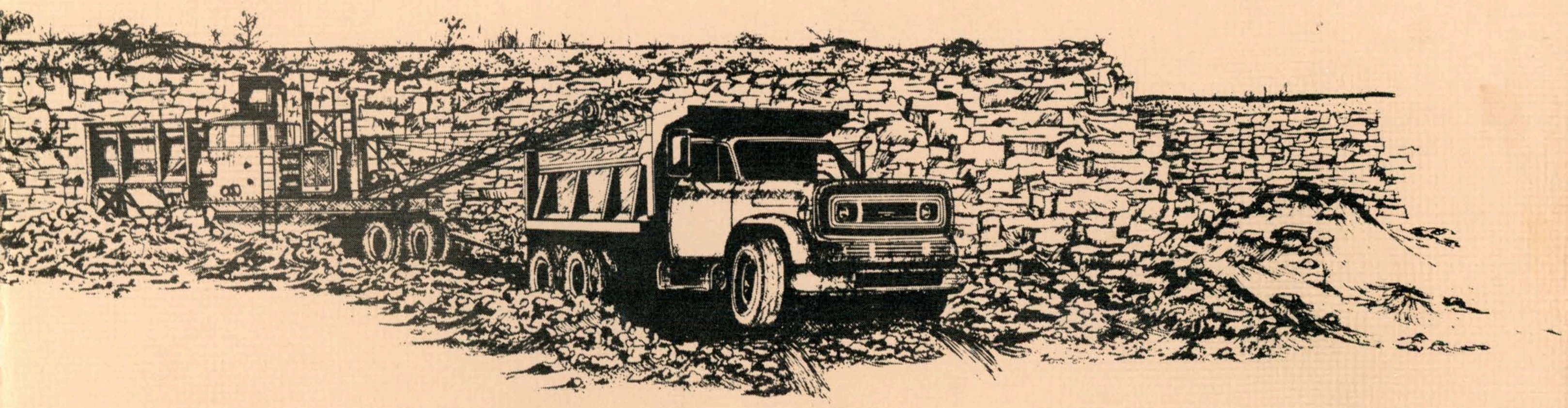
REPORT NO. 36

CONSTRUCTION MATERIALS INVENTORY



GREENWOOD COUNTY, KANSAS

Kansas Department of Transportation
Bureau of Materials & Research
Bureau of Transportation Planning

CONSTRUCTION MATERIALS INVENTORY

OF

GREENWOOD COUNTY, KANSAS

by

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

1982

Construction Materials Inventory No. 36

Copies are available from the Bureau of Transportation Planning
Kansas Department of Transportation

CONTENTS

the WHY?

WHAT?

HOW?

of This Report

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

Construction materials include all granular material, consolidated rock, and mineral filler suitable for use in highway construction.

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

The diagram on page iv shows how the MATERIALS INVENTORY SECTION may be used to evaluate and locate mapped sites.

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

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

TO LOCATE AND EVALUATE

A MAPPED SITE OF CONSTRUCTION MATERIAL IN GREENWOOD COUNTY

TURN TO THE MATERIALS INVENTORY SECTION

See
TABULATION OF CONSTRUCTION MATERIALS
Figure 7 Page 15

for material
BY TYPE

USE COLUMN 1

For Quality
Data
See Figure 23
Page 30

for material
BY INTENDED USE

USE COLUMN 2

for DESCRIPTION of material

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

for AVAILABILITY of material

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

MATERIALS MAP

SEE PINK SHEET, PAGE 31

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

SITE DATA FORMS

OPEN MATERIALS SITES:	SAMPLED	GREEN SHEET, PAGE 64
OPEN MATERIALS SITES:	NOT SAMPLED	GREEN SHEET, PAGE 96
PROSPECTIVE MATERIALS SITES:	SAMPLED	GREEN SHEET, PAGE 138

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

PREFACE

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

General geologic data were obtained from bulletins of the Kansas Geological Survey and detailed geologic and soil data were obtained from soil surveys and centerline geological profiles prepared for design of major highways in the county by the Kansas Department of Transportation. Geological correlations developed in this study represent interpretations by the various geologists involved in the investigation.

Appreciation is extended to J. L. Farrell, Fourth Division Materials Engineer, for verbal information concerning construction materials in the area. The authors also acknowledge the contributions made by S. E. Anderson, former Greenwood County Engineer, for verbal information on material resources of the county. This report was prepared under the guidance of the project leader, G. N. Clark, Geotechnical Engineer, and L. A. Rockers, Chief Geologist. Several geologists who have been or are employed by KDOT have contributed to various parts of the report writing and mapping processes. They include; Gerald Hargadine, Joe Walker, John Jimenez, Don Brison, Walt Fredericksen, Paul Clark, A. H. Stallard and George Peterson.

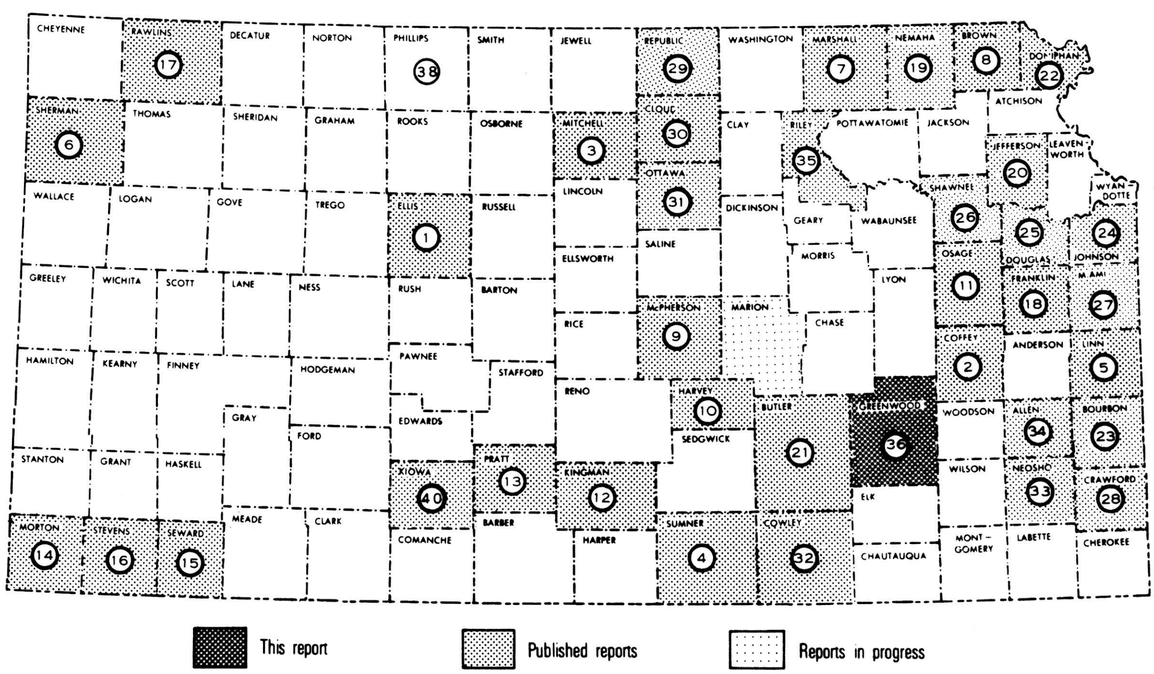


Figure 1. Index map of Kansas showing the location of Greenwood County along with the report numbers and locations of counties for which reports have been or are being completed.

ABSTRACT

Greenwood County lies within the Osage Cuesta and Flint Hills physiographic divisions of the state. Major topographic features of the county include the benched topography formed by the differential erosion of alternating beds of limestone, shale and sandstone. Flood plains of the Fall and Verdigris River form lowlands in the eastern and southern parts of the county.

Limestone is the dominant construction material in the county. Members of the Oread, Deer Creek, Topeka and Bern Formations are qualitatively and quantitatively the best aggregate resources. Variations in lithology predicate the use of proper sampling and testing of prospective sources to determine if the material meets current standard specifications, special provisions and supplemental specifications for construction aggregate.

