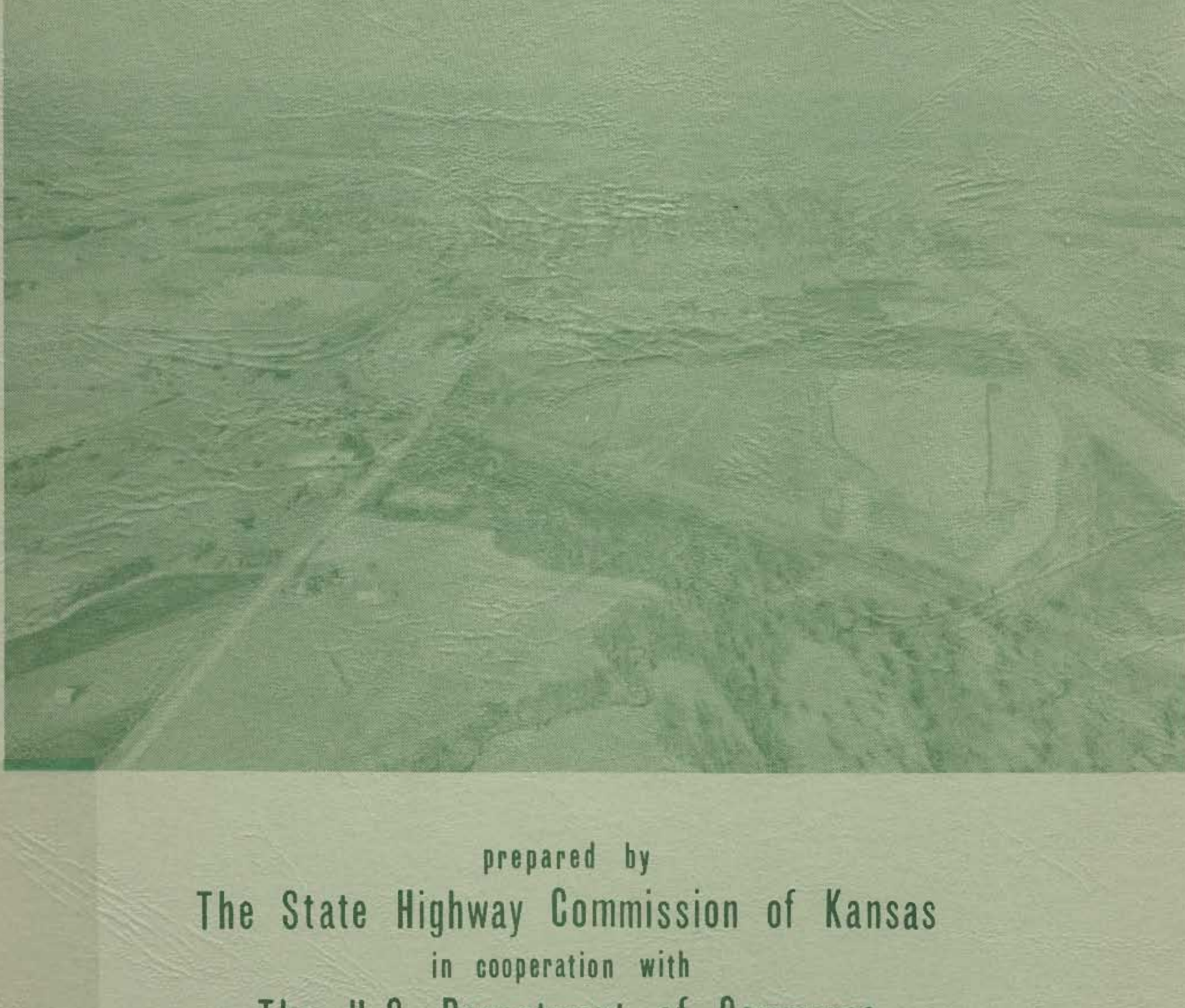
Materials Inventory of Brown County, Kansas



prepared by

The State Highway Commission of Kansas

in cooperation with

The U.S. Department of Commerce

Bureau of Public Roads

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

MATERIALS INVENTORY OF BROWN COUNTY, KANSAS

by

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Prepared in Cooperation with
U. S. Department of Commerce
Bureau of Public Roads

1966

Materials Inventory Report No. 8

COVER -- An areal view of Hiawatha, Kansas, the county seat and principal city of Brown County.

