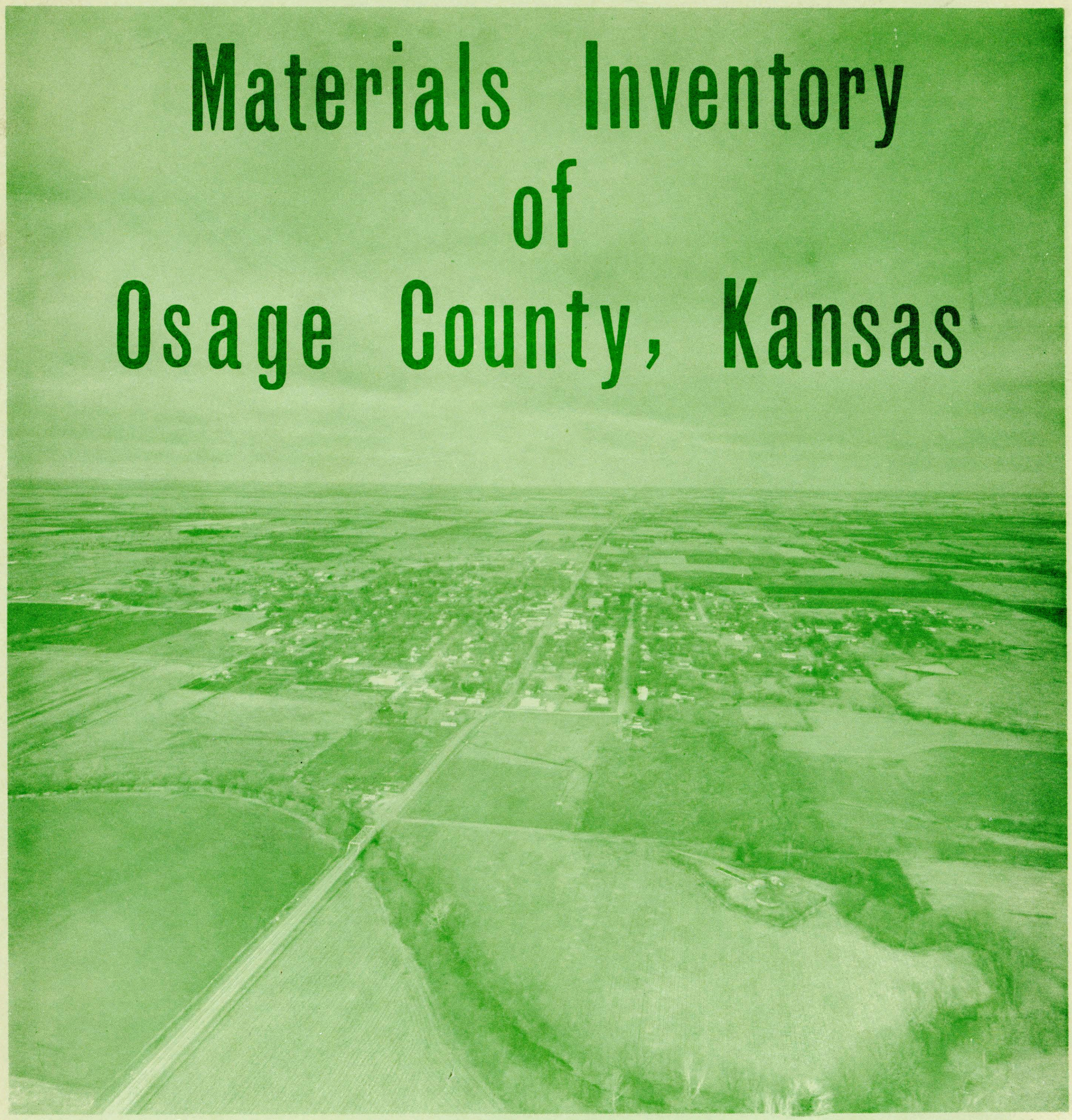
Materials Inventory of Osage County, Kansas



prepared by the

State Highway Commission of Kansas

in cooperation with the

U. S. Department of Transportation

Federal Highway Administration

Bureau of Public Roads

State Highway Commission of Kansas
Planning and Research Department - Photronics Department

MATERIALS INVENTORY OF OSAGE COUNTY, KANSAS

BY

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Prepared in Cooperation with the
U. S. Department of Transportation
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1966

Materials Inventory Report No. 11

COVER -- An aerial view of Lyndon, Kansas, county seat of Osage County.

SUGGESTED USE OF THE REPORT

The Osage County materials inventory report includes: 1. an introduction which describes the nature of the report and gives general information concerning Osage County; 2. an explanation of the procedures used in compiling the information contained herein; 3. a brief explanation of the origin of the geologic units that are source beds for construction material in the county, and a detailed description of the materials which have been produced from these units; 4. appendices I through III which contain site data forms for each open and prospective material site. Each site data form has a sketch showing the site and surrounding landmarks, the name of the landowner, the name of the geologic source bed, and a resume' of all test data available for that location and 5. county materials maps (plates I through VI) which show the geographic locations where the various source beds can be found in the county, along with the locations of all open and prospective material sites.

When this report is used as a guide for planning an exploration program or making an assessment of the materials resources of Osage County, the reader may find the following suggestions helpful.

After becoming familiar with the nature of the report, the reader may wish to refer to the section entitled, "Construction Materials Resources of Osage County." In this portion of the report a geologic history of Osage County is presented which describes the geologic events which led to the deposition of the various source beds and sets forth the geologic nomenclature used throughout the report. The construction materials resources of Osage County are also inventoried in this section. A study of the construction materials inventory will reveal the types of material available in the county, their geologic source beds, the localities where they are found, and a description of their engineering properties.

When the reader has determined which geologic source may contain material that will meet his requirements, he should then refer to the county materials maps. From these he can determine the areas in which this geologic source unit is present, the location of sites which have produced material from this source, the locations of prospective material sites or the exposure pattern of this source unit, and references to site data forms for each open or prospective site.

For example, one determines from the study of the construction materials inventory that limestone aggregate from the Topeka Limestone may fulfill the materials specifications for a project in the south-central part of the county. The materials map (plate V) shows an open site in this area. If the reader is interested in site $\frac{LS+43}{Pto}$, he refers to appendix II, where detailed information about this particular location is given on a site data form. This information will enable him to plan his exploration program in an orderly fashion.

PREFACE

This is one of a series of county construction materials reports compiled as a product of the Highway Planning and Research Program, Project 64-6, "Materials Inventory by Photo Interpretation," a cooperative effort between the Bureau of Public Roads and the State Highway Commission of Kansas financed by Highway Planning and Research funds. The materials inventory program was initiated to provide a survey of all existing construction materials in Kansas on a county basis to help meet the demands of present and future construction needs.

The objectives of the program are to map and describe all material source beds in the respective counties and to correlate geological nomenclature with the material source beds for classification purposes. The materials inventory program does not propose to eliminate field work, but it should substantially reduce and help to organize field investigations.

Several publications issued by the State Geological Survey of Kansas concerning Osage and surrounding counties provided the basic geologic and some of the material data used in this investigation. Material quality test results and other general facts pertaining to construction materials resources of Osage County were furnished by the Materials Department of the State Highway Commission of Kansas. Numerous preliminary soil surveys and geologic investigations have been conducted for road design purposes by the State Highway Commission of Kansas along the various major highways that traverse Osage County. These surveys provide detailed information concerning the location and thickness of the various geologic units exposed in Osage County.

The report was prepared under the guidance of J. D. McNeal, Engineer of Planning and Research, and the project leader, R. R. Biege, Jr., Engineer of Aerial Surveys and Photogrammetry. Appreciation is extended to L. D. Pierce, Osage County Engineer, for verbal information on construction materials in the area.

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ABSTRACT

Osage County is located in east-central Kansas and is a part of the Osage Questas physiographic division. The terrain is characterized by alternating beds of unequally resistant limestones and shales which give rise to a gentle rolling topography. Most of the county is drained by the Marais des Cygnes River and its tributaries. The county is served by two railroad companies and an extensive network of federal, state and county roads.

Construction material can be produced from Pennsylvanian limestones and shales and from unconsolidated deposits of Pleistocene and Pliocene(?) age. The quality of material which may be obtained from each source is variable, especially when unconsolidated deposits are being produced.

A fairly good quality aggregate, riprap, and light type surfacing material can be produced from thick limestone units that are exposed in the eastern half of the county. Similar material can be produced from thinner limestone beds exposed in the western half of the county.

Sandstone has been produced from the Lawrence Shale (exposed in the extreme southeast corner of the county) and Severy Shale (exposed in the northwest corner of the county) for use as light type surfacing material and the fine fraction of hot mix aggregates. Clayey shale from several Pennsylvanian units have been tested for use as lightweight aggregate.

Chert gravel is available in terraces that occupy high terrain along the major drainage channels in Osage County. This material is used extensively in some parts of the county for light type surfacing material. In nearby counties, some chert gravel has been used as a coarse aggregate in concrete construction; however, it was necessary to wash this chert in order to eliminate the highly plastic clay matrix.

Some siliceous sand and gravel can be produced from the floodplain and low terraces associated with the major drainage channels; however, the material is poorly sorted and contaminated with particles of limestone, sandstone and shale.

Geo-engineering problems are a consideration from three aspects: 1. embankment and subgrade construction, 2. ground-water problems in road construction and 3. mineralization of water resources as it pertains to use in concrete mixes.

Most of the material available for embankment and subgrade construction is composed of clayey shales or soil mantle derived from the same. Such materials have high plastic indices and may cause stability problems in road construction.

Potential ground-water problems exist throughout the county. Limestone, sandstones, and coal beds which are near the surface may carry water and, eventually, saturate the subgrade causing road failures in some areas. To prevent such problems, the alignment of the

proposed improvement may be changed or special underdrains and ditches constructed. Most of the water available for concrete mixes in Osage County is of good quality; however, water produced at depths greater than 345 feet from the Lawrence Shale in the southeast part of the county and that produced from the White Cloud and Severy, in the northwest part of the county, has excessive amounts of chloride and sulfate ions. Such highly ionized water would be undesirable for use in concrete mixes.

INTRODUCTION

Purpose and Scope

The purpose of this report is to present information concerning the availability, location, and nature of material deposits that can be used in highway construction and similar projects in Osage County and to provide a guide for materials prospecting in this area. A geo-engineering section is included to discuss the geologic units which exhibit undesirable engineering properties, to provide information concerning potential ground-water problems in road construction, and to present data concerning the quality and quantity of water available in Osage County that may be used for concrete mixes.

The investigation includes all of Osage County. All geological units and deposits that were considered to be a source or a potential source of construction material were mapped and described. The term construction material, as used in this report, includes: 1. limestone suitable for making crushed stone and riprap; 2. sandstone suitable for crushing into fine aggregate; 3. shale which is a source for lightweight aggregate and 4. unconsolidated terrace deposits, which in their natural state or through processing, are suitable for various phases of road construction.

Nature of the Report

This investigation was based primarily on the geology of Osage County with special considerations given to the materials and engineering significance of various geologic units. In order to establish a uniform method of classification from one county to another, current geologic nomenclature was used as a guideline in the classification and designation of material source units. Generally, the thickness and the quality of material derived from one source unit are fairly uniform within a county; however, local variations in depositional environments and weathering conditions may have caused a change in thickness and engineering properties within a relatively small area. Such variations are more commonly observed in unconsolidated deposits.

In most cases, the geologic classification assigned to unconsolidated deposits denotes age and not material type. For example, two deposits which were laid down during the same period, but in different parts of the state, may have the same classification but may vary in composition because of different parent material. The gradation of the material present in unconsolidated deposits is greatly affected by the mode of deposition and the carrying capacity or energy of the depositing agent.

In essence, the geology of the county provides a basis of mapping and classifying material source units. In addition, the general engineering properties of the material that can be produced from the various source units can be determined by extending known engineering data on the basis of geological information. Consequently, prospective sites can be selected for development on the general merits of the material.

The material source units were mapped on aerial photographs on the basis of geological information obtained during previous investigations of the area and data obtained during this study.

Because of their continuous nature, most consolidated units can be mapped with a minimum amount of field checking. Unconsolidated deposits of sand and gravel are less extensive and more difficult to detect; however, they can be located on aerial photographs through the interpreter's knowledge of the geology of the county and by his interpretation of significant terrain features that are discernible on the aerial photographs.

