B)	1.86	0.96	SHC Lab No. 66-1136	Crushed
		4-4-66	2.66	2.62	25.7(B)	1.53	0.96	SHC Lab No. 66-924	Crushed
		3-29-66	2.65	2.62	27.8(B)	1.74	0.97	SHC Lab No. 66-818	Crushed
		6-21-61	2.61	2.56	27.8(B)	1.99	0.96	SHC Lab No. 17272	Crushed
					27.3(C)				
LS+20	Limestone	10-21-69	2.60	2.54	30.0(B)	2.19	0.97	SHC Lab No. 69-2874	Crushed
			2.61	2.55		2.17			
		5-1-69	2.60	2.56	28.6(B)	1.48	0.97	SHC Lab No. 69-1003	Crushed
			2.63	2.58		1.83			
		4-10-69	2.63	2.60	27.1(B)	1.33	0.98	SHC Lab No. 69-827	Crushed
			2.64	2.61		1.39			
		1-15-69	2.63	2.58	26.9(B)	1.77	0.98	SHC Lab No. 68-4527	Crushed
		1-15-69	2.57	2.49	30.9(B)	3.18	0.97	SHC Lab No. 68-4526	Crushed
		11-22-68	2.60	2.54	29.9(C)	2.46	0.97	SHC Lab No. 68-4053	Crushed
		11-25-68	2.54	2.45	33.8(C)	3.71	0.98	SHC Lab No. 68-3940	Crushed
		11-5-68	2.56	2.48	33.4(B)	3.03	0.98	SHC Lab No. 68-3793	Crushed
		5-21-68	2.53	2.45	34.0(B)	3.28	0.99	SHC Lab No. 68-1392	Crushed
		2-1-68	2.60	2.54	29.9(B)	2.30	0.96	SHC Lab No. 68-104	Crushed
		9-21-67	2.62	2.57	31.0(B)	1.88	0.97	SHC Lab No. 67-3701	Crushed
		4-25-67	2.63	2.58	26.0(B)	1.81	0.98	SHC Lab No. 67-1361	Crushed
		3-15-67	2.53	2.44	36.6(B)	3.59	0.99	SHC Lab No. 67-214	Crushed
		3-13-67	2.49	2.41	33.1(B)	3.48	0.98	SHC Lab No. 67-571	Crushed
		9-23-66	2.64	2.59	26.7(B)	1.73	0.94	SHC Lab No. 66-4215	Crushed
		9-20-66	2.53	2.44	35.4(B)	3.48	0.97	SHC Lab No. 66-4216	Crushed
		5-12-66	2.64	2.60	26.7(B)	1.32	0.98	SHC Lab No. 66-1611	Crushed
		4-25-66	2.59	2.54	30.9(B)	2.13	0.98	SHC Lab No. 66-1280	Crushed
		12-20-65	2.64	2.61	28.2(B)	1.41	0.99	SHC Lab No. 65-5601	Crushed
		9-16-65	2.65	2.61	27.2(B)	1.54	0.94	SHC Lab No. 65-3885	Crushed
		7-15-65	2.64	2.60	27.1(B)	1.56	0.97	SHC Lab No. 65-2430	Crushed
		5-6-65	2.62	2.58	25.8(B)	1.44	0.98	SHC Lab No. 65-1065	Crushed
		5-11-65	2.64	2.61	23.4(B)	1.32	0.97	SHC Lab No. 65-1223	Crushed
LS+21	Limestone	3-6-67	2.56	2.50	32.3	2.37	0.98	SHC Lab No. 46-39	Unknown
			2.57	2.50	32.0	2.36			
LS+22	Limestone	4-4-67	2.56	2.48	33.0(B)	3.03	0.99	SHC Lab No. 67-964	Crushed
		2-21-67	2.57	2.49	30.8(B)	2.89	0.94	SHC Lab No. 66-4825	Crushed
		12-8-66	2.45	2.32		5.37		SHC Lab No. 66-5511	Crushed
			2.47	2.35		4.73		SHC Lab No. 66-5511	Crushed
			2.45	2.32		5.21		SHC Lab No. 66-5511	Crushed
			2.45	2.33		5.09		SHC Lab No. 66-5511	Crushed
			2.45	2.34		5.03		SHC Lab No. 66-5511	Crushed
		10-6-66	2.41	2.26	51.6(B)	6.62	0.96	SHC Lab No. 66-4614	Crushed
		10-25-66	2.50	2.40	36.2(B)	4.49	0.96	SHC Lab No. 66-4741	Crushed
		10-18-66	2.57	2.49	30.8(B)	2.89		SHC Lab No. 66-4825	Crushed
		11-14-66	2.50	2.42	34.3(B)	3.34	0.98	SHC Lab No. 66-5029	Crushed
		10-6-66	2.41	2.26	51.6(B)	6.62		SHC Lab No. 66-4614	Crushed
		10-18-66	2.54	2.46	32.2(B)	3.17	0.98	SHC Lab No. 66-4613	Crushed
		9-8-64	2.56	2.48	38.9(C)	3.10	0.99	SHC Lab No. 36239	Crushed
		8-21-64		2.51	29.8(B)	2.58	0.96	SHC Lab No. 35903	Crushed
		8-24-64	2.57	2.49	29.2(B)	2.96	0.95	SHC Lab No. 35936	Crushed
		9-24-63	2.56	2.48	31.3(B)	3.01	0.98	SHC Lab No. 30662	Crushed
		9-12-63	2.57	2.49	30.3(B)	2.96	0.97	SHC Lab No. 30540	Crushed
		9-12-63	2.54	2.47	34.8(B)	2.94	0.99	SHC Lab No. 30393	Crushed
		2-8-61	2.57	2.50	27.8(B)	2.50	0.96	SHC Lab No. 15134	Crushed
		4-26-60	2.57	2.50	27.3(C)	2.69	0.93	SHC Lab No. 11146	Crushed
		5-3-60	2.42	2.27	47.6(B)	6.42	0.94	SHC Lab No. 11280	Crushed
					45.6(C)				