SUGGESTED USE OF THE REPORT

This investigation was conducted to provide information concerning the quality, quantity, and availability of construction material in Brown County, Kansas. The report includes: 1. an introduction which describes the nature of the report and provides general information concerning Brown 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 locations where the various source beds can be found along with the locations of all open material sites and prospective areas; 5. appendices I through III which contain site data forms for each open and sampled prospective material site. Each data 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 available for that site.

When this report is used as a guide for planning an exploration program or making an assessment of the materials resources of Brown 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 Brown County." In this portion of the report a brief explanation of the geology of Brown County is presented which describes some of 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 Brown County are inventoried in this portion of the report. Study 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.

Once the types of material present in the county have been reviewed, reference should be made to the county materials maps. These maps show the area in which each source bed is exposed or near surface, the location of sites where material has been produced from the various units, the location of prospective areas for the respective source units, and references to site data forms for each open and sampled prospective site.

For example, through a study of the "Construction Materials Inventory" one determines that material produced from the Neva Limestone fulfills the specifications for a particular project in northwest Brown County. Plates I, III, and V show the areas where the Neva is available and the sites where it has been produced. If more detailed information concerning the Neva is desired, the site"s designation indicates the appropriate data form which will be found in the appendices of this report.

By using this information in conjunction with the materials maps, a thorough assessment of the materials available in Brown County can be made and an exploration program can be planned in an orderly fashion.

PREFACE

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

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

Prior to this time, no extensive or county-wide materials investigation had been completed in Brown County. 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 Brown County. Aggregate quality test results, pertinent information pertaining to materials produced, and geologic data on Brown County used in this report were supplied by the Materials Department and the Geology Section of the Design Department. Test holes were drilled by personnel from the office of the First Division Materials Engineer.

Appreciation is extended to the State Geological Survey of Kansas for the use of data to be included in their report, Geology and Ground-water Resources of Brown County, Kansas, by Charles K. Bayne and Walter H. Schoewe, which provided much of the background information for this report. Appreciation is extended also to Albert Ross, Brown County Engineer, for verbal information concerning construction materials in the area.

The report was prepared under the guidance of John D. McNeal, Engineer of Planning and Research, and the project engineer, R. R. Biege, Jr., Engineer of Aerial Surveys and Photogrammetry.

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Abstract

Sources of construction materials in Brown County are restricted to thicker limestone beds, a limited number of High Terrace Deposits composed of predominantly chert gravel, glacial sand and gravel, and limestone gravel found in the Alluvium of some of the major drainage channels in the county. Because of the thick blanket of glacially deposited drift and outwash material which covers most of the county, only a limited amount of construction material can be economically produced.

Two limestone units of Pennsylvanian age, which are exposed in the southeastern part of the county, have been designated as source units but both are difficult to produce because of their limited outcrop area and heavy overburden. Two Permian limestone units have been produced in the western part of the county; however, both exhibit high absorption and wear properties. Adverse engineering characteristics preclude the usage of most of these limestone units for bituminous and concrete construction; however, all units provide material suitable for light type surfacing and riprap.

Terrace deposits composed of chert gravel cap the high terrain in northwestern Brown County; however, these deposits are few and the material is highly contaminated with silt and clay. This source provides material for light type surfacing but extensive washing operations would be necessary to acquire a usable material for concrete or bituminous construction. Since no water is available in the immediate area of these deposits due to their high topographic position, such an operation is generally not economically feasible.

Siliceous sand and gravel is produced from Kansan age glacial drift throughout the county. Usually, however, these deposits contain a high percentage of silt and clay, are poorly sorted, and have only limited areal extent.

A limited amount of alluvial limestone gravel, highly contaminated with silt and clay particles, is available in some of the terraces and flood plains of the larger drainage channels in north-central Brown County.

Due to the extensive cover of drift and outwash deposits, the geo-engineering problems confronting highway planners and constructors in Brown County are typical of those found in other glaciated areas of northeastern Kansas. No unusual or extreme conditions are anticipated; however, each situation encountered will pose its individual problems. The major considerations, from the geo-engineering aspect, are discussed under the following subtitles; 1. material usage, 2. possible hydrology problems in road construction, and 3. pollution of water resources.

Most highway improvements in Brown County will encounter glacial drift which is generally characterized by high swell properties and high plasticity indices. Along major drainage channels thick shale units will be encountered possessing similar engineering characteristics.

