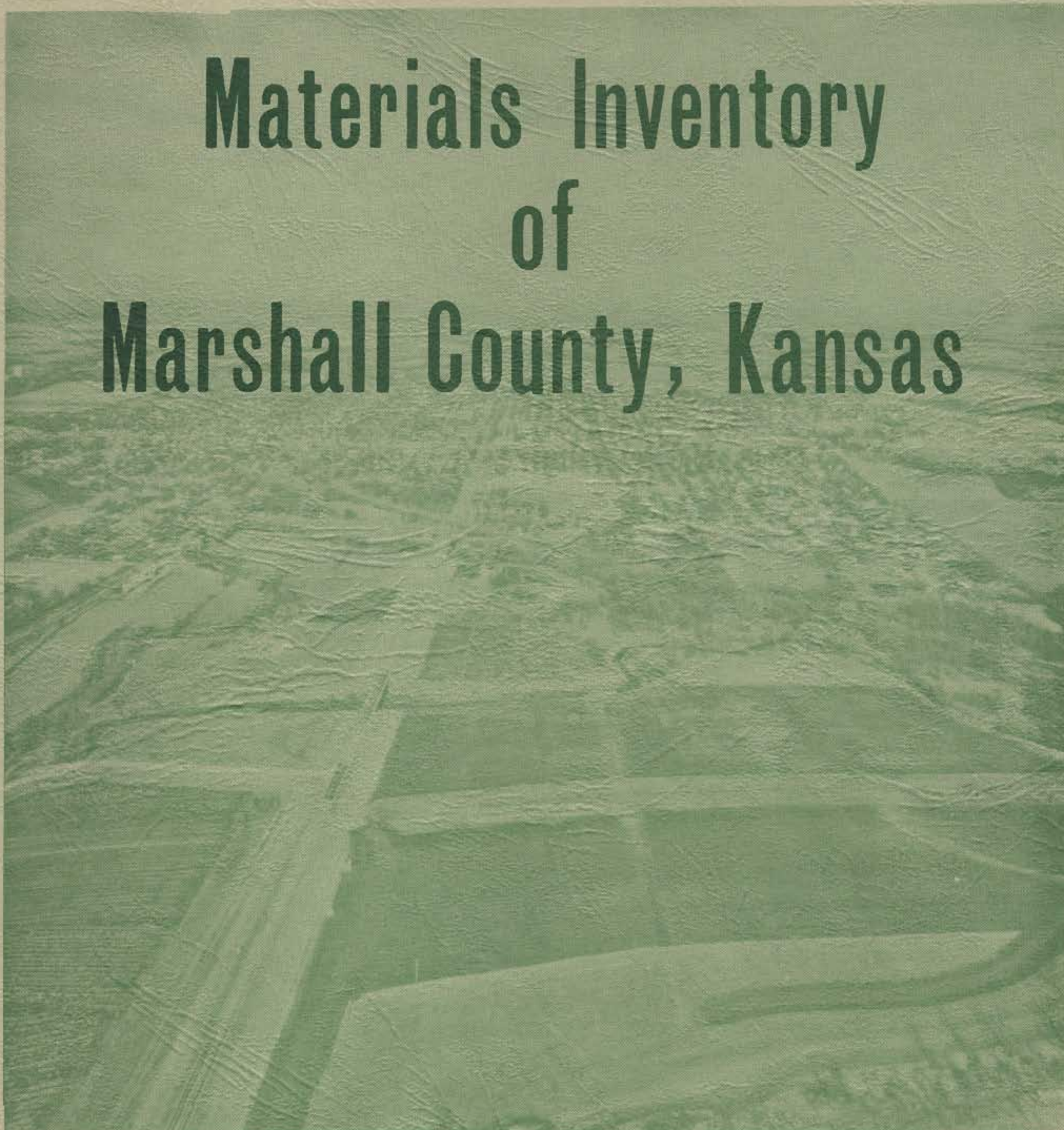
Materials Inventory of Marshall County, Kansas



prepared by the

State Highway Commission of Kansas

in cooperation with the

U. S. Department of Transportation

Federal Highway Administration

Bureau of Public Roads

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

MATERIALS INVENTORY OF MARSHALL COUNTY, KANSAS

BY

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

1965

Materials Inventory Report No. 7

COVER - An aerial view of Marysville, Kansas, county seat of Marshall County.

SUGGESTED USE OF THE REPORT

The Materials Inventory of Marshall County is the seventh of a series of county materials inventories prepared by the State Highway Commission of Kansas in cooperation with the Bureau of Public Roads. This report includes: (1) an introduction which describes the nature of the report and gives general information concerning Marshall County; (2) an explanation of the procedures used in compiling the information contained herein; (3) a brief explanation of the origin of the geologic units that are source beds for construction materials in the county, and a detailed description of the materials which have been produced from these units; (4) county materials maps (Plates I through VI) which show the geographic location of the various source beds in the county, along with the locations of open and prospective materials sites and (5) appendices I through IV which contain site data forms for each open and prospective materials site. Each form has a sketch showing the materials site and surrounding landmarks, the name of the landowner, the name of the geologic source bed, and a resume' of all test data avilable for that site.

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

After becoming familiar with the nature of the report, the reader may wish to refer to the section "Construction Materials Resources of Marshall County." In this portion of the report a geologic history of Marshall County is presented which describes the geologic events that led to the deposition of the various source beds and sets forth the geologic nomenclature used throughout the report.

The construction materials resources of Marshall County are also inventoried in this section of the report. A study of the construction materials inventory will reveal the types of material available in the county, their geologic source beds, the localities where they are found, and a description of their engineering properties.

When the reader has determined which geologic source bed contains material that may meet his requirements, he should then refer to the county materials maps. From these maps he can find the areas in which this bed is present, the locations of prospective materials sites in this source bed, and references to data forms for each open or prospective site.

For example, the reader determines from the study of the construction materials inventory that sand and gravel found in the Alluvium of the Big Blue River Valley may fulfill the materials specifications for a project in the south-central part of the county. The materials map (Plate V) shows several open pits along the Big Blue River. If the reader is interested in site $\frac{SG+93}{Qal}$ he refers to appendix II where detailed information is given on the site data form. This information enables him to plan his exploration in an orderly fashion.

PREFACE

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

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

Previous to this time, no extensive or county wide materials investigation had been completed in Marshall County. Two reports which are particularly useful are Frye and Leonard "Pleistocene Geology of Kansas" (1952) and Walters, "Geology and Ground-Water Resources of Marshall County, Kansas" (1957). In addition, several preliminary soil surveys have been made and centerline profiles prepared for road design purposes by the State Highway Commission of Kansas along the major highways that traverse Marshall County; however, available information on materials suitable for construction purposes has been very meager.

Aggregate quality test results, pertinent information pertaining to materials produced, and some geologic data on Marshall County used in this report were supplied by the Materials Department and the

Geology Section of the Design Department. This report was prepared under the guidance of Mr. J. D. McNeal, Engineer of Planning and Research; the project leader, Mr. R. R. Biege, Jr., Engineer of Aerial Surveys and Photogrammetry Section; and Mr. A. H. Stallard of the Photogrammetry Section. Appreciation is extended to Mr. C. T. Mohrbacher, Marshall County Engineer and Mr. R. E. Fincham, a Resident Engineer for the State Highway Commission for verbal information on construction in the area.

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ABSTRACT

Sources of construction materials in Marshall County are restricted to the thicker limestone beds, glacial sand and gravel, the Grand Island Formation and Alluvium of the Big Blue River Valley.

Five limestone beds provide material, which is now or has been in the past, suitable for use in some phase of road construction. Although some limestone produced in the county has been used in bituminous mat construction, the most important use of the limestone beds is in the production of crushed rock for surfacing of lightly traveled rural roads.

Deposits of sand and gravel closely associated with early glaciation are of two different ages in Marshall County. These are: (1) Pre-Kansan Gravel, and (2) gravel deposits found in the Kansan Till. Material from these deposits has been utilized only for surfacing material on lightly traveled rural roads. All glacial gravel pits in Marshall County are found above the water table; therefore, dry pit excavation is used to produce material from this source.

Terrace deposits of late Kansan age which contain sand and gravel of the Grand Island Formation are found along the major valleys in Marshall County. Material from the Grand Island is uniformly of good quality and can be produced economically by dry production methods until the water table is reached, at which time, pumping operations will be required to recover the remaining material.

The most important source of good quality sand and gravel is produced by pumping methods from the Alluvium of the Big Blue River Valley. The abundant supply and consistent quality make it the most important reserve of construction material in the county.

Geo-engineering problems confronted by the highway engineer in Marshall County are typical of those found elsewhere in the glaciated areas of northeastern Kansas. The major considerations, from the geo-engineering aspect, are discussed under the following subtitles; (1) Material Usage in Road Construction, (2) Hydrology Problems in Road Construction and (3) Mineralization of Water Resources.

The incorporation of some of the highly plastic soils and the plastic weathered shales in embankment and subgrade construction is a major concern in material usage determinations. These materials are undesirable because of their shrinkage and swell characteristics. Other considerations from the usage aspect include backslope steepness and stabilization in cuts through the various geologic units found in Marshall County.

Nearly all of the geologic units exposed in Marshall County have properties which could contribute to ground-water problems in road construction when encountered under adverse conditions. Detailed surface investigations should be conducted with this fact in mind to ascertain the extent and severity of the problems which may exist along the proposed alignment.

Mineralization of ground-water is of concern to the engineer because high chloride and sulfate contents are undesirable in concrete mixing water. It appears that mineralization is not a problem in Marshall County inasmuch as test results indicate a relatively low mineral content in the water supply according to a detailed report prepared by Walters in 1954.

INTRODUCTION

The purpose of this report is to present information concerning the availability, location, and nature of deposits of material for use in highway construction and similar projects in Marshall County, and to provide a guide for materials prospecting within the county.

Scope

This investigation includes all of Marshall County, and all geological units and deposits considered to be construction material sources are mapped and described. The term "construction material," as used in this report, includes limestone beds and granular material which, in their natural state or through various stages of processing, can be used in some phase of road construction. Mineral filler of high quality is also included in the term.

Nature of the Report

Because all materials source beds are products of geologic agents, the materials inventory program is based largely on the geology of the county being investigated. This enables one to ascertain the general engineering properties of the material source unit and to identify and classify each source bed according to current geologic nomenclature. By adapting geologic nomenclature to materials inventories, a uniform system of materials source bed classification is established; however, the quality of material that can be produced from a given source may vary from one county to another, especially when dealing with unconsolidated deposits. In most cases, the geologic classification attached to unconsolidated deposits denotes age and not material type. Therefore, two deposits which were laid down during the same time in different parts of the state may have the same geologic name or classification, but may vary in composition because of different parent material. The sorting and gradation of materials are greatly affected by the mode of deposition and the carrying capacity or energy of the depositing agent.

Consolidated geologic units, such as limestone, are usually characterized by more consistent engineering qualities throughout a given county; however, a change in material quality and thickness may be noted in some areas because of variation in local depositional environments and weathering conditions.

In essence, the geology of the county provides a basis for mapping material source beds and criteria for evaluating the general qualities of the material.

The mapping of the various geologic units was accomplished on aerial photography of the county. Because of their continuous nature, most consolidated geologic units can be mapped with a minimum amount of field checking. Unconsolidated deposits of sand and gravel are less extensive and more erratic, but some can be located on aerial photographs by having a knowledge of the geology of the county and by interpreting significant terrain features that are discernible on the aerial photographs.

