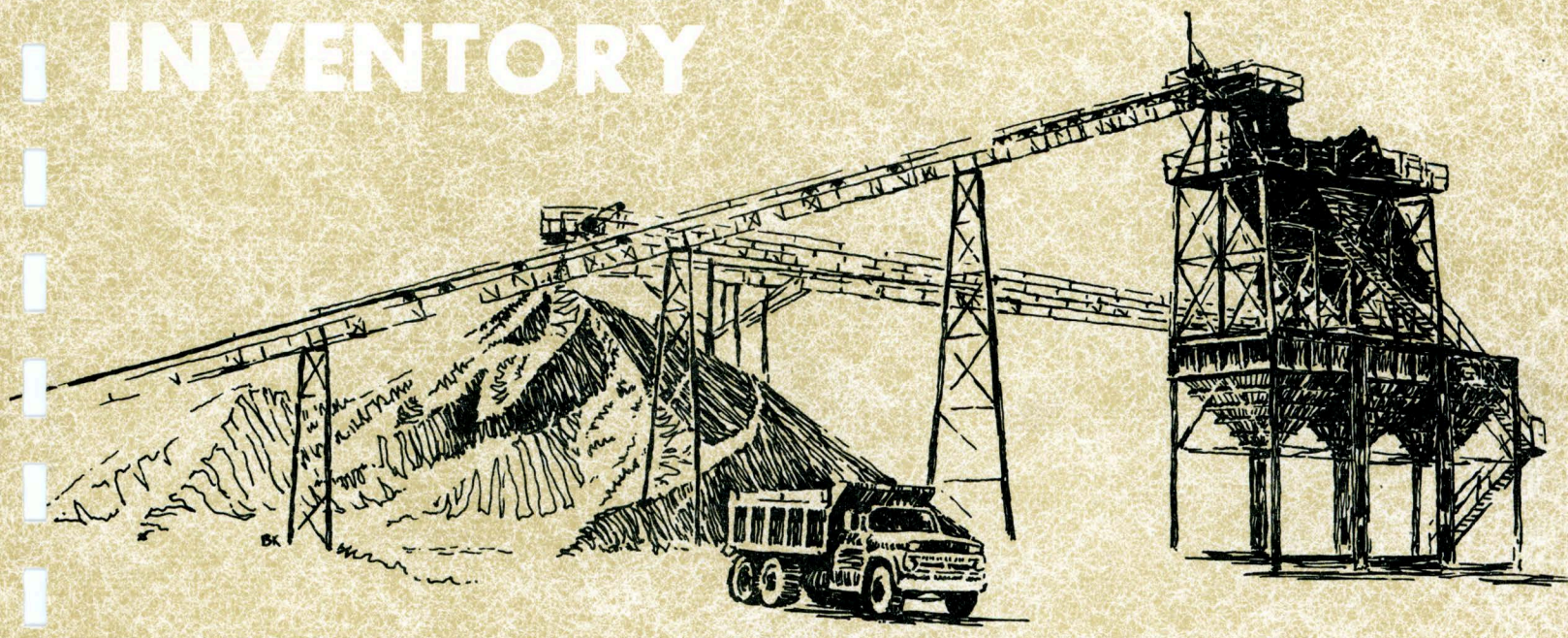
REPORT NO. 23

CONSTRUCTION MATERIALS INVENTORY



BOURBON COUNTY, KANSAS

DEPARTMENT OF TRANSPORTATION
KANSAS

Kansas Department of Transportation
Location and Design Concepts Department
Planning and Development Department

CONSTRUCTION MATERIALS INVENTORY OF BOURBON COUNTY, KANSAS

by

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

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Construction Materials Inventory Report No. 23

Copies are available from the Planning & Development Department
Kansas Department of Transportation

the **WHY?**

WHAT?

and **HOW?**

of This REPORT

This report was compiled for use as a guide for locating construction material in Bourbon 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 a source of construction material are described and mapped.

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

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

Material found in individually mapped sites represent only a small portion of the construction material resources in the county. Although data used to evaluate the material are based on limited sampling, these can be used to assess the general characteristics of the material source units elsewhere in the county.

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

TO LOCATE AND EVALUATE

A MAPPED SITE OF CONSTRUCTION MATERIAL IN BOURBON COUNTY

TURN TO THE MATERIALS INVENTORY SECTION
See
TABULATION OF CONSTRUCTION MATERIALS
Figure 6, Page 13

for material
BY TYPE
USE COLUMN 1

For Quality Data
See Figure 19
Page 25

for material
BY INTENDED USE
USE COLUMN 2

for **DESCRIPTION** of material

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

for **AVAILABILITY** of material

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

MATERIALS MAP

SEE PINK SHEET, PAGE 27

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

SITE DATA FORMS

OPEN SITES; SAMPLED	GREEN SHEET, PAGE 30
OPEN SITES; NOT SAMPLED	GREEN SHEET, PAGE 46

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

CONTENTS

PREFACE

This report is one of a series compiled for the Highway Planning and Research Program, 'Materials Inventory by Photo Interpretation'. The program is a cooperative effort of the Federal Highway Administration and the Kansas Department of Transportation, 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 and maintenance needs.

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

Appreciation is extended to Mr. James L. Farrell, Fourth Division Materials Engineer, Mr. Walt Fredericksen, Regional Geologist, and Mr. Bill Jones, Geologist, of the Kansas Department of Transportation, for verbal information concerning construction materials discussed in this report.

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

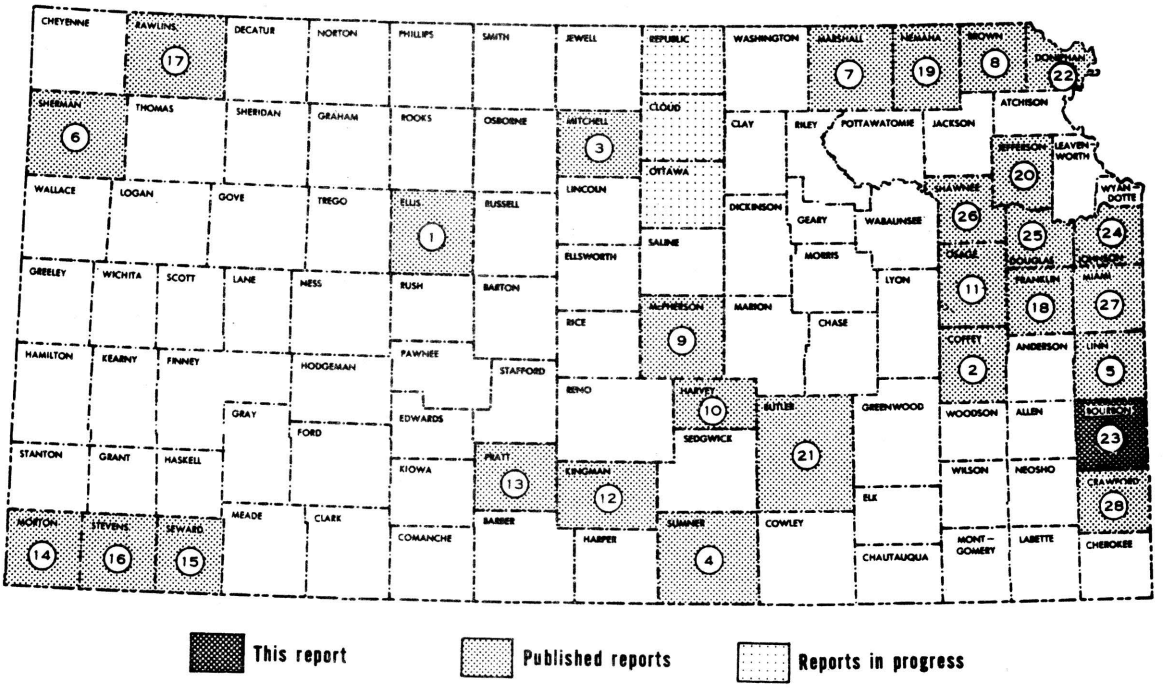


Figure 1. Index map of Kansas showing the location of Bourbon County along with the report numbers and location of counties for which reports have been or are being completed.

ABSTRACT

Bourbon County is located in the Osage Questa - Plains and Cherokee Lowlands Sections of the Central Lowlands physiographic province. Dominant topographic features of the county are gently sloping upland - plains and steep valley walls formed by the erosion of thick limestones and shales of the Cherokee, Marmaton, Pleasanton and Kansas City Groups. The erosional pattern developed by the Little Osage and Marmaton Rivers has had a dominant influence on the availability of construction materials resources and the type of geo-engineering problems encountered in Bourbon County.

Chat has been imported from the lead-zinc mining areas of Cherokee County and adjacent counties in Missouri for use as construction aggregate. Chert gravel has been obtained from the Neosho River Valley to the west; however, neither chert gravel, chat, nor sand and gravel has been produced in Bourbon County.