Nearly all of the geologic units exposed in Brown County have properties which contribute to ground-water problems. Some of the most severe are encountered when the designed grade of the improvement passes through isolated sand pockets in glacial drift.

Mineralization of water that might be used in mixing concrete is not a severe problem in Brown County; however, some aquifers in the northwestern part of the county yield water with high sulfate content. Normally chloride concentrations are not a problem at the depth reached by most of the wells; however, deeper wells (100 feet or more) in the county have produced water with chlorides content of 4,275 parts per million.

INTRODUCTION

Purpose of the Investigation

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 Brown County, and to provide a guide for materials prospecting in the county.

Scope

This investigation includes all of Brown County. All geologic units and deposits considered to be a construction material source are mapped and described. In this report, the term "construction material" includes all crushed aggregate, granular material, and mineral filler suitable for use in various types of highway construction.

Nature of the Report

Geology is used as the basis for conducting the materials inventory program because all material source beds and deposits are the products of geologic agents. This procedure enables one to ascertain the general engineering properties of the material source, to identify and classify each according to current geologic nomenclature, and to establish a uniform system of material source bed classification. The quality of material, however, that can be procured from a given source may vary from one county to another, especially when dealing with unconsolidated deposits. In most instances, the geologic classification attached to unconsolidated deposits denotes age rather than material type; therefore, two deposits laid down during the same time period in different parts of the state may have the same geologic name or classification, but may vary in composition because of difference in parent material, mode of deposition, or carrying capacity of the depositing agent.

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

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

Mapping of the various geologic units is accomplished through the use of aerial photography of the county. Most consolidated units can be mapped with only a minimum amount of field checking because of their continuous nature. Unconsolidated deposits of sand and gravel are less extensive and more erratic, but they can be located on the photographs by having knowledge of the county geology and by accurate interpretation of significant terrain features discernible on the aerial photographs.

By knowing the mode of deposition, type of source bed, geologic age, type of landform associated with a particular source unit, and the results of 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

Brown County has an area of 576 square miles and a population of 13,229 according to the 1960 census. It lies in the glaciated region physiographic province and is bounded by parallels 39° 39' and 40° 00' north latitude and meridians 95° 21' and 95° 47' west longitude.

It is situated in the northern tier of counties in the state and is the second county west of the eastern border of Kansas. Brown is bounded on the north by Richardson County, Nebraska, on the west by Nemaha County, on the south by Jackson and Atchison Counties, and on the east by Doniphan County. Figure 1 (Page 3), is a state map of Kansas showing the location of Brown County and other counties currently included in the materials inventory program.