By knowing the mode of deposition, source bed, type of landform associated with a particular materials site, and the results of the quality tests completed on samples obtained from similar deposits, one can derive general information concerning the material in prospective sites. Consequently, prospective sites can be selected for development on the basis of the general merits of the material.

General Information

Marshall County has an area of 911 square miles and a population of 15,321 according to figures compiled by the Kansas State Board of Agriculture in 1966. It lies in the Glaciated Region and the Flint Hills physiographic provinces of Kansas and is bounded by parallels 39° 34' and 40° 00' north latitude and meridians 96° 14' and 96° 48' west longitude. The county is bordered on the west by Washington County, on the south by Riley and Pottawatomie Counties, on the east by Nemaha County, and on the north by the state of Nebraska.

The county is dissected by two major drainage channels, the Big Blue River which extends southward through the eastern part of the county and the Black Vermillion River which trends westward through the southern part of the county. Major tributaries of the Big Blue River include Horseshoe Creek, Spring Creek, and the Little Blue River, while those of the Black Vermillion River are Vermillion Creek, Oikierman Creek, South Fork Creek, and Clear Creek.

Marshall County is served by the Topeka cut-off section of the Union Pacific Railroad which connects Topeka, Kansas with the main west coast line of that company. A Union Pacific branch line extends northeast from a point near Home City and terminates at St. Joseph, Missouri, and the central branch of the Missouri Pacific Railroad Company extends east-west through the southern part of the county. Prior to the construction of Tuttle Creek Dam and Reservoir, a branch line of the Union Pacific Railroad Company existed in the Big Blue River Valley from Manhattan, in Riley County, to Beatrice, Nebraska. Because of the construction of this dam and reservoir, it was necessary to remove the track in the area which would be flooded or subject to flooding. The track removal has been accomplished to a point approximately a mile north of Blue Rapids at the Bestwall

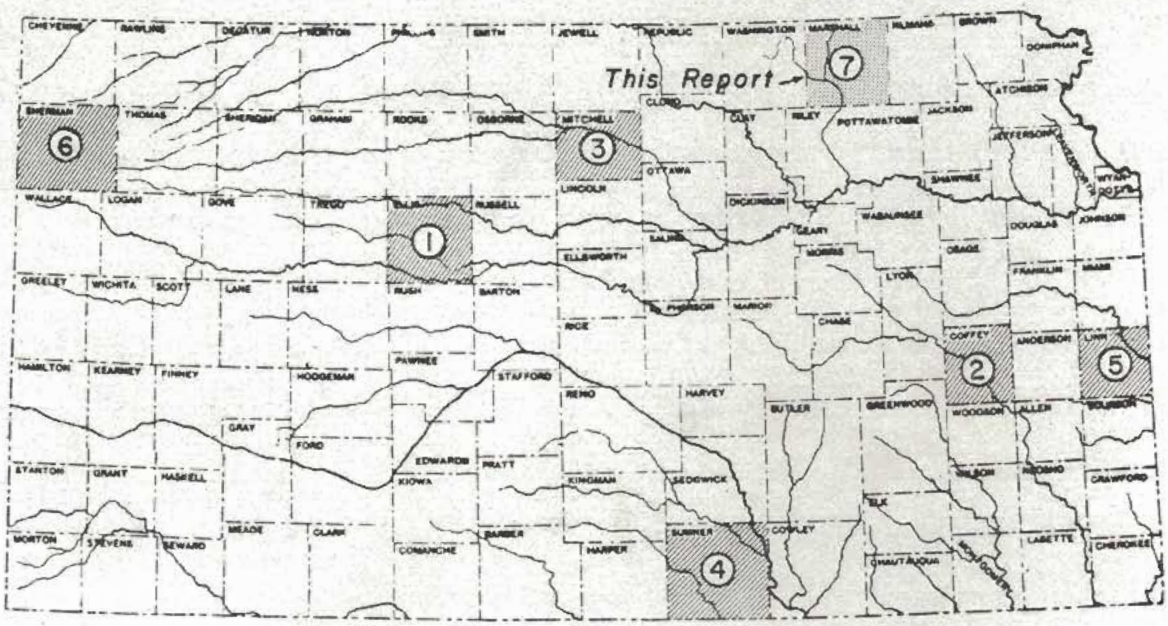


Figure 1. Index map of Kansas showing the location of Marshall County along with the report number and location of other counties for which reports have been or are being completed.

Gypsum Mine.

The county is traversed by U.S. Highway 36 in an east-west direction through Home City and Marysville, and U.S. Highway 77 which passes north-south through Marysville, Blue Rapids, and Waterville. State Highway 99 runs north-south through Summerfield, Beattie, and Frankfort, and State Highway 9 passes east-west through Frankfort, Blue Rapids, and Waterville. State Highway 87 extends north from Vliets to State Highway 9, connecting it with U.S. Highway 36.

PROCEDURES

The investigation procedure for this report was carried out essentially in the following four phases: first, research and review of available information; second, photo interpretation; third, field reconnaissance; and fourth, final correlation of data, map compilation, and report writing. With the exception of the first, the phases

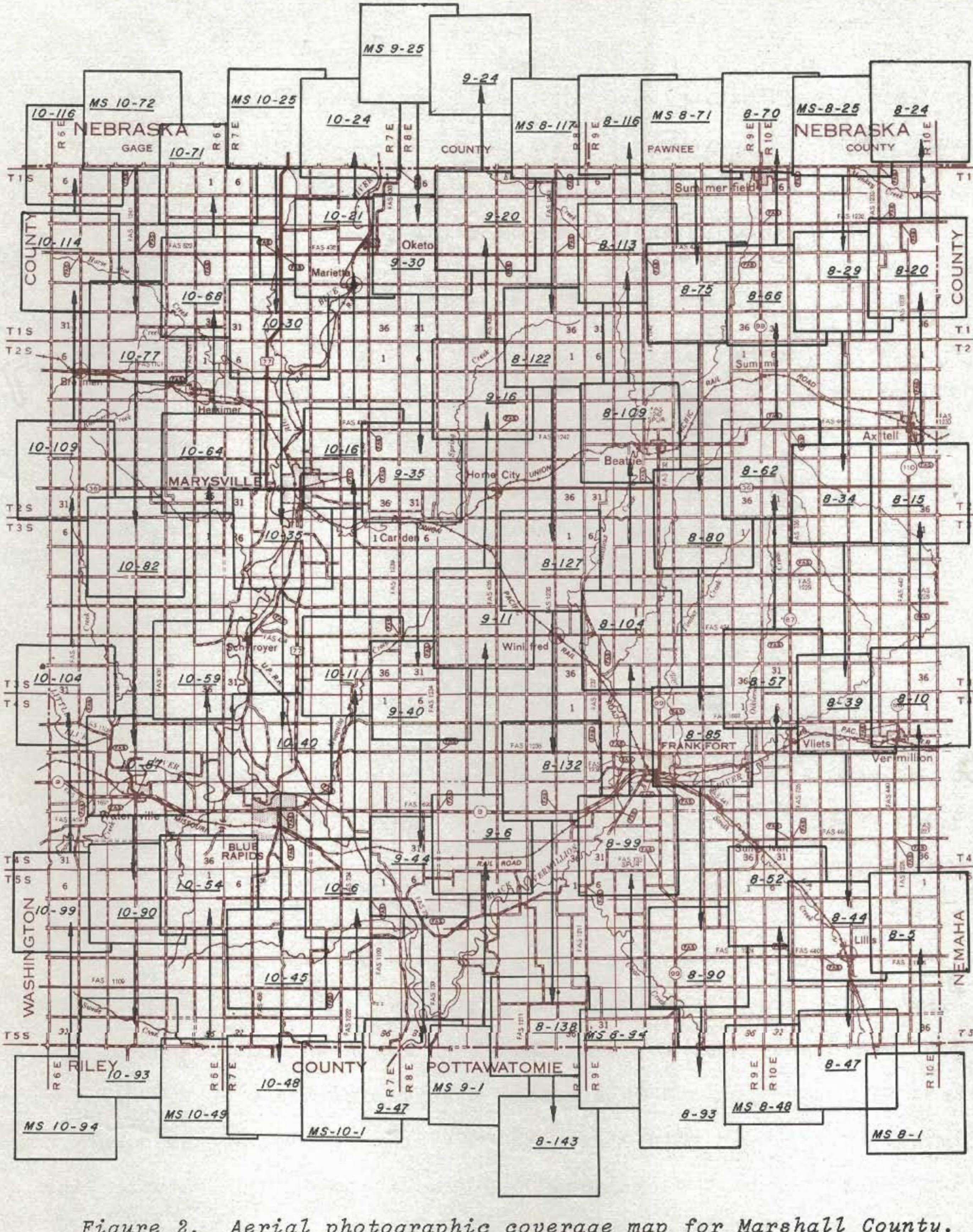


Figure 2. Aerial photographic coverage map for Marshall County. The numbers which are underlined indicate photograph numbers on flights taken by the Photogrammetry Section, State Highway Commission of Kansas, March 22, March 28, and April 5, 1963, at a scale of 1:2,000. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

of this investigation were not handled as separate operations, but were completed contemporaneously as each section of the report required. A detailed discussion of the procedures employed in each phase is included in this section of the report.

Research of Available Information

All available information pertaining to the geology, soils, and construction materials of Marshall County was reviewed. The general geology of the county, relative to construction materials, was determined. During this process, the results of quality tests already completed on samples taken in Marshall County correlated with the various geologic units and deposits.

Photo Interpretation

The second phase of the investigation consisted of study and interpretation of aerial photographs taken by the State Highway Commission of Kansas at a scale of 1:24,000 (one inch represents 2,000 feet). Figure 2 (Page 5) is a photographic coverage map of Marshall County which shows the area covered by individual photographs.

Initially, the entire county was studied on aerial photographs. During this process, all open materials sites which had been sampled and tested and those which had not been sampled were located on the aerial photographs and on a cronar base map of the county. All materials sites were then correlated with the geology of the county and the source beds were mapped and classified on the photos. Figure 3 (Page 7) illustrates this procedure. This information was then transferred to the base map. Prospective sites were tentatively selected on the basis of the geology of the county and the aerial photographic pattern elements.