Significant sources of construction aggregate are available from limestone members of the Marmaton and Kansas City Groups of Pennsylvanian Age. The quality and thickness of these members vary within the county and quality tests should be conducted before production is started at a new location.

Water supplies for municipalities are generally obtained by storage of surface water. Limited amounts of water are available from alluvial deposits and consolidated rock aquifers; however, water from these sources is often hard and may contain an objectionable iron content.

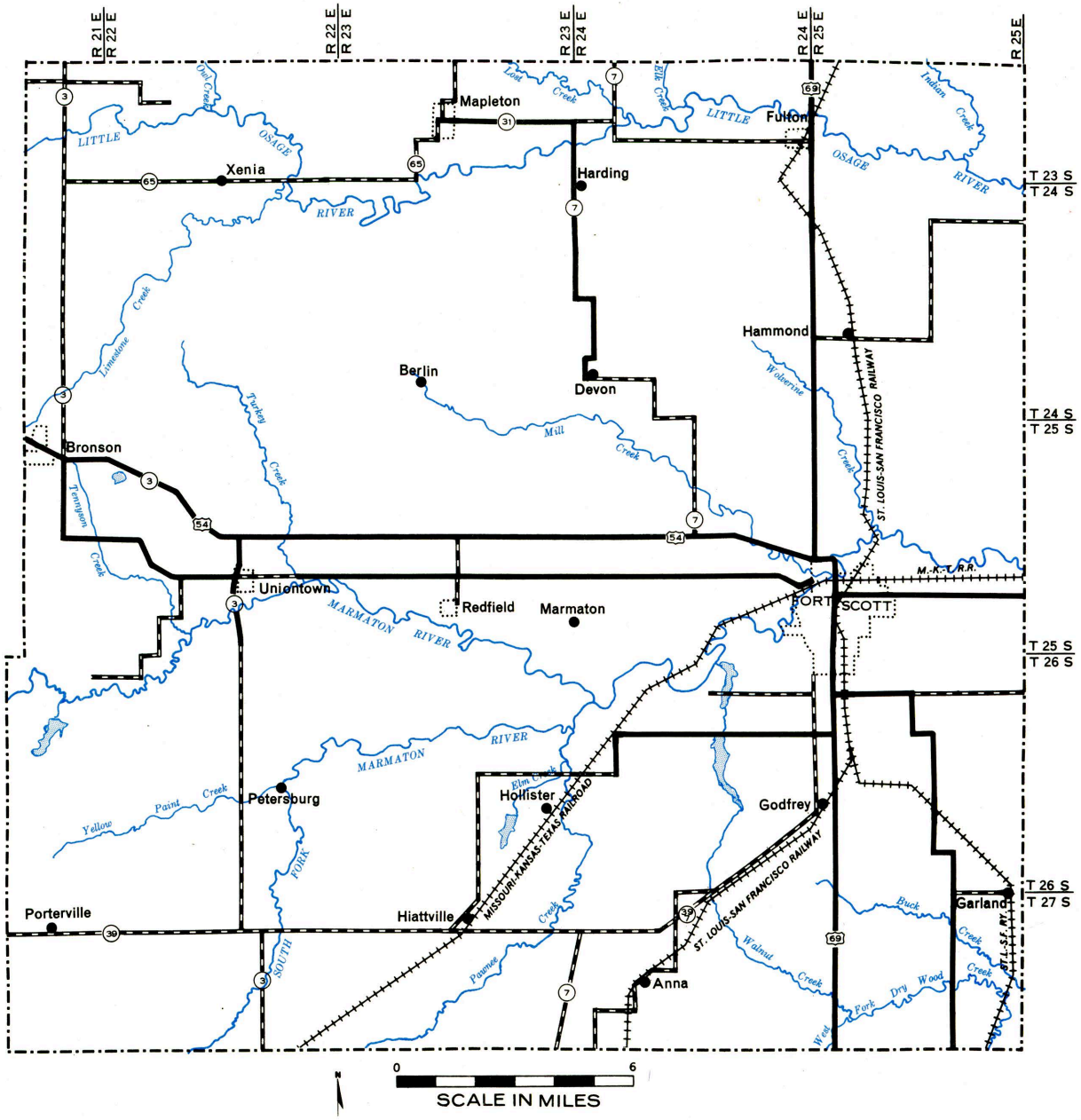


Figure 2. Drainage and major transportation facilities in Bourbon County.

FACTS ABOUT BOURBON COUNTY

Bourbon County is located on the Missouri border in southeast Kansas (figure 1, page v) It has an area of 639 square miles and a population of 15,740, according to the Kansas State Board of Agriculture (1975). Figure 2, page 1 shows the major drainage and transportation facilities within 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.

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 Bourbon County were then correlated with the various geologic units.

Phase Two: A study and interpretation of aerial photographs taken by the Kansas Department of Transportation at a scale of one inch equals 2,000 feet was accomplished. Figure 3 illustrates aerial photographic coverage of Bourbon County. Geologic source beds and all open materials sites were mapped and classified on aerial photographs. All materials sites were then correlated with the geology of the county.

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

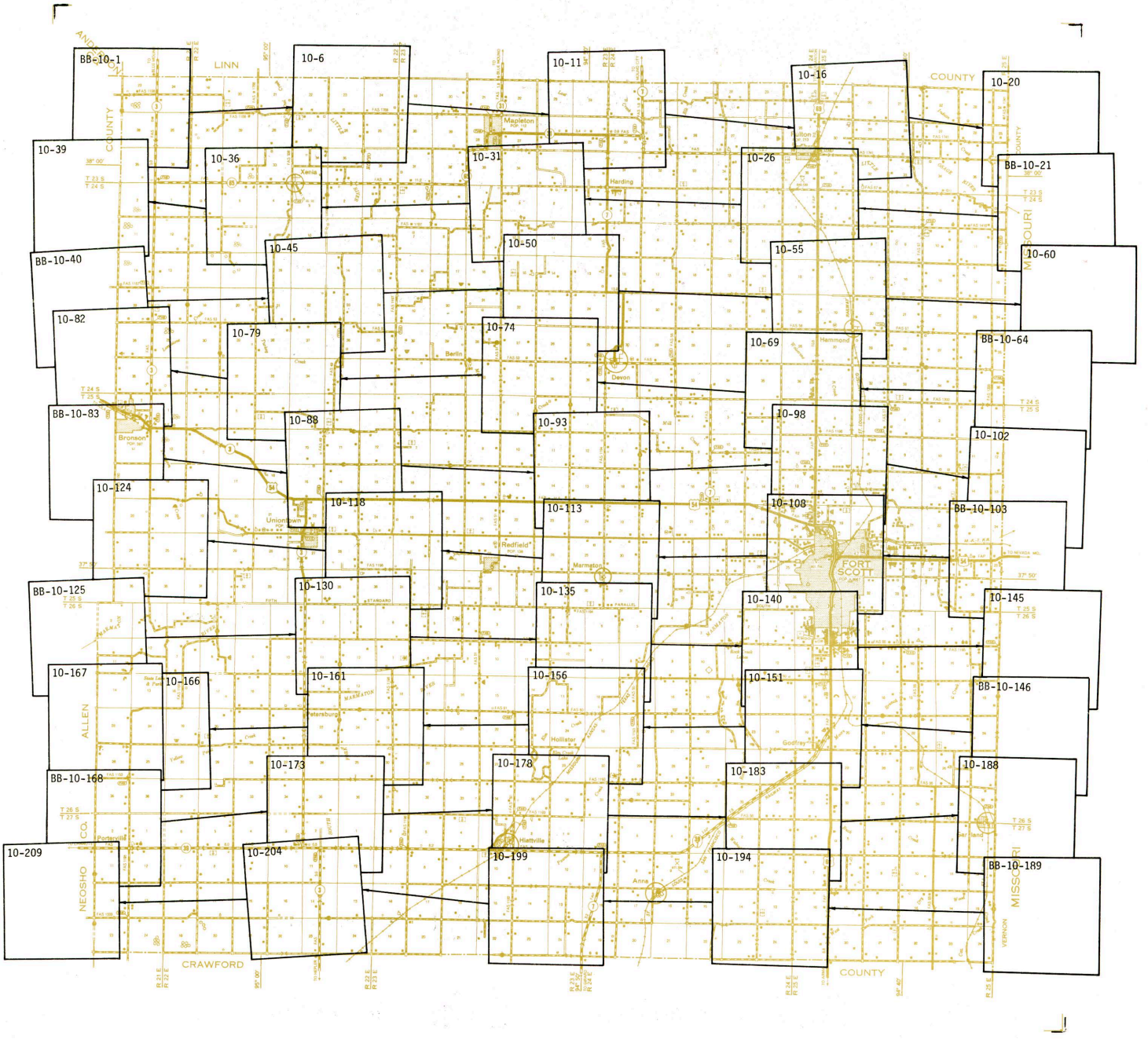
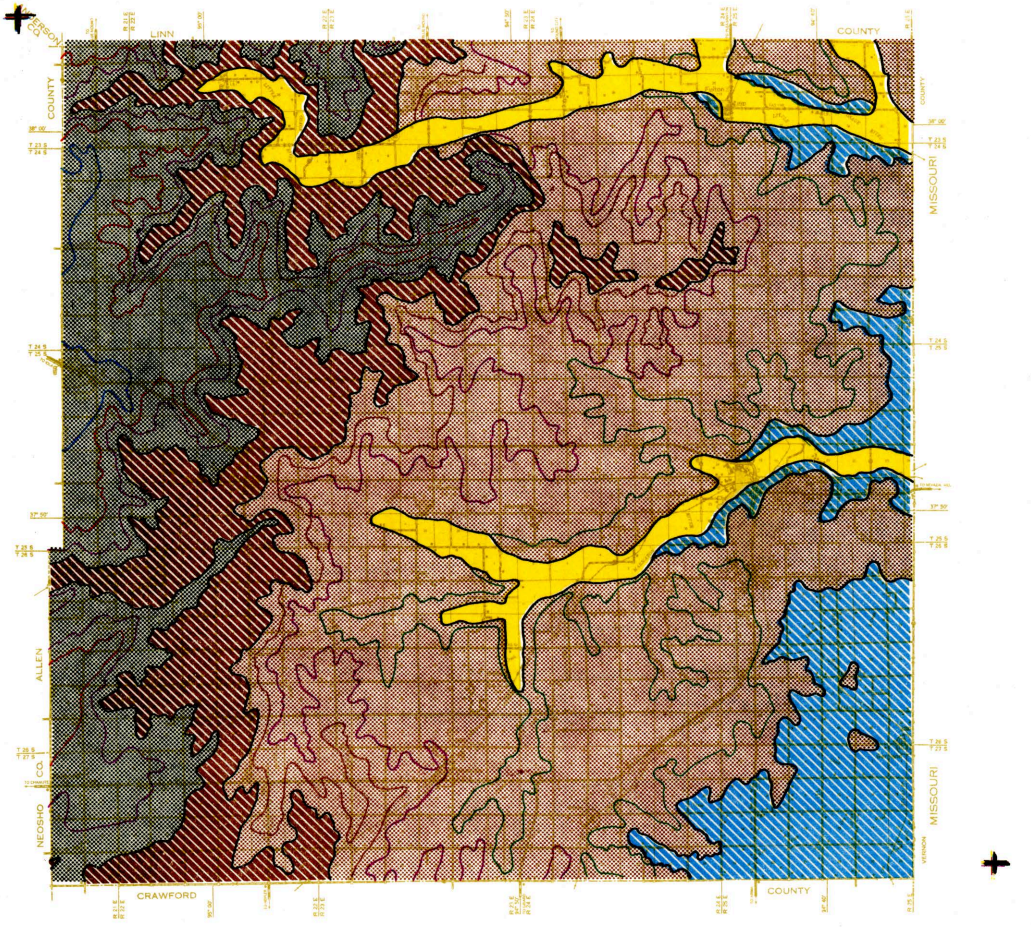