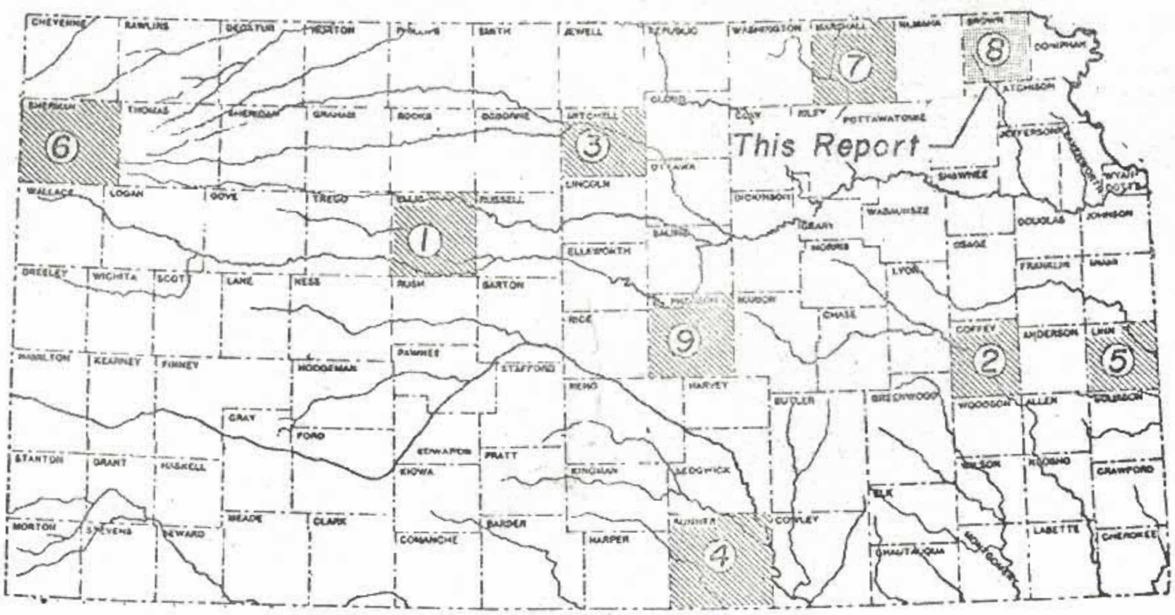


Figure 1. Index map of Kansas showing the location of Brown and other counties for which reports have been published or are in progress.

The interstream land surface is characterized by broad, smooth, well-rounded topography, developed on the ground moraine deposits left by the retreating Kansan glacier. Adjacent to the major streams the surface is highly dissected, forming rough, hilly terrain.

The drainage of Brown County is controlled in the southeastern and east-central part by Wolf River; in the southwestern and south-central portion by the Delaware River and its tributaries; and in the northern part by Pony Creek, Walnut Creek and Roys Creek.

Brown County is served by lines of the Chicago, Rock Island and Pacific Railroad; the Missouri Pacific Railroad; and the Union Pacific Railroad. U. S. Highway 75 extends north-south in the extreme western part of the county while U. S. 73 and 159 traverse in a north-south direction through the central part of the county, serving the towns of Reserve, Hiawatha and Horton. The central portion of the county is traversed in an east-west direction by U. S. 36 which passes through Hiawatha and Fairview, and the extreme southern part of the county is served by State Highway 20 which trends east-west. There is also a well developed system of secondary roads throughout Brown County.

PROCEDURES

The investigation for this report was organized into 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, these phases 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.

Phase I Research of Available Information

All available data and information pertaining to the geology, soils, and construction materials were reviewed, and the general geology of the county, relative to material sources, was determined.

During this process, the results of quality tests previsouly completed on samples taken in Brown County were correlated with the various geologic units and deposits found in the county.

Phase II 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 (1" represents 2,000'). Figure 2 (Page 6), is a photographic coverage map of Brown County on which index numbers have been placed to indicate the actual area covered by individual photos.

Initially, the entire county was studied on aerial photographs. During this process, all open material sites which had been sampled or reported were located on the aerial photographs and on a cronar base map of the county. The geologic source beds were mapped and classified on the photographs, and all material sites were correlated with the geology of the county. This information was then transferred to the base map. Prospective areas were tentatively selected on the basis of the geology and the aerial photographic pattern elements. Figure 3 (Page 7), illustrates the correlation procedure by showing High Terrace Deposits in northwestern Brown County. These terraces were detected on aerial photographs by their topographic position. Because the material in these terraces were derived from the same parent beds and deposited at the same time by the same mode of deposition, the engineering characteristics of each deposit will generally be the same.

Phase III Field Reconnaissance

A field reconnaissance of the county was conducted after the first study of the aerial photographs had been completed. This