General Information

Osage County is located in east-central Kansas (see figure I) and has an area of approximately 720 square miles. It is bounded by

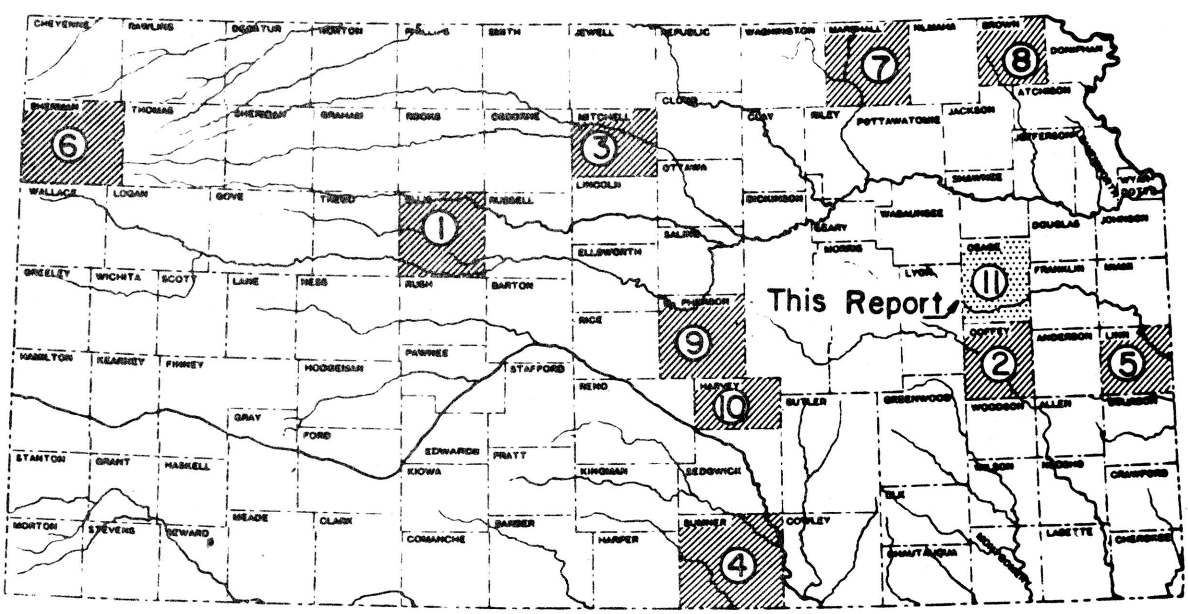


Figure 1. Index map of Kansas showing the location of Osage County along with the number and location of counties for which reports have been or are being completed.

parallels 38° 26' and 38° 52' north latitude and meridians 95° 30' and 95° 57' west longitude. The county is bordered on the north by Shawnee County, on the east by Douglas and Franklin Counties, on the south by Coffey County, and on the west by Lyon and Wabaunsee Counties. It had a population of 13,051 in 1966 according to the Kansas Board of Agriculture.

The area is a part of the Osage Cuestas physiographic division of Kansas. The topography is that of a dissected plain developed on unequally resistant limestone and shale formations. This gives rise to a gently rolling topography of vales and escarpments with moderate to steep slopes adjacent to most of the river and creek valleys. The Marais des Cygnes River and its tributaries drain about 90 percent of the county and the remaining 10 percent is drained by the Wakarusa River. Normal annual precipitation is approximately 35 inches.

Osage County is served by lines of the Atchison, Topeka and Santa Fe and the Missouri Pacific Railroad Companies. One line of the Atchison, Topeka and Santa Fe traverses the northwest corner of the county serving the towns of Carbondale, Scranton, and Burlingame. At Burlingame the line junctions with another line which extends south connecting the cities of Osage City and Emporia. A main line of the Atchison, Topeka and Santa Fe which connects the cities of Kansas City and Emporia, extends through the towns of Quenemo, Melvern and Olivet in the southeast corner of the county. A line of the Missouri Pacific Railroad extends across the central part of the county from east to west serving Lomax, Vassar and Osage City. Another line extends north from Lomax through Michigan Valley and Overbrook and leaves the county in the northeast corner.

There is a well developed system of federal, state and county roads in Osage County. U.S. Highway 75, a north-south transcontinental route, extends through the central part of the county serving Lyndon (the county seat) and Carbondale. U.S. Highway 56 traverses the northern half of the county in an east-west direction serving the cities of Overbrook, Scranton, Burlingame, and Osage City. Other state and county highways connect all other towns in Osage County to these two main highways. An extensive system of county and township roads has been developed, most of which follow section lines and have all-weather surfaces.

PROCEDURES

The investigation for this report was carried out essentially in the following four phases: first, research and review of available information; second, photo interpretation; third, field reconnaissance and fourth, correlating data, compiling material maps, and writing the report. With the exception of the first, the phases were not approached as separate operations, but were completed contemporaneously as each section of the report required.

Phase I Research of Available Information

All available information pertaining to the geology, soils and construction materials in Osage County was reviewed. All data were screened as to its relevancy to the project and the initial correlation of engineering data and geologic information was completed.

Phase II Photo Interpretation

A major part of this investigation consisted of the study and interpretation of aerial photographs flown by the State Highway Commission of Kansas on April 6, 1965 at a scale of 1:24,000 (one inch represents 2,000 feet). Figure 2 (page 6) is a photographic coverage map of Osage County.

By using information derived from the research phase of this project along with field observations, various geologic units were designated as source or potential source units of construction materials. These units were mapped on the aerial photographs and all open material sites were correlated with the appropriate geologic source unit. Prospective sites were tentatively selected on the basis of geology and aerial photographic pattern elements. The quality of material that might be produced from a particular source

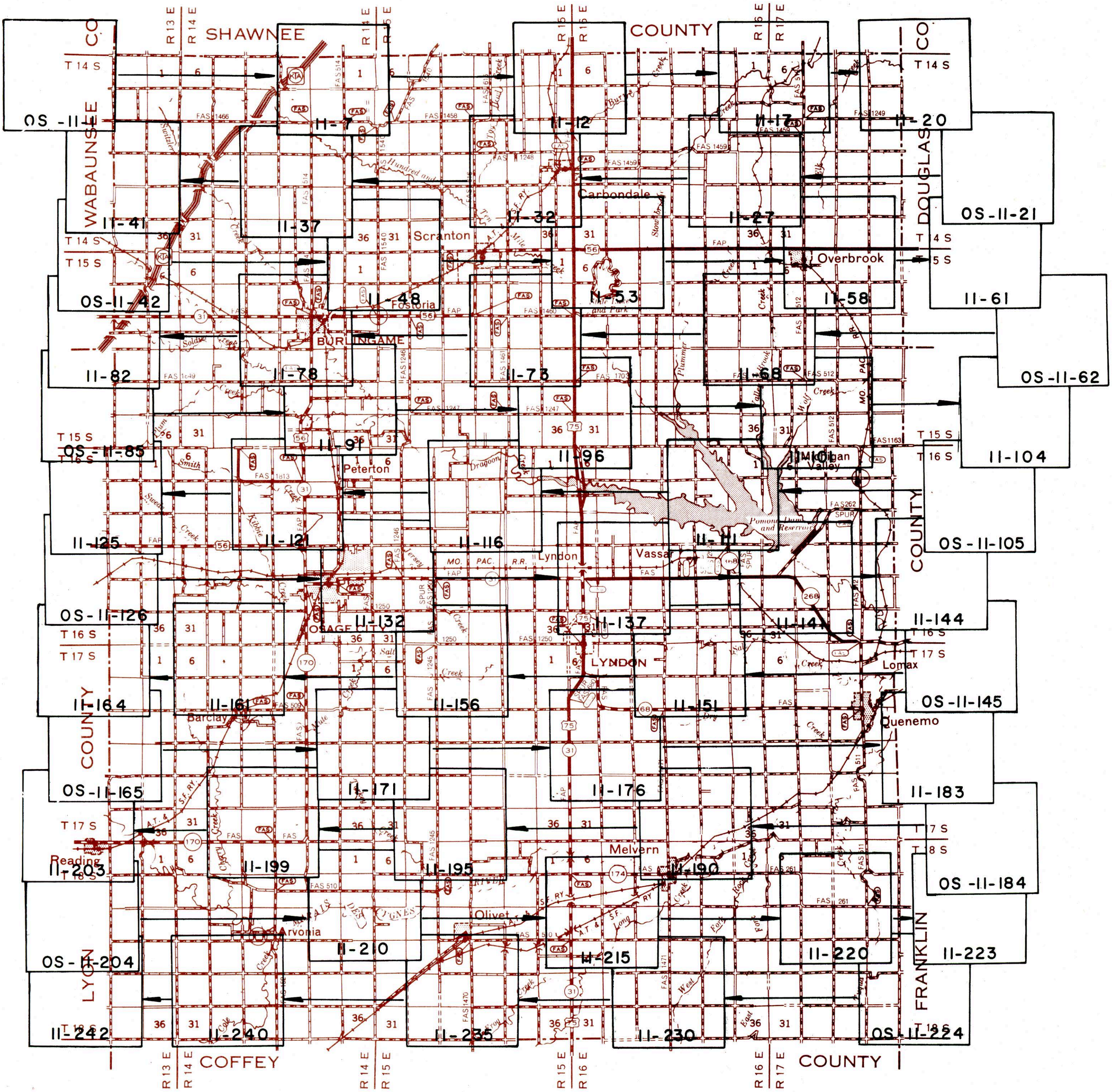


Figure 2. Aerial photographic coverage map for Osage County. The numbers indicate photograph numbers on flights taken by the Photogrammetry Section, State Highway Commission of Kansas, April 6, 1965, at a scale of 1:2,000. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

was ascertained by correlating the results of quality tests with the geologic unit from which the test samples were obtained and by field study of the producing units. This correlating process is illustrated in a general way by figures 3 and 4 and by the following discussion.

Figure 3 is an aerial view of a quarry which is producing from the Topeka Limestone in southwest Osage County. Results of quality

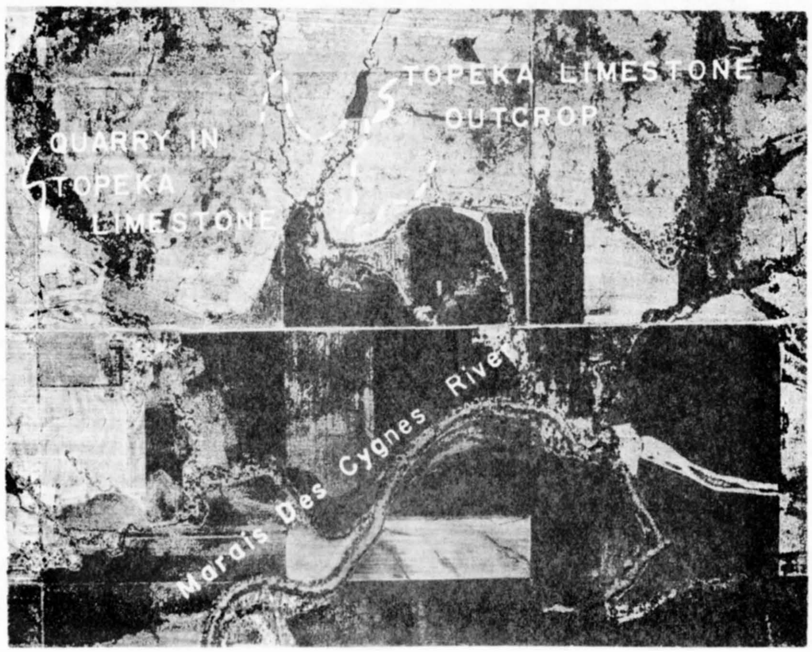


Figure 3. An aerial view of a quarry in the Topeka Limestone located in southern Osage County. Note that the outcrop pattern of the Topeka is discontinuous in this area because high terrace deposits, laid down by the Marais des Cygnes River, cover the older limestone units. Approximate scale, 1:24,000.

tests completed on samples taken at this site indicate that a good quality crushed limestone is produced from the Topeka. Figure 4 (page 8) shows the outcrop pattern of the same ledge which has been mapped in central Osage County. Inasmuch as the Topeka Limestone displays fairly consistent geologic properties in Osage County,

Figure 4. An aerial view of the Topeka Limestone in central Osage County. In this area the Topeka occupies high terrain and has a fairly consistent outcrop pattern except in cultivated fields. Approximate scale, 1:24,000.

the quality of material that might be produced in the central part of the county should be comparable to that produced in the southwestern portion.

Part III Field Reconnaissance

A field reconnaissance of the county was conducted in order to verify doubtful mapping situations and to study the geologic characteristics of the source units in more detail. All open sites were inspected to verify the geologic classifications.

Part IV Map Compilation and Report Writing

The fourth phase consisted of correlating all new information with that previously gathered, writing the report, completing the site data forms, and compiling the county construction materials maps.

The text of the report presents the general geology of the county as it pertains to the various material source units, and a general description of geologic units, which in the past, have displayed unsound engineering properties.

In order to furnish the users of the report with all available information, a data form was completed for each materials site depicted on the materials map. The site data forms are included as appendices I through III in this report. When available, test data are presented on these forms along with pertinent geologic information. To aid further in determining the type of material which might be expected at untested sites, references are made to nearby locations where test results are available on samples from the same source bed. A sketch of each site was drawn illustrating major cultural and natural features to help locate the exact area in the field.

Current geologic nomenclature was used as a guideline to map consolidated geologic source units; however, some of the map designations used for unconsolidated deposits depart from current usage in order to group two or more geologic beds together as a single construction material source unit. All existing and prospective sites are identified on the county materials maps by appropriate designations and symbols.

CONSTRUCTION MATERIALS RESOURCES OF OSAGE COUNTY

General Geology of Osage County

This section of the report presents a general review of the geology of Osage County. The main objective of this discussion is to provide the reader with a general understanding of the geological events that were responsible for the deposition of the present day construction materials resources in Osage County. Inasmuch as the different geological source units vary in age, it is imperative that geologic time be discussed. Therefore, a major portion of nomenclature used in this report consists of terms representing segments of geologic time. Figure 5 (page 11) is a geologic timetable reproduced with the permission of the State Geological Survey of Kansas, which shows in graphic form the major time periods and the approximate duration of each.