Figure 3. AERIAL PHOTOGRAPHIC COVERAGE MAP for Bourbon County. The numbers refer to photographs taken by the Photogrammetry Section, Kansas Department of Transportation on February 15, 1972 at a scale of 1"=2000'. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

GEOLOGY SECTION



LEGEND

- Alluvium
- Pleasanton Group
- Kansas City Group
- Marmaton Group
- Chanute Shale Base
- Lenapah Limestone Base
- Dennis Limestone Base
- Altamont Limestone Base
- Swope Limestone Base
- Pawnee Limestone Base
- Cherokee Group

GENERAL GEOLOGY

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

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

This discussion is based primarily on information obtained from field observations, reports of the Kansas Department of Transportation, and bulletins pertaining to Bourbon and surrounding counties by the Kansas Geological Survey. The geologic timetable, figure 4, shows in graphic form the major time periods and the approximate duration of each. Figure 5, page 7 , illustrates the surface geology and stratigraphic position of each material source unit in Bourbon County.

Subsurface rocks in the county range in age from Precambrian to Pennsylvanian. Precambrian rocks are marine sedimentary and granitic (Merriam, 1963). Marine Paleozoic rocks consisting of limestone, dolomite and shale overlie the Precambrian basement rocks. Non-marine sandstones and coal measures were also deposited during the Paleozoic interval. Sandstones were laid down by streams flowing across low relief surfaces, and coal beds were deposited in low lying swampy areas.

Middle Pennsylvanian Cherokee deposits, which outcrop in the eastern part of the county, are the oldest rocks exposed. Coal beds, which are in some cases economical to mine, occur in the Cherokee and Marmaton Groups. Marine limestones in the Marmaton and Kansas City Groups are the most abundant and important material source units in the county. These limestones outcrop throughout the county and open sites are located within a reasonable distance of every major transportation facility.

Mesozoic sediments are absent in Bourbon County. During most of Mesozoic time (Triassic and Jurassic Periods) it is assumed that the area was part of a landmass where large amounts of Paleozoic rocks were removed by erosion. During Cretaceous time, the sea made its final advancement into Kansas; however, if any sediments were deposited in Bourbon County during this time, they were subsequently removed by erosion during Cenozoic time.

Geologic processes active during Cenozoic time have had a very significant effect on the present day construction materials resources in Bourbon County. Differential erosion of Pennsylvanian rocks produced distinctive landforms. In the eastern part of the county, Cherokee rocks were reduced to a low flat plain, referred to as the 'Cherokee Lowland' (Schoewe, 1949). Erosion of rocks of the Marmaton, Pleasanton and Kansas City Groups through the remainder of the county produced the 'Osage Questa' landforms. Resistant limestones and sandstones form sharp escarpments and thick shale sequences were reduced to rolling plains between the escarpments. Antecedent streams of the present day drainage systems deposited limited amounts of chert and limestone gravels on upland areas in the western part of the county. However, erosion during the Pleistocene has thinned these gravels and they are of little or no value as construction aggregate.

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

Figure 4. Geologic Timetable

System	Series	Graphic Legend	Formations and Members		Map Symbol	Thickness	General Description	Construction Materials
Quaternary	Pleistocene	Recent	Alluvium and Terrace Deposits		Qal	0'-30'+		
Pennsylvanian	Upper Pennsylvanian	Kansas City Group	Cherryvale Shale			15'+		
			Dennis Limestone	Winterset Ls. Mbr.	Pd	50'+	Light-gray to gray limestone, thick to medium bedded and highly fractured.	Concrete and bituminous aggregate, light-type surfacing.
				Stark Shale Mbr.		3'		
				Canville Ls. Mbr.		1.5-3.5'	A dense, even-bedded, dark-gray limestone, weathers brown.	Light-type surfacing.
			Galesburg Shale			7-15'		
			Swope Limestone Formation	Bethany Falls Ls. Mbr.	Ps	20-27'	The upper part of this limestone is oolitic, light gray and cross-bedded, the lower part is massive, mottled dark gray and gray.	Concrete and bituminous aggregate, light type surfacing, riprap.
				Hushpuckney Shale		2-4'		
				Middle Creek Ls. Mbr		4'±	A unit-bedded, dense, gray limestone which weathers brown.	Light type surfacing.
			Ladore Shale			3-17'±		
			Hertha Limestone Fm.	Sniabar Ls. Mbr.	Ph	3-12'	A massive to wavy-bedded dark-gray to gray limestone, often contains numerous brachiopods.	Light type surfacing.
				Mound City Sh. Mbr.		1-6'		
				Critizer Ls. Mbr.		2-9'	A thin to unit-bedded gray-brown limestone, extremely variable, may include shale partings.	Light type surfacing.
		Pleasanton Group	Tacket Formation	'Bourbon Flag' Zone		0-60'+	Thin beds of dense blue-gray limestone and alternating beds of dark-gray to black shale.	Concrete and bituminous aggregate, light type surfacing.
						0-150'+		
			Seminole Fm.	South Mound Sh. Mbr.				
				Hepler Ss. Mbr.				
	Middle Pennsylvanian	Marmaton Group	Holdenville Shale					
			Lenapah Ls. Fm.	Idenbro Ls. Mbr.		1.0'±		
			Nowata Shale					
			Altamont Limestone Formation	Worland Ls. Mbr.	Pa	7'	Irregularly bedded, blue-gray, finely crystalline limestone, weathers gray with a thin-bedded brecciated appearance.	Concrete and bituminous aggregate, light type surfacing.
				Lake Neosho Sh.		1.5±		
				Amoret Ls. Mbr.		4'±		
			Bandera Shale					
				Bandera Quarry Ss.		0-17'+	A thin-bedded, gray, micaceous sandstone, weathers brown.	Light-type surfacing.
				Mulberry Coal Bed		0-2'		
			Pawnee Limestone Formation	Laberdie Ls. Mbr.	Pp	16-20'+	Gray to blue-gray limestone, massive-thin-bedded with several shale partings. Chaetetes colonies common.	Concrete and bituminous aggregate, light-type surfacing.
				Mine Creek Sh. Mbr.		0-4'		
				Myrick Station Ls.		8-15'	Massive to thin bedded limestone, often comprised almost entirely of chaetetes colonies.	Concrete and bituminous aggregate, light-type surfacing.
				Anna Shale		4'±		
			Labette Shale			40-80'		
			Fort Scott Limestone Formation	Higginsville Ls. Mbr.	Pf	10-17'	The upper 0-4' is massive, lower part is even-bedded. The unit is gray to light brownish gray. Chaetetes colonies abundant upper part.	Concrete and bituminous aggregate, light-type surfacing, riprap.
				Little Osage Sh. Mbr.		4-8'		
				Blackjack Creek Ls. Mbr.		0-9'	A massive-to medium-bedded light-gray limestone. Often includes chaetetes colonies.	Light-type surfacing.
		Cherokee Group	Cabaniss Formation	Mulky Coal Bed				
				Breezy Hill Ls. Mbr.				
				Bevier Coal Bed				