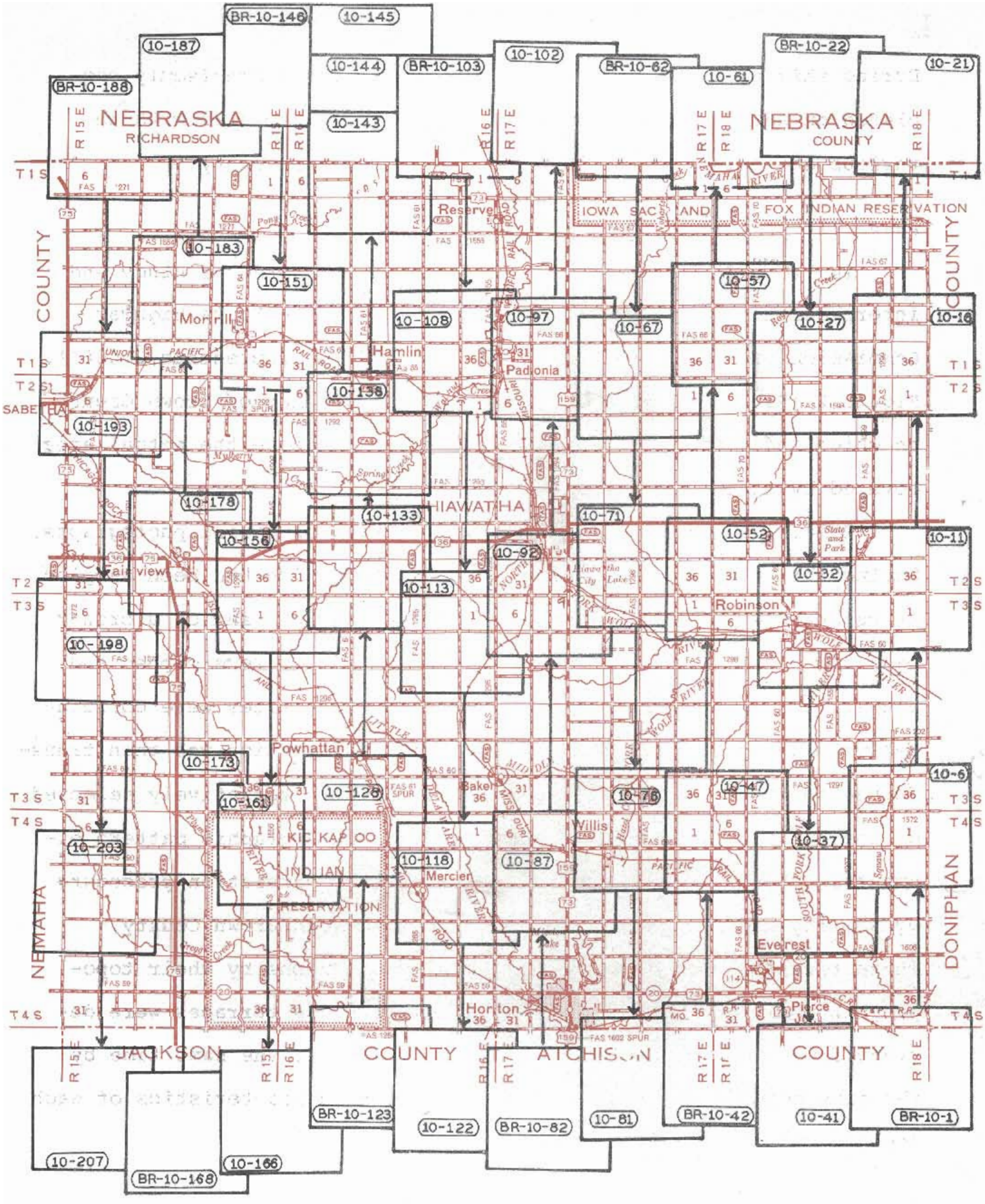


Figure 2. Aerial photographic coverage map for Brown County. The numbers which are in brackets indicate print numbers of aerial photography obtained by the Photogrammetry Section, State Highway Commission of Kansas. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