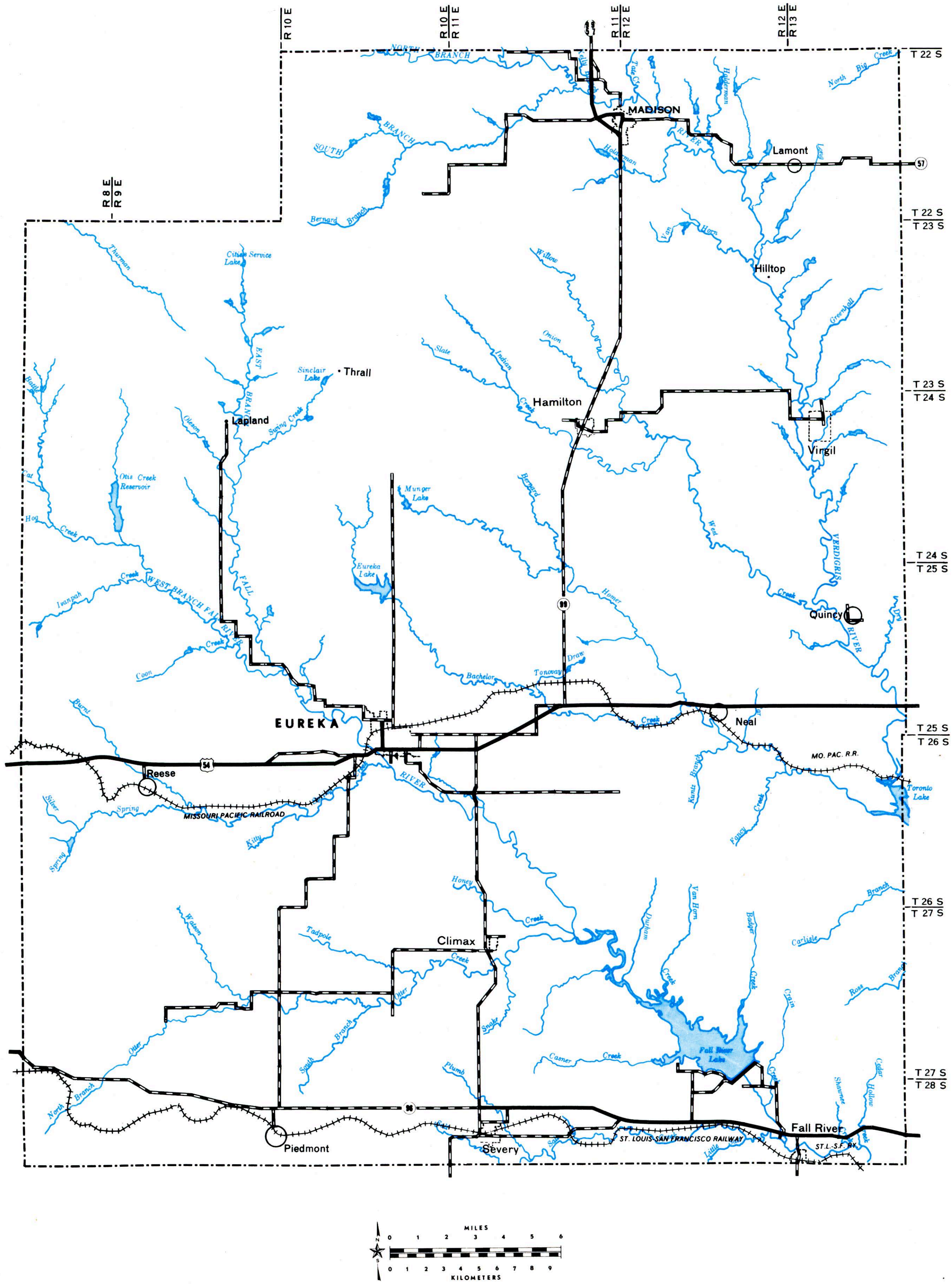


Figure 2. Drainage and major transportation facilities in Greenwood County, Kansas.

FACTS ABOUT GREENWOOD COUNTY

Greenwood County is located in southeast Kansas in the Flint Hills and Osage Cuesta physiographic divisions of the state. The county has 1,155 square miles and according to the State Board of Agriculture the population was 9,544 in 1971.

The topography of the county is extremely rough due to thick limestone and sandstone beds which make prominent outcrops especially along the Fall and Verdigris River valleys. The drainage is to the southeast through these main arterial streams. Figure 2 illustrates the major drainage systems and transportation facilities in the county. Because of the sparse population and the rough terrain the county road system is not well developed; however, oil field roads provide access in a round-about-way, to much of the county.

METHODS OF INVESTIGATION

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

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

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

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

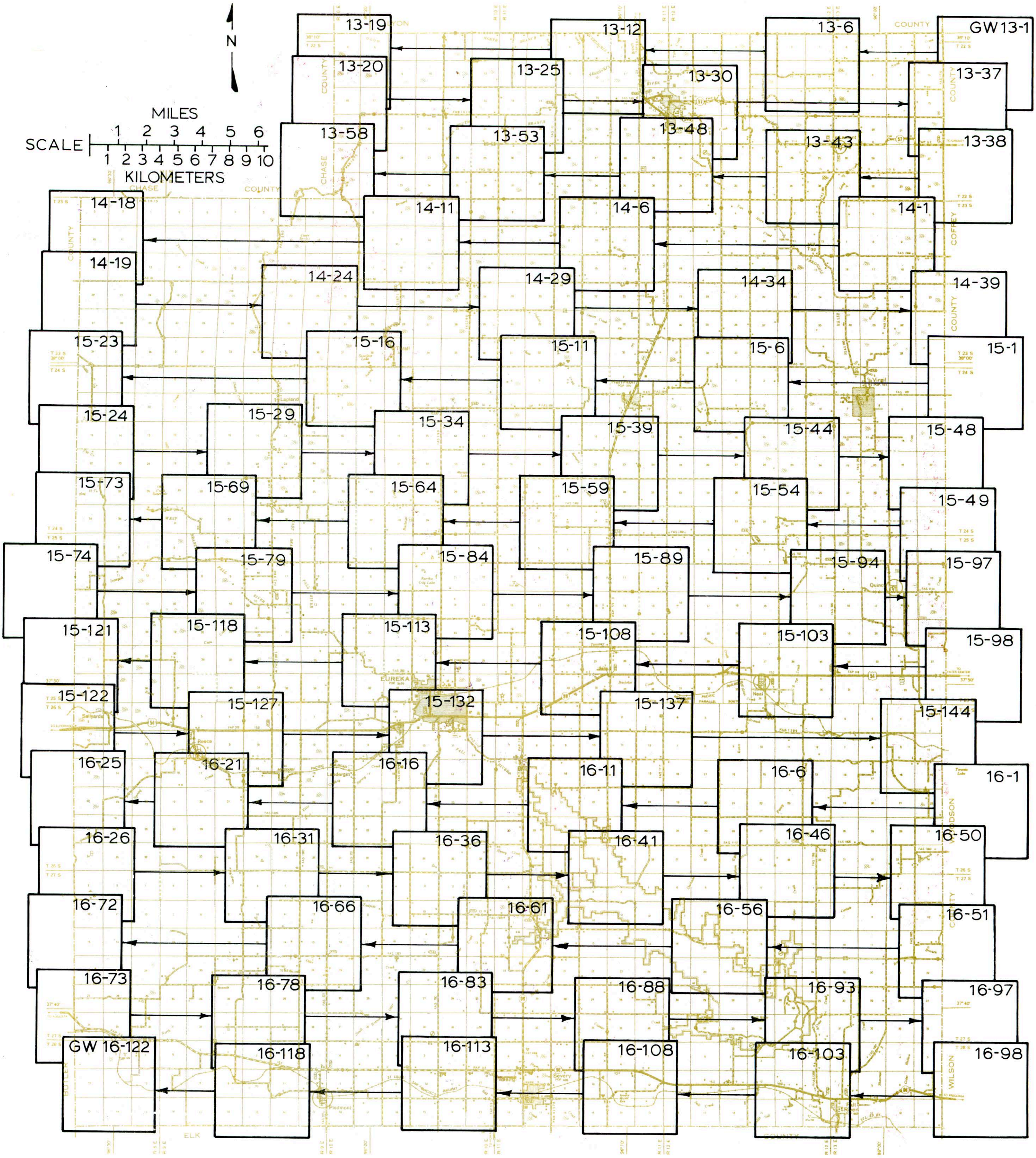
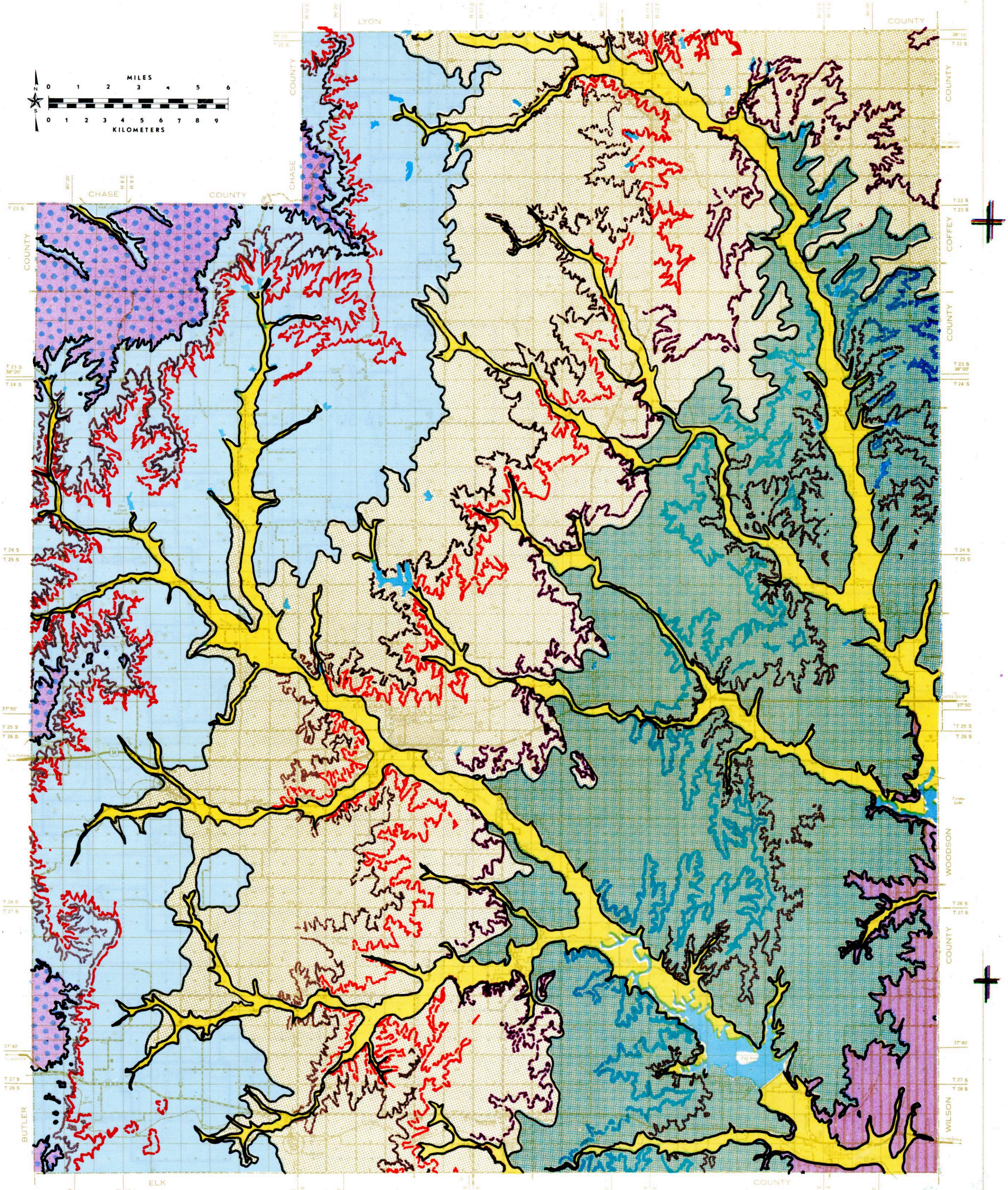