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

Fluvial deposits were laid down in stream valleys of the present day drainage systems during Pleistocene and Recent times. These deposits contain only scattered lenses of limestone gravel and are of little or no value as a source of construction material.

GEO–ENGINEERING

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

Major geo–engineering problems in Bourbon County are associated with alluvium of major drainage channels, escarpment forming limestones, and variations in soil mantle type and thickness.

Major scarp forming units are the Fort Scott, Pawnee and Hertha Limestone Formations. Large quantities of rock excavation will be encountered in deep cut sections in these escarpments. Above the Hertha Formation the Swope and Dennis Formations follow in close sequence, which form a broad area in which thick limestones are exposed. The Fort Scott and Pawnee Formations form a similar outcrop pattern within the county. The magnitude of rock excavation will depend on the limestone thickness, topographic relationships and the character of overlying shales.

Soil mantle varies in thickness from more than thirty (30) feet of alluvium in the valleys of the Marmaton and Little Osage Rivers to a few inches of cover over limestones of the Kansas City and Marmaton Groups. Based on information gathered through photo interpretation and field data obtained by our Soils and Geology Sections, a generalized concept of soil mantle thicknesses over upland areas was formulated. Soils occurring over limestones and on slopes with a 3 percent or steeper slope average less than 3 feet in thickness. Soils developed over shales on relatively flat areas average 10 feet in thickness. The sandy character of most shale formations in the Cherokee, Marmaton, and Pleasanton Groups is reflected in overlying soils. Soils developed over limestone formations show higher clay contents which exhibit poor engineering characteristics.

Abandoned meanders which contain loose unconsolidated material will be encountered in the alluvium of river valleys. Broad, flat, poorly drained areas will be encountered in the alluvium of the Marmaton and Little Osage Rivers east of US-69 (plates 2, 4 and 6). Special construction procedures will be necessary if such conditions are encountered on a highway alignment.

Hydrology problems have been associated with nearly every geologic member in the county. The most persistent problems have occurred in the Sniabar Limestone and at the soil mantle-bedrock contact. Local variations in dip are common in the area and may create traps for vadose water which would require underdrains on a highway alignment.

Coal mining has been accomplished in the eastern half of the county. Strip mining along the Fort Scott Limestone outcrop is quite extensive, but limited to a small width in the area of the outcrop. Other scattered areas of strip mining are located in the Cherokee and Bandera Formations. If spoil material is encountered during construction of highway projects, recompaction may be required. Shaft mines are also located in the above areas. These mines are relatively shallow and limited in area due to the occurrence of methane gas at relatively shallow depths. Detailed studies would be necessary during highway alignment studies to determine the location and extent of these mines as no evidence of their existence was noted on the aerial photos.

Oil has been produced in the extreme western part of the county and gas at scattered locations throughout the county. Some gas production occurs in well defined fields (Jewett, 1949). Nearly all production of petroleum hydrocarbons has been from sandstones in the Cherokee Group. Inasmuch as exploration and production has been active since the turn of the century, many unrecorded wells may have been abandoned. Careful study will be necessary during location, design and construction stages of a highway project to assure that uncased open holes do not create structural stability problems, particularly in areas where secondary recovery repressuring will be or is being utilized.

Limited water supplies are available from consolidated rock and alluvial deposits; however, water quality from these sources may be impaired by dissolved minerals. All municipalities and rural water districts in the county depend on the collection of surface run-off for water supplies.

MATERIALS INVENTORY SECTION

GENERAL INFORMATION

Pennsylvanian limestones and a very limited amount of sandstone make up the construction materials resources of Bourbon County. Chat can be imported from the lead-zinc district of the Tri-State area and chert gravel is available from the Neosho River Valley in Neosho and Allen Counties.

Construction material types, their uses and availability are tabulated in figure 6. Test results from a limited amount of sampling and testing are presented in figure 19, page 25.

CONTENTS
MATERIALS INVENTORY SECTION

Type Material and Geologic Source	Use	Page	Availability
LIMESTONE Blackjack Creek Member	Light type surfacing.	14	Fair, eastern part of county. Plates 2, 4 and 6.
Higginsville Member	Concrete and bituminous aggregate light type surfacing, riprap.	15	Good, eastern part of county. Plates 2, 4 and 6.
Myrick Station Member	Concrete and bituminous aggregate light type surfacing, riprap.	16	Good, eastern and central part of county. Plates 2, 3, 4, 5 and 6.
Laberdie Member	Concrete and bituminous aggregate light type surfacing.	16	Very good, eastern and central part of county. Plates 2, 3, 4, 5 and 6.
Worland Member	Concrete and bituminous aggregate light type surfacing.	17	Central part of county. All plates.
'Bourbon Flag' zone	Concrete and bituminous aggregate light type surfacing.	18	Very limited, northwest part of county. Plate 1.
Critzer Member	Light type surfacing.	19	Limited, northwest part of county. Plates 1 and 2.
Sniabar Member	Light type surfacing.	20	Good, western part of county. Plates 1, 2, 3 and 5.
Middle Creek Member	Light type surfacing.	22	Very limited, western part of county. Plates 1, 2, 3 and 5.
Bethany Falls Member	Concrete and bituminous aggregate light type surfacing, riprap.	22	Good, western part of county. Plates 1, 2, 3 and 5.
Canville Member	Light type surfacing.	23	Very limited, western part of county. Plates 1, 3 and 5.
SANDSTONE Bandera Quarry Member	Light type surfacing.	24	Very limited, south central part of county. Plates 3 and 5.

Figure 6. Tabulation of construction material types and their availability in Bourbon County.

DESCRIPTION OF CONSTRUCTION MATERIALS

Limestone

Fort Scott Limestone Formation

The Fort Scott Formation consists of two limestone members separated by a shale member. These are, in ascending order, the Blackjack Creek Limestone, Little Osage Shale and Higginsville Limestone. The exposed thickness of this formation varies from 22 to 30 feet in the county. Production of construction aggregate from the formation has been limited to the Higginsville Member in this area. The outcrop pattern of the Fort Scott Formation is shown on plates 2, 4 and 6.

Blackjack Creek Limestone Member

The Blackjack Creek varies from a few inches to 9 feet at measured locations. The upper part of the unit is a nodular limestone which is irregularly bedded. The lower part is a massive, unit-bedded, argillaceous limestone which initially weathers along joint planes to large rounded blocks. The member often includes large colonies of tabulate coral (chaetetes), brachiopods and unusually large crinoid stems. The entire unit is light gray on fresh exposures and weathers to a tan brown. A name of local usage, 'Cement Rock', has been applied to the unit because of its past use in the manufacture of cement in the quarry immediately north of Fort Scott. This limestone is suitable for light type surfacing; however, careful sampling and testing at selected locations will be necessary to determine if it will meet specifications for other types of aggregate.