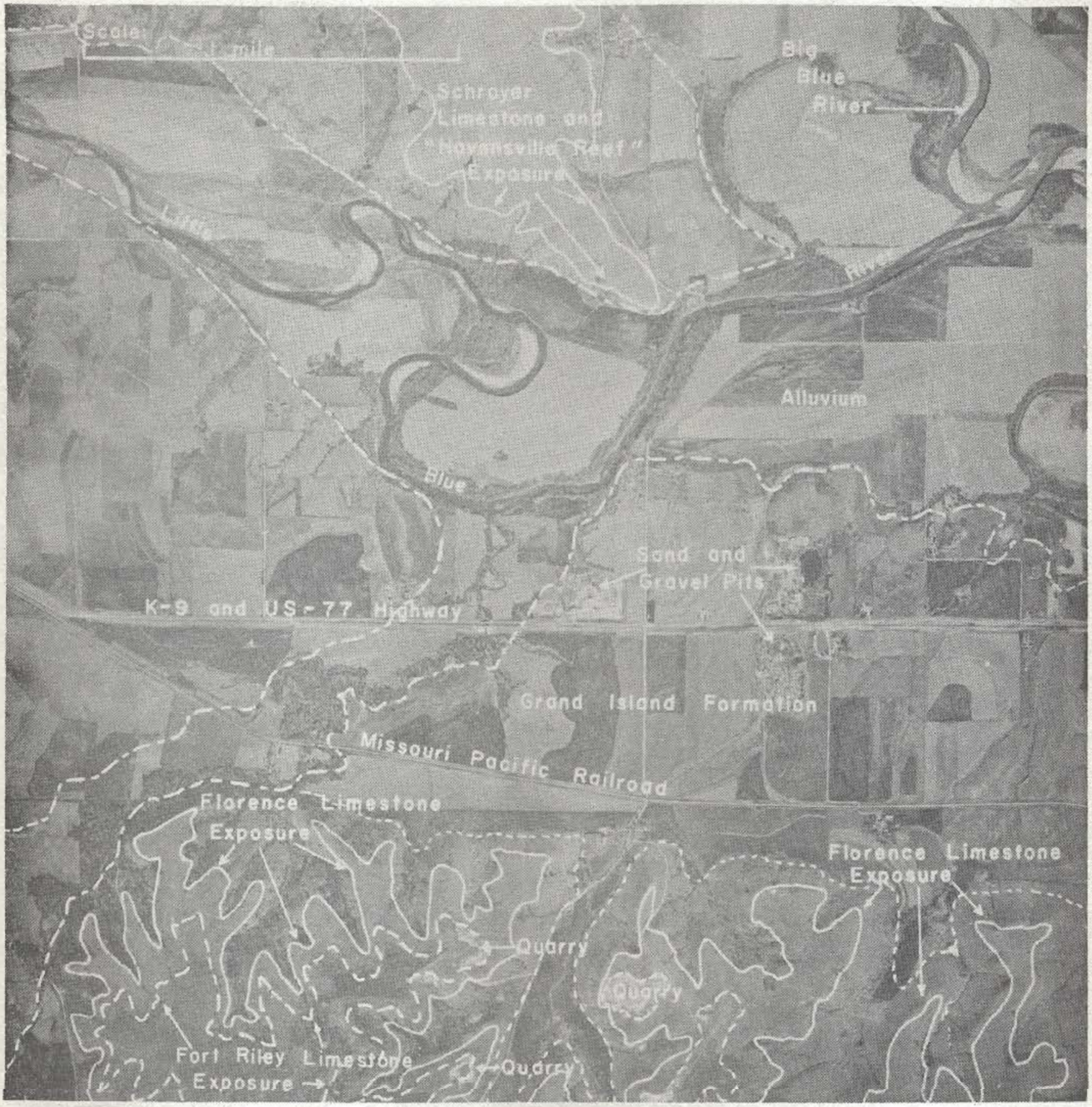


Figure 3. Big Blue and Little Blue Rivers and the associated deposits of those streams. Limestone bedrock exposures are outlined along the valley walls.

Figure 3 is a portion of an aerial photograph taken in southwestern Marshall County, near the city of Blue Rapids, which shows the valleys of the Big Blue and Little Blue Rivers and the unconsolidated deposits associated with these streams. Also outlined are the significant material bearing rock units exposed along the valley walls. When viewed stereoscopically, the boundaries between the different deposits can be recognized. A break in the terrain on the south side of the Little Blue River marks the division between the present alluvial flood plain, and a higher elevation river terrace which includes the Grand Island Formation. The Alluvium and the high terrace deposits can be distinguished from the high bedrock upland areas by the abrupt change in elevation, the change in drainage pattern, and by the change in land use. The lack of cultivation on the high areas is due to the lack of mantle and the rough terrain of the bedrock surfaces. The distinct bench levels in the bedrock exposure areas indicate the presence of resistant limestone ledges. It is known from a study of research data that the quarries shown in the lower portion of the photograph are in the Fort Riley Limestone Member. From geologic study it is known that the bench close below the Fort Riley is the thick, cherty Florence Limestone Member and the next bench, some distance below the Florence, is the resistant, cherty Schroyer Limestone Member.

Following a field check, the mapping process was completed, and a general description of the geologic source units was written. The quality of the material that might be produced from a particular source bed was, in most cases, ascertained by correlating the results of quality tests with the geologic unit from which the test samples were obtained, and by field study of the producing units. The general description of the material should be used as a guide in selecting geologic units for production purposes.

Field Reconnaissance

The field reconnaissance of the county, conducted after the first study of the aerial photographs was completed, enabled the photo interpreter to examine the material with which he was working, to verify doubtful mapping situations, and more adequately to acquaint himself with the geology of the county. All open sites were inspected to confirm the geologic classification.

Map Compilation and Report Writing

The fourth phase consisted of the final correlation of all new information, gathered during the investigation, with existing data, writing the report, and completion of site data forms and construction materials maps.

Only geologic units that contribute to the construction materials resources of Marshall County were mapped. The general engineering characteristics of the bedrock units are fairly consistent in Marshall County; however, some variation in the gradation and quality of unconsolidated deposits may be anticipated. For example, the alluvial deposits, found along the major streams, generally contain coarser material than those along the tributaries, while glacial deposits, laid down either directly by ice or as alluvial outwash, contain material ranging from silt size particles to boulders weighing several tons.

All existing sites and prospective sites are identified on the county materials map by appropriate designations and symbols. The site symbol will indicate the status of the material site to the user of this report; that is, whether it is a prospective or an open site, and whether or not it has been sampled. The site designation will convey to the reader the type of material found at the location, the estimated quantity of material available, the number of the corresponding data sheet for that site, and the geologic age and name of the source bed. The map legend associated with each plate explains all letter and map symbols used in the site designation.

To furnish the user of the report with all available information, a data form was completed for each site depicted on the materials map. The site data forms are included as appendices I through IV in this report. Appendix I contains site data forms for all sites that are open but have not been tested by the State Highway Commission of Kansas; while appendix II contains data forms for all sites shown on the materials map as "open sites; sampled." Test results are presented on the site data forms for each site in this appendix. Appendix III contains a form for each location depicted on the materials map as a "prospective site; not sampled." Appendix IV contains data forms for sites shown on the materials map as being "prospective sites; sampled." Test information is also presented on the data forms for each site included in this appendix.

Geologic data is included on each form to facilitate future correlation. To aid further in determining the type of material to be expected in untested sites, references are made to nearby locations where test results are available for the same source bed.

A sketch of each site was drawn, illustrating major cultural and natural features of the immediate area, to help locate its exact position in the field. Landowner information is presented for each materials site as it is listed in the Marshall County Register of Deeds office.

The text of the report was completed by presenting the general geology of the county as it pertains to various material source beds and by generally describing the available material in the county and the significant geo-engineering problems.

CONSTRUCTION MATERIALS RESOURCES OF MARSHALL COUNTY

Geologic History of Marshall County

The geologic history of Marshall County is presented in this report in general terms intended for the layman. Figure 4 (Page 12) is a timetable reproduced with the permission of the State Geological Survey of Kansas which shows the divisions of geologic time and the approximate length of each period. It should be noted that most periods represent several million years and that the total age of the earth probably exceeds two billion years. To further understand the events which have taken place, it is necessary for the reader to realize that climatic and geographic conditions have been vastly different from those which exist at the present time.

The rocks exposed in Marshall County total only a few hundred feet in thickness. From these, the geologic history of the near-surface deposits may be interpreted; however, the history of older deposits must be studied through the use of drill-hole information or from surface exposure of the units found in other areas of the country.

Marshall County, like the remainder of Kansas, is underlain by igneous and metamorphic rock of Pre-Cambrian age. It is generally believed that this area was inundated by a sea in early Paleozoic time and, except for relatively short periods of emergence, remained so until the end of the Mississippian depositional time. This belief is based on the presence of Ordovician, Silurian, Devonian, and Mississippian rocks in the subsurface of this portion of the state. The end of the Mississippian depositional period in Marshall County was marked by the rise of the Nemaha Anticline. The uplift of the

ERAS	PERIODS	ESTIMATED LENGTH IN YEARS*	TYPE OF ROCK IN KANSAS	PRINCIPAL MINERAL RESOURCES
CENOZOIC	QUATERNARY (PLEISTOCENE)	1,000,000	*Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.*	Water, agricultural soils, sand and gravel, volcanic ash.
	TERTIARY	59,000,000	*River silt, sand, and gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.*	Water, sand and gravel, volcanic ash, diatomaceous marl.
MESOZOIC	CRETACEOUS	70,000,000	*Chalk, chalky shale, dark shale, vari-colored clay, sandstone, conglomerate. Outcropping igneous rock.*	Ceramic materials; building stone, concrete aggregate, and other construction rock; water.
	JURASSIC	25,000,000	*Sandstones and shales, chiefly subsurface.*	
	TRIASSIC	30,000,000		
PALEOZOIC	PERMIAN	25,000,000	*Limestone; shale; evaporites (salt, gypsum, anhydrite); red sandstone and siltstone; chert; some dolomite.*	Natural gas; salt; gypsum; building stone, concrete aggregate, and other construction materials; water.
	PENNSYLVANIAN	25,000,000	*Alternating marine and non-marine shale, limestone, and sandstone; coal; chert.*	Oil, coal, limestone and shale for cement manufacture, ceramic materials, construction rock, agricultural lime, gas, water.
	MISSISSIPPIAN	30,000,000	*Mostly limestone, predominantly cherty.*	Oil, zinc, lead, gas, chat and other construction materials.
	DEVONIAN	55,000,000	*Subsurface only. Limestone, black shale.*	Oil
	SILURIAN	40,000,000	*Subsurface only. Limestone.*	Oil
	ORDOVICIAN	80,000,000	*Subsurface only. Limestone, dolomite, sandstone, shale.*	Oil, gas, water.
	CAMBRIAN	80,000,000	*Subsurface only. Dolomite, sandstone.*	Oil
PRE-CAMBRIAN	(Including PROTEROZOIC and ARCHEOZOIC ERAS)	1,600,000,000 +	*Subsurface only. Granite, other igneous rocks, and metamorphic rocks.*	Oil and gas.

(Not scaled for geologic time or thickness of deposits)

*Committee on Measurement of Geologic Time, National Research Council

State Geological Survey of Kansas

Figure 4. Geologic timetable

anticline subjected sedimentary rocks of Mississippian and older age to varying degrees of erosion. Drill logs indicate that very little, if any, Mississippian rock in Marshall County survived the severe erosion and, in some places, all Devonian, Silurian, and Ordovician rocks were removed down to the Pre-Cambrian granite.

During the Pennsylvanian and the early part of the Permian Period, limestone, dolomite, shale, sandstone, and coal were deposited. After the deposition of the Wellington Shale Formation, thick, red, silty shales and evaporites were laid down by sluggish streams or in temporary lakes over much of the western two-thirds of Kansas. If any of these red beds were present in Marshall County, they were removed by subsequent erosion, inasmuch as the Wellington Formation is the youngest bedrock unit exposed.

The Mesozoic Era is represented by a few Triassic and Jurassic units found, mostly, in the subsurface of the western one-fifth of the state and in rocks of Cretaceous age which exist at the surface or in the subsurface in western and central Kansas. Eastern Kansas, including Marshall County, was probably a landmass during the Triassic and Jurassic Periods as no deposits of these ages are found in the area. Presumably, the sea made its final invasion of Kansas during Cretaceous time. Although this sea may have spread over most of Kansas, erosion has removed all the rocks of this age from Marshall County.

The uplift of the Rocky Mountains marked the end of the Mesozoic Era and ushered in the Cenozoic Era. Erosion has probably predominated in Marshall County since that time.

The Pleistocene Epoch of the Quaternary Period represents a time of repeated glacial and intergalcial cycles. Figure 5 (Page 14) is a geologic timetable which indicates the divisions of the Quaternary

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

Figure 5. Geologic timetable of the Quaternary Period.