Figure 3. AERIAL PHOTOGRAPHIC COVERAGE MAP for Greenwood County. Numbers refer to photographs taken by the Photogrammetry Section, Kansas Department of Transportation in 1967 at a scale of 1" = 2000'. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

GEOLOGY SECTION



ALLUVIUM

CHASE

COUNCIL GROVE / ADMIRE
- Cottonwood Ls.
- Neva Ls.
- Americus Ls.

WABAUNSEE
- Readir g Ls.
- Burlingame Ls.
- Bachelor Cr. Ls.

SHAWNEE
- Hartford Ls.
- Rock Bluff Ls.
- Spring Branch Ls.

DOUGLAS

GENERAL GEOLOGY

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

Previously published studies by the Kansas Geological Survey and others as described in the SELECTED REFERENCES Section were used to provide general geologic information. Supplemental data from highway centerline geologic profiles and quarry site investigations by the KDOT Geology Section were used as well as a field reconisssance along existing roads by the author and others.

The study area lies on the south side of the Bourbon Arch, a regional structural feature between the Cherokee and Forest City Basins. Outcropping rocks generally dip to the west-northwest at a rate of 20 feet to the mile. Local structures deviate from this trend as evidenced in the attitude of outcropping units. Outcropping Pennsylvanian and Permian rocks exhibit facies changes southward into the Cherokee Basin. Changes in the thickness and character of limestones are of particular interest because they are the most important construction material resource in the county.

Sedimentary deposits from Quaternary to Cambrian in age underlie Greenwood County and overlie a basement complex of Pre-Cambrian igneous and metamorphic rock. Deposits of Silurian, Devonian, Triassic, Jurassic and Tertiary age are not present. The thickness of Paleozoic bedrock ranges from approximately 3100 to 3800 feet. These indurated sediments consist of limestone, dolomite, sandstone, and shale.

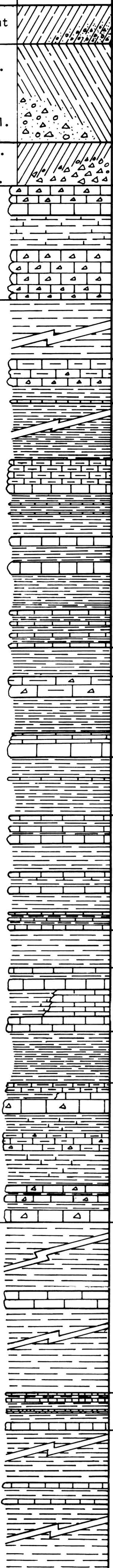
Sources of construction material in Greenwood County are Pennsylvanian and Permian Limestones and Quaternary chert and limestone gravel deposits. Figure 4 is a geologic timetable which illustrates the relative stratigraphic positions of Pennsylvanian, Permian and Quaternary units.

Deposits of upper Pennsylvanian age are the oldest exposed bedrock in the county. Figure 5 is a generalized geologic column of Pennsylvanian and younger units exposed in Greenwood County. Interbedded shales, limestone and sandstone of Pennsylvanian age, belonging to the Shawnee and Wabaunsee Groups, form prominent outcrops in Greenwood County. Limestone formations in the Shawnee Group are good material resource units. The Wabaunsee Group is comprised largely of shale and thin limestone units.

Lower Permian formations are exposed in the western part of the county and include shales, limestones and sandstones of the Admire, Council Grove, and Chase Groups. Several limestone units which have been or have the potential to be produced for construction material occur in these groups.

ERAS	PERIODS	ESTIMATED LENGTH IN YEARS	TYPE OF ROCK IN KANSAS	PRINCIPAL MINERAL RESOURCES
CENOZOIC	QUATERNARY (PLEISTOCENE) 	1,800,000	Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.	Sand and gravel; volcanic ash; agricultural soils; water.
	TERTIARY 	63,500,000	Silt, sand, and gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.	Sand and gravel; volcanic ash; diatomaceous marl; water.
MESOZOIC	CRETACEOUS	71,000,000	Chalky shale, dark shale, vari-colored clay, sandstone, conglomerate; outcropping igneous rock.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and building stone; ceramic materials; water.
	JURASSIC	59,000,000	Sandstone and shale, chiefly subsurface.	
	TRIASSIC	30,000,000		
PALEOZOIC	PERMIAN 	55,000,000	Limestone, shale, evaporites (salt, gypsum, anhydrite), red sandstone and siltstone, chert, and some dolomite.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and building stone; natural gas, salt, gypsum, water.
	PENNSYLVANIAN 	40,000,000	Alternating marine and non-marine shale; limestone, sandstone, coal, and chert.	Concrete and bituminous aggregate, light type surfacing, shoulder and subgrade material, riprap, and limestone and shale for cement; ceramic materials; oil, coal, gas, and water.
	MISSISSIPPIAN 	25,000,000	Mostly limestone, predominantly cherty.	Chat and other construction materials; oil, zinc, lead, and gas.
	DEVONIAN	50,000,000	Subsurface only. Limestone and black shale.	Oil.
	SILURIAN	45,000,000	Subsurface only. Limestone.	Oil.
	ORDOVICIAN	60,000,000	Subsurface only. Limestone, dolomite, sandstone, and shale.	Oil, gas, and water.
	CAMBRIAN 	70,000,000	Subsurface only. Dolomite and sandstone.	Oil.
PRE-CAMBRIAN	(Including PROTEROZOIC and ARCHEOZOIC ERAS)	4,600,000,000 +	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.	Oil and gas.