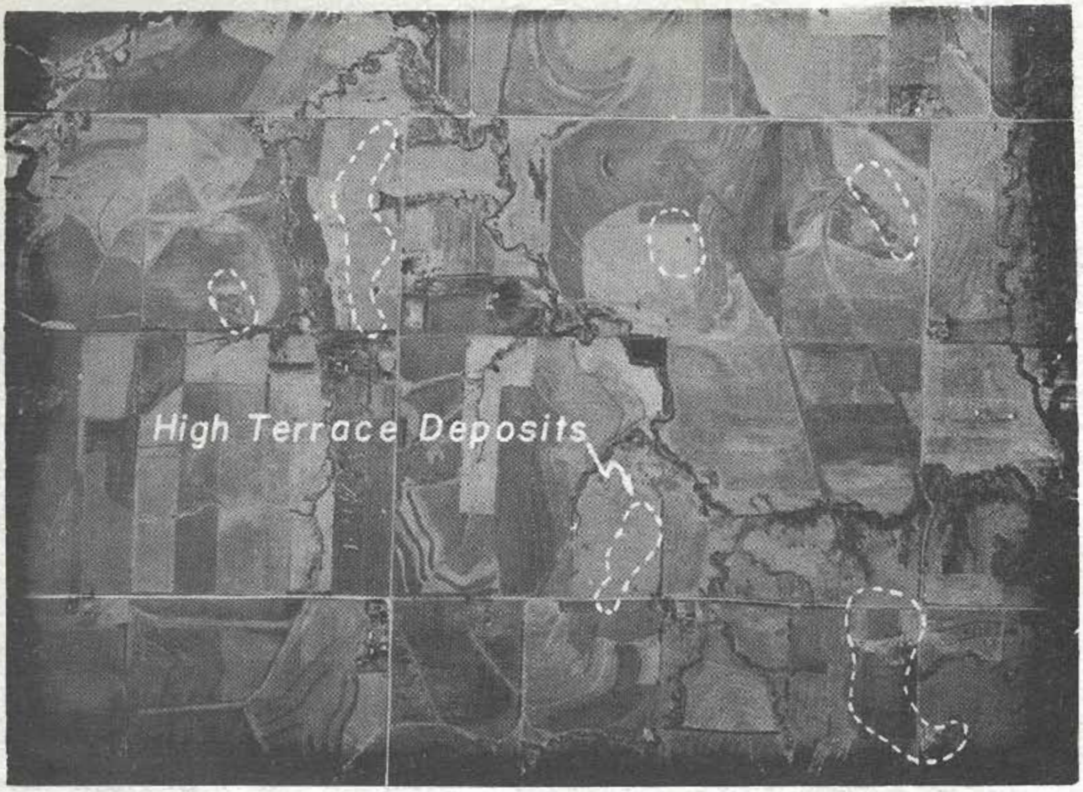


Figure 3. High Terrace Deposits located in northwestern Brown County.

enabled the interpreter to examine the material with which he was working, to verify doubtful mapping situations, and better to acquaint himself with the county geology. All open sites were inspected to confirm the geologic classification. The quality of the material producible from a given source bed was ascertained by correlating the results of qualitative tests with the unit from which the samples were obtained and by field study of the producing unit. Following the field check, the mapping process was completed and a more detailed description of the geologic source units was written.

Phase IV <u>Map Compilation and Report Writing</u>

The fourth phase consisted of the final association of all new information gathered during the investigation to previously existing data, writing the report, and the final compilation of site data forms and the county construction materials map.

The Brown County materials map was divided into six sections approximately equal in area (Plates I through VI). The map units were based, primarily, on geologic age and, except for glacial deposits, the engineering properties of material deposited during a particular age are relatively consistent throughout the county.

All existing sites and prospective areas are identified on the materials map by the appropriate designations and symbols. The site designations conveys to the reader the type of material, the estimated quantity, the number of the corresponding data sheet for the site, and the geologic age and unit name of the source bed. The site symbol indicates if it is prospective or open, and whether or not it has been sampled.

The map legend accompanying each of the six plates explains all letter and map symbols used in the site designations.

To furnish the reader with a comprehensive coverage of all available information, a data form was compiled for each material site included on the plates. The site data forms are included as Appendices I through III in this report. Appendix I contains data forms for open sites not tested by the State Highway Commission, while Appendix II includes forms for those sites designated as open and sampled. Test data is presented on the forms for each site in this appendix. Appendix III contains data forms which incorporate test result information for the prospective sites which have been sampled.

Geologic data is presented on each site data form to facilitate future correlation, and when possible, references are made to nearby locations where test results are available on samples taken from the same source bed.

A sketch of each site was drawn to illustrate the major natural and cultural features of the general area to assist in field location.

As a final aid, landowner information is presented for each materials site as it is listed in the Brown County Register of Deeds Office.

The rest of the report was completed by presenting the general geology of the county as it pertains to the various source beds and deposits, a general description of the available material, and a discussion of the units which have displayed unsound engineering characteristics in the past.