Rocks which occur in the subsurface, but do not crop out in Osage County, range from Precambrian to late Pennsylvanian age. The Precambrian rocks are believed to be primarily granitic types. As much as 3,000 feet of Paleozoic rocks, composed of limestone, dolomite, sandstone and shale, overlie the older Precambrian rocks.

Marine deposits of late Pennsylvanian age, which are the oldest rocks exposed in this area, make up more than 99 percent of the terrain in the county. The remaining surface area, located in the extreme northwest corner of the county, is characterized by exposures of lower Permian limestones and shale. Limestone units of late Pennsylvanian age are the most abundant and significant material source units in Osage County. Permian rocks have no material significance in this area.

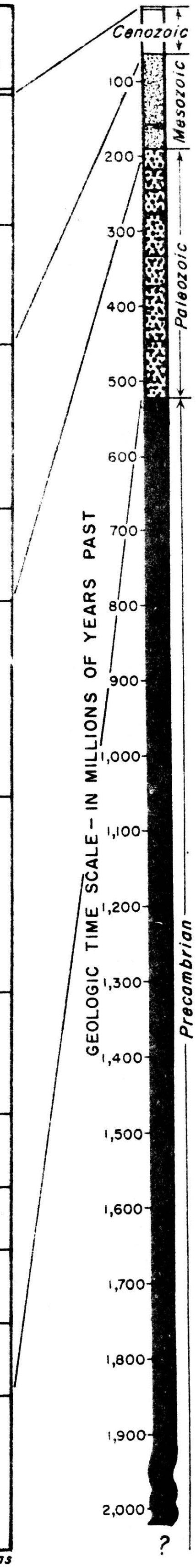
Mesozoic sediments are not found in Osage County inasmuch as the county is part of an area which was probably a landmass during most of the Mesozoic Era (Triassic and Jurassic Periods). It is assumed that during this time large amounts of older Paleozoic rocks were removed by erosion.

The sea made its final invasion of Kansas during the late Mesozoic (Cretaceous Period) and if any sediments were deposited in Osage County during this time, they were removed subsequently by erosion during Cenozoic time.

The events that took place during the Cenozoic Era have had a dominant influence on the construction material resources of Osage

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.*	Water, agricultural soils, sand and gravel, volcanic ash.
CENOZOIC	TERTIARY	59,000,000	*River silt, sand, and gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.*	Water, sand and gravel, volcanic ash, diatomaceous marl.
MESOZOIC	CRETACEOUS	70,000,000	*Chalk, chalky shale, dark shale, vari-colored clay, sandstone, conglomerate. Outcropping igneous rock.*	Ceramic materials; building stone, concrete aggregate, and other construction rock; water.
MESOZOIC	JURASSIC	25,000,000	*Sandstones and shales, chiefly subsurface.*	
MESOZOIC	TRIASSIC	30,000,000		
PALEOZOIC	PERMIAN	25,000,000	*Limestone; shale; evaporites (salt, gypsum, anhydrite); red sandstone and siltstone; chert; some dolomite.*	Natural gas; salt; gypsum; building stone, concrete aggregate, and other construction materials; water.
PALEOZOIC	PENNSYLVANIAN	25,000,000	*Alternating marine and non-marine shale, limestone, and sandstone; coal; chert.*	Oil, coal, limestone and shale for cement manufacture, ceramic materials, construction rock, agricultural lime, gas, water.
PALEOZOIC	MISSISSIPPIAN	30,000,000	*Mostly limestone, predominantly cherty.*	Oil, zinc, lead, gas, chat and other construction materials.
PALEOZOIC	DEVONIAN	55,000,000	*Subsurface only. Limestone, black shale.*	Oil
PALEOZOIC	SILURIAN	40,000,000	*Subsurface only. Limestone.*	Oil
PALEOZOIC	ORDOVICIAN	80,000,000	*Subsurface only. Limestone, dolomite, sandstone, shale.*	Oil, gas, water.
PALEOZOIC	CAMBRIAN	80,000,000	*Subsurface only. Dolomite, 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.

(Not scaled for geologic time or thickness of deposits)



*Committee on Measurement of Geologic Time, National Research Council

State Geological Survey of Kansas

Figure 5. Geologic timetable

County. During most of the earlier Tertiary Period, the surface of Osage County was probably subjected to erosion. However, it is believed that chert gravel terraces were deposited by the antecedent streams of the present day channels during late Tertiary time. Today, these deposits occur between 140 and 160 feet above the present channels.

The Quaternary Period represents a time of repeated glacial and interglacial cycles. Glacial activities in Kansas were restricted to the northeastern corner of the state; however, the sequence of glaciation, which occurred during this time, played a controlling role in the stream activity in Osage County as well as in much of the state. Figure 6 (page 13) is a geologic timetable which shows the divisions of the Quaternary Period and the approximate length of each. The glacial ages (Nebraskan, Kansan, Illinoisan and Wisconsinan) represent the advance of the glaciers, while the three interglacial ages (Aftonian, Yarmouthian and Sangamonian) represent periods of major glacial recession. The Recent Age represents the time which has elapsed since the last retreat of the Wisconsinan glacier.

The deposition of chert gravel that presumably took place during late Tertiary time continued into the Quaternary Period. At different intervals of time the streams degraded their channels leaving the previously deposited material at higher elevation and at the same time exposing older Pennsylvanian bedrock.

During the Nebraskan Stage, degradation of the land surface and deposition of chert gravel took place in Osage County leaving terrace deposits at a lower elevation than the late Tertiary deposits. The Nebraskan terraces are believed to be represented in Osage County by chert gravel deposits situated between 60 and 95 feet above the

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.

present day drainage channels (O'Connor and others, 1955, page 7).

Degradation of the stream's channels continued into early Kansan time. However, later in this age, streams became sluggish and extensive deposition took place in the streams' valleys. Today, chert gravel terraces occurring 10 to 30 feet above the present floodplain are believed to represent Kansan deposits.

Like the Kansan, the Illinoisan Age was characterized by cycles of stream degradation and aggradation. Chert gravel terraces of this age lie 10 to 15 feet above the present day streams' channels.

Presumably, the present day channels were alluviated during Wisconsinan time; however, by Recent time, streams in this area began to erode their channels and, therefore, began to cut into their own sediments and bedrock.

In this report, the alluvial terraces which were deposited during late Tertiary and Quaternary time have been mapped as three separate material source units. The grouping of the various age deposits as single material map units was based on similarity in topographic position and lithology. The chert gravel terraces which were deposited presumably during late Tertiary and those of Nebraskan age (Quaternary Period) are shown on the materials map as Tertiary Terraces. Kansan and Illinoisan Terraces have been designated as one source unit and are mapped as Quaternary Terraces. Floodplains and terraces deposited during Wisconsinan and Recent time have been mapped as Quaternary Alluvium.

Construction Materials Inventory

General Information

This section of the report inventories the construction materials in Osage County. Figure 7 (page 15) is a generalized column of the surface geology of Osage County which illustrates the relative stratigraphic position of each source bed and indicates the map unit which represents each source bed. It should be noted that the map units that represent Quaternary deposits in Osage County, are based primarily on material type and not geologic age.

Figure 8 (page 17) tabulates the results of gradation and quality tests performed on the various construction material source units that are exposed in Osage County.

A tabulation of the various types of material available in Osage County is shown in figure 9 (page 19). The source beds, from which each material type can be produced, are listed along with the page

System	Series	Graphic Legend	Thickness	Type of Deposit	Stage	Map Symbol	Generalized Description	Construction Material
Quaternary	Pleistocene		40'	Alluvium and Low Terrace	Recent and Wisconsinan	Qal	Composed of silt and clay with varying amounts of poorly sorted sand and gravel. Coarse fraction includes varying quantities of hard (limestone, chert and quartz) and soft (shale, siltstone and sandstone) rocks.	Light type surfacing material.
			75'	Terrace Deposit	Illinoisan (?) and Kansan (?)	Qt	Lower (younger) deposits composed of silt and clay with varying amounts of poorly sorted sand and gravel. Higher (older) deposits consist of similar material which has been subjected to weathering processes for a longer duration of time.	Light type surfacing material.
			0' to 12'	Terrace Deposit	Nebraskan (?)	Tt	Composed of siliceous sand and gravel, mainly chert, with a brownish-red clay matrix which fills the interstices between the gravel.	Light type surfacing material.
Tertiary	Pliocene			Terrace Deposit				

Note: Pleistocene deposits and Pliocene (?) Chert Gravel Terraces may be in contact with any older outcropping rock.

System	Series	Group	Graphic Legend	Thickness	Formations and Members			Generalized Description	Construction Material
Permian		Admire		0' to 35'	Janesville Shale				
				12'±	Falls City Limestone				
				21' to 32'	Onaga Shale				
Pennsylvanian	Virginian	Wabaunsee		17' to 30'	Woodsiding Formation				
				10.5' to 46'	Root Shale				
				7' to 28'	Stotler Limestone	Grandhaven Limestone			
						Dry Shale			
				1.5' to 4'		Dover Limestone	Pd	Light gray to light tan limestone which weathers light gray-tan. Algae in the upper part and fusulinids in the remainder of the bed.	Crushed aggregate. Light type surfacing material.
				0' to 35'	Pillsbury Shale				
				1'±	Zeandale Limestone	Maple Hill Limestone			
				24' to 28'		Wamego Shale			
				2' to 5'		Tarkio Limestone	Pt	Massive, gray limestone which weathers a deep rich brown and contains an abundance of large fusulinids.	Crushed aggregate. Light type surfacing material. Rip rap
				12' to 24'	Willard Shale				
				1.5' to 7'	Emporia Limestone	Elmont Limestone			
				2' to 10'		Harveyville Shale			
				3' to 7'		Reading Limestone	Pr	Dark gray-blue, dense limestone which weathers yellow-brown. Fusulinids are abundant in lower parts of the members.	Crushed aggregate. Light type surfacing material.
				45' to 50'	Auburn Shale				
				3' to 8'	Bern Limestone	Wakarusa Limestone	Pb	Massive, thick to medium-bedded limestone containing a variety of fossils. This limestone is bluish-gray and brown which weathers to a light to dark brown color.	Crushed aggregate. Light type surfacing material. Rip rap
				2' to 7'		Soldier Creek Shale			
				2' to 9'		Burlingame Limestone		Variable from one outcrop to another. Most commonly, the Burlingame is one or more massive-bedded, light-gray and buff limestones which weathers buff to brown.	
				45.5' to 157'	Scranton Shale			Three thick shale and two thin limestone members. Basal shale member (White Cloud Shale) characterized by gray, olive and tan shale with a large part consisting of fine, gray, brown-weathering sandstone.	Lightweight aggregate
				5' to 16'	Howard Limestone	Utopia Limestone	Pu	Several limestones separated by thin shales. Upper bed being a light to medium-gray limestone with fusulinids and algae in upper part. Lower part characterized by thin gray calcareous shale and thin unfossiliferous silty to fine sandy, gray, flaggy, limestone.	Crushed aggregate. Light type surfacing material. Rip rap
				1' to 3'		Winzeler Shale			
				2'±		Church Limestone			
				12' to 14'		Aarde Shale		Upper part a gray to blue-gray, silty to calcareous shale underlain by a nearly black fissile shale. Nodaway coal is present in the middle part. Below the Nodaway, a gray, clayey shale with thin limestones occurring locally.	
				2' to 3'		Bachelor Creek Limestone			
				70'±	Severy Shale			Gray and olive clayey to sandy shale with gray, fine grained, micaceous sandstone. The unit is comprised of as much as 40 of sandstone in the northern part of the county.	Lightweight aggregate, sandstone and fine aggregate
		Shawnee		0.5' to 1'	Topeka Limestone	Du Bois Limestone			
				2'±		Turner Creek Shale			
						Sheldon Limestone			
				1.5' to 2.5'		Jones Point Shale			
				9' to 12'		Curzon Limestone	Pto	Interbedded limestone and limy shale. Gray limestone in upper part containing scattered chert nodules. Lower part characterized by interbedded gray limestone and shaly limestone.	Crushed aggregate. Light type surfacing material. Rip rap
				6' to 9'		Hartford Limestone		Massive gray to blue-gray limestone which weathers a deep yellow-brown color.	
				35' to 55'	Calhoun Shale			Upper part consists chiefly of gray to olive, sandy and silty shale, locally with thin sandstone beds. Lower part characterized by gray, very fine-grained micaceous sandstone and gray shale.	Lightweight aggregate
				8' to 22'	Deer Creek Limestone	Ervine Creek Limestone	Pde	Light-gray to nearly white hard fine-grained limestone locally containing scattered chert nodules. Individual beds are thin, wavy bedded with several small gray shale partings.	Crushed aggregate. Light type surfacing material. Rip rap
				2' to 6'		Larsh-Burroak Shale			
				1' to 2'		Rock Bluff Limestone			
				3' to 11'		Oskaloosa Shale			
				10' to 17'		Ozawkie Limestone	Pdo	Upper bed comprised a light buff to yellow-brown impure limestone underlain by a light-gray to tan clayey to slightly sandy shale. Basal bed comprised a light gray-white gray or blue-gray massive limestone with limy shale zones occurring in the lower part.	
				25' to 55'	Tecumseh Shale			Mostly clayey to silty and sandy blue-gray shale. Limestone or limy zones are found in the upper part. Shale below this is gray clay shale and sandy micaceous shale.	Lightweight aggregate
				2'±	Lecompton Limestone	Avoca Limestone			
				17'±		King Hill Shale			
				5' to 6'		Beil Limestone	Pl	Ranges from alternating beds of limy fossiliferous shale and thin limestones which weathers gray to tan in the north to an irregular massive limestone in the south.	Crushed aggregate. Light type surfacing material. Rip rap
				3'±		Queen Hill Shale			
				1'±		Big Springs Limestone			
				5' to 27'		Doniphan Shale			
				5'±		Spring Branch Limestone		A massive yellow-brown to brown somewhat sandy or silty limestone. Limestone is slightly wavy bedded, locally somewhat sandy or silty with thin shale partings occurring in the middle.	
				62' to 83'	Kanwaka Shale			Upper part is a blue-gray to gray clayey silt and sandy shale and very fine micaceous sandstone underlain by the Clay Creek Limestone. Lower part is characterized by a bluish-gray, yellow-tan weathering sandy shale and gray tan-weathering fine grained quartz sandstone.	Lightweight aggregate
				16' to 25'	Oread Limestone	Kereford Limestone	Pok	This unit is variable in lithology, the upper part is grandular or oolitic algal-molluscan limestone. The next lower is thin dense blue-gray flaggy limestone, the basal part ranges from a platy unfossiliferous limestone down to a wavy-bedded fossiliferous bed.	Crushed aggregate. Light type surfacing material. Rip rap
				1' to 5'		Heumader Shale	Pop	A dense fine-grained light bluish-gray to nearly white limestone that weathers light gray or tan. Limestone is wavy bedded with scattered nodules of blue-gray chert. Thin shale partings are common in the unit.	Crushed aggregate. Light type surfacing material. Rip rap
				13' to 22'		Plattsmouth Limestone			
				3.5' to 10'		Heebner Shale			
				0.9' to 2.5'		Leavenworth Limestone			
				5' to 40'		Snyderville Shale		A sequence of beds with a gray or tan-gray blocky clay underlain by calcareous gray to yellow-tan shale. Basal part characterized by impure limestone beds.	
				8' to 16'		Toronto Limestone	Pot	It ranges from a nodular light-gray weak limestone to a more massive buff to brown weathering hard limestone with a variety of fossils.	Crushed aggregate. Light type surfacing material. Rip rap
		Douglas		5' to 32'	Lawrence Shale			Upper part characterized by beds of gray silty to sandy shale and the upper Williamsburg coal. The Amazonia Limestone, a thin gray to blue-gray dense limestone, occurs in the middle of this unit. Lower part (Iceland sandstone) is characterized by light gray sandstone which weathers to various shades of tan, buff and brown.	Sandstone and fine aggregate