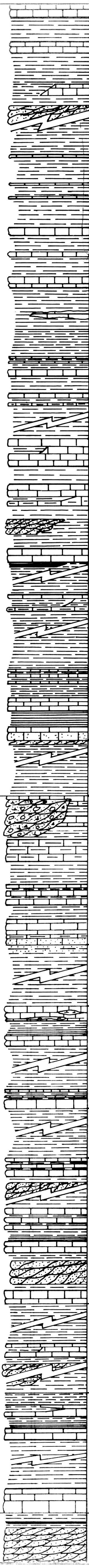
Figure 4. Geologic timetable.



System	Series	Stage or Group	Graphic Legend	Formation	Member	Map Symbol	Approx. Thickness (Feet)	General Description	Present or Potential Use
Quaternary	Pleistocene	Recent Wis. to Ill.		Alluvium and Terrace Deposits		Qal	0-30	Silty clays, basal gravel deposits, coarse gravels in some stream channels.	Light type surfacing
		Kan. to Neb.		Undifferentiated Quaternary Terraces		Qt	0-6	Angular to subrounded, tan to brown chert in a clay matrix.	Construction aggregate
Permian	Permian	Chase		Wreford Limestone	Schroyer Limestone		8-13	Two flinty, thin bedded to massive, gray to tan limestones separated by a green and gray limy shale.	Light type surfacing
					Havensville Shale		3-10		
					Threemile Limestone	Pwt	15		
		Council Grove		Speiser Shale			29-38		
				Funston Limestone			15		
				Blue Rapids Shale			13		
				Crouse Limestone			13		
				Easly Creek Shale			12-18		
				Bader Limestone	Middleburg Limestone		7-15		
					Hooser Shale		3-21		
					Eiss Limestone		12		
				Stearns Shale			4-8		
				Beattie Limestone	Morrill Limestone		5-8		
					Florena Shale		5		
					Cottonwood Limestone	Pbc	5-6	Massive to slabby limestone, tan to cream, fossiliferous (algal) also brachiopods and bryozoa.	Light type surfacing Construction aggregate?
				Eskridge Shale			25		
				Grenola Limestone	Neva Limestone	Pgn	14-18		
					Salem Point Shale		10-12		
					Burr Limestone		7-10		
					Legion Shale		9		
					Sallyards Limestone		9-14		
				Roca Shale			12		
				Red Eagle Limestone	Howe Limestone		2		
					Bennett Shale		13-19	Reef facies consists of light gray to tan limestone that is massive with brecciated zones.	Construction aggregate
					Glenrock Limestone		1-4		
				Johnson Shale			23		
	Lower			Foraker Limestone	Long Creek Limestone		6-13	White to cream, thin bedded to massive limestone, includes chert and shaly zones.	Light type surfacing
					Hughes Creek Shale		29-55	"Thrall" zone is a soft, light gray limestone, thin bedded to massive with some chert nodules.	Light type surfacing
					Americus Limestone	Pfa	10-16	Three limestone beds separated by gray-green shale, yellow, soft, blocky, abundant fusilina, weathers light tan.	Light type surfacing
		Admire		Janesville Shale	Hamlin Shale		52-65		
					Five Point Limestone		1-3		
					West Branch Shale		29-36		
				Falls City Limestone			10-21		
				Onaga Shale	Hawxby Shale		13-38		
					Aspinwall Limestone		3-5		
					Towle Shale		21		

Figure 5. Generalized geologic column of the surface geology in Greenwood County, Kansas.

continued next page



System	Series	Group	Formation	Member	Symbol	Thickness	Description	Use
Pennsylvanian	Upper Pennsylvanian	Wabaunsee	Wood Siding Formation	Brownville Limestone		2		
				Pony Creek Shale		16		
				Grayhorse Limestone		1		
				Plumb Shale		7-14		
				Nebraska City Limestone		0-3		
			Root Shale	French Creek Shale		66		
				Jim Creek Limestone		1		
				Friedrich Shale		19		
			Stotler Limestone	Grandhaven Limestone		1-8		
				Dry Shale		17-19		
				Dover Limestone		20		
			Pillsbury Shale			6		
			Zeandale Limestone	Maple Hill Limestone		2		
				Wamego Shale		13		
			Willard Shale			19-30		
			Emporia Limestone	Elmont Limestone		2-3		
				Harveyville Shale		1-3		
				Reading Limestone	ℙer	1-3		
			Auburn Shale			18-41		
			Bern Limestone	Wakarusa Limestone		8-28	Massive to irregularly bedded limestone, light to dark gray, weathers to a light brown "reef" thickening.	Construction Aggregate
				Soldier Creek Shale		4-7		
				Burlingame Limestone	ℙbb	4-7	Brown, unit bedded limestone, lower portion shaly and impure, weathers light brown, dark brown at base. Fossiliferous.	Construction Aggregate
			Scranton Shale	Silver Lake Shale		29-38		
				Rulo Limestone		2-3		
				Cedar Vale Shale		22-30		
				Happy Hollow Limestone		2-7		
				White Cloud Shale		50-56		
			Howard Limestone	Utopia Limestone		4-6		
				Winzeler Shale		5-6		
				Church Limestone		2-4		
				Aarde Shale		2-5		
				Batchelor Creek Limestone	ℙhb	3		
			Severy Shale			53-75		
		Shawnee	Topeka Limestone	Coal Creek Limestone		0-3	Conglomeritic zone is cross bedded and made up of fragments of limonite, sandstone, limestone, shale and fossil fragments.	Construction Aggregate
				Holt Shale		0-5		
				DuBois Limestone		0-1		
				Turner Creek Shale		0-1		
				Sheldon Limestone		0-7	Thin bedded light gray to buff limestone.	Construction Aggregate
				Jones Point Shale		0-10		
				Curzon Limestone		0-8	Light gray even bedded limestone with thin limy shale partings.	Construction Aggregate
				Iowa Point Shale		0-19		
				Hartford Limestone	ℙth	3-6	Gray to brown, thick bedded to slabby limestone, fossiliferous throughout, sandy near base.	Construction Aggregate
			Calhoun Shale			3-31		
			Deer Creek Limestone	Ervine Creek Limestone		6-9	Light gray to white, wavy bedded limestone with thin shale partings.	Construction Aggregate
				Larsh & Burroak Shale		1-4		
				Rock Bluff Limestone	ℙdr	2-3		
				Oskaloosa Shale		28-32		
				Ozawkie Limestone		4-8		
			Tecumseh Shale			21-41		
			Lecompton Limestone	Avoca Limestone		3-7	Slabby to nodular upper part, blocky to thick bedded lower part, gray fossiliferous limestone.	Construction Aggregate
				King Hill Shale		6-27		
				Beil Limestone		1-10		
				Queen Hill Shale		2		
				Big Springs Limestone		1-2		
				Doniphan Shale		3-30		
				Spring Branch Limestone	ℙls	2-3		
			Kanwaka Shale	Stull Shale		100-113		
				Clay Creek Limestone		1-4		
				Jackson Park Shale		40-100		
			Oread Limestone	Heumader Shale		6-25		
				Plattsmouth Limestone		1-3		
				Heebner Shale		2-4		
				Leavenworth Limestone		1-2		
				Snyderville Shale		42-75		
				Toronto Limestone	ℙot	6-13	Tan to brownish limestone. Upper part thin bedded, lower portion massive, weathers slabby to wavy bedded.	Construction Aggregate
		Douglas	Lawrence Shale			64+		

The Quaternary Period represents approximately the last two million years of time. The Pleistocene Epoch of this period includes times of repeated glacial activity in northeast Kansas. Although glaciers did not reach Greenwood County, the sequence of glaciation was a controlling role in the evolution of Pleistocene geology. Figure 6 illustrates divisions of the Pleistocene Epoch and the approximate durations of glacial-interglacial periods.

The present day drainage system in Greenwood County began to form during early Quaternary Time. A channel traversed eastern Greenwood County flowing southeastward across the corner of Woodson County into Wilson County during Nebraskan time. Chert gravel found in the upland area adjacent to the Verdigris and Fall Rivers was probably initially deposited by this stream.

Limited changes in drainage patterns occurred in Kansan time. Streams eroded to lower elevations due to movement of large volumes of water and the antecedent Fall River drainage extended into southern Greenwood County.

Divisions of the Quaternary Period				
Period	Epoch	Age	Estimated length of age duration in years	Estimated time in years elapsed to present
Quaternary	Pleistocene	Recent		10,000
		Wisconsinan Glacial	80,000	90,000
		Sangamonian Interglacial	160,000	250,000
		Illinoisan Glacial	110,000	360,000
		Yarmouthian Interglacial	160,000	520,000
		Kansan Glacial	280,000	800,000
		Aftonian Interglacial	450,000	1,250,000
		Nebraskan Glacial	550,000	1,800,000 +

Figure 6. Geologic timetable of the Quaternary Period.