CONSTRUCTION MATERIALS RESOURCES OF BROWN COUNTY

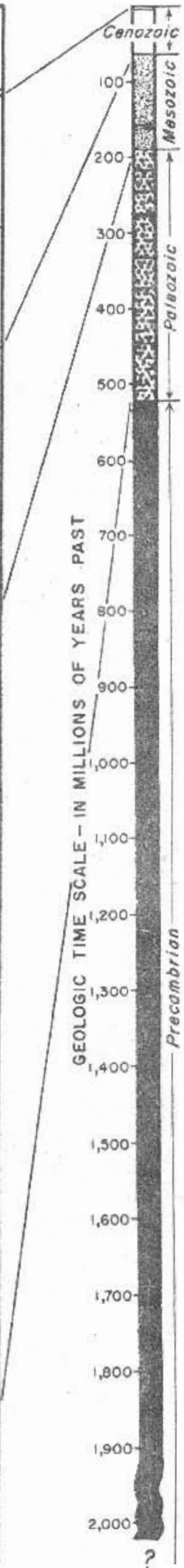
General Geology of Brown County

This section of the report presents a brief and general review of the geology of Brown County. The main objective is to provide the reader with a general understanding of the geological events that were responsible for the present day construction materials resources of Brown County. Much of the discussion refers to geologic time and, therefore, a major portion of the nomenclature used in this report consists of terms representing segments of geologic time. A geologic timetable, Figure 4 (Page 10), reproduced with the permission of the State Geological Survey of Kansas, shows in graphic form the major time periods and the approximate duration of each. In order to understand better the geologic events that occurred, the reader must comprehend the magnitude of geologic time and realize that climatic and geographic conditions have differed vastly from those presently existing.

(Not scaled for geologic time or thickness of deposits)

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

*Committee on Measurement of Geologic Time, National Research Council



State Geological Survey of Kansas

Figure 4. Geologic timetable

Brown County geology, as discussed in this report, is based primarily on unpublished field information acquired by Charles K. Bayne and Walter H. Schoewe of the State Geological Survey of Kansas for use in the forthcoming bulletin "Geology and Ground-water Resources of Brown County, Kansas."

Rocks which occur in the subsurface but do not outcrop in Brown County range from Precambrian to late Pennsylvanian age. The Precambrian rocks are believed to be primarily granitic types which occupy an assymetrical trough. Approximately 3,250 feet of Paleozoic sediments overlie the older Precambrian rocks and are composed of limestone, dolomite, sandstone and shale.

Marine deposits of late Pennsylvanian age are the oldest rocks found at the surface in the county; however, exposures are confined to the major stream valleys in the eastern and southern portion of the county. Lower Permian rocks of marine origin are exposed in the western part of the county along major drainage channels.

No Mesozoic sediments are found in this county. It is part of an area which was probably a land mass during most of the Mesozoic Era (Triassic and Jurassic Periods). It is assumed that during this time large amounts of older Paleozoic rocks were removed by erosion. The sea made its final invasion of Kansas during the late Mesozoic (Cretaceous Period) and if any sediments were deposited in Brown County during this time, they were subsequently removed by erosion during Cenozoic time.

The events that took place during the Cenozoic Era have had a dominant influence on the construction material resources of this area. Most of these events took place, however, in the late Cenozoic (Quaternary Period). During the earlier Tertiary Period which represents most of Cenozoic time, the surface of Brown County was believed to have been eroded with some significant deposition taking place in late Tertiary time. Chert gravel deposits resting on Permian bedrock are found capping the topographic highs in northwestern Brown County. In this report these deposits have been dated as Pliocene(?) in age (late Tertiary); however, there is some speculation as to their age.

The Pleistocene Epoch of the Quaternary Period represents a time of repeated glacial and interglacial cycles. The glacial ages (Nebraskan, Kansan, Illinoisan, and Wisconsinan) represent the advance of the glaciers, while the three interglacial ages (Aftonian, Yarmouthian, and Sangamonian) represent periods of major glacial recession. Figure 5 (Page 13), is a geologic timetable which shows the divisions of the Quaternary Period and the approximate duration of each.

Only two glaciers, the Nebraskan and the Kansan, reached Kansas during the Pleistocene Epoch. Both entered Brown County; however, positive identification of deposits associated with the Nebraskan Stage of glaciation was not made during this investigation. The Kansan glacier covered virtually all of the county, leaving drift and outwash deposits over most of the area.

Glaciolacustrine deposits, termed the Atchison Formation, have been identified as being associated with early Kansan glaciation. This formation, composed of sand and silt, occurs near the base of a buried channel in the northeastern part of Brown County.

A maximum of 115 feet of drift associated with the Kansan glacier was reported in test holes in Brown County. This material is poorly sorted and consists predominantly, of silt and clay, but

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

Figure 5. Geologic timetable of the Quaternary Period

does contain some sand, gravel, and boulders.

During and following the retreat of the Kansan glacier, outwash deposits were laid down by meltwater flowing away from the ice front. The material consists of moderately-sorted silt, sand, and gravel and has a maximum thickness of approximately 100 feet. These deposits occur in poorly defined channels which generally are not traceable more than a short distance from the outcrop area.