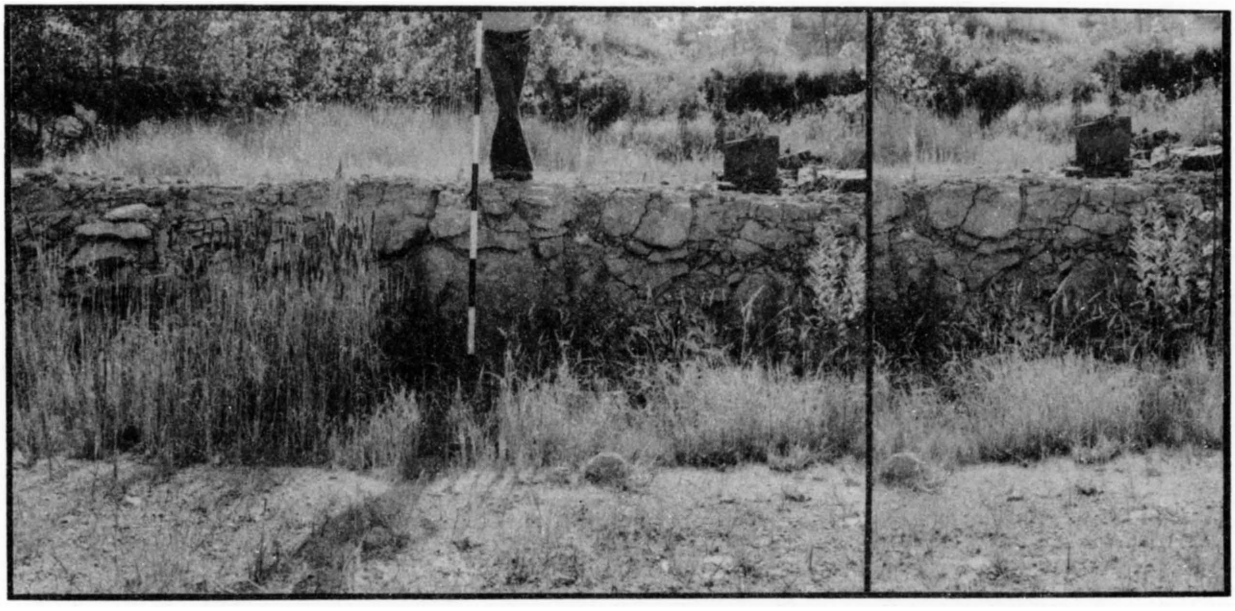


Figure 7. Blackjack Creek Limestone exposed in a quarry in the NW ¼ sec. 19, T25S, R25E (stereogram).

Higginsville Limestone Member

Exposures of the Higginsville Limestone Member vary from 10.0 to 17.2 feet at measured locations in the county. Up to 4 feet of the upper part of this unit is irregularly bedded to massive, gray, and weathers rusty brown. Abundant chaetetes colonies characterize this part of the member along with brachiopods and large crinoid stems. A light-brownish-gray to light-gray hard crystalline limestone characterizes the lower 10 to 17 feet; it is more evenly bedded and weathers slabby to blocky. Brachiopods, chaetetes colonies, and large crinoid stems are common but not as abundant as in the upper 4 feet of the member. Limited quality tests from open sites show that the Higginsville Limestone has very good characteristics for construction aggregate.

Figure 8. Higginsville Limestone exposed in a quarry in the NW ¼ sec. 19, T25S, R25E (stereogram).

Pawnee Limestone Formation

Two shale and two limestone members make up the Pawnee Formation. They are, in ascending order, the Anna Shale, Myrick Station Limestone, Mine Creek Shale and the Laberdie Limestone. The exposed thickness of this formation varies from 23 to 42 feet in the county. Construction aggregate is produced from the Laberdie and Myrick Station Members. Quality tests on samples from open sites show that material from both sources has good characteristics for concrete and bituminous construction. The Pawnee Formation is mapped on plates 2, 3, 4, 5 and 6.

Myrick Station Member

The Myrick Station Member varies from 8 to more than 15 feet in the county. The member consists of a more massive irregular-to wavy-bedded upper unit which is separated by a shale parting from a thinner-bedded lower unit. Chaetetes colonies often comprise a large part of this member. Partings may be controlled by these colonies which stand out from the weathered outcrop. Crinoid stems and brachiopods are also common but are not diagnostic of this member.

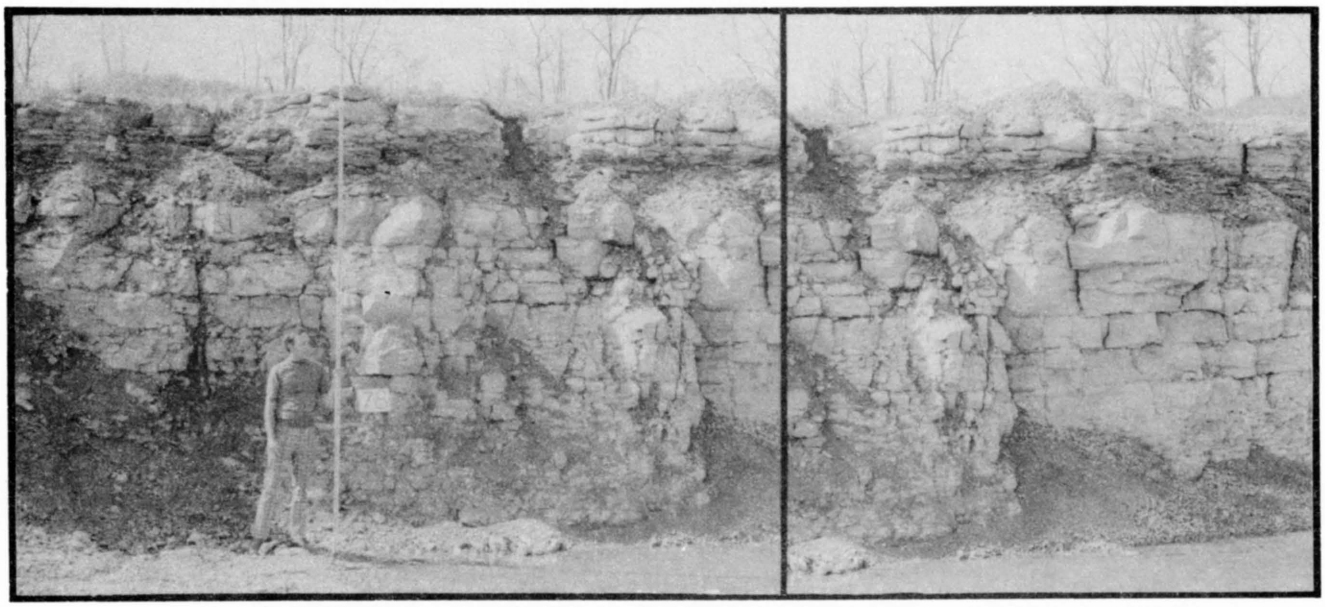


Figure 9. Myrick Station Limestone exposed in a quarry in the NE ¼ sec. 17, T26S, R24E (stereogram).

Laberdie Limestone Member

Through most of Bourbon County the Laberdie Member is from 16 to more than 20 feet thick. At the north county line it thins to about 8 feet, and in the vicinity of Fort Scott it averages about 16 feet. This limestone is massive to thin bedded with several shale partings and weathers slabby. Color is gray to blue gray, and on weathered surfaces is tan gray to tan. Often, significant accumulations of talus are found in the soil mantle adjacent to this limestone. Chaetetes colonies, brachiopods and crinoid stems are common throughout this member.

A factor to consider in quarrying the Laberdie Member is that the Mulberry Coal, if present, occurs 3 to 6 feet above this limestone in the Bandera Shale. Its thickness ranges from 0 to 23 inches. Under certain conditions it could be feasible to strip-mine this coal during the removal of overburden.

Figure 10. Laberdie Limestone exposed in a quarry located in the SE ¼ sec. 16, T26S, R24E (stereogram).

Altamont Limestone Formation

Outcrops of this formation consist of two limestone members separated by a shale. The members are, in ascending order, the Amoret Limestone, Lake Neosho Shale and Worland Limestone. The thickness of this formation is from 10.5 to 12.0 feet at measured locations and its outcrop pattern is shown on all plates. Production of limestone aggregate is limited to the Worland Member in the county.

Worland Limestone Member

The Worland Member is an irregularly-bedded, blue-gray, finely-crystalline, almost lithographic limestone. This unit weathers gray with a thin-bedded brecciated appearance and is about 7 feet thick in Bourbon County. Quality test data for the Worland Limestone are not available; however, from its appearance and from test data for sites in Neosho County the material should be suitable for concrete and bituminous construction.