Figure 7. Generalized geologic column of the surface geology in Osage County.

Location	2	1½	3/4	3/8	4	8	16	30	50	100	G.F.	Wash.	Sp.Gr. Dry	Sp.Gr. Sat	L.A. Wear	Soundness	Wt. Cu.Ft.	Source of Data
					Percent Retained													
SOURCE OF MATERIAL: Chert Gravel Tertiary Terrace																		
SW¼,NW¼,Sec. 4,T18S,R15E	0	2	25	47	59	68	72	74	75	77	4.99	22.34	2.49	2.53	17.2(A)	0.47	96.7	Quality Sample
	0	4	35	68	84	91	92	93	94	95	6.56	5.05						
NW¼,Sec.27,T17S,R14E	-	-	33	53	65	74	80	83	84	85	5.57	15.28	2.51	2.56	19.5(A)	1.00		Quality Sample
SOURCE OF MATERIAL: Chert Gravel Quaternary Terrace																		
NE¼,NW¼,Sec.12,T15S,R15E	-	-	25	44	56	64	68	70	71	72	4.70	27.6	2.46	2.53	20.0(B)			Quality Sample

Location	Sp.Gr. Dry	Sp.Gr. Sat.	L.A. Wear	%Abs.	Soundness	Source of Data
SOURCE OF MATERIAL: Dover Limestone						
SW¼ Sec.18,T14S,R14E	2.61	2.65		1.5		Quality Sample
SOURCE OF MATERIAL: Tarkio Limestone						
SE¼,SE¼,Sec.12,T15S,R13E	2.40	2.49	30.1(A)	4.01	0.83	Quality Sample
	2.44	2.53	26.3(A)	3.45	0.89	
NE¼,Sec.30,T14S,R14E		2.62	25.0(B)	3.00	0.93	SHC Form 619 #70-41
SOURCE OF MATERIAL: Reading Limestone						
Sec.8&9,T15S,R14E	2.38	2.44		2.87		Quality Sample
NE¼,NW¼,Sec.23,T16S,R13E	2.59	2.64	26.7(A)	1.94	0.79	Quality Sample
SE¼,Sec.31,T15S,R14E	2.65	2.67		0.9		Quality Sample
SOURCE OF MATERIAL: Bern Limestone						
SE¼,Sec.36,T14S,R14E	2.46	2.55		3.5		Quality Sample
NW¼,Sec.30,T18S,R14E	2.56	2.62		2.2		Quality Sample
SOURCE OF MATERIAL: Utopia Limestone						
NE¼,SW¼,Sec.23,T14S,R15E		2.65	21.0(B)	2.04	0.94	SHC Form 619 #70-43
	2.60	2.63		1.2		
NW¼,Sec. 6,T15S,R16E	2.58	2.61		1.4		Quality Sample
Sec.36,T17S,R14E	2.38	2.49		4.9		Quality Sample
NE¼,SE¼,Sec.13,T16S,R14E	2.57	2.62		2.2		Quality Sample
NW¼,NW¼,Sec.18,T16S,R15E	2.60	2.64		1.4		Quality Sample
NE¼,NW¼,Sec. 6,T16S,R15E	2.63	2.67	23.6(A)	1.39	0.78	Quality Sample
SW¼,Sec. 2,T15S,R15E	2.64	2.67	22.2(A)	1.41	0.88	Quality Sample
SW¼,NE¼,Sec.36,T14S,R15E	2.54	2.60		2.3		Quality Sample
SE¼,Sec.34,T17S,R14E	2.80	2.83		1.0		Quality Sample
NE¼,Sec. 3,T18S,R14E	2.78	2.81		1.0		Quality Sample
NW¼,Sec.13,T17S,R14E	2.80	2.82		0.9		Quality Sample
NW¼,Sec.11,T15S,R15E	2.58	2.63		1.8		Quality Sample
NE¼,SW¼,Sec. 7,T16S,R15E	2.62	2.65	26.8(A)	1.07	0.89	Quality Sample
NE¼,SW¼,Sec.19,T15S,R15E	2.68	2.71	20.9(A)	1.31	0.89	Quality Sample
NW¼,Sec.35,T15S,R14E	2.61	2.64		1.40		Quality Sample
	2.57	2.61		1.8		
SOURCE OF MATERIAL: Topeka Limestone						
NE¼,Sec.31,T14S,R17E	2.52	2.59		2.6		Quality Sample
SW¼,Sec.26,T15S,R15E	2.43	2.55	37.1(B)	4.76	0.77	Quality Sample
	2.37	2.51	40.0(B)	5.85	0.87	
SW¼,NW¼,Sec.11,T18S,R14E	2.53	2.59	29.2	2.72	0.95	SHC Form 619 #70-44
	2.53	2.59		2.54		
	2.56	2.62		2.20		
	2.56	2.61		2.12		
	2.57	2.62	30.0(B)	2.00	0.97	SHC Form 645 #27555
E ½,Sec.25,T16S,R15E	2.65	2.68	25.8(B)	1.14	0.98	SHC Form 619 #70-46
	2.45	2.54	38.8(B)	3.44	0.93	

Location	Sp.Gr. Dry	Sp.Gr. Sat.	L.A. Wear	%Abs.	Soundness	Source of Data
SOURCE OF MATERIAL: Ervine Creek Limestone						
NE¼,NW¼,Sec.35,T16S,R15E	2.52	2.59	29.4	2.65	0.93	SHC Form 619 #70-42
	2.57	2.62	31.1(B)	1.89	0.93	SHC Form 645 #82136
	2.50	2.58	28.6(B)	2.84	0.93	SHC Form 645 #5812
	2.50	2.57	31.3(B)	3.05	0.93	SHC Form 645 #24917
	2.50	2.57		2.88		SHC Form 645 #25003
	2.53	2.59		2.42		
	2.47	2.56		3.39		
	2.47	2.55	31.5(B)	3.08	0.94	SHC Form 645 #25002
	2.52	2.59	29.4(B)	2.65	0.93	SHC Form 645 #13826
S ½,SW¼,Sec.29,T14S,R17E	2.63	2.65	26.1(A)	0.88	0.92	Quality Sample
NE¼,NW¼,Sec.32,T14S,R17E		2.57	28.6(B)	3.10	0.91	SHC Form 619 #70-28
	2.39	2.46	33.3(B)	2.92	0.90	SHC Form 645 #96866
	2.46	2.55	31.2(B)	3.61	0.91	SHC Form 619 #15719
Center Sec. 6 T16S,R16E	2.56	2.61	27.6(B)	1.92	0.94	SHC Form 619 #70-45
SOURCE OF MATERIAL: Ozawkie Limestone						
NE¼,SE¼,Sec.12,T16S,R15E	2.32	2.45		5.6	0.97	SHC Form 619 #70-48
					0.97	
Sec. 7,T16S,R16E	2.42	2.52	30.6(B)	3.96	0.96	SHC Form 619 #70-47
E ½,N ½,Sec.13,T16S,R15E	2.63	2.65		1.0		Quality Sample
	2.60	2.64		1.4		
SW¼,Sec.29,T18S,R16E	2.51	2.58		2.8		Quality Sample
SW¼,SE¼,Sec. 5,T16S,R16E	2.58	2.61		1.1		Quality Sample
	2.60	2.63		1.2		
NE¼,SE¼,Sec.18,T15S,R17E	2.58	2.62	25.2(A)	1.50	0.88	Quality Sample
SW¼,SW¼,Sec. 4,T16S,R16E	2.54	2.58		1.7		Quality Sample
SE¼,NE¼,Sec.33,T14S,R17E	2.46	2.52		2.6		Quality Sample
SOURCE OF MATERIAL: Lecompton Limestone						
N ½,SE¼,Sec.36,T18S,R15E		2.56	27.6(A)	2.31	0.87	SHC Form 619 #70-16
		2.67	26.6(A)	1.44	0.90	
		2.60	31.8(A)	1.98	0.90	
		2.66	26.6(A)	1.10	0.87	
Sec.33,T18S,R16E	2.52	2.56		1.3		Quality Sample
SE¼,Sec. 5,T17S,R16E	2.63	2.65		0.7		Quality Sample
SW¼,Sec.24,T17S,R16E	2.54	2.59		2.0		Quality Sample
W ½,SW¼,Sec.18,T16S,R17E	2.52	2.58	29.6(B)	2.72	0.81	Quality Sample
SOURCE OF MATERIAL: Kereford Limestone						
SE¼,Sec. 8,T17S,R17E		2.56	30.8(A)	2.36	0.90	SHC Form 619 #70-21
NE¼,Sec.15,T16S,R17E	2.49	2.56	27.6	2.61	0.96	SHC Form 645 #17804
NW¼,Sec. 4,T17S,R17E	2.47	2.54	28.9(B)	2.98	0.97	SHC Form 619 #70-49
SOURCE OF MATERIAL: Plattsmouth Limestone						
SE¼,SE¼,Sec. 3,T18S,R16E		2.59	30.6(B)	2.60	0.94	SHC Form 619 Osage County #2
	2.52	2.59	30.4(C)	2.81	0.93	SHC Form 645 #100563
SW¼,Sec.34,T17S,R16E		2.67	26.0(A)	0.98	0.94	SHC Form 619 #70-36
		2.59	35.7(A)	1.96	0.94	
		2.57	32.8(A)	2.31	0.88	
		2.51	39.2(A)	3.78	0.85	
NE¼,Sec.22,T16S,R17E		2.58	36.3(A)	2.60	0.95	SHC Form 619 #70-40
SW¼,Sec.35,T17S,R16E	2.54	2.58		1.5		Quality Sample
NE¼,Sec.15,T16S,R17E	2.49	2.56	27.6	2.61	0.91	Quality Sample
SW¼,NW¼,Sec. 3,T17S,R17E	2.54	2.58		1.6		Quality Sample

Figure 8. Results of tests completed on samples of material from geologic source units in Osage County.