As the Kansan glacier retreated to the north, the volume of water in the drainage systems in Greenwood County became less and deposition occurred in the stream valleys. At this time, some of the older chert gravel deposits were modified and substantial floodplains were developed along the Fall and Verdigris Rivers.

Illinoisan and later stream patterns in the county were influenced by a continuation of adjustments associated with Kansan glaciation. Limited changes, except for downcutting, occurred in the drainage system in Greenwood County. Alluvium in the major stream valleys and thin eolian deposits in the uplands were probably deposited during this time.

By Wisconsinan time, the drainage in Greenwood County had developed to its present form. Like the Illinoisan, Wisconsinan deposits are not prominent in Greenwood County. Only a limited amount of valley fill in the major stream valleys and some thin eolian deposits are of this age.

During Recent time, significant chert and limestone gravel deposits have accumulated in the stream channels which headwater in the Flint Hills.

GEOENGINEERING

This section is a general appraisal of the materials available in Greenwood County for use in highway construction. Potential ground-water problems and the quality of water available for concrete are briefly reviewed. Detailed field investigations will be necessary to ascertain the severity of specific problems and to make recommendations in design and construction procedures.

Exposed bedrock in Greenwood County ranges from the Wreford Limestone of Permian age to the Lawrence Shale of Pennsylvanian age. Bedrock characteristics vary considerably across the county and three physiographic regions are identified where different geoengineering problems will be encountered. The western quarter of the county is comprised of lower Permian rocks belonging to the Admire and Council Grove Groups; the central portion is comprised of Upper Pennsylvanian rocks belonging to the Wabaunsee Group; and the eastern quarter is comprised of Upper Pennsylvanian rocks belonging to the Shawnee and Douglas Groups.

The western region is characterized by rough terrain. Highway improvements will necesitate the construction of numerous cut and fill sections. Cherty limestones and relatively thick shales will be encountered. A thin residual soil mantle characterizes the terrain and is classified as A-6 or A-7 by A.A.S.H.O. standards. Some Permian shales, such as the Havensville, Hamlin and Towle will require special attention in subgrade and shoulder construction. Groundwater movement in the Sallyards, Glenrock, Long Creek, Americus, Gray Horse limestone units and in the Bennett, Hughes Creek and French Creek shale units may cause soft subgrade problems when intercepted at or near grade.

The central region is characterized by thick shale and thin limestone units. Sandstone occurs in many of the shale units. Most soils are residual, derived from silty to clayey shales, and classified as A-6 or A-7 according to A.A.S.H.T.O. standards. Unstable clay shale is commonly present in many of the shale units found in the region such as the Root, Willard, White Cloud, Aarde and Severy. Coal seams and associated underclays found in the Cedar Vale, Silver Lake, Soldier Creek, Pillsbury and French Creek shale units will require special attention, if found at or near grade during construction.

The eastern region is characterized by alternating shale and relatively thick limestone units. The Ervine Creek, and Toronto Limestone form prominent benches in the area and sandstone in the Lawrence and Kanwaka Shales form prominent escarpments in the southeastern part of the county. Groundwater problems are common in limestone and sandstone units. Stability problems will be encountered in the Stull, Jackson Park, Snyderville and Lawrence Shale units. Coal seams and underclays, which will require special attention, are common in the Lawrence, Jackson Park and Stull shale.

Very little data are available concerning the quality of water available in Greenwood County for use in concrete. Data collected by the United States Geological Survey between 1962 and 1965 show that water from the Fall and Verdigris Rivers is acceptable for use in Portland Cement concrete.

MATERIALS INVENTORY SECTION

GENERAL INFORMATION

Limestone and gravel are the only construction material resources produced in Greenwood County. Crushed stone is available from the Oread, Lecompton, Deer Creek, Topeka, Bern, Foraker, and Red Eagle limestone formations. Chert gravel is available from terraces located in scattered high areas adjacent to the Fall and Verdigris Rivers. The Toronto, Ervine Creek, and Wakarusa members are probably the best limestone sources.

The use of any one material source is dependent upon the part of the county where an aggregate is needed. That is, the outcropping of rock extends, younger to older, from west to east through the county. Thus, a north-south band through southeastern Greenwood County may yield only Toronto Limestone and a band in the western portion may yield extensive Wakarusa Limestone.

The construction material types, their uses and availability are tabulated on page 15. Test results from a limited amount of sampling and testing are presented in figure 23 (page 30). IT SHOULD BE NOTED THAT AGGREGATE FROM THE VARIOUS SITES MUST CONFORM TO CURRENT STANDARD AND SUPPLEMENTAL SPECIFICATIONS AND SPECIAL PROVISIONS BEFORE THE MATERIAL IS USED IN ANY TYPE OF CONSTRUCTION.

CONSTRUCTION MATERIALS SECTION

CONTENTS

Material Type	Geologic Source	Use	Page	Availability
LIMESTONE	Toronto Member	Construction Aggregate	16	Southeast 1/4 of the County, shown on Plates XV and XIV.
	Avoca Member	Construction Aggregate	17	North-South band in the eastern 1/3 of the county. Shown on Plates V, VIII, XI, and XIV.
	Ervine Creek Member	Construction Aggregate	17	North-South band in the eastern 1/3 of the county. Shown on Plates V, VIII, XI, XIII and XIV.
	Curzon/Hartford Members	Construction Aggregate	18	North-South zone east of Eureka. Plates II, V, X, XI, XII and XIV.
	Sheldon Member	Concrete Aggregate Bituminous Base Base Course, Light Type Surfacing	20	Small area in east-central part of county. Plates VIII and XI.
	Coal Creek Member (conglomerate)	Construction Aggregate	20	Small area in east-central part of county. Plates VIII and XI.
	Burlingame and Wakarusa Members	Construction Aggregate	21	North-South zone roughly through the central part of the county. Shown on Plates I, II, IV, VI, VII, IX, X, and XIII.
	Americus Member Long Creek and "Thrall" Members	Construction Aggregate Light Type Surfacing	22 23	North-South band in western part of the county, mapped on Plates I, III, IV, VI, VII, IX and XII.
	Bennett "Reef"	Construction Aggregate	25	Southwestern corner of county, Plate XII.
	Cottonwood Member	Light Type Surfacing	25	Western edge of county shown on Plates I, III, VI, IX, and XII.
	Threemile/Schroyer Members	Light Type Surfacing	26	Western edge of county, Plates I, III, IV, VI, IX and XII.
CHERT AND(OR) LIMESTONE GRAVEL	Chert Gravel Terrace Deposits	Construction Aggregate	27	Scattered remnants of high terraces adjacent to the Verdigris and Fall Rivers.
	Alluvial Chert and Limestone Gravel	Light Type Surfacing	28	Found in the stream channels of some tributaries in the western part of the county

Figure 7. A tabulation of construction material types and availability in Greenwood County.

LIMESTONE

Oread Limestone Formation

The Oread Formation includes three limestone and two shale members. They are, in ascending order, the Toronto Limestone, Snyderville Shale, Leavenworth Limestone, Heebner Shale and the Plattsmouth Limestone. Total thickness of the formation is less than 100 feet through the county.

The Leavenworth member is one to two feet thick and the Plattsmouth ranges from less than a foot to 3.6 feet thick (two thin limestones separated by a shale where thicker). The Toronto member is the only unit that is economically significant as a materials resource.

Toronto Limestone

The Toronto member is the lowest unit of the Oread Formation with the Lawrence Shale Formation lying below and the Snyderville Shale Member above. The Toronto is a gray-brown thin bedded to massive limestone that weathers dark brown. The thickness ranges from 13 feet in the northern part of its outcrop to six feet near the south county line.

Figure 8. Toronto Limestone in a quarry near Toronto Reservoir in the SE 1/4, Sec. 3, T28S, R12E.

The Toronto outcrops in the eastern portion of the south half of Greenwood County along the Verdigris and Fall River valleys (Plates X and XIV). Identification of the limestone can be accomplished by identification of the upper Williamsburg coal zone, which occurs below the base of the limestone.

Results of tests conducted on the Toronto are shown in figure 30. Tests reveal that the Los Angeles wear ranges from 26 to 31 percent, the soundness loss ratio from 0.83 to 0.98, and the absorption from 0.93 to 2.67 percent.

Material from this source could be used in bituminous surfacing, concrete, base course, shoulders, light type surfacing, and its massive nature at some locations makes it especially desirable as riprap.

Lecompton Limestone Formation

The Lecompton Formation ranges in thickness from 74 feet in the northern part of its outcrop to 55 feet along the south county line. Members of the formation include, in ascending order, the Spring Branch Limestone, Doniphan Shale, Big Springs Limestone, Queen Hill Shale, Biel Limestone, King Hill Shale and the Avoca Limestone. The Avoca member is the only unit of sufficient thickness to be utilized as a materials resource.