Period and the approximate length of each. The glacial ages (Nebraskan, Kansan, Illinoisan, and Wisconsinan) represent time of glacial advancement, while the three interglacial ages (Aftonian, Yarmouthian, and Sangamonian) represent periods of major glacial recession. Glacial activity in Kansas was restricted to the northeastern portion of the state, including Marshall County, and only two glaciers, the Nebraskan and the Kansan, reached Kansas during this period.

The sequence of glaciation, which occurred during this time, has played a controlling role in the development of Pleistocene nomenclature and in the classification of Pleistocene deposits throughout the state. The geologic history of the Pleistocene, as discussed here, is based chiefly on a report by Frye and Leonard (1952).

As the Nebraskan glacier started to accumulate, north-central Kansas was an area of moderate relief with numerous bedrock exposures. A major stream flowed east-southeast out of Marshall County in the vicinity of the Black Vermillion River, and through southern Nemaha, northern Jackson, and southern Atchison Counties. As the glacier grew, the streams in Kansas deepened their valleys. Upon retreat of the ice, the stream velocities decreased, causing them to aggrade their channels. In Marshall County a few deposits of clay bound chert gravel, derived from chert bearing limestone beds, were possibly laid down during this age; however, due to disagreement in dating this material, it has been termed Pre-Kansan Gravel in this report.

After a period of stability, the Kansan glacier began to form and move southward. Kansan ice entered Kansas from the northeast and advance well beyond the limit of Nebraskan glaciation. It overrode the Flint Hills upland in Washington County and covered parts of this same divide in Marshall and Pottawatomie Counties. During the advance phase of Kansan glaciation, the streams generally deepened their channels. The prominent valley across southern Marshall and Nemaha Counties and northern Jackson County was deepened and then alluviated with silt and sand which now represent the Atchison Formation. The western and southern extremity of the Kansan glacier produced the eventual drainage of the Kansas River system. As the glacier retreated, melt water began to flow through the newly formed Big Blue, Little Blue, and Black Vermillion River channels. Immense quantities of water flowed southward through the Big Blue channel to the Kansas River, thence west and south through the now abandoned McPherson Channel and eventually to the newly formed Arkansas River. In Marshall County high terrace deposits, termed the Grand Island and Sappa Formations, formed along the major drainage from sediment laden melt water of the Kansan glacier.

The terminus of the Illinoisan glacier was in southern Illinois; however, some events of geologic importance did occur in Marshall County as well as in the remainder of Kansas during this age. In the major river valleys of Marshall County, downcutting through the Grand Island and Sappa Formations occurred during this time. Also, some wind deposited silts (Loveland Formation) were laid down, the source of which is thought to have been barren flood plains of the major drainage.

The advance of the Wisconsinan glacier, like the Illinoisan, stopped several hundred miles north of Kansas. Conditions were similar to those which existed during Illinoisan time, including deposition of wind-blown silts (The Peoria Formation of Wisconsinan age).

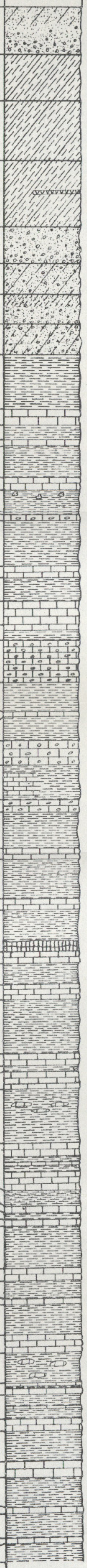
The Recent Age represents the time which has elapsed since the last retreat of the Wisconsinan glacier. Throughout this time period, climatic conditions have been similar to those which exist today. In this Age, the major streams have developed their present channels and have reworked older Pleistocene deposits consisting of clay, silt, sand, and gravel. These reworked deposits are referred to in this report as Alluvium. This period of geologic stability has also resulted in the formation of the soil mantle which covers much of the bedrock surfaces and older Pleistocene deposits in Marshall County.

Construction Materials Inventory

This section of the report inventories the construction material resources of Marshall County. Only geologic units which are producers or are considered to be potential material sources are discussed. Figure 6 (Page 17) is a generalized geologic column of the

System	Series	Stage	Group	Formation	Member	Material Usage
Quaternary	Pleistocene	Recent		Alluvium		Concrete and Bituminous Aggregate Light Type Surfacing Material Mineral Filler
Quaternary	Pleistocene	Wisconsinan Sangamonian Illinoisan		Peoria		
				Loveland		
		Kansan Yarmouthian		Sappa		
				Grand Island		Concrete and Bituminous Aggregate Light Type Surfacing Material Mineral Filler
				Kansan Till		Light Type Surfacing Material
				Atchison		
				Pre-Kansan Gravel		Light Type Surfacing Material
Permian	Lower Permian	Gearyan	Sumner	Wellington Shale		
			Chase	Nolans Limestone	Herington Limestone	
					Paddock Shale	
					Krider Limestone	
				Odell Shale		
				Winfield Limestone	Cresswell Limestone	
					Grant Shale	
					Stovall Limestone	
				Doyle Shale	Gage Shale	
					Towanda Limestone	
					Holmesville Shale	
				Barneston Limestone	Fort Riley Limestone	Light Type Surfacing Material Riprap
					Oketo Shale	
					Florence Limestone	Bituminous Aggregate Light Type Surfacing Material Riprap
				Matfield Shale	Blue Springs Shale	
					Kinney Limestone	
					Wymore Shale	
				Wreford Limestone	Schroyer Limestone	Light Type Surfacing Material Concrete and Bituminous Aggregate Riprap
					Havensville Shale	
					Threemile Limestone	
			Council Grove	Spéiser Shale		
				Funston Limestone		
				Blue Rapids Shale		
				Crouse Limestone		
				Easly Creek Shale		
				Bader Limestone	Middleburg Limestone	
					Hooser Shale	
					Eiss Limestone	
				Stearns Shale		
				Beattie Limestone	Morrill Limestone	Light Type Surfacing Material Bituminous Aggregate Riprap
					Florena Shale	
					Cottonwood Limestone	
				Eskridge Shale		
				Grenola Limestone	Neva Limestone	Light Type Surfacing Material Bituminous Aggregate Riprap
					Salem Point Shale	
					Burr Limestone	
					Legion Shale	
					Sallyards Limestone	
				Roca Shale		
				Red Eagle Limestone	Howe Limestone	
					Bennett Shale	
					Glenrock Limestone	
				Johnson Shale		
				Foraker Limestone	Long Creek Limestone	
					Hughes Creek Shale	
					Americus Limestone	
			Admire	Janesville Shale	Hamlin Shale	
					Five Point Limestone	
					West Branch Shale	
				Falls City Limestone		
				Onaga Shale	Hawxby Shale	
					Aspinwall Limestone	
					Towle Shale	
Pennsylvanian	Upper Pennsylvanian	Virgilian	Wabaunsee	Woodsiding	Brownville Limestone	
					Pony Creek Shale	

Graphic Legend



Key To Graphic Legend

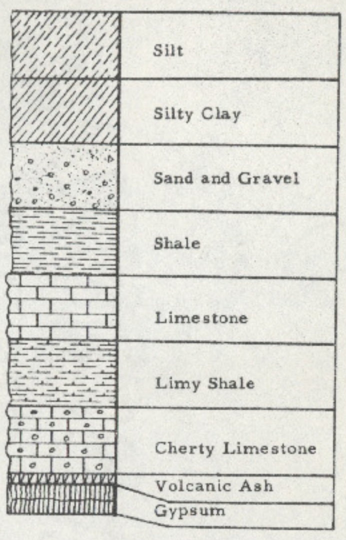


Figure 6. Generalized geologic column of the surface geology in Marshall County.

Location	Sp. Gr. (Sat.)	Sp. Gr. (Dry)	Absorption	Wear	Soundness	Ledge Thickness	Source of Data
SOURCE OF MATERIAL: Neva Limestone Member							
NE 1/4, SW 1/4, Sec. 20, T2S, R9E	2.41	2.25	7.18	42.9	0.96	-	1 sample
E 1/2, NE 1/4, Sec. 4, T3S, R9E	2.34	2.18	7.55	40.6	0.88	-	Average of 2 samples
NW 1/4, NE 1/4, Sec. 9, T3S, R9E	2.52	2.43	3.88	28.8	0.85	-	Average of 2 samples
SOURCE OF MATERIAL: Morrill and (or) Cottonwood Limestone Members							
SW 1/4, Sec. 7, T5S, R9E	2.39	2.24	7.16	43.5	0.91	-	Average of 4 samples
W 1/2, SE 1/4, Sec. 23, T4S, R8E	2.37	2.22	6.80	42.0	0.84	-	Average of 6 samples
N 1/2, Sec. 32, T2S, R9E	2.38	2.25	5.70	36.4	0.97	-	1 sample
S 1/2, Sec. 36, T3S, R8E	2.39	2.25	6.26	43.5	0.94	-	1 sample
NE 1/4, NE 1/4, Sec. 15, T5S, R9E	2.39	2.22	4.95	34.4	0.86	8'	Average of 4 samples
NE 1/4, SE 1/4, Sec. 15, T5S, R9E	2.37	2.23	6.22	34.3	0.93	-	Average of 2 samples
SW 1/4, Sec. 3, T3S, R9E	2.41	2.29	5.51	36.5	0.90	8'	1 sample
S 1/2, Sec. 17, T2S, R9E	2.44	2.29	6.26	36.1	0.79	-	Average of 8 samples
SE 1/4, Sec. 2, T5S, R8E	2.41	2.25	6.86	38.0	0.83	-	Average of 4 samples
W 1/2, SW 1/4, Sec. 34, T5S, R9E	2.33	2.17	5.70	37.8	0.83	-	Average of 5 samples
SOURCE OF MATERIAL: "Havensville Reef" and (or) Schroyer Limestone Member							
NE 1/4, Sec. 16, T4S, R7E	2.39	2.27	5.37	35.9	0.81	7'	Average of 9 samples
NE 1/4, Sec. 31, T3S, R7E	2.47	1.99	2.94	29.8	0.95	-	Average of 6 samples
SOURCE OF MATERIAL: Florence Limestone Member							
NE 1/4, SE 1/4, Sec. 12, T1S, R7E	2.36	2.16	7.71	49.3	0.89	-	Average of 4 samples
SE 1/4, Sec. 20, T3S, R7E	2.47	2.33	6.05	46.3	0.80	-	Average of 21 samples
SW 1/4, Sec. 22, T3S, R7E	2.40	2.28	5.21	33.7	0.98	-	Average of 3 samples
NE 1/4, Sec. 25, T4S, R7E	2.32	2.20	6.42	37.0	0.93	-	Average of 2 samples
SOURCE OF MATERIAL: Fort Riley Limestone Member							
SW 1/4, Sec. 20, T2S, R7E	2.32	2.11	9.72	60.9	0.99	-	Average of 2 samples
NW 1/4, Sec. 30, T4S, R6E	2.33	2.16	7.51	59.4	0.93	-	Average of 3 samples
W 1/2, NW 1/4, Sec. 13, T1S, R7E	2.23	1.98	12.27	43.0	0.93	-	1 sample
NW 1/4, Sec. 6, T1S, R8E	2.32	2.11	9.50	62.6	0.69	-	Average of 4 samples
SW 1/4, NW 1/4, Sec. 6, T3S, R8E	2.33	2.11	10.26	65.6	0.65	-	Average of 2 samples
NE 1/4, Sec. 4, T3S, R7E	2.38	2.21	7.47	42.3	0.72	-	1 sample
Sec. 36, T4S, R6E	2.34	2.19	6.84	34.8	0.94	4'	1 sample

Figure 7. Results of tests completed on samples taken from some limestone beds in Marshall County.

surface geology in Marshall County which illustrates the relative stratigraphic position of each source bed. The county materials map, which is divided into six equal portions, Plates I through VI, shows the geographic areas where construction materials source beds are exposed or nearly exposed.