Material Types	Geologic Source (map unit)	Material Usage	Description	Availability
Limestone	Toronto Limestone	Light type surfacing material. Rip rap	Page 22	Limited source in southeast part of county. Plates IV and VI.
	Plattsmouth Limestone	*Crushed aggregate. Light type surfacing material. Rip rap	Page 23	Moderate source in southeast part of county. Plates IV and VI.
	Kereford Limestone	Crushed aggregate. Light type surfacing material. Rip rap	Page 26	Moderate source in southeast part of county. Plates IV and VI.
	Lecompton Limestone	*Crushed aggregate. Light type surfacing material. Rip rap	Page 29	Moderate source in eastern part of county. Plates II, IV and VI.
	Ozawkie Limestone	Crushed aggregate. Light type surfacing material. Rip rap	Page 32	Moderate source in eastern part of county. Plates II, IV and VI.
	Ervine Creek Limestone	*Crushed aggregate. Light type surfacing material. Rip rap	Page 35	Moderate source in eastern and south-central part of county. Plates II, IV, V and VI.
	Topeka Limestone	*Crushed aggregate. Light type surfacing material. Rip rap	Page 37	Moderate source in northeast, central and south-central part of county. Plates II, III, IV, V and VI.
	Utopia Limestone	*Crushed aggregate. Light type surfacing material. Rip rap	Page 40	Very limited source in western half of county. Plates I, II, III and V.
	Bern Limestone	Light type surfacing material.	Page 41	Very limited source in western part of county. Plates I, III and V.
	Reading Limestone	Light type surfacing material.	Page 44	Very limited source in western part of county. Plates I, III and V.
	Tarkio Limestone	Crushed aggregate. Light type surfacing material. Rip rap	Page 44	Moderate source in northwestern part of county. Plates I and III.
	Dover Limestone	*Light type surfacing material.	Page 47	Very limited source in northwestern part of county. Plates I and III.
Chert Gravel	Tertiary Terraces	Light type surfacing material.	Page 50	Numerous sites of low volume production found along all major drainage channels. All Plates.
	Quaternary Terrace	Light type surfacing material.	Page 52	Numerous sites of low volume production found along all major drainage channels. All Plates.
	Quaternary Alluvium	Light type surfacing material.	Page 53	Very limited source in valleys of major drainage channels. All Plates.
Siliceous Sand and Gravel	Quaternary Alluvium	Light type surfacing material. Fine aggregate.	Page 53	Very limited source in valleys of major drainage channels. All Plates.
Sandstone	Lawrence Shale	Light type surfacing material. Fine aggregate.	Page 48	Very limited source in extreme southeast corner of county.
	Severy Shale	Light type surfacing material. Fine aggregate.	Page 49	Very limited source in extreme northwest corner of county.
Shale	Pennsylvanian Shales	Lightweight aggregate.	Page 48	Moderate source throughout county.

* Crushed aggregate refers to aggregate used for concrete and bituminous construction.

Figure 9. A summary of the construction materials types and their availability in Osage County.

number where the engineering characteristics of each unit are described.

Pennsylvanian limestones make up a major part of the construction materials resources of Osage County. Generally the units meet specifications for construction purposes when properly processed; however, many units contain shale seams and in many cases, are contaminated by overlying residual clay. A large amount of chert gravel is available along and in the floodplains of the major drainage channels in the county. However, these gravels fail to meet grading specifications for most concrete and bituminous construction projects and, in most cases, they have to be washed because of the clay matrix associated with them. According to Mr. L. D. Pierce, Osage County Engineer (Personal Communication), siliceous sand and gravel is imported from Shawnee (Kansas River Alluvium) and Lyon (Neosho River Alluvium) Counties; however, most of the limestone aggregate is produced in the county.

Pennsylvanian Limestones

Oread Limestone Formation

In Osage County the Oread Limestone Formation has an average thickness of approximately 75 feet. This unit is divided into four limestone and three shale members. Only three limestone members, the Toronto, Plattsmouth and Kereford, are considered to be important sources of construction material. Although these three limestone members outcrop in the same general area, they have been mapped as separate units. Figure 10 (page 22) is an aerial view of the Oread Limestone Formation which illustrates the mapping procedure.

Figure 10. An aerial view of the outcrop pattern of the Oread Limestone Formation illustrating the proximity of the three limestone members that make up a large part of the construction materials resources in southeastern Osage County. Approximate scale, 1:24,000.

Toronto Limestone Member

The Toronto Limestone Member is the basal member of the Oread Limestone Formation and is the oldest geologic unit mapped in Osage County. It is a light gray, fossiliferous limestone that weathers to a buff to brown color. It varies from a thin-bedded to a more typically, massive, hard limestone, Thickness of the unit is commonly eight or nine feet but may be as much as 16 feet. Figure 11 (page 23) shows a weathered exposure of the Toronto in a road cut in southeastern Osage County.

The Toronto has not been produced in Osage County because of its inaccessibility and because of the thick overburden that characterizes most exposures.

Figure 11. An exposure of the Toronto Limestone Member in a road cut in the NE¼NE¼ sec.10, T18S, R17E.

No quality tests have been completed on samples of the Toronto obtained in Osage County. A limited quantity of rock has been produced from this unit in Coffey County (adjacent to Osage County to the south); however, results of quality tests completed on samples indicate that the material would not meet specifications for bituminous construction because of high absorption properties. The following are the results of quality tests completed on samples of the Toronto taken in Coffey County.

Sample Number	1	2	3
Specific gravity (saturated)	2.51	2.48	2.48
Specific gravity (dry)	2.41	2.36	2.33
Los Angeles wear test	31.4 %(B)	38.18%(B)	34.6 %(B)
Absorption	4.46%	4.90%	5.26%
Soundness loss ratio	.96	.91	.95

Exposures of the Toronto are restricted to the southeastern part of Osage County. The outcrop pattern is illustrated in plates IV and VI. Heavy overburden will be encountered in most areas and where the Toronto occupies high terrain, residual clay overlies the rock ledge and is present in and along joint planes. The material produced from the Toronto will meet specifications for riprap and light type surfacing material but in most cases it will fail to meet specifications for bituminous construction. However, according to quality test results, it may be usable in concrete construction.

Plattsmouth Limestone Member

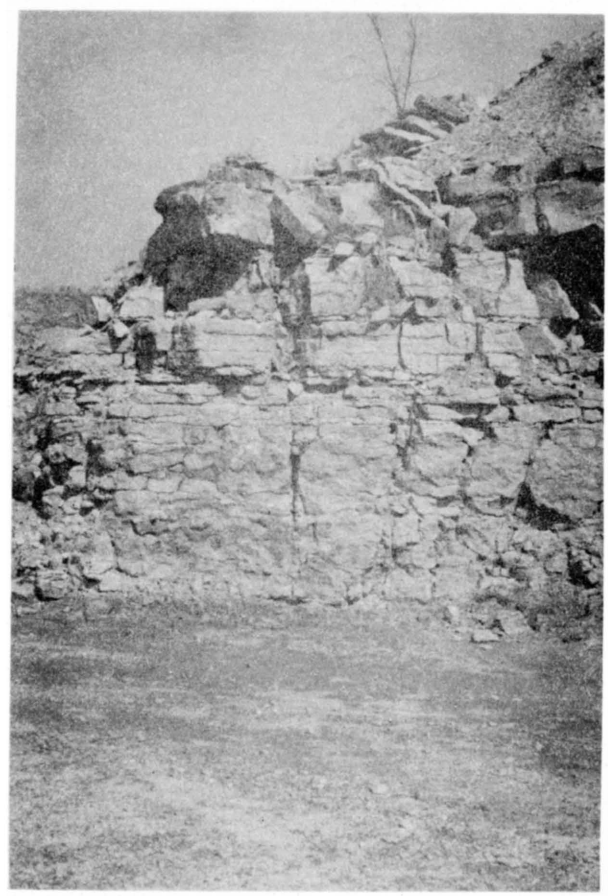
The Plattsmouth Limestone Member is a light bluish-gray, fine grained, wavy-bedded limestone with scattered nodules of blue-gray chert. Thin shale seams are commonly found in most exposures. In Osage County, the Plattsmouth varies in thickness from approximately 13 feet at its southernmost exposure to approximately 22 feet to the north. At the time this report was being prepared (April, 1966) only one quarry in Osage County was producing from the Plattsmouth; however, several quarries have been active in the past. Figure 12 (page 25) shows an exposure of the Plattsmouth in an abandoned quarry located in the east-central part of the county. It should be noted that the face of the quarry has been shattered by blasting. Figure 13 (page 25) shows a face of the Plattsmouth near the city of Melvern. Because of the high percent of calcium carbonate, agricultural lime is produced from the Plattsmouth at this location. A chemical analysis of a composite sample of the Plattsmouth was conducted by the State Geological Survey (O'Connor and others, 1955, page 21). The following is a tabulation of the results of this analysis:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	Calculated $CaCO_3$
3.89%	1.04%	1.32%	49.59%	2.15%	Trace	0.16%	88.31%

Available quality test information on this unit shows the Los Angeles wear ranges from 26.0 to 39.2(A) percent and from 30.6 to

Figure 12. The Plattsmouth Limestone Member in an abandoned quarry located in the center of the NE¼ sec.22, T16S, R17E. The geological pick in the center of the photo is embedded in a shale seam.

Figure 13. An exposure of the Plattsmouth Limestone Member in a quarry producing agricultural lime in the SW¼SW¼ sec.34, T17S, R16E



38.2(B) percent, the absorption from 0.98 to 3.78 percent, the specific gravity (dry) from 2.48 to 2.54, and the specific gravity (saturated) from 2.51 to 2.67. Additional test information is shown in chart form in figure 9 (page 19).

Aggregate from the Plattsmouth is suitable for use as light type surfacing material, riprap and structural stone. Based on the results of quality tests, material from the Plattsmouth is suitable for concrete aggregate and in some cases for bituminous construction; however, the aggregate is marginal in some areas and will have to be washed because of the presence of shale seams in the unit.

According to the results of quality tests (absorption, soundness, Los Angeles wear, and specific gravity) completed on samples in seven northeastern Kansas counties, the Plattsmouth is a better quality limestone in Osage County than in the counties to the north.

In Osage County, the Plattsmouth, for the most part, is exposed along valley walls and, therefore, heavy overburden will be encountered in most areas. The outcrop pattern of the Plattsmouth is illustrated on plates IV and VI.

Kereford Limestone Member

The Kereford is the uppermost and thickest limestone member of the Oread Limestone Formation. Over much of the county it makes a secondary bench above the more resistant Plattsmouth. In Osage County, the Kereford is variable both in thickness and lithology. Generally, it has an average thickness of 16 feet, but locally it has a thickness of 25 feet. The upper part is a granular, oolitic limestone with shale seams. Figure 14 (page 27) shows an exposure of the middle Kereford near the spillway of Pomona Dam. The lower part is a wavy-bedded limestone with some shale or shaly limestone.

Figure 14. A portion of the Kereford Limestone Member in a road cut in the SW¼NW¼ sec. 20, T16S, R17E.

The Osage County Highway Department has used a limited amount of Kereford from a quarry located two miles east of Pomona Dam (L. D. Pierce, personal communication). Other smaller quarries located in the southeastern part of the county have provided limestone for local use. At the time this report was being prepared (April, 1966), only the Killough-Clark quarry (NE¼NW¼ sec. 4, T17S, R17E) was producing the Kereford in Osage County. The rock was being crushed for agricultural lime and as aggregate for local use. Figure 15 (page 28) shows an exposure of the Kereford in this quarry. The riprap used in the construction of Pomona Dam was produced from the Kereford at a site near the north end of the dam (NW¼ sec.17, T16S, R17E). This quarry was partially inundated by the impounded water of the Pomona Reservoir. Figure 16 (page 28) shows an exposure of the Kereford at this quarry.

Only a limited number of quality tests have been conducted on the Kereford in Osage County by the State Highway Commission of

Figure 15. Quarry face of the Killough-Clark quarry which produces the Kereford Limestone for agricultural lime and aggregate for local use.

Figure 16. The Kereford Limestone Member in the quarry form which riprap for the Pomona Dam was produced.

Kansas. These test results show the Los Angeles wear ranges from 27.6 to 28.9(B) percent, the absorption from 2.61 to 2.98 percent, the specific gravity (dry) from 2.47 to 2.49, the specific gravity (saturated) from 2.54 to 2.56, and the soundness loss ratio from 0.96 to 0.97. These test results should not be interpreted as being representative of the Kereford Limestone Member but that a relatively good quality limestone can be produced from certain horizons in the ledge. In many areas, only marginal material is produced from this unit for concrete and bituminous construction; however, material from the upper and lower part of the Kereford will generally meet specifications for riprap and light type surfacing material.

Exposures of the Kereford are restricted to the southeastern part of Osage County. The outcrop pattern is illustrated in plates IV and VI. Because the Kereford occupies high terrain in this area, residual clay along with some discontinuous loess deposits overlie the rock ledge and are present in and along joint planes. Although the Kereford is exposed in many counties in northeast Kansas, only a very limited amount has been used in concrete and bituminous construction because of its poor quality and the availability of better quality material.

Lecompton Limestone Formation

The Lecompton Limestone Formation has an average thickness of approximately 40 feet but may have a local thickness up to 66 feet. Four limestone and three shale members comprise this formation; however, only two limestone members (the Spring Branch and Beil Limestone) are considered to be important sources of construction material. The Spring Branch is the basal member and the Beil occurs in the middle part of the Lecompton. Because the exposure pattern of these members are similar, they have been included in the same map unit and have been designated as the Lecompton Limestone Formation.