Avoca Limestone

The Avoca Member is a moderately dense, gray fossiliferous limestone. The upper part is slabby to irregularly nodular and the lower part is blocky to thick bedded.

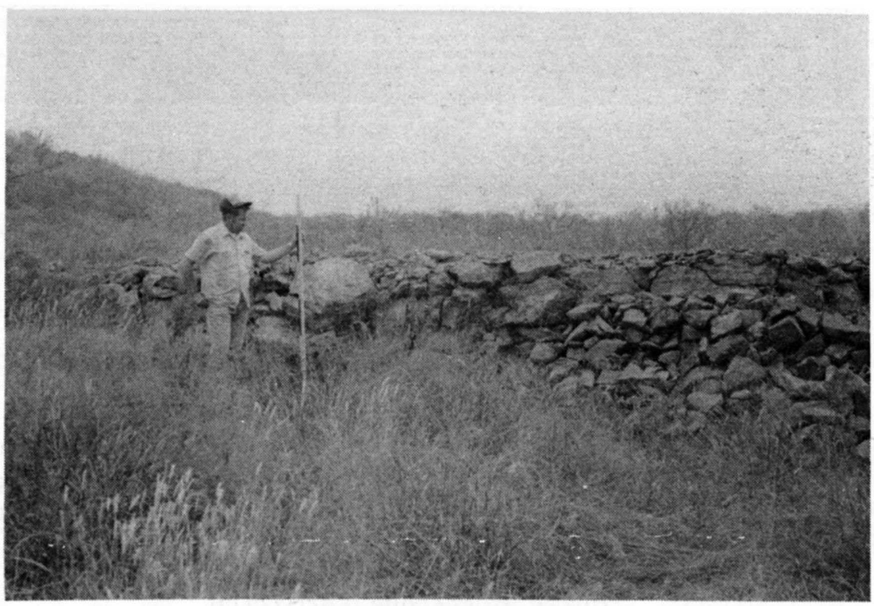


Figure 9. Avoca member in a quarry in the NE 1/4, Sec. 4, T25S, R12E.

The member is approximately seven feet thick in the central and northern part of the county and thins to 2.5 feet in the southern part of the county. Quality test data on material from one site indicates selected locations will meet requirements of the Standard Specifications for all types of construction aggregate.

Deer Creek Limestone Formation

Two shale and three limestone members are included in the Deer Creek Formation. They are, in ascending order, the Ozawkie Limestone, Oskaloosa Shale, Rock Bluff Limestone, Larsh-Burroak Shale and the Ervine Creek Limestone. Total thickness of the formation ranges from 50± feet in the northeast part of the county to 45 feet along the south county line. The Ervine Creek Member is the only unit of sufficient thickness to be economically quarried.

Ervine Creek Limestone

The Ervine Creek Member is a light gray to white, wavy-bedded limestone. Thin shale partings less than one inch thick are common. The unit is about six feet thick in the northern part of its outcrop area to approximately nine feet in the south part of the county.

Figure 10 Quarry face in the Ervine Creek Limestone, SE 1/4, Sec. 31, T27S, R9E.

This limestone outcrops in the eastern one-third of Greenwood County roughly along the Verdigris River valley and a short area along the Fall River. According to current Standard Specifications, material from this source may be used in all phases of road construction however, some material may be marginal because of the thin shale zones.

Topeka Limestone Formation

Limestone and shale members of the Topeka Formation include, in ascending order, the Hartford Limestone, Iowa Point Shale, Curzon Limestone, Jones Point Shale, Sheldon Limestone, Turner Creek Shale, DuBois Limestone, Holt Shale and the Coal Creek Limestone. Locally, a conglomeritic limestone replaces the upper part of the Topeka Formation. This clastic unit appears to be equivalent in age to the middle part of the Coal Creek member. Also, limestone members above the Hartford grade southward to thin ledges separated by shale. The approximate thickness of the entire formation ranges from 80 feet in the northern part of its outcrop to 60 feet in the area east of Severy.

Hartford/Curzon Limestone Members

The Hartford member is a blue-gray limestone and ranges from three to six feet thick throughout the county. The unit is thick bedded in the upper part and thin, wavy bedded and sandy toward the base. The shale between the Hartford

Figure 11 Hartford member in a quarry in the SW 1/4, Sec. 16, T26S, R11E.

and Curzon members thins from approximately 19 feet in the central part of the county to less than two feet in the northeastern part of the county. The Curzon Member is tan to gray thin bedded limestone with shale partings and ranges from five to eight feet thick in the north and central part of the outcrop and grades to shale and thin limestones along the south county line.

Figure 12. Curzon member outcropping in a road cut in the NE 1/4, Sec. 13, T23S, R12E.

Marked changes in the lithology and thicknesses of both units occur throughout the northern 2/3 of the county. It is doubtful that quality characteristics will be consistent from one quarry location to another.

Sheldon Limestone Member

The Sheldon member is a uniformly thin bedded unit that is tan to buff in color. The maximum thickenss of the unit is approximately seven feet in an area along US-54 highway near Tonovay.

Figure 13. Sheldon Member in a quarry in the NW 1/4, SE 1/4, Sec. 34, T25S, R11E.

This limestone appears to be soft and shaley on weathered outcrops. Quality test data from one location shows a soundness loss of 0.87 which is not acceptable for some types of bituminous aggregates. Acceptability for other types of construction aggregate is indicated provided that the material from this location qualifies under applicable Special Provisions or Supplemental Specifications. Other locations should be tested extensively before a commitment for use is made.

Limestone Conglomerate (Coal Creek)

A limestone conglomerate has been observed in quarries and on highway projects in an area from Lamont south to U.S. 54 Highway. The centerline highway geologic profile shows the unit to occupy from two to 12 feet of the Coal Creek stratigraphic interval. The unit is soft, current bedded and composed of fragments of fossils, limestone, shale, sandstone, ironstone and chert and at some locations has been observed to be oolitic. The unit is highly variable in thickness and may unconformably replace members of the Topeka Formation from the Coal Creek down to the top of the Hartford.

Figure 14. Conglomeritic limestone in the Coal Creek stratigraphic interval NE 1/4, Sec. 8, T24S, R12E.

This materials source unit appears to be porous and soft at all locations. Tests on aggregate from one open site shows a Los Angeles wear of 30 percent, a soundness loss ratio of 0.87, and an absorption of 2.88 percent.

Bern Limestone Formation

The Bern Limestone Formation consists of three members which are, in ascending order, Burlingame Limestone, Soldier Creek Shale, and Wakarusa Limestone. The total thickness of the formation ranges from 18 feet in the northern part of the county, 31 feet near U.S. Highway 54 and 43.2 feet 3 miles north of the south county line. Reefing in the Wakarusa Member appears to be the dominant cause of the radical increase in thickness.

Wakarusa Limestone

The Wakarusa Member is massive to irregularly bedded light to dark gray and weathers to a light brown. The unit is approximately 8 feet thick in the north part of the county, 20 feet near US-54, 28 feet three miles north of the south county line and 18.5 feet on K-96. A shale zone up to twelve feet thick replaces some of the upper part of the member along the south county line (K-96).

Figure 15 Wakarusa Limestone in a quarry in the NW 1/4, Sec. 18, T26S, R9E.

Tests indicate that material produced from this limestone meets current Standard Specifications for all types of construction aggregates. Local variations in the lithology may adversely affect quality and extensive testing should be conducted before use from any location.

Burlingame Limestone

The Burlingame Member is approximately four feet thick in most of the county. At some locations in the area south of US-54 and north of K-96 a thickness of seven feet has been observed. The unit is separated from the overlying Wakarusa Member by four to seven feet of Soldier Creek Shale. The limestone is fossiliferous, fairly dense and massive with a few thin shale partings, light gray and weathers brown to tan-brown.

No quality tests are available for the unit however, field observations indicate the limestone should have good characteristics. Also, sites that presently utilize the Wakarusa Member have the potential to be deepened to produce additional material from the Burlingame Limestone.

Foraker Limestone Formation

The Foraker Limestone Formation consists of three members in ascending order; Americus Limestone, Hughes Creek Shale, and Long Creek Limestone. Total thickness of the formation ranges from 45 feet to 83 feet north to south through the county.

Americus Limestone

The Americus Member generally consists of two limestone ledges three to 5 feet thick separated by four to five feet of shale. The upper limestone includes some chert and both ledges have been described as being soft, yellow and fossiliferous.