Figure 7 (Page 19) tabulates the results of quality tests performed on construction material taken from the Neva Limestone Member, Morrill and Cottonwood Limestone Members, "Havensville Reef" and Schroyer Members, Florence Limestone Member, and the Fort Riley Limestone Member. Figure 8 (Page 21) provides the same type of information along with a typical sieve analysis for materials taken from the Kansan Till, the Grand Island Formation, and the Alluvium. In general, material with the same basic engineering characteristics can be found throughout each source bed.

Care should be taken when sampling any of the limestone beds because the weathered face may show better quality test results than the unweathered portion. This unweathered material will soon be encountered once quarrying operations are in progress.

A tabulation of the various types of material available in Marshall County is shown in Figure 9 (Page 23). The source beds from which each material type can be produced are also listed along with the page number where the engineering characteristics of each of these geologic source beds are described.

Neva Limestone Member, Grenola Limestone Formation

The Neva is a light gray limestone, massive at the base, with alternate thin limy shale and limestone beds in the middle portion and a thick massive limestone at the top. The thickness of the

Location	Material Type	Percent Retained 2"	1 1/2"	3/4"	3/8"	4	8	16	30	50	100	Wash	G.F.	L.L.	P.I.	Wet Sp.Gr.	Dry Sp.Gr.	Wt./Cu.Ft.	Wear	Soundness	Absorption	Source of Data
SOURCE OF MATERIAL: Kansan Till																						
SW 1/4, Sec. 3, T4S, R9E	Fine Sand	-	-	-	-	-	-	-	-	5	78	3	0.83	-	-	-	-	-	-	-	-	SHC Form 619, No. 58-1
NW 1/4, Sec. 29, T1S, R6E	Sand - Gravel	-	-	9	33	56	71	80	83	85	86	13	5.03	54	32	-	-	-	33.7	0.91	-	SHC Form 619, No. 58-6
NW 1/4, Sec. 22, T3S, R7E	Glacial Gravel	-	-	20	31	44	57	70	81	90	92	-	-	39	20	-	-	-	28.0	0.90	-	Laboratory No. 65-2745
NE 1/4, Sec. 21, T3S, R9E	Fine Sand	-	-	-	-	-	1	1	1	3	72	17	0.78	30	15	-	-	-	-	-	-	Average of 2 samples
SE 1/4, Sec. 16, T3S, R7E	Gravel	-	-	7	16	28	46	66	74	80	82	17	3.99	-	-	-	-	-	-	-	-	SHC Form 619, No. 58-40
SOURCE OF MATERIAL: Grand Island Formation																						
SW 1/4, Sec. 19, T4S, R7E	Sand - Gravel	-	-	1	5	20	45	74	91	98	99	-	4.33	-	-	2.61	-	112.1	31.6	0.99	0.8	1 sample
SE 1/4, Sec. 24, T4S, R6E	Sand - Gravel	-	-	1	7	24	47	66	79	91	96	2	4.11	-	-	2.57	-	110.8	32.9	0.94	-	SHC Form 619, No. 58-24
SOURCE OF MATERIAL: Alluvium																						
NW 1/4, Sec. 16, T2S, R7E	Sand - Gravel	-	-	-	6	18	39	71	93	99	99	-	4.25	-	-	2.60	-	111.66	34.8	-	0.50	1 quality sample
SE 1/4, Sec. 27, T4S, R7E	Crushed Gravel	-	3	23	87	93	94	94	94	96	97	-	6.82	-	-	2.48	2.40	-	24.8	0.95	3.37	1 quality sample
SE 1/4, Sec. 27, T4S, R7E	Mixed Aggregate	-	6	9	14	26	48	68	82	94	97	-	4.38	-	-	2.60	-	119.25	38.3	0.93	1.00	1 quality sample
SW 1/4, Sec. 31, T5S, R8E	Sand - Gravel	-	2	2	5	15	31	53	76	93	98	-	3.75	-	-	2.60	-	114.55	34.6	0.98	1.21	1 quality sample
NW 1/4, Sec. 21, T4S, R7E	Sand - Gravel	-	-	-	6	14	31	53	83	98	99	-	3.84	-	-	2.62	-	113.32	38.5	0.98	0.50	1 quality sample
NW 1/4, Sec. 16, T2S, R7E	Mixed Aggregate	-	-	5	12	23	40	59	80	96	99	-	4.14	-	-	2.55	-	119.1	36.0	0.97	-	1 quality sample
NE 1/4, Sec. 34, T4S, R7E	Mixed Aggregate	-	-	5	12	23	45	67	81	95	98	-	4.26	-	-	2.60	-	119.4	39.4	0.97	-	1 quality sample
SE 1/4, Sec. 7, T3S, R7E	Sand - Gravel	-	-	2	10	19	35	52	74	94	98	-	3.84	-	-	2.61	-	116.4	33.2	0.95	0.6	1 quality sample
NE 1/4, Sec. 19, T3S, R7E	Sand - Gravel	-	-	-	4	18	41	69	89	98	100	-	4.19	-	-	2.60	-	113.3	38.4	0.99	0.7	1 quality sample
NW 1/4, Sec. 35, T4S, R7E	Sand - Gravel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.58	-	119.3	36.4	0.96	0.6	SHC Form 619, No. 58-25
SE 1/4, Sec. 27, T4S, R7E	Mineral Filler	-	-	-	-	-	-	-	-	1	6	79	-	23	3	-	-	-	-	-	-	SHC Form 619, No. 58-29
SE 1/4, Sec. 4, T2S, R7E	Mineral Filler	-	-	-	-	-	-	-	-	-	5	92	-	26	4	-	-	-	-	-	-	SHC Form 619, No. 58-30
NE 1/4, Sec. 32, T2S, R9E	Mineral Filler	-	-	-	-	-	-	-	1	10	22	76	-	29	11	-	-	-	-	-	-	SHC Form 619, No. 58-31
NW 1/4, Sec. 17, T3S, R7E	Sand - Gravel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.57	-	119.3	37.0	-	0.90	1 quality sample
SW 1/4, Sec. 8, T3S, R7E	Sand - Gravel	-	-	8	14	26	46	66	82	96	99	1	4.37	-	-	2.58	-	116.1	36.6	-	0.80	SHC Form 619, No. 58-46
NW 1/4, Sec. 17, T3S, R7E	Sand - Gravel	-	-	11	19	29	47	67	85	96	99	1	4.52	-	-	2.55	-	116.5	37.2	0.94	0.75	SHC Form 619, No. 58-49
SE 1/4, Sec. 27, T4S, R7E	Sand - Gravel	-	-	1	8	22	59	69	83	95	99	-	4.36	-	-	2.60	-	116.7	38.3	0.97	0.90	SHC Form 619, No. 58-50
SW 1/4, NE 1/4, Sec. 31, T3S, R7E	Sand - Gravel	-	-	2	7	21	40	64	83	96	99	1	4.12	-	-	2.61	-	114.1	35.0	0.96	0.70	SHC Form 619, No. 58-54
S 1/2, Sec. 22, T4S, R7E	Mineral Filler	-	-	-	-	-	-	-	-	1	6	74	-	21	3	-	-	-	-	-	-	SHC Form 619, No. 58-29

Figure 8. Results of tests completed on samples taken from the Kansan Till, Grand Island Formation and Alluvium.

Material Type	Geologic Source	Description	Locality where available
Limestone	Neva Limestone Member	Page 20	Eastern half of the county along the margins of the major stream valleys.
	Cottonwood and Morrill Limestone Members	Page 25	Eastern half of the county along the margins of the major stream valleys.
	"Havensville Reef" and Schroyer Limestone Member	Page 27	Southwestern one-fourth of the county.
	Florence Limestone Member	Page 29	Western half of the county, especially along the Big Blue River and its tributaries.
	Fort Riley Limestone Member	Page 31	Western half of the county, especially along the Big Blue River and its tributaries.
Clay-bound gravel	Pre-Kansan Gravel	Page 32	Southern one-third of the county
	Kansan Till	Page 33	Primarily north of the Black Vermillion and east of the Big Blue River.
Sand and Gravel	Grand Island Formation	Page 35	In the valleys of the Big Blue, Little Blue, and Black Vermillion Rivers.
	Alluvium	Page 37	In the Big Blue River valley.
Mineral Filler	Grand Island Formation	Page 35	In the valleys of the Big Blue, Little Blue, and Black Vermillion Rivers.
	Alluvium	Page 37	In the Big Blue River valley.

Figure 9. A recapitulation of the construction material types and their availability in Marshall County.

Figure 10. Neva Limestone quarry face, NE¼ sec. 4, T3S, R9E.

member is approximately 13 feet. Figure 10 is a photograph of a quarry face in this unit.

Exposures of the Neva may be found in the eastern one-half of Marshall County along the margins of the major stream valleys. Locations where the Neva is not overlain by younger bedrock are limited because the extremely weather-resistant Cottonwood Limestone often caps the higher terrain in areas where the Neva is present. Thus, when the Neva is found exposed on the valley walls, one might expect to encounter the Eskridge Shale and the Cottonwood Limestone above the Neva as quarrying operations proceed into the hillside.

This member is an important source of crushed aggregate in Marshall County; however, the quality of the material is marginal so far as its use as concrete or bituminous construction aggregate. The Los Angeles wear, Figure 7 (Page 19) as determined from available test results on the Neva, ranged from 28.8 to 42.9 percent, the soundness loss ratio from 0.85 to 0.96, and the absorption from 3.88 to 7.55 percent. In oral communications Mr. R. E. Fincham, Resident

State Highway Engineer at Marysville, stated that the Neva, like nearly all the limestone in Marshall County, is generally undesirable for use in concrete and bituminous construction.

Although the Neva is marginal, occasionally it will meet specifications for concrete construction and is an important material for base course and shoulder construction on state and federal projects in Marshall County. No specifications exist at the present time on its absorption for use as concrete aggregate, but a high value is generally considered undesirable and limits the use of the material for such a purpose. On secondary roads, where less rigid specifications and lighter wheel loadings are the case, crushed limestone from this source may provide a suitable aggregate. This material is entirely suitable for use as light type surfacing material on rural roads but has not been used too extensively because of easier access (less overburden) to other units which equally fit the need for such a purpose. Although the Neva has not been extensively used for slope protection, it has some potential for use as riprap.

<u>Cottonwood and Morrill Limestone Members, Beattie Limestone Formation</u>

The Cottonwood and Morrill Limestone Members are discussed together because of quarrying conditions in some locations in Marshall County. In a quarry near Beattie, in northeastern Marshall County, the intervening Florena Shale is not more than one foot thick which enables both limestones to be quarried as a unit approximately 15 or 20 feet in thickness.

The Cottonwood Limestone is a massive, soft limestone containing abundant fusulinids (fossils which appear like grains of wheat) and scattered chert nodules. Exposures of this unit are generally light tan in color; however, in quarry sites, where unweathered material has been uncovered, the limestone is gray. The thickness of this member ranges from five to eight feet, and because of its resistance to weathering, it forms a conspicuous bench which rims many hills in its exposure area.