The Spring Branch is a massive yellow-brown, slightly wavy-bedded limestone which is highly fossiliferous. Locally, it is slightly sandy or silty with a thin shale seam occurring in many outcrops. Thickness of the member averages about five feet. Figure 17 illustrates an exposure of the Spring Branch in a road cut in eastern Osage County.

Figure 17. The Spring Branch Limestone in a road cut in the NW¼ sec.29, T16S, R17E.

The Beil Limestone is a massive yellow-brown, slightly wavy-bedded limestone with a thin shale break near the middle of the ledge. It has an average thickness of about five feet. Figure 18 (page 31) shows an exposure of the Beil in a road cut near the Pomona Reservoir.

Only a limited amount of the Lecompton has been quarried in Osage County, most of which has been used for local purposes. Material produced from the Lecompton is suitable for use as light type surfacing

Figure 18. The Beil Limestone in a road cut in the SW¼ sec.19, T16S, R17E.

material and riprap but in order to be used as concrete or asphalt aggregate, the rock would have to be selected in the outcrop to avoid sandy and silty zones and shale seams.

Available quality test information on samples of the Beil and Spring Branch taken in Osage County shows the Los Angeles wear ranges from 26.6 to 31.8(A) percent and 27.6 to 30.6(B) percent, the absorption from 0.7 to 3.96 percent, the specific gravity (dry) from 2.42 to 2.63, the specific gravity (saturated) from 2.52 to 2.67 and the soundness loss ratio from 0.81 to 0.97. Additional test information is shown in chart form in figure 8 (page 17). It should be noted that many of these samples were obtained from only the limestone outcrop and no shale was included. During production of the ledge, the material derived from the shale may be included and would have a detrimental affect upon the overall quality of the material.

Exposures of the Lecompton are restricted to the eastern half of the county. The exposure pattern is shown on plates II, IV and VI. In the east-central part of the county (plate IV), the Lecompton occupies the high terrain which makes the ledge more accessible for material purposes; however, residual mantle and discontinuous loess deposits overlie the ledge in many areas.

Deer Creek Limestone Formation

The Deer Creek Limestone Formation ranges from 42 to 62 feet and averages about 50 feet. It is comprised of three limestone and two shale members but only the top (Ervine Creek Limestone) and basal (Ozawkie Limestone) members are considered significant material source units.

Ozawkie Limestone Member

The Ozawkie Limestone Member ranges from 10 to 17 feet in thickness in Osage County. The member is divided into one shale and two limestone units. The basal bed is a light gray to blue-gray massive limestone which varies from five to seven feet in thickness. Figure 19 (page 33) shows an exposure of the lower Ozawkie. The lower Ozawkie bed is overlain by tan colored clayey to slightly sandy shale which varies from one to seven feet in thickness. The upper Ozawkie is a light buff to brown colored massive bed which varies from two to six feet in thickness. Figure 20 (page 33) shows an exposure of the Ozawkie in a road cut.

The Ozawkie was used for riprap during the construction of primary and secondary roads associated with the Pomona Dam and Reservoir. Although several old quarries are located in this unit, most production has been for local use. The basal unit may meet specification for concrete and bituminous construction but material produced from the upper unit would be marginal.

A limited amount of quality information on samples from this unit shows the Los Angeles wear runs about 30.6(B) and 25.2(A) per-

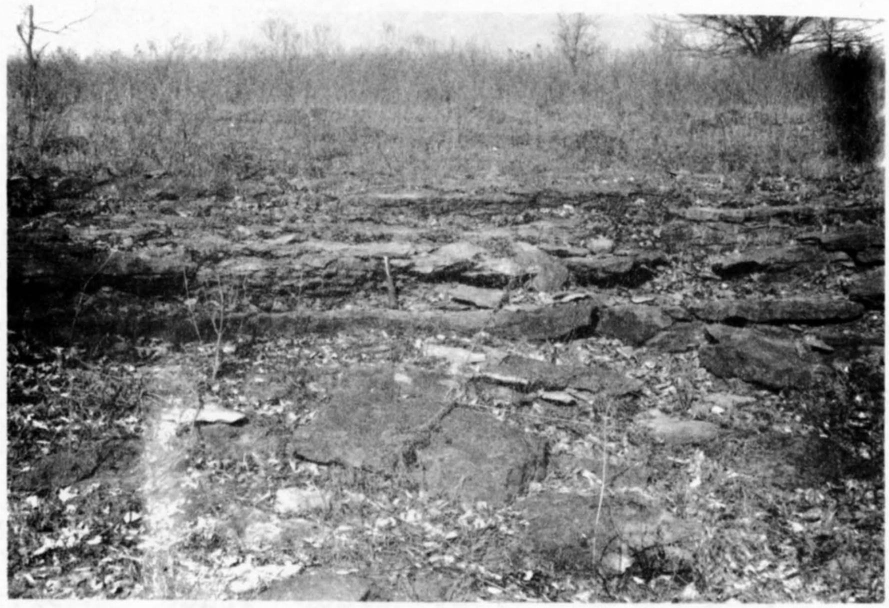


Figure 19. The basal Ozawkie Limestone along a stream bank located in the center of SE¼SE¼ sec.14, T14S, R16E.

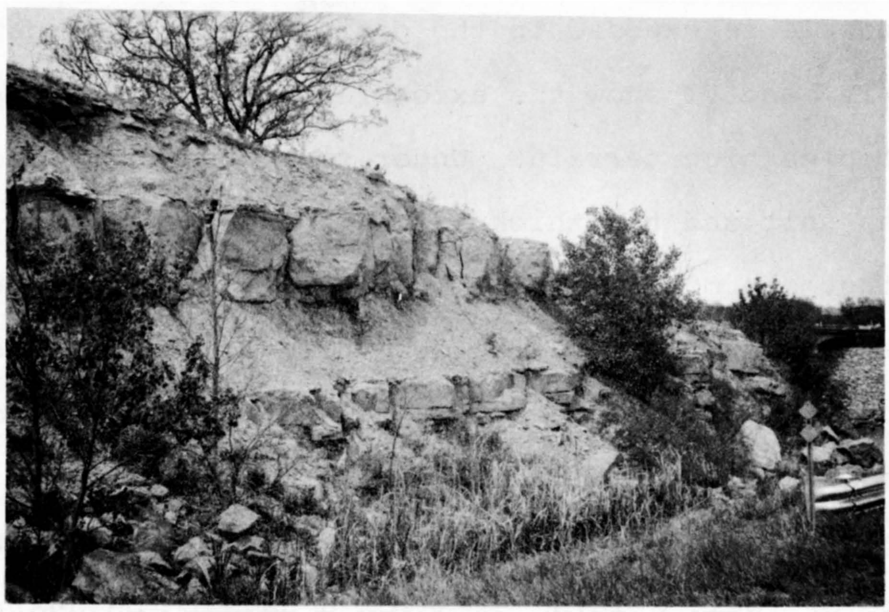


Figure 20. The Ozawkie Limestone in a road cut in the center of sec. 7, T16S, R16E. illustrating the upper and lower units of the limestone member.

cent, the specific gravity (dry) ranges from 2.32 to 2.63, the specific gravity (saturated) from 2.45 to 2.64, the absorption from 1.0 to 5.6 percent, and the soundness loss ratio from 0.88 to 0.97. The State Geological Survey completed a chemical analysis on a composite sample of the Ozawkie (O'Connor and others, 1955, page 21) obtained in the NW¼NE¼ sec. 4, T15S, R17E (shale interval excluded). The following is a tabulation of the results of this analysis:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	Calculated $CaCO_3$
3.87%	0.82%	2.73%	51.28%	0.88%	Trace	Trace	91.52%

Generally the Ozawkie will not meet specifications for concrete and asphalt aggregate but may be used for light type surfacing material and riprap.

The Ozawkie is exposed in the eastern half of Osage County, and plates II, IV, and VI show the exposure pattern. In many areas the Ozawkie occupies high terrain. Under such conditions, residual soil overlies the unit and the thickness of the ledge will be less due to weathering. In most cases, the limestone can be produced without removing large volumes of overburden; however, residual clay will be encountered in the joint planes. Figure 21 (page 35) shows a quarry where the basal Ozawkie is located on high terrain south of Overbrook. The rock ledge is near the surface and in order to produce a large volume of rock, a large area would have to be quarried because the thickness of the ledge has been reduced by weathering. This situation will be encountered when producing other source units (such as the Topeka and Ervine Creek) that form the uppermost resistant ledge of the local terrain.

Figure 21. An Ozawkie Limestone quarry in the NE¼SE¼ sec.18, T15S, R17E where the Ozawkie occupies the highest element of topography.

Ervine Creek Limestone Member

The Ervine Creek Member is a light gray to white, fine-grained limestone containing scattered chert nodules. The individual beds are thin and wavy-bedded with several thin shale seams. The member ranges in thickness from about eight to 22 feet. Figure 22 (page 36) shows an exposure of the Ervine Creek in a quarry located near the town of Overbrook.

The quality of material produced from the Ervine Creek in Osage County is comparable to that produced at other quarries in eastern Kansas. Available test data on samples of the Ervine Creek taken in Osage County show that the specific gravity (dry) ranges from 2.39 to 2.63, the specific gravity (saturated) from 2.46 to 2.65, the absorption from 0.88 to 3.61 percent, and the soundness loss ratio from 0.91 to 0.94, and the Los Angeles wear from 27.6 to 33.3(B) percent. More detail quality information is shown in figure 8 (page 17).

Figure 22. The face of an Ervine Creek Limestone quarry located in the NE¼NW¼ sec.32, T14S, R17E.

The State Geological Survey of Kansas completed a chemical analysis on a composite sample of the Ervine Creek taken in the NE¼NW¼ sec.32, T14S, R17E (O'Connor and others, 1955, page 21). The results of this analysis are listed as follows:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	Calculated $CaCO_3$
2.77	0.85%	1.32%	52.12%	1.03%	Trace	Trace	93.02%

At the time this report was being prepared, two quarries (near the cities of Lyndon and Overbrook) were producing from the Ervine Creek. The material was being used primarily for light type surfacing material; however, concrete aggregate (coarse fraction) had been produced from the site near Lyndon.

Generally, the material from the Ervine Creek will meet specifications for concrete and bituminous construction; however, because of the presence of shale seams, good quality material from this rock ledge is sometimes difficult to produce for such purposes. The

Ervine Creek can be used for riprap and light type surfacing material, and is exposed in the eastern half of Osage County. Plates II, IV, V and VI show the outcrop pattern of this source unit.

Topeka Limestone Formation

The Topeka Limestone Formation is divided into four shale and five limestone members; however, in Osage County several of the upper units are too thin to be recognized as members. The Topeka ranges from 13 to 26 feet and averages about 20 feet in thickness. In some areas the upper members have been removed and replaced by sandstone in the overlying Severy Shale. The two lower limestone members (Hartford and Curzon Limestone Members) comprise most of the formation and make up a major material source unit in Osage County. In this report, these two lower members are mapped and designated as the Topeka Limestone.

The Topeka Limestone source unit (Hartford and Curzon Members) varies from 13 to 21 feet in thickness. The upper part (Curzon Limestone Member) is characterized by interbedded limestone and limy shale with a gray fossiliferous limestone containing scattered chert nodules capping the ledge. The lower part (Hartford Limestone Member) is a massive, gray to blue-gray limestone that weathers a deep yellow-brown color. Figure 23 (page 38) shows the Topeka in a quarry in central Osage County.

The Topeka has been commercially produced from two quarries in Osage County. Material produced from both quarries is used for light type surfacing material by the Osage County Highway Department. The Topeka has been used elsewhere for concrete and bituminous construction but the quality of the rock is variable from one area to another. Available test data on samples of the Topeka taken in Osage

Figure 23. An exposure of the Topeka Limestone Formation in a quarry located in the SW¼NW¼ sec.11, T18S, R14E.

County show that the specific gravity (dry) ranges from 2.37 to 2.57, the specific gravity (saturated) from 2.51 to 2.62, the absorption from 1.92 to 5.85 percent, the Los Angeles wear from 27.6 to 40.0(B) percent, and the soundness loss ratio from 0.77 to 0.97. Chemical analysis of several samples of the basal Topeka conducted by the State Geological Survey are tabulated in table I(page 39).

In some areas, the Topeka will meet specifications for bituminous and concrete construction, but the material would probably have to be washed. Generally, the material is marginal for such purposes but can be used for light type surfacing material and riprap.