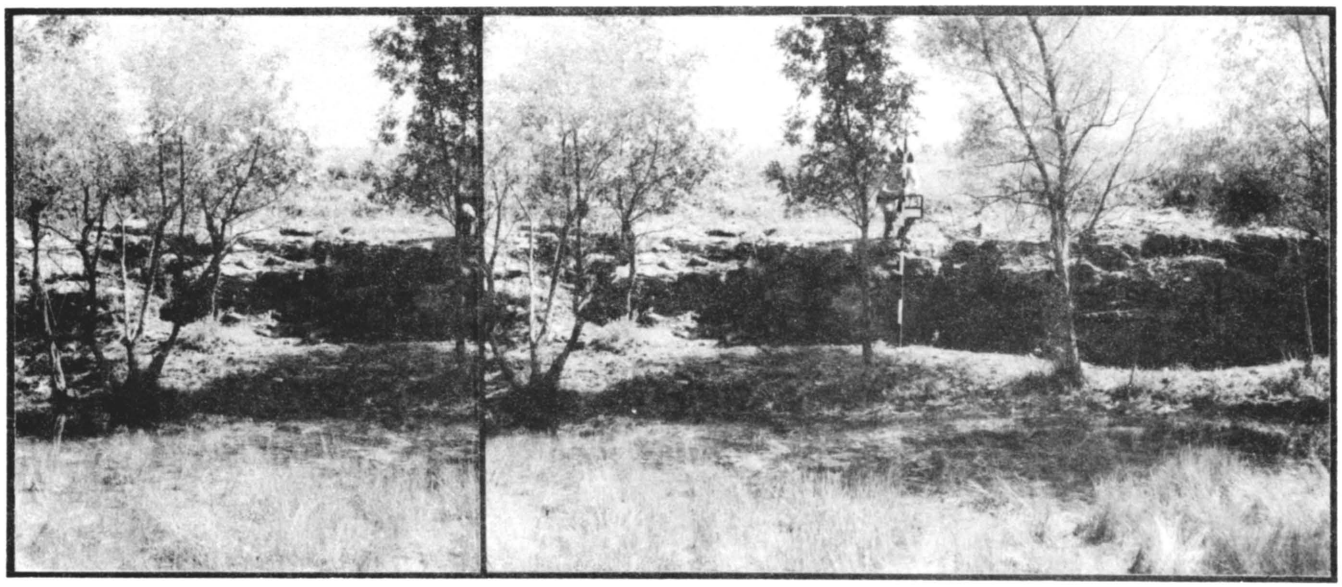


Figure 11. Worland Limestone exposed in a quarry in the NE ¼ sec. 30, T24S, R24E (stereogram).

Tacket Formation

In southern Bourbon County the Tacket Formation is up to 150 feet thick and is a blue-gray shale with a few thin limestones. In the extreme northern part of the county the formation thins to about 50 feet and this interval is occupied by the 'Bourbon Flags'. The formation occurs immediately below the Hertha Formation which is mapped on plates 1, 3 and 5.

Bourbon Flag Zone

This zone is composed of thin beds of dense, blue-gray limestone and alternating beds of dark-gray to black shale. Locally, the shales in the lower part of the zone thin and the limestone has been quarried. One locality in the area (Site LS +3, plate 1) has been tested and the material was well within specifications for construction aggregate. Any potential site in this zone should be carefully explored and tested because of extreme variations in lithology common in the Tacket Formation.

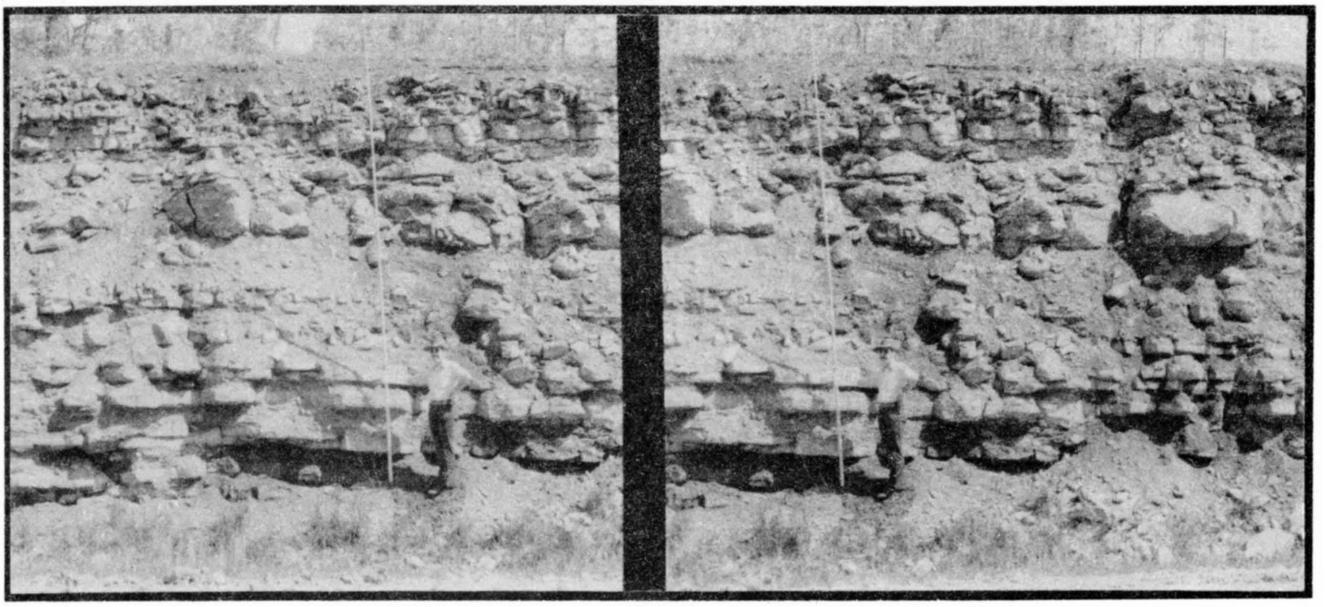


Figure 12. 'Bourbon Flag' zone overlain by the Critzer Limestone in a road cut in the SE ¼ SE ¼ sec. 23, T23S, R22E (stereogram).

Hertha Limestone Formation

The Hertha Formation, mapped on plates 1, 3 and 5 consists of two limestone members separated by a shale, and has an average thickness of 25 feet in the county. Members are, in ascending order, the Critzer Limestone, Mound City Shale, and Sniabar Limestone. The only observed production of construction aggregate from this formation has been from the Sniabar Member.

Critzer Limestone Member

Through most of the outcrop area, the Critzer Member consists of two thin limestones less than 12 inches thick separated by 1 to 4 feet of shale. This sequence could hardly be considered a source of construction material because of the thin nature of the limestones.

In the northern portion of the outcrop area along FAS 1768, the member thickens to approximately 9 feet. In the SE ¼ sec. 20, T23S, R22E, it is massive, unit bedded, with poorly developed joint planes. Fresh exposures are gray brown and weather to a dark-brown color. Based on field observations the material at this location is suitable for all types of construction aggregate. East of this location in the SE¼ sec. 23, T23S, R22E, the lithology changes to a thin-to medium-bedded limestone with numerous shale partings. Production of higher quality material from this location would be difficult.

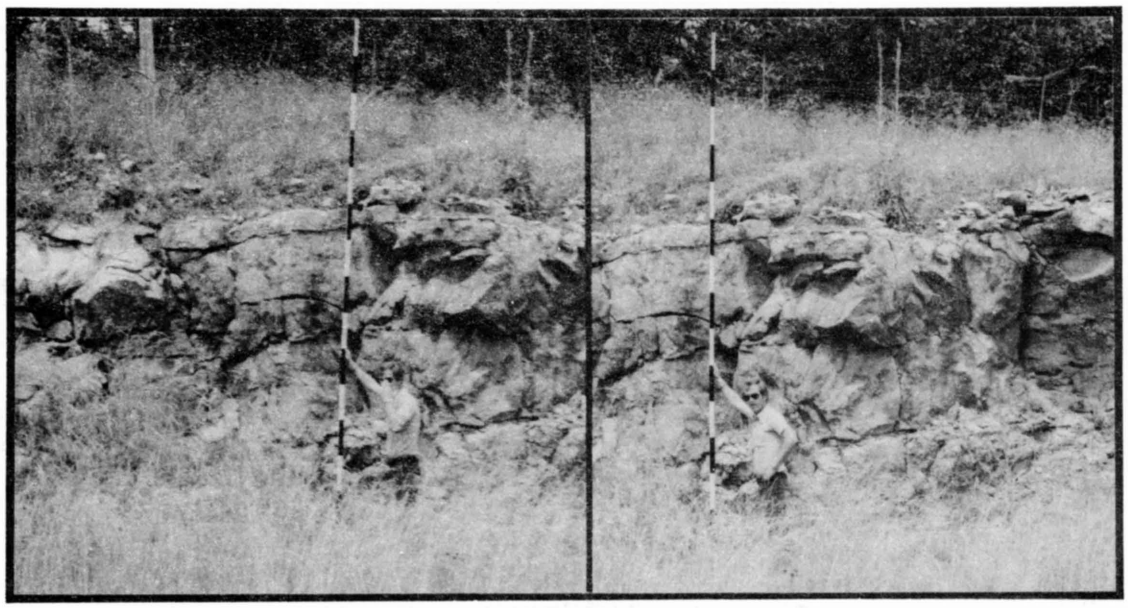


Figure 13. Critzer Limestone exposed in a road cut in the SE ¼ sec. 20, T23S, R22E (stereogram).