The Morrill Limestone Member is a massive, soft, light gray limestone, which like the Cottonwood, weathers tan in color. This unit is less resistive to erosion and weathering than the Cottonwood; thus, it is not well exposed. The thickness of this unit ranges from 3.5 to 7 feet.

Abundant exposures of the Cottonwood (especially) and the Morrill are found in the eastern half of Marshall County along the valley margins where stream erosion has removed the glacial and (or) eolian overburden.

The Cottonwood and Morrill Limestone Members are important sources of road construction aggregate in Marshall County. Most of the material from these units does not meet the State Highway Commission of Kansas specifications for use in concrete mixes or bituminous construction; however, this material has been a source of aggregate for certain bituminous construction projects on rural roads where lowered specification requirements were justified from the traffic and economic standpoint. It is also an important source of subgrade and shoulder aggregate for primary road construction in Marshall County as well as in many areas of eastern Kansas. Figure 11 (Page 27) is a ground view of the Koppes Brothers quarry where both of the units are being quarried for materials purposes. Total thickness of the usable limestone at this location ranges from 15 to 20 feet.

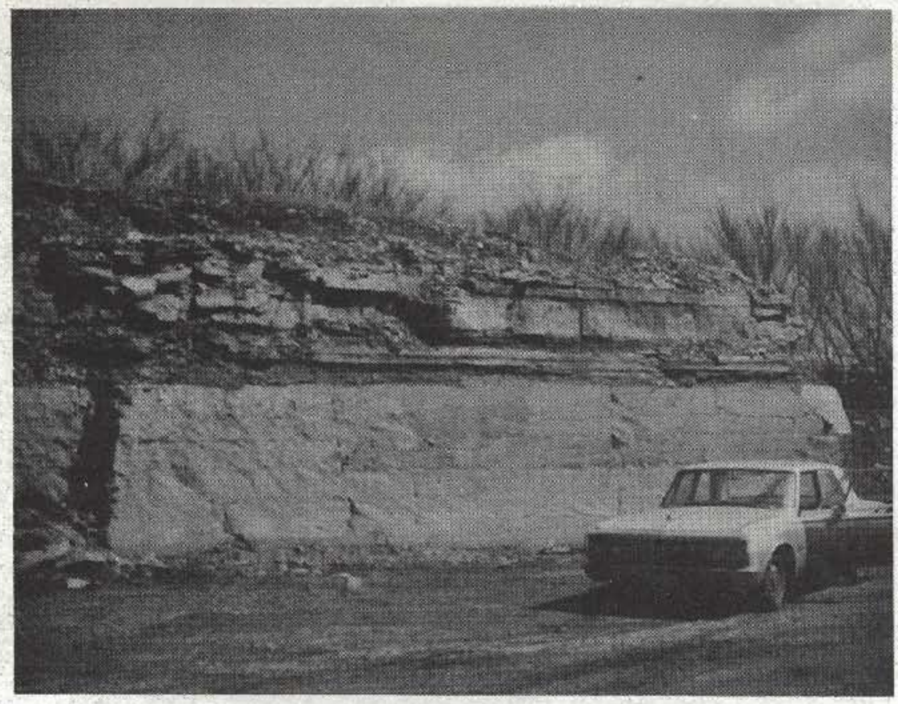


Figure 11. Cottonwood and Morrill Limestone Members in the Koppes Brothers Quarry, S½ sec. 17, T2S, R9E.

In the Tuttle Creek Reservoir project, which extends into Marshall County, some limestone from the Cottonwood and Morrill was used as riprap material for protection of dikes and fills subject to periodic water action.

Quality test results available on the Cottonwood and Morrill Limestone Members indicate the Los Angeles wear ranged from 34.3 to 43.5 percent, the soundness loss ratio from 0.79 to 0.97, and the absorption from 4.95 to 7.16 percent. Figure 7 (Page 19) lists the available quality test information for some specific quarries in this material.

"Havensville Reef" and the Schroyer Limestone Member, Wreford Limestone Formation

The Havensville Shale Member may be of two material types. Generally, it is a gray-green, calcareous shale, but locally, as in

Marshall County, it may be composed of soft, thin bedded, gray limestone. This limestone facies has been termed the "Havensville Reef" by some geologists, and is referred to in this report as such. In all materials pits investigated in Marshall County, limestone from the "Havensville Reef" and Schroyer Limestone Member have been utilized together (Figure 12).

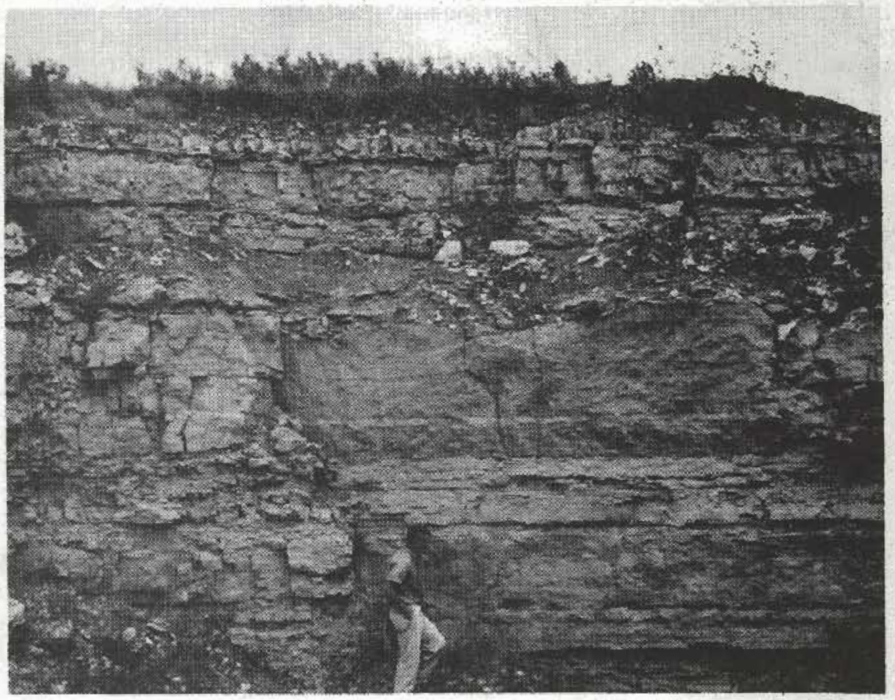


Figure 12. "Havensville Reef" and Schroyer Limestone quarry face, NE¼ sec.16, T4S, R7E.

The Schroyer Limestone Member is a light gray, limestone which weathers tan and contains several bands of gray chert. The thickness of the Schroyer ranges from 10 to 13 feet.

Exposures of the Havensville and Schroyer are limited to the southwestern one-fourth of Marshall County. The chert bearing zones in the Schroyer are resistant to weathering; therefore, a bench is generally formed by this cherty limestone.

Quality information on the Schroyer and Havensville indicates some of this material may be acceptable for use in bituminous and

and concrete construction for primary roads, but because of its marginal nature, its major application is a light type surfacing material on lightly traveled roads. It could be used for surfacing and subgrade modification on secondary roads as well as shoulder material on both primary and secondary roads. The chert contained in the Schroyer, has proved to have undesirable characteristics when used in aggregate mixes because it fractures when subjected to pressure and temperature changes. When used as a light type surfacing material, the chert also fractures such that sharp edges are common and may result in damage to automobile tires.

The Los Angeles wear for these particular limestones ranged from 29.8 to 35.9 percent, the soundness loss ratio from 0.81 to 0.95, and the absorption from 2.94 to 5.37 percent. Figure 7 (Page 19) includes additional test data available for these units.

<u>Florence Limestone Member, Barneston Limestone Formation</u>

The Florence Limestone is a very distinct bed because of its thickness, weather resistance, and the numerous chert bands which it contains. The unweathered limestone is light gray, but, when weathered, becomes light tan in color. Clean exposures of the Florence are uncommon; however, a thinly mantled terrain, underlain by the limestone, shows up distinctly on aerial photographs. Figure 13 (Page 30) shows an exposure of the Florence along a creek bank in northern Marshall County. Exposures of the Florence are abundant in the western half of the county, especially along the Big Blue River and its tributaries. Note should be taken that in some locations in Marshall County, as well as other areas of the Flint Hills, the limestone portion of the Florence may be weathered badly, and only clay and chert rubble remain. An example of this may be viewed in a

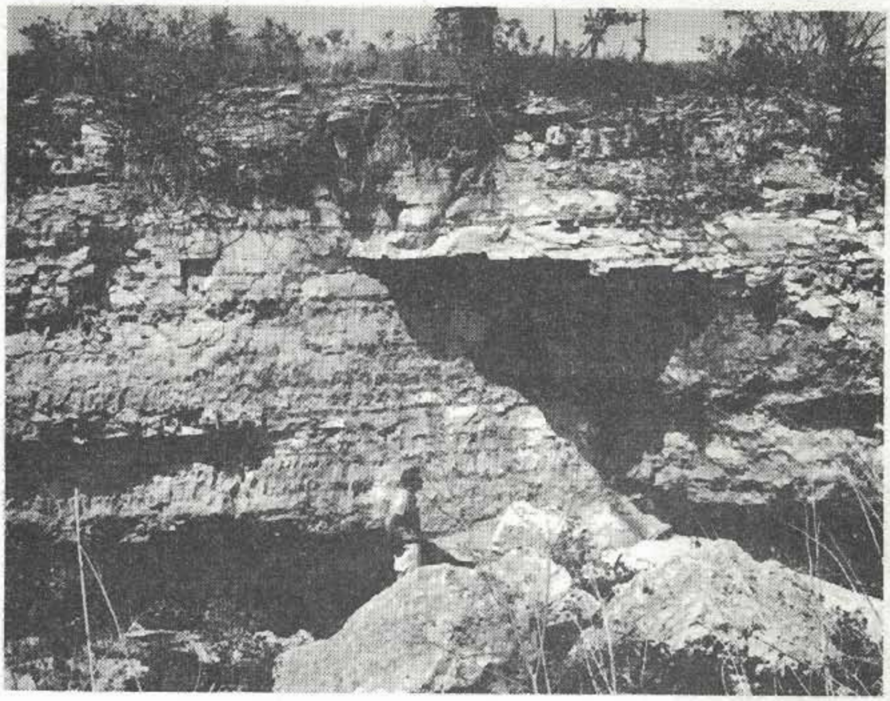


Figure 13. Florence Limestone Member in a creek bank, SW¼ sec. 5, T1S, R7E.

limestone quarry in the SW¼ sec.22, T3S, R7W.

The Florence is one of the poorer quality material beds in the county. On samples tested, the Los Angeles wear ranged from 33.7 to 49.3 percent, the soundness loss ratio from 0.80 to 0.98, and the absorption from 5.21 to 7.71 percent. This material would probably not meet the State Highway Commission of Kansas specifications for use either in concrete or bituminous construction; however, some material from the Florence was supplemented with material from another source and used in the construction of the bituminous surface on U.S. 77 highway. Quality test results on specific locations are shown in Figure 7 (Page 19). The hard chert contained in the unit poses crushing problems and makes the material somewhat undesirable for use as light type surfacing material because of the sharp jagged fragments. The fact that the unit is hard to quarry and spalls badly when subjected to weathering, limits its use as a possible riprap material.

Fort Riley Limestone Member, Barneston Limestone Formation

The Fort Riley Limestone Member is a soft, fine textured, gray limestone which weathers to a light tan color. A massive bed of limestone, termed the "rimrock" zone, occurs near the base of the unit. The "rimrock", which may be as much as six feet thick, was used extensively in earlier years for building stone. The total thickness of the Fort Riley is approximately 25 feet. Figure 14 (Page 32) illustrates a limestone face in a Fort Riley Limestone quarry.