The Topeka Limestone is exposed across Osage County in a north-northeast, south-southwest direction. In central Osage County, it forms the highest element of topography. In this area most of the Topeka has been weathered and only a part of the basal Topeka (Hartford Limestone) is present. Although a topographic bench is present, only a limited amount of rock can be produced in these areas. In

Curzon Limestone Member

Sample 1	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	$CaCO_3$
SE¼NE¼ sec.27, T15S, R15E	3.61%	0.81	1.22	52.75	0.47	0.11	Trace	93.83*
Sample 2	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	$CaCO_3$
SE¼SW¼ sec.14, T18S, R14E	13.45%	0.75	0.66	51.84	0.96	.06	Trace	92.39*

Hartford Limestone Member

Composite Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	$CaCO_3$
NW¼SE¼ sec.12, T18S, R14E	0.74	0.24	0.53	54.37	0.51	0.07	---	96.81*
Upper Ledge Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	$CaCO_3$
SE¼SW¼ sec.14, T18S, R14E	2.88	3.89	5.01	30.77	13.54	0.20	0.13	54.30*
Lower Ledge Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	$CaCO_3$
SE¼SW¼ sec.14, T18S, R14E	0.82	0.25	0.67	54.56	0.53	0.08	---	97.11*

* Calculated

Table I. Results of chemical test conducted on samples of the Topeka Limestone.

order to obtain a full thickness of the Topeka, the rock ledge would have to occupy lower terrain so that the effects of weathering would have not penetrated the unit.

Plates II, III, IV, V and VI shows the exposure pattern of the Topeka in Osage County.

Howard Limestone Formation (Utopia Limestone Member)

The Utopia Limestone Member is the top member of the Howard Limestone Formation, and the only one of material significance. It consists of several limestones separated by thin shales. The upper bed, ranging from about one to five feet in thickness, is a light gray fossiliferous limestone and is the main source of construction material. The lower part of the unit is characterized by calcareous shale and gray, flaggy limestone. Figure 24 shows the Utopia in a road cut in southwestern Osage County. Although the Utopia is relatively thin, it has been used for construction purposes; however, the quarry was located near the project and a relatively thin overburden was encountered.

Figure 24. The upper part of the Utopia Limestone Member in a road cut in the SW¼ sec. 3, T18S, R14E

Available test data on samples of the Utopia taken in Osage County shows that the specific gravity (dry) ranges from 2.38 to 2.80, the specific gravity (saturated) from 2.49 to 2.83, the absorption from 0.9 to 4.9 percent, the Los Angeles wear from 20.9 to 26.8(A) percent, and the soundness loss ratio from 0.78 to 0.94.

The Utopia can be used for light type surfacing material, riprap, and in some areas for concrete and bituminous construction. The rock ledge is relatively thin and the bed would have to be near surface and close to the construction project in order for it to be economically produced.

The Utopia is exposed in the western half of the county, and the pattern is depicted on plates I, II, III and V.

Bern Limestone Formation

The Bern Limestone Formation comprises one shale and two limestone members. It varies from eight to 15 feet in thickness. In this report the upper and lower members (Wakarusa and Burlingame Limestones) have been mapped as construction material source units and designated as the Bern Limestone.

The Burlingame Limestone is highly variable in thickness and lithology. It ranges from two to nine feet and averages about three feet in thickness. Most commonly this unit is characterized by one or more massive-bedded, light gray and buff limestone. Elsewhere, the unit is a brecciated, fossiliferous unit and, locally, the limestone is conglomeratic. Figure 25 (page 42) shows a typical outcrop of the Burlingame in northwest Osage County.

The upper unit, the Wakarusa Limestone, ranges from about three to eight feet in thickness. It comprises a massive, thick to medium-bedded limestone containing a variety of fossils. Fresh surfaces of the limestone are bluish-gray which weathers a light to dark brown color.

Figure 26 (page 42) shows the Wakarusa in a road cut in western Osage County. Although only two to seven feet of shale separate these two limestone units, the two ledges are rarely exposed in the same area.

Figure 25. An exposure of the Burlingame Limestone in a road cut in the SW¼ sec.20, T15S, R14E.

Figure 26. The Wakarusa Limestone in a road cut located in the SW¼ sec. 7, T16S, R14E.

The Bern has been produced for construction material elsewhere in the northeastern part of the state but has not been quarried on a commercial basis in Osage County.

A limited number of quality tests conducted on samples of the Bern in Osage County indicate that the specific gravity (dry) ranges from 2.46 to 2.56, the specific gravity (saturated) from 2.55 to 2.62 and the absorption from 2.62 to 3.5 percent.

Material from the Bern would meet specifications for light type surfacing material and riprap; however, the unit would have to be near the surface in order for it to be economically feasible to produce.

The Bern is exposed in the northwestern part of Osage County as illustrated on plates I, III and V.

<u>Emporia Limestone Formation</u> (Reading Limestone Member)

The Reading Limestone Member is the basal member of the Emporia Limestone Formation and is considered the only unit in this formation which is of material significance. It averages about three feet in thickness but is as much as seven feet where shale partings are prominent in the limestone. The Reading is dark gray-blue, dense limestone which weathers yellow-brown. Figure 27 (page 44) shows the Reading in a road cut in south-central Osage County.

Because of its thin nature, only a very limited amount of the Reading has been quarried in Osage County. Rock from this unit has been used, primarily, for structural stone. A limited number of quality tests completed on samples of the Reading taken in Osage County show that the specific gravity (dry) ranges from 2.38 to 2.65, the specific gravity (saturated) from 2.44 to 2.67 and the absorption from 0.9 to 2.87 percent. Additional test information is included in figure 8 (page 17).

Figure 27. The Reading Limestone Member in a road cut located in the SW¼ sec.13, T15S, R13E.

Material from the Reading would meet specifications for riprap and light type surfacing material, but according to quality tests completed, it would not meet requirements for bituminous or concrete construction. The exposure pattern of the Reading is shown on plates I, III, and V.

Zeandale Limestone Formation (Tarkio Limestone Member)

The Tarkio Limestone Member is the basal member of the Zeandale Limestone Formation and the only member of material significance. It is about seven feet thick in the northern part of the county but is much thinner to the south. It ranges from two to five feet in most outcrops. The Tarkio is a massive, gray limestone which weathers a deep rich brown and contains an abundance of large fusulinids. Figure 28 (page 45) shows an outcrop of the Tarkio in northwestern Osage County.

Quality tests completed on samples of the Tarkio taken in Osage County indicate that the specific gravity (dry) ranges from 2.40 to

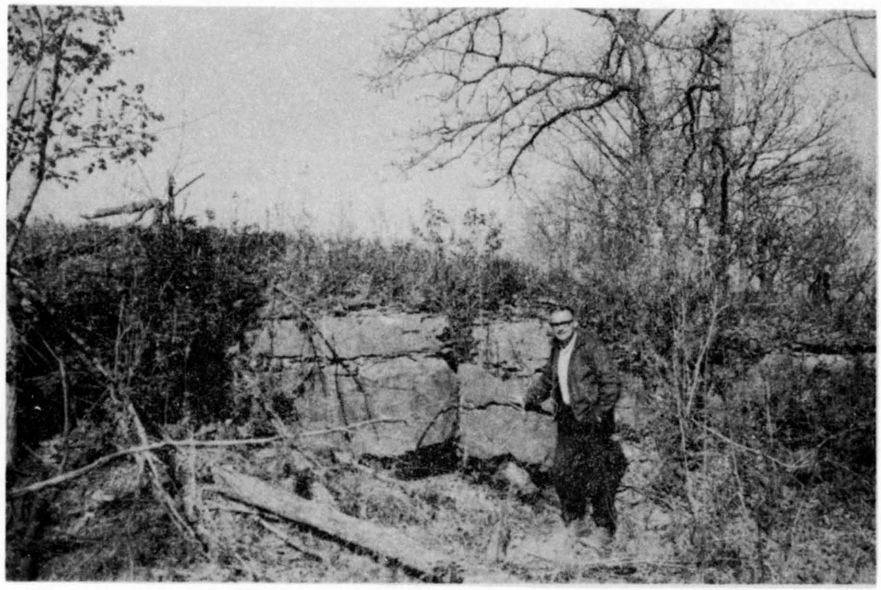


Figure 28. An exposure of the Tarkio Limestone Member in the NE¼SE¼ sec. 8, T14S, R14E.

2.56, the specific gravity (saturated) from 2.49 to 2.63, the absorption from 2.83 to 4.01 percent, the Los Angeles wear from 24.0 to 25.0(B) percent, and 26.3 to 30.0(A) percent and the soundness loss ratio from 0.83 to 0.97.

A chemical analysis was completed on a sample from the lower Tarkio (obtained from the SE¼SE¼ sec.12, T15S, R13E) by the State Geological Survey. The following shows the results of this analysis:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	SO_3	Calculated $CaCO_3$
5.34%	1.64%	2.24%	49.32%	0.95%	0.07%	Trace	87.80%

Although the Tarkio has been quarried in the northeastern part of the state, the rock, in many cases, has to be selected in the outcrop in order to produce a usable material. Quality test results show that a better quality material is available from the Tarkio in Osage County; however, the unit is highly variable in thickness and lithology. Material from the Tarkio will meet specifications for riprap and light type surfacing material but is marginal for use in concrete and bituminous construction.

Exposures of the Tarkio are restricted to the northwest corner of the county and are shown on plates I and III.

Stotler Limestone Formation (Dover Limestone Member)

The only member of the Stotler Limestone Formation of material significance is the Dover Limestone Member which is the basal unit of the formation. Exposures of the Dover range in thickness from 1.5 to about four feet and average about three feet. It is a light gray limestone which weathers a light gray-tan. Figure 29 shows an outcrop of the Dover in northwestern Osage County.

Figure 29. An exposure of the Dover Limestone Member in the SE¼ sec.13, T14S, R13E.

One quality test, completed on the Dover in Osage County, indicates the following:

Specific gravity (saturated)	2.61
Specific gravity (dry)	2.65
Percent Absorption	1.5

Generally, material produced from the Dover will meet specifications for most phases of construction; however, because the ledge is relatively thin, the unit would have to be near the surface in order for it to be produced economically. Exposures of the Dover, which are restricted to the northeastern part of the county, are shown on plates I and III.

Pennsylvanian Shales

Several shales that outcrop in Osage County have potential usefulness as construction material. These shales are the Lawrence, Kanwaka (Jackson Park and Stull Members), Tecumseh, Calhoun, Severy and White Cloud (Scranton Shale Formation).

The Lawrence Shale Formation is the oldest shale exposed in Osage County. Stratigraphically, the Lawrence is located beneath the Toronto Limestone and has a similar exposure pattern. Outcrops are present along the valley walls in the extreme southeastern part of Osage County (plate VI). The Lawrence contains one or more beds of sandstone which are erratic in thickness and lithology. The sandstone is commonly composed of fine quartz with a small percentage of mica and clay minerals (O'Connor and others, 1955, page 19). Some sandstone can be found at various horizons in the Lawrence which, if broken down by crushing to its individual grain size, can be used to supplement hot mix aggregate for gradation purposes (percent retained on no. 80 sieve). If the sand grains are left in the cemented state, coarser aggregate will be obtained, but such material would fail to meet soundness requirements because of the poor binding properties of the cementing agent. Tests conducted on sandstone from the Lawrence obtained in a nearby county shows that approximately 33 percent was retained on the no. 80 sieve and 68 percent retained on the no. 100 sieve.

A limited amount of sandstone from the Severy Shale has been used for light type surfacing material. According to O'Connor (1955, page 24) sandstone has been produced from a quarry located in the NW¼ sec. 1, T14S, R15E, for this purpose.

The remaining shales have been tested by the State Geological Survey (O'Connor and others, 1955, page 23) as a potential source of lightweight aggregate. The relative stratigraphic position of the Jackson Park, Stull, Tecumseh, Calhoun, Severy and White Cloud Shales can be determined by studying the geologic column, figure 7 (page 15). Their outcrop pattern will be similar to limestone material source units that are located stratigraphically above or below the respective shale units.

The results of the lightweight aggregate bloating tests on Osage County shales are shown in table II. Additional information can be obtained from the Geology, Mineral Resources, and Ground-water Resources of Osage County, Kansas, State Geological Survey of Kansas, Volume 13, Page 23.

Shale Unit	Unit Weight Lbs. Per cu. ft.	Color of Crushed Aggregate
Jackson Park	41.90	Black and tan
Stull	41.40	Black and tan
Tecumseh	38.10	Dark gray
	28.40	Red and gray
	54.30	Dark gray
Calhoun	55.00	Black and tan
	43.80	Dark gray
Severy	48.80	Dark gray
	48.10	Dark gray
	49.10	Tan and dark gray
	47.73	Dark gray
White Cloud	47.73	Dark gray

Table II. Results of bloating tests conducted on samples of Pennsylvanian Shales obtained in Osage County.

Tertiary Terraces

Remnants of alluvial terraces occur between 60 and 160 feet above the floodplains of Dragoon, Soldier, One Hundred and Ten Mile and Salt Creeks, the Marais des Cygnes River, and their major tributaries. Some of these terraces occur several miles from the streams which deposited them. The deposits are most commonly found on the north side of the channel which indicates that the degradational process progressed laterally from north to south. The highest deposits are thought to be late Tertiary in age while the lower ones are probably Nebraskan age (O'Connor and others, 1955, page 7). Figure 30 (page 50) shows a terrace deposit occupying the highest element of topography in south-central Osage County. Inasmuch as all of these terraces are lithologically similar, consisting of siliceous sand and gravel (primarily of chert), they have been included in the same map unit and designated as Tertiary Terraces. Brownish-red clay matrix (plastic index 30 and higher) fills the interstices between the gravel. All calcareous material has been leached from these deposits which indicate an extended period of weathering. Figure 31 (page 50) is a ground view of a pit producing from a Tertiary Terrace showing the textural aspects of the deposits.