Because of variations in lithology, careful exploration, sampling and testing would be necessary to determine the suitability of a site located in the Critzer Member as a source of construction material. Open sites in the Bethany Falls Member of the Swope Formation offer more attractive opportunities for limestone production in this area.

Sniabar Limestone Member

The Sniabar Member varies from a maximum of 12 feet in the southern part of the county to approximately three feet in the northern part of the county. In southern Bourbon County the upper 0-4 feet of this member is massive, has a brecciated gray-brown appearance, and weathers to a rusty brown; the lower wavy-bedded section is dark gray to gray, weathers gray brown and contains numerous brachiopods, many of which are made up of crystalline calcite. In the northern part of the county the unit is dense, massive and unit bedded. Its dark-gray surface weathers brown on exposure.

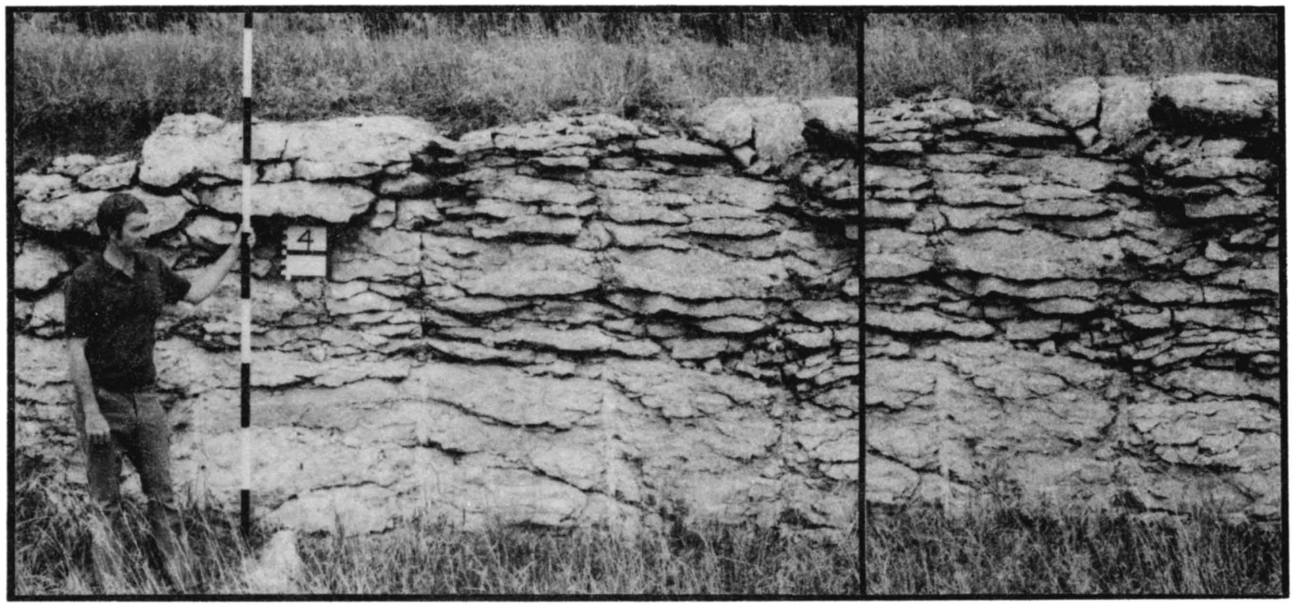


Figure 14. Sniabar Limestone exposed in a road cut in the SE ¼ sec. 34, T25S, R22E (stereogram).

Quality test data are not available for this member, but it appears suitable for all types of construction aggregate. At some localities it could be advantageous to quarry this member in conjunction with members of the overlying Swope Limestone Formation as approximately 4 feet of Ladore Shale separates the Swope and Hertha Formations.

Swope Limestone Formation

Two limestones separated by a shale comprise the Swope Formation. The members are, in ascending order, the Middle Creek Limestone, Hushpuckney Shale, and Bethany Falls Limestone. Distinctive lithologic characteristics of the members form outcrops that are readily identified in the field. The Swope Formation is mapped on plates 1, 2, 3 and 5.

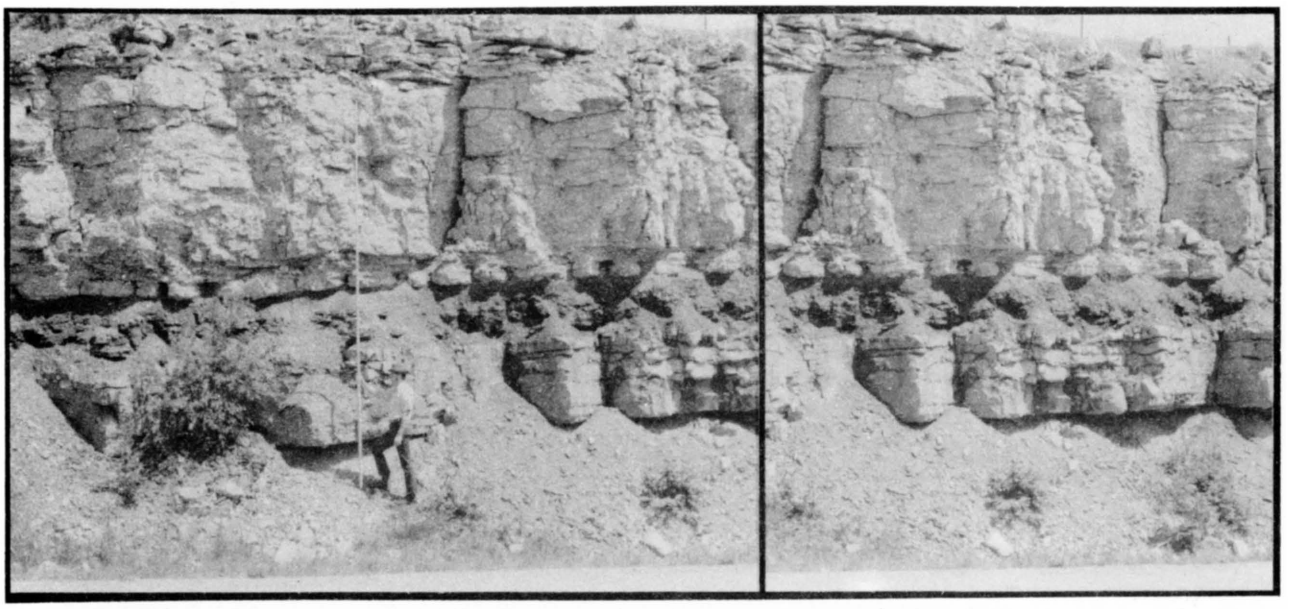


Figure 15. Swope Limestone Formation exposed in a road cut in the SE ¼ sec. 20, T23S, R22E (stereogram).

Middle Creek Limestone Member

The thickness of the Middle Creek Member averages 4 feet in Bourbon County. Typically, it is unit bedded, hard, dense, gray and weathers to a tan gray. This unit has not been tested in the county; however, field observations indicate it should be suitable for concrete and bituminous aggregate. The Hushpuckney Shale, which is 2 to 4 feet thick, separates the Middle Creek from the Bethany Falls Member. Because of the position of the member in relation to the Bethany Falls Limestone, it is doubtful that any extensive quarry operation would be feasible unless the units were used together.

Bethany Falls Limestone Member

Typically the Bethany Falls Member consists of two types of limestone. The lower 7 to 12 feet is massive, mottled dark gray and gray with a hackly surface texture. A diverse assemblage of fossil fragments is found in this section.

Cross-bedded oolitic limestone from 8 to 20 feet thick comprises the upper part of this unit (Mossler - 1973). Thickest sections of the oolitic zone are found in the central and southern part of the outcrop area (plates 3 and 5). Fresh exposures of this material have a light-gray color. It weathers gray with a grainy surface texture.

Quality tests on this material are only available from sites in the northern part of the outcrop area (plate 1). Quality of material is well within specifications for construction aggregate at these locations. Some degradation of quality will occur with increased shale content toward the south.

Dennis Limestone Formation

The Dennis Formation, mapped on plates 1, 3 and 5, is represented by three members. They are, in ascending order, the Canville Limestone, Stark Shale and Winterset Limestone. The total thickness of the formation is approximately 60 feet. The formation occurs in western Bourbon County as mapped on plates 1, 3 and 5.

Canville Limestone Member

The thickness of the Canville Member varies from 1.5 to 3.5 feet. It is dense, dark gray, even bedded and weathers brown. This member is not quarried in the county because of the character and thickness of the other members of the Dennis Formation. The member is suitable for light type surfacing and, based on field data, should have the characteristics necessary to qualify as construction aggregate. It would be possible to produce this unit in conjunction with the Winterset Member as they are separated by approximately 3 feet of Stark Shale.