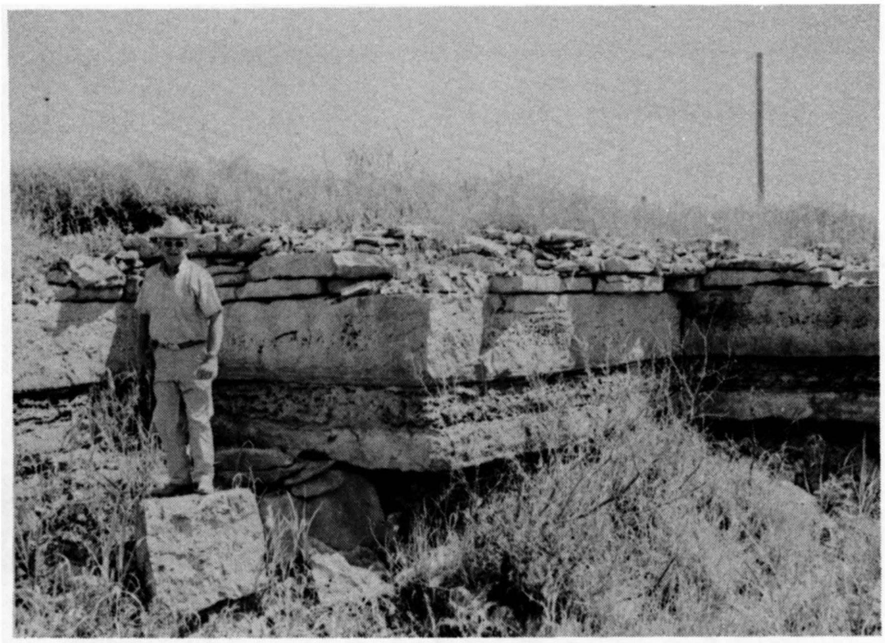


Figure 16. Americus Limestone in a road cut in the SE 1/4, Sec. 4, T28S, R9E.

One materials site is located in the Americus Member. One laboratory test indicates the material should be suitable for all types of construction aggregate.

Hughes Creek Shale

The Hughes Creek Member ranges from 29 feet to 55 feet at observed locations. Generally the member thickens in the southern part of its outcrop. The only unit of importance within the member is the "Thrall" limestone which is separated from the underlying Americus Member by approximately eleven feet of shale. The zone has been described as a soft, light gray limestone which is thin bedded near the top to massive near the base and includes some chert. According to highway geology profiles, the zone thickens from six feet on US-54 to fourteen feet on K-96.

Figure 17. "Thrall" limestone zone in the NE 1/4, Sec. 36, T27S, R8E, (lower ledge).

Aggregate produced from the "Thrall" zone should be suitable for light type surfacing and similar uses, however, field observations indicate the quality of the material is probably marginal for any other purpose.

Long Creek Limestone

The Long Creek Member ranges from approximately six to thirteen feet thick from north to south along its outcrop. Where thinner the upper part of the unit (3.5') is thin bedded, white, fine grained and dense; the lower part (2.1') is blocky, weathers platy and is fossiliferous. Thicker facies of the unit are more massive and include some chert.

Figure 18. Long Creek Member in the NE 1/4, Sec. 36, T27S, R8E, (upper ledge).

Field observations indicate the unit may produce higher quality aggregate, particularly in the southern outcrop area. At present there are no quality tests to confirm this observation.

Red Eagle Limestone Formation

The Red Eagle Formation generally consists of two thin limestones separated by shale. These members are, in ascending order, the Glenrock Limestone, Bennett Shale and Howe Limestone which in the aggregate range from 10 to 20 feet north to south along the outcrop. The entire formation changes to a limestone approximately 20 feet thick in the southwestern corner of the county. This change in lithology has been attributed to "reefing" in the Bennett Shale. In that area the limestone has been described as light gray to tan, massive with brecciated zones. The unit is fossiliferous and includes thin shale zones.

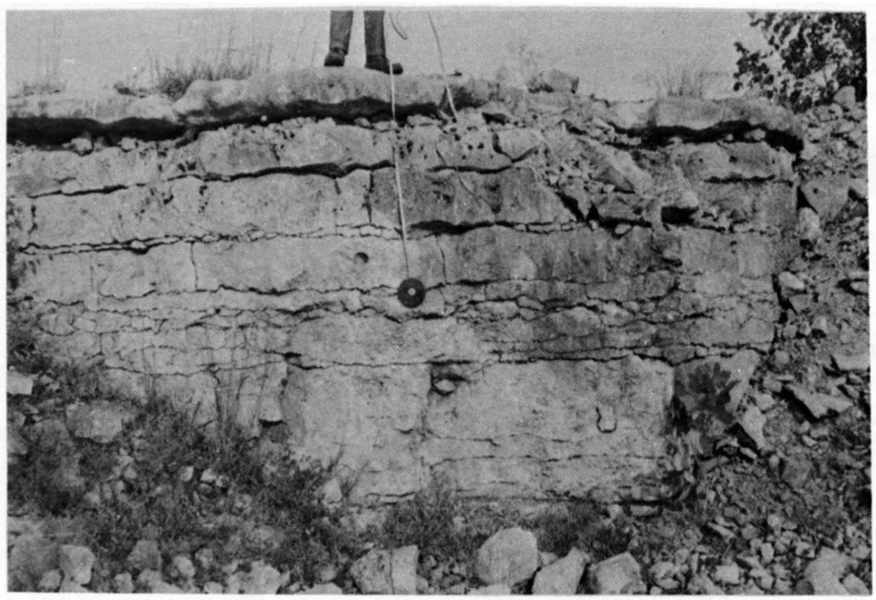


Figure 19. Bennett "reef" exposed in a quarry in the SE 1/4, Sec. 31, T27S, R9E.

Quality test data indicate that material from select sites will meet the standard specifications for all types of construction aggregate. Wear, soundness loss and absorption at some locations do not meet the specifications for certain types of aggregates. Extensive sampling and testing and exploration work will be necessary to locate select sites that will meet the standard specifications for construction aggregate.

Beattie Limestone Formation

The Beattie Limestone Formation is composed of the Cottonwood Limestone, Florena Shale, and Morrill Limestone. The Cottonwood, (basal member) is the only unit of material significance.

Cottonwood Limestone Member

The Cottonwood is a tan-brown limestone about six feet thick (figure 20). It is thin-bedded in the upper portion and a massive crenulated unit in the lower part.

No open materials pits were found in the Cottonwood in the county. However, aggregate from this source could be used where small quantities of aggregate would meet a construction need. The abundance of thicker high quality rock (Bern) within close proximity of the Cottonwood outcrop area probably precludes its utilization as a construction material.

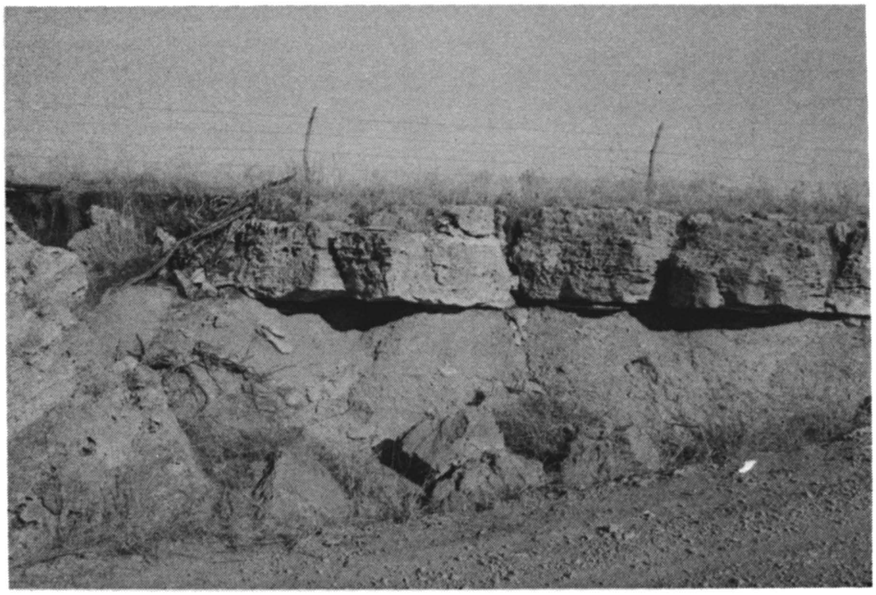


Figure 20. Cottonwood Limestone in a road cut one mile east of the Greenwood-Butler county line, N 1/2, Sec. 35, T25S, R8E.

No test data are available on the Cottonwood in Greenwood County. However, it may be assumed that it is a marginal quality rock useful only for light type surfacing, shoulders, and riprap.

Wreford Limestone Formation

The Wreford Limestone is comprised of three members: the Threemile Limestone, Havensville Shale, and Schroyer Limestone. In the western part of Greenwood County the Havensville Shale is thin (less than ten feet) and the hard cherty Threemile and Schroyer Limestones form one prominent outcropping ledge (figure 21). The Threemile and Schroyer are prominent beds making up the Flint Hills physiographic division of Kansas.