Thickness of the chert gravel deposits range from a few inches to about 12 feet.

High chert gravel deposits have been produced extensively in Osage and other counties and used primarily for light type surfacing material. A limited amount of the material produced from these terraces has been used in concrete construction; however, the gravel had to be transported to lower areas where water was available for washing. Also, past experience has revealed that when chert aggregate is used in concrete, the extreme hardness of the chert makes it very difficult to saw joints.

Quality test data on samples obtained in other counties indicate that these gravels, when washed, meet all quality specifi-

Figure 30. A ground view of Tertiary Terraces situated on high terrain in south central Osage County.

Figure 31. A ground view of a chert gravel deposit located in the NW¼ sec.12, T15S, R15E.

cations for bituminous and concrete construction. Finer material would have to be added to meet gradational requirements.

Chert gravel from Tertiary Terraces in Osage County has been used only for light type surfacing material. A limited number of quality tests conducted on samples of chert gravel indicate that the specific gravity before washing ran about 2.51 and about 2.56 after washing, the Los Angeles wear about 17.2 to 19.5(A) percent, and the soundness loss ratio from 0.97 to 1.00.

Chert gravel from Tertiary Terraces in Osage County will meet specifications for light type surfacing material and for bituminous and concrete construction if the gravel is washed. Finer material will have to be added to meet gradation requirements.

Chert gravel deposits are located along Dragoon Creek, the Marais des Cygnes River, and their major tributaries. Their geographic distribution is depicted on plates I through VI.

Quaternary Terraces

Remnants of terrace deposits occurring between 10 and 30 feet above the floodplains of the major drainage channels in Osage County have been designated as Quaternary Terraces. The higher terraces within this classification are probably Kansan and the lower Illinoisan in age (O'Connor and others, 1955, page 7). The lower deposits are made up, primarily, of silt and clay size particles with smaller amounts of siliceous sand and chert gravel. The material found in some of the higher deposits is similar to the higher Tertiary Terraces. These deposits attain a maximum thickness of 35 feet. In Osage County, chert gravel from these areas has been used for light type surfacing material but not in any other type of road construction.

A limited number of test results which are available on samples of chert taken in Osage County, indicate that the soundness loss ratio is approximately 0.95, the Los Angeles wear about 20.0(B) percent and the specific gravity (unwashed) has a value of 2.46 and approximately 2.53 when washed.

Chert gravel from the Quaternary Terraces in Osage County will meet specifications for most types of construction if properly processed; however, finer material will have to be added to meet gradation requirements. In essence, material from the Quaternary Terrace will be similar to that produced from the Tertiary Terrace although the lower Quaternary Terraces will have a higher percent of clay and silt size material. Quaternary Terraces are found throughout the county and are mapped on all plates.

Quaternary Alluvium

The material which comprises the floodplains and low terraces in the valley of the drainage channels have been mapped as Quaternary Alluvium. This material was deposited during Recent and Wisconsinan time. These deposits are made up, primarily, of clay, silt, and sand in the upper part with larger size material in the lower portion. The Alluvium attains a maximum thickness of 40 feet in the floodplain of the Marais des Cygnes River (O'Connor and others, 1955, page 6). Chert gravel has been commercially produced from this source in other major drainage channels in eastern Kansas but not from any that traverse Osage County. Inasmuch as the headwaters of of the Marais des Cygnes River are located in Permian beds to the west (source beds for chert gravel), it is conceivable that chert gravels could be produced from the Quaternary Alluvium in Osage County. However, because of the thick overburden and because the deposits are poorly sorted, production from this unit would be difficult. Such material probably would have to be produced by a pumping operation in the Marais des Cygnes River valley if the pit was located in the the floodplain. Elsewhere, dry pit production methods would be used.

Although the Quaternary Alluvium map units appear on all sections of the Osage County materials map, granular material is most likely to be found in the valleys of the larger drainage channels such as the Marais des Cygnes River and Dragoon Creek.

Geo-Engineering

General Information

This section of the report discusses the quality of the material available in Osage County for normal or selected embankment purposes and for subgrade construction. In addition, ground-water problems that may be encountered on construction projects and the availability of water suitable for concrete mixing purposes are discussed briefly.

Inasmuch as the main objective of this section of the report is to familiarize the reader with some of the adverse field conditions that may be encountered in Osage County, the information presented is general in nature. Detailed field investigations will be required to ascertain the severity of any specific problem and to make recommendations concerning design and construction procedures.

Because of the diversified geological conditions that exist in Osage County, a variety of geo-engineering problems are encountered throughout the area. Thick limestone and shale units characterize the eastern half of the county, especially the southeastern corner. Relatively thin limestone and thick shale units outcrop in the western half of the county. The shales are characterized by erratic sandstone beds and thin coal seams.

Material Usage Consideration

Most of the material available for embankment and subgrade construction in Osage County consists of clay shales or soil mantle derived from thick shale units. Most of the soil mantle derived from shale in this area is characterized by high liquid limits and plastic indices that range from 15 to 45. The material is classified as a silty clay loam, silty loam, and in the more severe cases, as a clay according to the Kansas textured classification system. Most of the material would be classified as A-6 or A-7 according to the American Association of State Highway Officials (AASHO) Soil Classification System.

The clay shales are undesirable for construction purposes because of a high volume change between wet and dry states. The swell values of many of the shales exceed four percent. Swell values referred to in this report are those determined in accordance with a specific test procedure employed by the State Highway Commission of Kansas.

Soil mantle and shales characterized by a high percentage of clay, high liquid limits, and high plastic indices should be avoided for subgrade construction; however, in many areas it is economically impossible to eliminate them because they constitute the major portion of the material available for subgrade construction. The recommended thickness of pavements should be figured to compensate for their use or in many cases, the material can be stabilized with hydrated limes. However, many of the clay shales found in Osage County are practically impossible to pulverize with ordinary construction equipment to a state where they can be effectively stabilized with lime. Unweathered sandstone that might be encountered in the shale units would be equally as hard to pulverize for use in subgrade construction.

Most of the material described in this section of the report would not ordinarily be recommended for shoulder construction. Such material may be useful for slope protection because of its resistance to erosion; however, if the development of turf is desired, it should be avoided. It should be noted that soil mantle comprised of a high percent of sand which might be derived from some of the sandstone units is highly susceptible to erosion and should not be used for slope protection.

If used for embankment construction, clayey material such as described previously should be placed in the lower portion and its shear strength should receive special attention if considered for use in high fills.

Possible Hydrology Problems in Road Construction

Many road failures are associated with the movement and accumulation of ground-water. Subsurface water problems are usually confined to definite zones within consolidated geologic units or in unconsolidated material where conditions are favorable for ground-water movement. Occasionally geologic units, which many times are considered insignificant from the construction point of view, may be the source of subsurface water problems. Special drains or ditches may be required to intercept the ground-water on a given project or the proposed alignment may be changed to avoid water bearing zones or beds.

Ground-water problems may be encountered along the base of the thicker limestone that outcrop in the eastern and southeastern part of the county. Such problems have been encountered on improvements that traverse the Oread, Lecompton, Deer Creek and Topeka Limestone

Formations. Relatively thin limestone units such as the Utopia, Reading, Tarkio and Dover, which are exposed in the western part of the county, can carry enough water to cause as severe failures in road structure as those caused by the thicker aquifers. Sandstone found in shale units that outcrop in Osage County are equally significant as potential water carriers. For example, ground-water problems were encountered when sandstones in the Snyderville (Oread Formation) and the Ireland Sandstone (Lawrence Formation) were crossed by improvements constructed in this general area. Several coal beds outcrop in Osage County which are potential water carriers and may present hydrology problems if encountered on a project. The Williamsburg Coal is found in the extreme southeastern part of the county (found stratigraphically below the Toronto Limestone in the Lawrence Shale). The Nodaway Coal, which has been mined extensively around the cities of Carbondale, Scranton and Osage City, is exposed in the north-central part of the county. Stratigraphically the Nodaway is found a few feet below the Utopia Limestone. Figure 32 (page 57) shows an exposure of the Nodaway in a road cut in the central part of Osage County. Several other relatively thin coal seams are found in the Cedar Vale, Silver Lake, Soldier Creek, Pierson Point, French Creek and West Branch Shale units, (see figure 7, page 15 for stratigraphy), all of which are exposed or near surface in the northwestern part of Osage County.

Other ground-water problems may be encountered when a proposed improvement crosses terrace deposits included in the Tertiary Terrace or Quaternary Terrace map units. Hydrology problems caused by these deposits may be seasonal depending upon the size of the terrace and drainage area. The ground-water table may be encountered in the

Figure 32. An exposure of the Nodaway Coal in a road cut in the SW¼SE¼ sec.15, T18S, R14E.

alluvial plains (Quaternary Alluvium) of the larger drainage channels depending upon the location and nature of the improvement being constructed.

Pollution of Water Resources

Because of the possible detrimental effects that highly mineralized mix water can have on the performance of concrete, emphasis is being placed on the quality of the water used for this purpose. Most of the following discussion is based on data presented by O'Connor and others (1955) on the geology, mineral resources and ground-water of Osage County, Kansas.

According to available data, most sources in Osage County provide good quality mix water. The most accessible sources are the Marais des Cygnes River, Dragoon Creek and their tributaries. Water from these streams, and that produced from their terraces, is generally of good quality; however, local contamination of these streams by man has been reported. In the southeastern part of the county, water is produced from the Ireland Sandstone (Lawrence Shale) which underlies this area. Water produced from the Ireland at depths greater than 345 feet contains an excessive amount of chloride and sulfate ions to be used as mix water. Water produced from this unit at shallower depths is generally of better quality.

In the central part of the county, water is produced mainly from sandstone in the Calhoun and Kanwaka Shales. Test results on samples from these sources indicate that the water could be used for mix water. In the northwestern part of the county, water which is produced from the White Cloud and Severy Shales, has an excessive amount of chloride and sulfate ions which may preclude its use for concrete construction purposes. All other aquifers in this area provide a good quality of water. Several man-made lakes located in Osage County provide a good quality of water for concrete mix water; however, local pollution may occur and, therefore, each source should always be checked.

GLOSSARY OF SIGNIFICANT TERMS

Absorption: Determined by tests performed in accordance with A.A.S.H.O. Designation T 85.

Alluvium: A deposit of clay, silt, sand, or gravel laid down by flowing water.

Consolidated geologic units: Usually refers to strata older than Pleistocene where there is some cementation of the individual grains. (i.e. shale, sandstone, and limestone).

Continental deposits: Deposits laid down on land by rivers, wind, glaciers, etc.

Dip of geologic units: Angle of incline of the bed with respect to horizontal and the direction in which these beds are inclined.

Geologic period: A unit of geologic time. Mississippian, Pennsylvanian, and Permian are examples.

Geologic unit: This term is used in this report to denote (1) a geologic formation, (2) a geologic member, or (3) an unconsolidated deposit of Tertiary or Pleistocene age.

Ground-water: Water in the zone of saturation, that is, below the water table. In a more general and popular sense, any water that is standing in or passing through the ground may be called "ground-water."

Light type surfacing material: Chert gravel or crushed limestone placed on roads to provide an all weather surface or more commonly "a gravel road."

Liquid limit: Determined by tests performed in accordance with Section Y1-18 of the State Highway Commission of Kansas Standard Specification, 1966 edition.

Los Angeles wear: Determined by tests performed in accordance with A.A.S.H.O. Designation T 96 as modified by Section Y1-14 of the State Highway Commission of Kansas Standard Specifications, 1966 edition.

Marine deposits: Deposits laid down in the sea as contrasted with those laid down on land or in lakes.

Material source bed: A geologic unit from which usable construction material can be produced or is being produced.

Open materials site: A pit or quarry which has produced or is producing material suitable for some phase or phases of road construction.

Plastic index: Determined by tests performed in accordance with Section Y1-18 of the State Highway Commission of Kansas Standard Specifications, 1966 edition.

Pleistocene age: A period of geologic time representing approximately the last one million years on the geologic time scale.

Pliocene age: The last and youngest major subdivision of the Tertiary Period.

Prospective materials site: A geographic location where the geological conditions are favorable for the discovery of construction material.

Soundness: Determined by tests performed in accordance with Section Y1-15 of the State Highway Commission of Kansas Standard Specifications, 1966 edition.

Specific gravity: Determined by test performed in accordance with A.A.S.H.O. Designation T 84 for sand and gravel and A.A.S.H.O. Designation T 85 for crushed stone.

Stratigraphic position: The vertical position of a geologic unit in relation to other geologic units.

Terrace: A plain located above the present floodplain, which is usually made up of older stream laid deposits.

Unconsolidated deposits: A geologic unit where the basic constituents of the material have not been cemented or do not adhere together as a unit bed. Silt, clay, sand, and gravel are the main constituents of unconsolidated deposits. Most unconsolidated deposits were laid down in Pleistocene time.

Wash: (Material passing the No. 200 sieve). Determined by tests performed in accordance with A.A.S.H.O. Designation T 11.

Weight per cubic foot: Determined by tests performed in accordance with A.A.S.H.O. Designation T 19.

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