Winterset Limestone Member

The Winterset Member is approximately 50 feet thick in Bourbon County. Outcrops of the complete section were not observed. The member forms a broad, rolling, rock strewn area above the Hertha-Swope escarpment. The limestone is light gray to gray, massive to medium bedded and highly fractured. Only one site in the county (LS + 9) has been tested and the material produced qualifies for all types of construction aggregate.

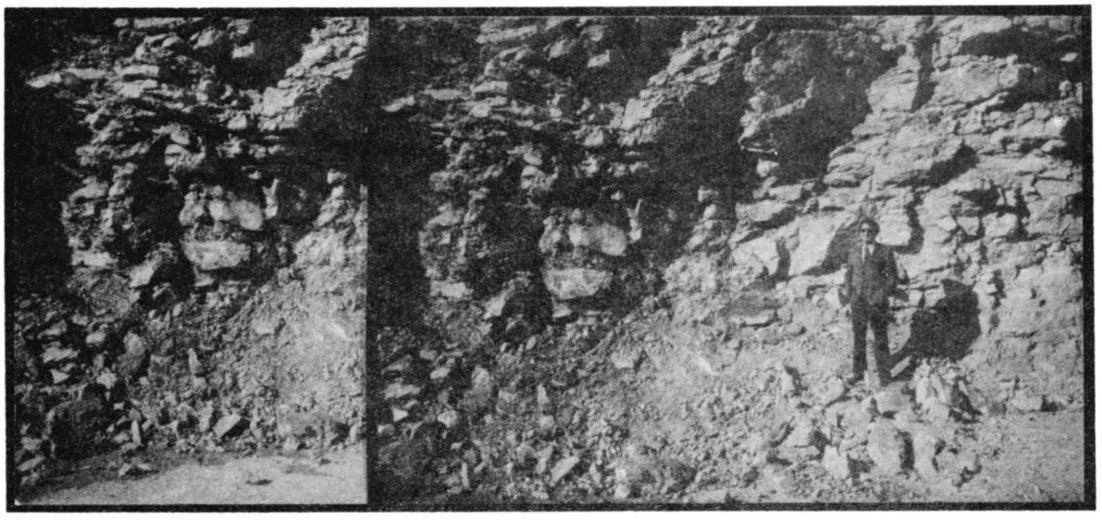


Figure 16. *Winterset Limestone exposed in a quarry in the SE ¼ SE ¼ sec. 6, T25S, R22E (stereogram).*

Bandera Shale Formation

The Bandera Formation is from 70 to 90 feet thick in the county. It occurs above the Pawnee Formation which is mapped on plates 2, 3, 4, 5 and 6. The formation is made up of non-marine shales, sandstones and thin coal beds. Lithology of the various units is highly variable.

Bandera Quarry Sandstone

This sandstone occurs in the middle to lower part of the Bandera Shale. Observed thickness ranges from 0 to 17 feet. This unit is thin bedded and has a gray micaceous surface on fresh exposures which weathers brown. The Bandera has been quarried in the Redfield area for ornamental purposes. The most common use of this material has been as 'flagging' stone for sidewalks and patio type structures. If processed to proper gradation, the sandstone might be suitable for light type surfacing; however, based on field observations, it is doubtful that it would meet specifications for any other type of aggregate.

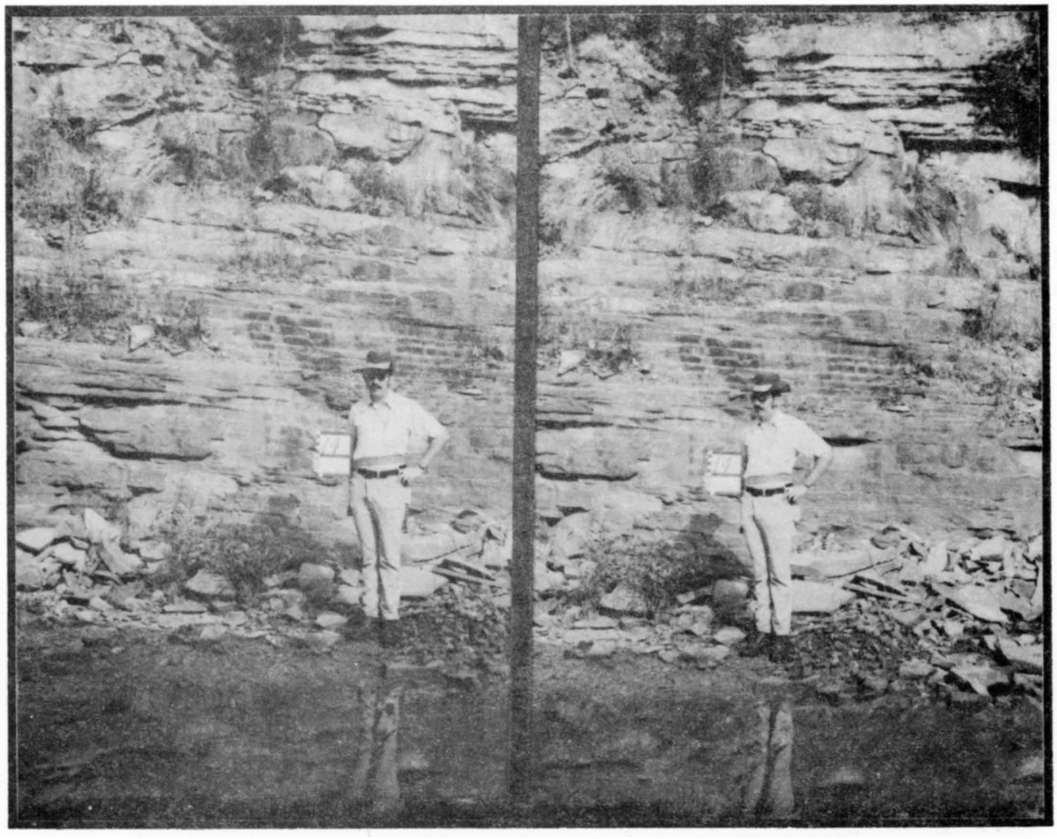


Figure 17. *Bandera Quarry Sandstone exposed in a quarry in the SE ¼ sec. 29, T25S, R23E (stereogram).*

Site Data Form No.	Material Type	Date of Test	Sp. Gr. Sat.	Sp. Gr. Dry	% Wear	Soundness	Absorption	Source of Data SHC Lab. No.	Type of Sample
Source of Material: Dennis Limestone Formation (Winterset) Pd									
LS + 9	Limestone	8-10-73	2.52-2.58	2.45-2.53	34(B)	0.99	3.06-2.04	73-1842	Crushed
Source of Material: Swope Limestone Formation (Bethany Falls) Ps									
LS + 1	Limestone	10-28-65	2.62	2.58	29.5(B)	0.98	1.54	65-4729	Crushed
LS + 2	Limestone	7-27-62	2.57	2.51	29.8(B)	0.98	2.20	23591	Crushed
LS + 4	Limestone	2-7-66	2.59	2.54	30.2(B)	0.98	1.84	66-173	Crushed
LS + 5	Limestone	3-6-62	2.54	2.48	33.0	0.99	2.50	21211	Crushed
Source of Material: Tacket Formation (Bourbon Flags)									
LS + 3	Limestone	12-7-62	2.61	2.56	27.5(B)	0.98	1.72	20374	Crushed
Source of Material: Pawnee Limestone Formation (Laberdie) Pp									
LS + 13	Limestone	9-1-64	2.65	2.61	24.1(B)	0.98	1.66	36182	Crushed
LS + 14	Limestone	3-14-69	2.54	2.48	33.8(B)	0.99	2.20	69-540	Crushed
Source of Material: Pawnee Limestone Formation (Myrick Station) Pp									
LS + 6	Limestone	2-3-65	2.57	2.53	24.2(B)	0.97	1.77	38418	Crushed
LS + 11	Limestone	2-3-75	2.53	2.59	25(B)	0.99	1.5	75-83	Crushed
LS + 12	Limestone	3-6-62	2.66	2.64	25.4	0.98	0.94	21206	Crushed
Source of Material: Fort Scott Limestone Formation (Higginsville) Pf									
LS + 7	Limestone	5-26-59	2.63	2.59	25.4(B)	0.96	1.64	6763	Crushed
LS + 8	Limestone	6-18-68	2.61	2.57	27.2(B)	0.98	1.59	68-1840	Crushed
		8-16-68	2.62	2.57	27.7(B)	0.95	1.68	68-2712	Crushed
LS + 10	Limestone	11-28-66	2.65	2.60	23.4(B)	0.94	1.72	66-5162	Crushed
		2-17-67	2.63	2.59	25.1(B)	0.94	1.71	67-317	Crushed
		3-18-68	2.64	2.40	27.0(b)	0.95	1.78	68-697	Crushed
		3-14-69	2.65	2.61	23.5(B)	0.98	1.58	69-538	Crushed

Figure 19. Results of tests completed on samples of material from the various geologic source beds in Bourbon County.