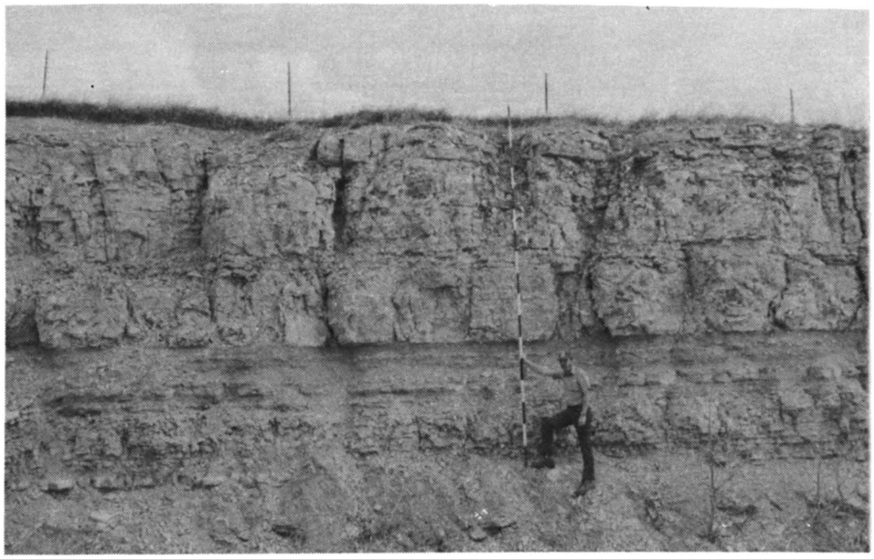


Figure 21. Threemile, Havensville, and Schroyer Members in a road cut, SE 1/4, Sec. 16, T23S, R9E.

Threemile and Schroyer Limestones

The two units have gray cherty limestone beds that weather tan. One reason for not using this material is because the cherty material abrades crushing equipment and, overall, the material is hard to work with. The units are somewhat massive with the plane of bedding developing along the cherty zones. This bedding is especially prominent when the members are weathered. The Havensville Shale is a greenish-gray limy shale that is much less weather resistant than the cherty beds. Although these cherty limestones form a relatively thick bed and could be quarried, they are not utilized.

A measured section of the Wreford in northwest Greenwood County shows the Threemile to be 11 feet thick, the Havensville Shale 3 feet and the Schroyer 10 feet. Extensive outcrops of the Threemile and Schroyer lie in remote areas of western Greenwood County that are not readily accessible.

No quality information is available on the Wreford Limestone in Greenwood County. It may be assumed that the crushed aggregate from this source is marginal. However, it is possible that material from this source could meet specifications for some phases of road construction. If used as aggregate in concrete, joints will be difficult to cut. Sometimes the brittle chert will fail when subjected to freeze and thaw even when the material passes the soundness test. The material will probably meet specifications for use as light type surfacing, subbase, and shoulder material. The material is somewhat undesirable for light type surfacing in that the sharp edges of chert are hard on automobile tires.

Chert and Limestone Gravel

Chert Gravel Terrace Deposits

Some thin terrace deposits, dated as Nebraskan and (or) Kansan in age, are found on high areas adjacent to the Verdigris and Fall River drainage systems.

These deposits, composed almost totally of chert gravel, are rarely more than five feet thick and generally are covered with only a few inches of overburden (figure 22). A red clay matrix is found in all these deposits that adheres to the gravel.

Figure 22. Chert Gravel Terrace Deposits in a road cut in the NE 1/4, Sec. 13, T23S, R12E.

Chert Gravel Terrace Deposits contain a high quality material if the red clay matrix is removed. If washed and sorted, it may used as bituminous and concrete aggregate, base course material and shoulder aggregate. If the gravel is used in concrete, it will be difficult to saw joints. The raw clay-bound gravel is an economical source of surfacing material for lightly traveled rural roads. The lack of water in areas where chert is found precludes most washing operations and thus prevents the production of good quality material.

Quality tests have not been conducted on the chert gravel terrace deposits in Greenwood County. However, in adjacent Butler County to the west and Lyon County to the north, similar material has been tested. These tests indicate a high quality material can be produced when the clay matrix is removed.

Alluvial Chert and Limestone Gravel

Deposits of alluvial gravel of Recent Age are found in the immediate stream bed of Ivanpoh Creek and some areas along the West Branch Fall River. Other streams in the county also contain deposits of gravel, especially those that headwater in the Flint Hills physiographic region.

The material is composed of tan-gray limestone and chert gravel. The deposits are medium to coarse textured, irregularly bedded and are generally not more than ten feet thick. When accumulations of gravel are depleted, they tend to be replenished during periods of heavy rainfall. Because of the variable stream velocity, bedrock outcrops, and certain aspects of the meandering of the channel, deposits tend to build up at certain locations.

Quality information is not available on the alluvial gravel deposits in Greenwood County. In Butler County to the west, alluvial gravel has been crushed, washed, and sorted with the end product being an acceptable aggregate. This type material could be utilized in a similar manner in Greenwood County, however, it is utilized only for light type surfacing material at the present time.

Geol. Member	Site No.	Year Tested	Sp.Gr. Sat.	Sp.Gr. Dry	% Wear	Sound. Loss	% Absorp.	Lab No.
Toronto	LS+19	1962	2.59	2.52	28	0.97	2.67	21425
"	LS+28	1946	2.68	2.65	26	0.83	0.93	50011
"	LS+27	1962	2.65	2.61	29	0.98	1.24	21496
"	LS+29	1962	2.62	2.58	31	0.98	1.33	21563
Avoca	LS+8	1957	2.71	2.68	23	0.97	1.22	96836
Ervine Creek	LS+24	1973	2.55	2.48	34	0.96	2.85	73-947
"	LS+25	1973	2.55	2.46	32	0.98	3.8	73-3549
"	LS+26	1962	2.63	2.59	28	0.98	1.36	21496
"	LS+65	1946	2.50	2.42	33	0.93	3.19	50006
"	LS+70	1946	2.62	2.59	30	0.95	1.24	50020
Hartford	LS+3	1978	2.62	2.57	30	0.98	1.5	78-907
Hartford/Curzon	LS+5	1965	2.61	2.55	34	0.98	2.17	65-2093
"	LS+18	1978	2.59	2.50	33	0.94	3.7	78-124
Curzon	LS+2	1965	2.58	2.53	32	0.97	1.90	65-1487
"	LS+7	1976	2.56	2.50	29	0.98	2.4	76-1137
"	LS+14	1973	2.68	2.53	25	0.99	2.9	73-3551
"	LS+15	1972	2.58	2.50	28	0.95	3.1	72-455
"	LS+16	1961	2.50	2.40	37	0.94	4.46	17348
"	LS+59	1964	2.52	2.45	33	0.98	2.89	33537
Sheldon	LS+17	1970	2.57	2.49	25	0.87	2.88	70-3592
Coal Creek	LS+60	1946	2.52	2.46	30	0.97	2.48	50023
Wakarusa	LS+1	1946	2.67	2.64	26	0.85	1.08	50022
"	LS+4	1977	2.60	2.53	26	0.93	2.8	77-291
"	LS+12	1978	2.58	2.51	28	0.97	3.1	78-3557
"	LS+10	1978	2.59	2.49	35	0.95	3.9	78-2654
"	LS+9	1981	2.62	2.58	26	0.97	1.9	81-1057
"	LS+11	1964	2.57	2.50	29	0.98	2.77	32306
"	LS+13	1953	2.61	2.55	31	0.90	2.22	81546
"	LS+21	1954	2.58	2.53	25	0.98	1.96	85456
"	LS+22	1977	2.54	2.48	33	0.99	2.5	77-1110
"	LS+23	1976	2.64	2.61	37	0.99	1.2	76-3436
"	LS+62	1946	2.63	2.60	28	0.91	1.24	50001
"	LS+63	1946	2.58	2.52	31	0.95	2.37	50002
"	LS+64	1947	2.62	2.57	25	0.91	1.90	55533
"	LS+68	1946	2.52	2.47	33	0.94	2.10	50004
"	LS+69	1948	2.46	2.46	28	0.97	3.11	59902
Americus	LS+61	1946	2.55	2.49	27	0.94	2.49	50009
Bennett "Reef"	LS+20	1946	2.27	2.11	46	0.92	7.44	50017
"	LS+66	1946	2.43	2.35	38	0.95	3.30	50005
"	LS+67	1946	2.55	2.49	33	0.83	2.74	50014

Figure 23. Results of tests on limestone sources. KDOT file data.