The exposure area of the Fort Riley, like the Florence, is limited mostly to the western half of the county, and is primarily found along the valleys of the Big Blue River and its major tributaries.

Material from the Fort Riley is of low quality and probably not suitable for use in bituminous or concrete mixes. It is also somewhat undesirable for use as a dry surfacing material because of its soft nature. Although some material from this source has been used for light type surfacing on a few projects, its major use today is for agricultural lime. In a recent project by the U. S. Army Corps of Engineers, the "rimrock" zone proved to be useful for riprap material on dikes and fills subject to periodic water action within the Tuttle Creek Reservoir project. On samples tested, the Los Angeles wear ranged from 34.8 to 65.6 percent, the soundness loss ratio from 0.65 to 0.99, and the absorption from 6.84 to 12.27 percent. Quality data for specific locations is shown in Figure 7 (Page 19).

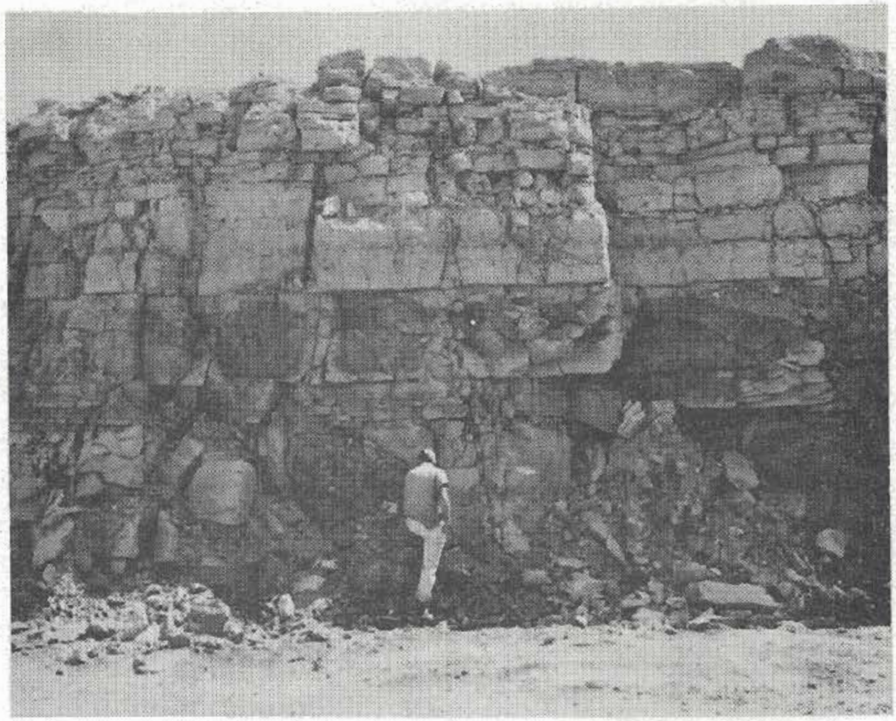


Figure 14. Fort Riley Limestone quarry face NW¼ sec. 6, T3S, R7E.

Pre-Kansan Gravel

A few small high elevation gravel deposits (which lack Kansan glacial erratics but have debris of the Kansan glacier covering them) have been termed Pre-Kansan Gravel in this report. These deposits are composed mainly of gray chert gravel embedded in a reddish-brown silt and clay matrix. According to Walters (1954, p. 59), the maximum thickness of these gravel deposits encountered during his geology and ground-water investigation was 22 feet; however, in existing materials pits it does not exceed eight feet. It is concluded that the material is of alluvial origin because it is well sorted and pebbles show the wear effects of alluvial processes.

The deposits do not generally give clear indications of their existence on aerial photographs or ground investigations. The deposits which have been found and produced have been developed from observation of the gravel on the ground surface.

The use of this material in Marshall County is limited to light type surfacing on rural roads. The chert is somewhat undesirable for this purpose because of its damaging effect on tires, but it serves as an economical source of material where other types of material are not available.

No quality tests have been performed by the State Highway Commission of Kansas on this material. Due to the fact that deposits of this material are extremely localized, no attempt was made to map their areal extent; however, two pits which produce material from this source are shown on the county materials map.

Kansan Till

Much of Marshall County is covered by glacial till deposited by the Kansan glacier. Especially prominent glacial cover masks the bedrock surfaces north of the Black Vermillion and east of the Big Blue Rivers.

The color of the glacial material varies from tan to reddish-brown, and the texture from very coarse to very fine (that is, from large boulders which may weigh more than a ton to fine material in the silt and clay size range). Exposures of the glacial material display erratic bedding and, in many instances, a complete lack of bedding. The thickness of the glacial deposits may be as much as 70 to 80 feet.

The composition of the Kansan Till is mostly silt and clay; however, some localized areas contain deposits of sand and gravel. In this materials inventory, the location of scattered sand and gravel deposits is the major concern, since material of this type may be used for surfacing on lightly traveled rural roads.

The individual glacial pits contain sand and gravel of variable composition depending on their location in the county. The pits located along U.S. 77 highway north of Blue Rapids and in the vicinity of Marysville contain clay-bound chert, limestone, and arkosic gravel, along with quartzite and granite boulders. Figure 15 illustrates the textural aspect of material contained in these pits.

Figure 15. Glacial gravel in materials pit, SE¼ sec.16, T3S, R7E.

A glacial gravel pit near Bremen in northwestern Marshall County and one south of Waterville in the southwestern portion of the county contain abundant iron cemented sandstone boulders and gravels along with badly decomposed shale balls. Pink granite boulders which easily crumble into fine rubble are also prominent features in these two pits. One small glacial pit located in the northwestern corner of the county contains material which is different from any of the other glacial types found in this investigation. This material is clay-bound gravel composed of quartz, feldspar, and metamorphic rock, but differs from other deposits because of the presence of abundant secondary calcite nodules. Although the material in the glacial pits was generally not found to be cemented, the pit south of Waterville appeared to have enough cementation to prevent feasible recovery without the use of special crushing equipment.

The results of quality tests conducted on glacial sand and gravel indicates that the material is of poor quality. The clay content, which results in a high plastic index, prevents the material from being utilized as aggregate in bituminous or concrete mixes. On samples tested, the plastic index ranged from 15 to 32, the Los Angeles wear from 28.0 to 39.0 percent and the soundness loss ratio from 0.90 to 0.97.

Grand Island Formation

The Grand Island Formation is a high river terrace-type deposit composed of tan colored siliceous sand and arkosic gravel of varying gradation. Scattered remnants of the terrace containing the Grand Island may be found along the Big Blue, Little Blue, and Black Vermillion Rivers. Rarely is the sand and gravel of this unit found in surface exposures because the clay, silt, and fine sand of the younger Sappa Formation generally mask it. In view of this, the Grand Island Formation map unit may include the overlying Sappa Formation.

The high terraces are easily defined at some locations, but in most instances the boundaries are indistinct. An example of a well defined terrace may be viewed west of Blue Rapids in the southwestern portion of the county. Figure 16 (Page 36) is a photograph taken in a Grand Island sand and gravel pit located just west of Blue Rapids.

Because of the lack of chert and limestone gravel and the abundance of quartz and feldspar, some material obtained from the Grand

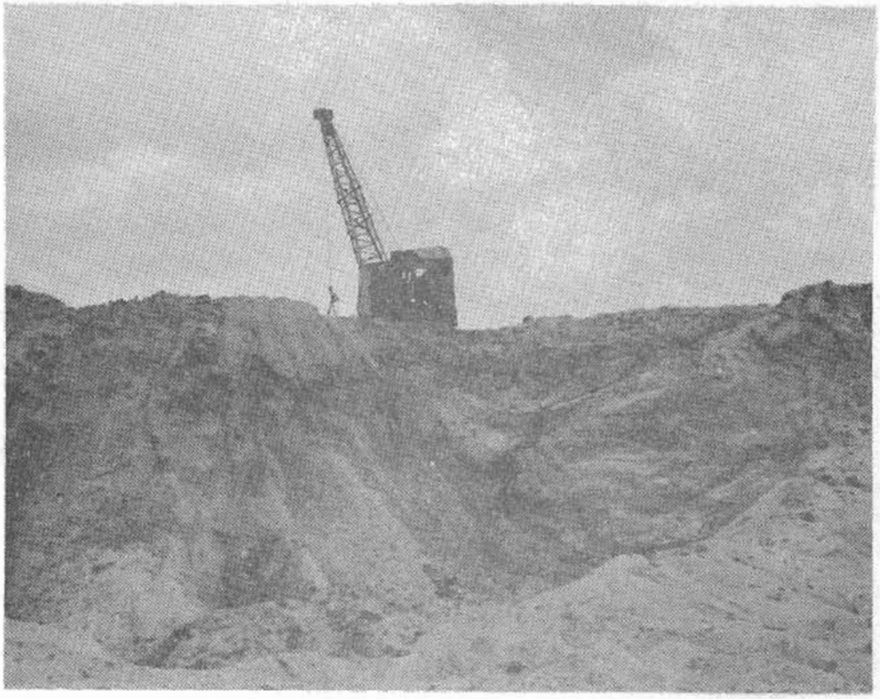


Figure 16. Dry pit excavation in the Grand Island Formation, SE¼ sec.24, T4S, R6E.

Island Formation is the best quality available in the county. Another feature which makes the Grand Island an economical source of material is the ease of production. Most pits are worked by dry pit excavation methods because the terraces are generally above the water table. At one location, however, the source had been exhausted above the water table, and a pumping system was established to extract the material under water. Available test results indicate that material from this source would meet quality requirements for both bituminous mixes and concrete aggregate. Although the primary use of the Grand Island is for bituminous and concrete aggregate as well as surfacing material for lightly traveled rural roads, some of the silt and fine sand, which has a low plastic index, may be used as mineral filler. The Los Angeles wear ranged from 31.6 to 32.9 percent, the soundness loss ratio from 0.94 to 0.99 and the absorption on one sample was 0.8 percent. Additional results on the two tested sites are shown in Figure 8 (Page 21).

Alluvium

The Alluvium of the Big Blue River is of major importance in the Marshall County Materials Inventory inasmuch as this river valley contains an abundance of coarse gravel suitable for all phases of road construction. The tributaries of the Big Blue generally contain a finer grained material which is not as useful for construction purposes as that derived from the Big Blue River.

The Alluvium of the Big Blue consists of coarse sand and gravel composed mostly of quartz, feldspar, and chert in the lower portion grading upward into fine sand and silt. In the pumping operation used to obtain this material, large pieces of gray chert are screened out and stockpiled separately because of their deleterious nature. According to Walters (1954, p. 62), the Alluvium has a maximum thickness of 50 feet in Marshall County. Figure 17 (Page 38) is a photograph taken in a sand and gravel pit, owned by the Blue River Sand and Gravel Company, in which material is being taken from the Alluvium.

The sand and gravel, obtained from the Big Blue River Alluvium, will meet specifications for both bituminous and concrete aggregate and is ideal for surfacing lightly traveled rural roads. The chert, which is contained, is known to lower the material quality from the soundness aspect, but it generally remains well within the specifications set by the State Highway Commission of Kansas. The supply of this material is nearly unlimited, but it can be obtained only by pumping operations. It may be possible to retain some find sand and silt during pumping operations for use as mineral filler. Specific quality ranges are as follows: Los Angeles wear- 24.8 to 39.4 percent, soundness loss ratio- 0.93 to 0.99, and absorption- 0.50 to 3.37. percent. Additional test data are given in Figure 8 (Page 21).

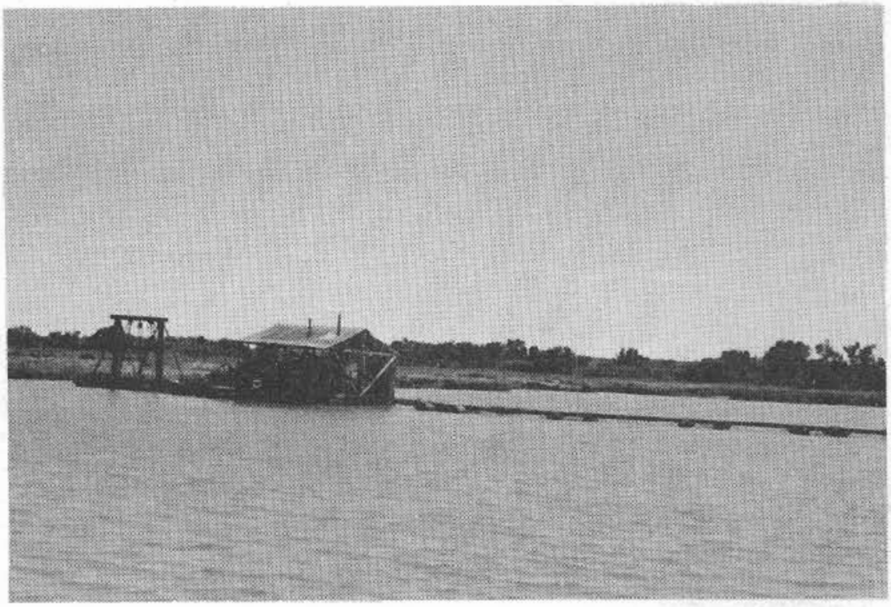


Figure 17. Alluvial sand and gravel pit owned by the Blue River Sand and Gravel Company, SE¼ sec.27, T4S, R7E.

Geo-Engineering

The geo-engineering problems that will be encountered in Marshall County are typical of those confronting highway engineers elsewhere in the glaciated areas of northeastern Kansas. Most road improvements in this county will require detailed field investigations prior to their construction to familiarize the engineer with problems which may exist; however, no severe geo-engineering problems are anticipated.

The following discussion deals with geo-engineering problems from three major points of view: (1) material usage in road construction, (2) hydrology problems in road construction, and (3) mineralization of water resources with regard to use in Portland Cement concrete.

Material Usage in Road Construction

Three aspects of material usage are discussed in this section of the report: (1) embankment and subgrade construction, (2) backslope steepness and stabilization, and (3) bridge foundation support.

Embankment and Subgrade Construction

It is probable that nearly all of the geologic units exposed in Marshall County have been used at some time in the construction of highway embankments or subgrades; however, clay shale or any of the highly plastic soils are not recommended for subgrade or shoulder construction due to their shrinkage and swell characteristics. Such materials may be beneficial for slope protection because of their resistance to erosion, but their use should be avoided if the development of a turf is desired. If used for embankment construction, they should be placed in the lower portion; however, consideration must be given to the height of the fill to insure that the shear strength of the material is not exceeded by the weight from above.

The general procedure for subgrade construction in Kansas is to remove the upper 18 inches of material in earth cuts and the upper 12 inches in bedrock and then backfill with a suitable material and compact. It is desirable for the backfill material to have a low swell and shrinkage factor, but frequently such material cannot be found within feasible hauling distance of the project. In most cases, it is necessary to utilize available material, which at times may require stabilization with lime.

Much of Marshall County is covered by thick glacial and windblown silt deposits which may display high swell and shrinkage charcteristics in some locations; however, due to the abundance of this and the general lack of any better material which can be easily acquired, it is necessary to use it to the best advantage possible.

Limestone and shale will be encountered in some cuts in the upland areas and will be very common along the margins of the major drainage. Of the bedrock units, the weathered shale will be of prime concern from the subgrade aspect, since it may display swell and shrinkage characteristics which are undesirable. Stabilization with lime or wasting of the material may be necessary in some situations.

Roads built in the flood plain of the major drainage (i.e. Big Blue and Little Blue Rivers) should have a more suitable subgrade material available because the natural state of the mantle is somewhat more sandy than in the upland areas. Also, the close proximity of the stream may give good access to fine sand suitable for subbase construction.

Backslope Steepness and Stabilization

Backslopes in mantle will be set on approximately a 3:1 slope and seeded to prevent erosion. Bedrock backslopes will vary with the type of material and degree of weathering. Hard, unweathered limestone may be set at a ¼:1 or ½:1 slope, but weathered units should be approximately 1:1. Hard unweathered shale may be set on a ½:1, but weathered shale slopes may range from a 1:1 to as high as 3:1, depending on the depth of the cut. Stabilization of hard limestone and shale is unnecessary; however, it is mandatory in soft, weathered shale. In an extremely deep bedrock cut situation, the given slope ratios for the various materials may vary with the depth, inasmuch as deep cuts require a gentler slope because they are more subject to severe erosion.

When blasting in bedrock cuts, the rock is sometimes overbroken and the shattered material may spall badly when subjected to weathering and become a maintenance problem. When overblasting occurs, additional consideration should be given to the design and steepness of the slope.

Bridge Foundation Support

Bridge foundation problems may be encountered in Marshall County, especially in areas covered by glacial drift and when soft shale is encountered as a foundation material. Solutioning of limestone and gypsum beds are also a consideration.

Because large glacial erratics are found in the glacial drift of Marshall County, apparent bearing may be obtained at erroneous elevations or the pile, whether steel or wood, may be damaged as a result of striking a boulder.

When shales such as those found in Marshall County are subjected to weathering processes (especially ground-water saturation), the weathered portion often becomes soft and unsatisfactory as a bridge foundation support. Of particular significance is the Wellington shale found exposed in western Marshall County, inasmuch as deep weathering and variable pile penetration are common characteristics of this unit.

In Marshall County and some surrounding areas, a gypsum zone is found in the Easly Creek Shale. Solutioning of this zone is a possibility and should be a consideration on a given bridge foundation investigation.

Some limestones, such as the Towanda and Fort Riley Limestone, tend to solution out badly when subjected to ground-water movement. The cherty Florence Limestone member will often weather away, leaving only a clayey chert rubble. Precaution should be exercised when a foundation in this material is being considered.

Hydrology Problems in Road Construction

The geology in Marshall County is characterized by alternating beds of limestone and shale covered with varying amounts of unconsolidated material. Because of properties inherent in this type of geology, ground-water problems are encountered frequently on road construction projects in the county. Inasmuch as a large number of geologic units are potential sources of ground-water problems, no specific recommendations are made in this report; however, the name of some units which are known problems, the general mechanics of hydrology problems and possible precautions which can be taken to prevent their causing road failures are discussed.

A limestone unit located near the ground surface is subject to several types of weathering processes. For example, water causes solutioning, ice produces cracking, and vegetation can influence the severity of mechanical weathering. The resulting cracks and solution cavities provide channels for the downward percolation of water from the surface. Following periods of heavy rainfall, water works its way through these channels until it reaches an impermeable layer such as a shale zone, along the top of which it will move until a surface outlet is reached. When these water-carrying zones are intercepted by road cuts, water may be discharged into the roadbed.

Although many bedrock units have a possibility of causing ground-water problems, some specific problem areas have been noted by geologists and engineers working on preliminary surveys and in construction. The most numerous ground-water problems were associated with the Florence Limestone, Fort Riley Limestone, Holmsville Shale, Towanda Limestone, and Glacial Till. A lesser number of problems occur in the Stearns Shale, Crouse Limestone, Blue Rapids Shale, Funston Limestone, Speiser Shale, Threemile Limestone and Schroyer Limestone. It is probable that part of the reason that ground-water problems in road construction are so abundant in the Florence, Fort Riley, Holmsville and Towanda Limestones is because of the large exposure area along the margin of the major drainage where road cuts are often necessary. The Glacial Till likewise has a large coverage area in the county, and because of the irregular bedding and numerous sand lenses which collect water, ground-water problems may occur.

When a road construction project is proposed, a geologic field survey should be conducted to ascertain if any water-carrying zones will be encountered along the proposed alignment. If troublesome conditions are found to exist, some of the following courses of action should be taken to prevent road failure due to water being induced into the subgrade.

1. Construct special ditches to intercept water-carrying zones and to provide drainage for the ground-water. The base of these ditches should be well below the source of the ground-water and should have sufficient grade to drain the water away before the subgrade can become saturated.
2. A system of underdrains may be constructed beneath the roadbed to intercept the water before it can enter the subgrade and cause damage to the roadbed.
3. Adjustments in proposed alignments can be made to avoid areas in which troublesome ground-water situations exist.

Mineralization of Water Resources

The discussion of ground-water is based chiefly on a report by Walters (1954), and is approached, here, with primary consideration given to the following: (1) the main source of water and (2) the degree of mineralization which can generally be expected in various aquifers.

Alluvial deposits associated with the Big Blue, Little Blue, and Black Vermillion Rivers provide the best source of ground-water due to the perennial nature of the streams and the coarse granular material contained in the alluvial fill.

The Grand Island terraces parallel the major rivers, but they are relatively thin and limited in area, thus, providing only a limited supply of ground-water.

Kansan Glacial Till and associated deposits provide water to many wells in the upland area. Due to the fine texture of the material, the quality of water which can be produced is often limited.

The Atchison Formation and Pre-Kansan Gravel provide moderate to large quantities of water under favorable natural conditions.

Bedrock units which are known producers of water include the Barneston, Beattie, and Grenola Limestone Formations. The most important single unit is the Florence Limestone Member of the Barneston.

When considering water for use in Portland Cement concrete, care should be taken to insure against high chloride or sulfide ion content. Highly mineralized water of this nature has not been found to be a problem in Marshall County. The lack of oil wells precludes a major amount of possible salt water (chloride) contamination which has proven to be troublesome in other counties.

GLOSSARY OF SIGNIFICANT TERMS

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

Aggrade: To raise the grade or level of a river valley or stream bed by depositing particles of silt, clay, sand, or gravel.

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

Arkosic gravel: Gravel composed of mineral fragments derived from weathered granite.

Chert: A dull, flint-like rock.

Consolidated deposit: Deposit of limestone, shale or sandstone. In Kansas this term generally applies to rock older than Pliocene Age.

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

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

Glacial deposit: Stratified and (or) unstratified deposits of clay, silt, sand, gravel, and boulders laid down by glaciers or glacial meltwater.

Gradation factor: The value obtained by adding the percentages of material retained on the 1 1/2", 3/4", 3/8", 4, 8, 16, 30, 50, and 100 mesh sieves respectively and dividing the sum by 100.

Igneous rocks: Rocks produced under conditions involving great heat, as rock crystallized from molten material.

Light type surfacing: A surface course constructed from aggregate which is not bound by water, cement, or bituminous material.

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

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

Material source bed: A particular geologic unit, consolidated or unconsolidated that provides material for construction purposes.

Matrix: The binding material such as that which bonds or encloses sand or gravel particles at their place of deposition.

Metamorphic rock: Rock which has been crystallized or otherwise altered by intense heat or pressure.

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

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

Pleistocene series: Deposits laid down during the Quaternary Period.

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

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

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

Stereoscopic vision: Vision through a stereoscope in which objects appear in three dimension.

Terrace: A plain built up by the deposition of sediments by water.

Unconsolidated deposits: Deposits of clay, silt, sand, or gravel. These deposits may be laid down by either wind or water action.

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

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

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