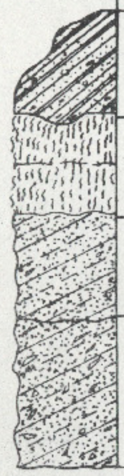
After the retreat of the Kansan glacier, a period of erosion began. This degradational situation continued during Illinoisan time, resulting in the removal of large quantities of material. It is speculated that some deposition also occurred during the Illinoisan Age; however, positive identification of any such deposits was not made during this investigation. Some loess and alluvial deposits of Illinoisan and Sangamonian age may be present in the form of discontinuous terraces along Walnut Creek in north-central Brown County. They are, however, small in areal extent and have not been definitely placed stratigraphically.

In early Wisconsinan time many older deposits were eroded, the present drainage system was established, and streams entrenched their channels to about their current level. Later in the Age, the valleys were partially filled with alluvial material, and the uplands and valley walls received depositions of loess from the barren stream valleys to the north. These deposits are composed of early Wisconsinan and late Wisconsinan loess, which can be differentiated in Brown County by their respective molluscan fauna, or locally, by a zone of leached calcium carbonate at the top of the older sediment. This material reaches its maximum thickness in the northeastern part of the county, near the Missouri River, but thins toward the west and southwest.

In Recent time alluvial and colluvial deposits have been laid down in many of the stream valleys. This material, composed of clay, silt, sand, and limestone gravel, is generally poorly sorted and ranges in thickness from only a few feet to a maximum of approximately 55 feet in the larger stream valleys.

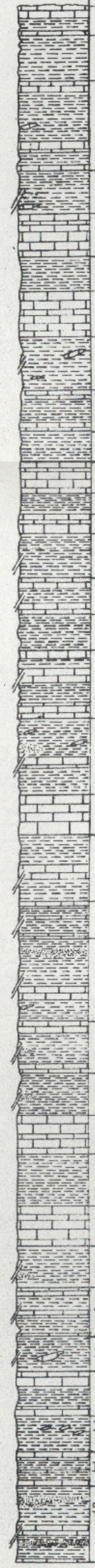
Construction Material Inventory

This section of the report inventories the construction material resources of Brown County. Only those geologic units which are producers or are considered to be potential producers of construction materials are discussed. Figure 6 (Page 15), is a generalized geologic column of the surface geology in Brown County which illustrates the relative stratigraphic position of each geo-



Thickness	Type of Deposit	Map Symbol	Stage	Series	System	Construction Materials	Generalized Description
0' to 55'	Alluvium and Terrace Deposits	Qal	Recent and Wisconsinan	Pleistocene	Quaternary	Light type surfacing	Predominantly silt and clay with local accumulation of limestone gravel along with a lesser amount of siliceous sand and gravel.
0' to 86'	Loess		Wisconsinan and Illinoisan				
0' to 115'	Glacial Drift	Qgd	Kansan and Nebraskan			Light type surfacing	Consists primarily of clay and silt with concentration of sand, gravel and boulders at various horizons.
0' to 10'	High Terrace Deposits	Tt		Pliocene (?)	Tertiary	Light type surfacing	Chert gravel with smaller amounts of siliceous sand highly contaminated with silt and clay.

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



Thickness	Formations and Members		Map Symbol	Group	Series	System	Construction Materials	Generalized Description
2'+	Crouse Limestone			Council Grove Group	Lower Permian	Permian		
11.5' to 14.8'	Easly Creek Shale							
18.5' to 21.6'	Bader Limestone							
5' to 27'	Stearns Shale							
2.5' to 3.0'	Morrill Limestone	Beattie Limestone	Pb				Light type surfacing and riprap	Basal unit is a light gray massive limestone, which is overlain by a silty, calcareous light gray to gray shale. Upper unit composed of two limestone beds separated by a shale unit. The upper unit being a hard, dense limestone and the lower bed a soft bed which weathers shaly.
5.5'	Florena Shale							
5.5' to 7.1'	Cottonwood Limestone							
30.5' to 52.0'	Eskridge Shale							
5.4' to 15.3'	Neva Limestone	Grenola Limestone	Pg				Light type surfacing and riprap	Interbedded soft limestone and shales with the upper limestone unit being the most significant material source. It is characterized by alternating beds of limestone and shale with the upper part being soft, shaly tan-gray limestone underlain by a fairly massive brownish-gray limestone.
3.5'+	Salem Point Shale							
6.8'+	Burr Limestone							
3.0'+	Legion Shale							
2.0'+	Sallyards Ls.							
27.3' to 34.3'	Roca Shale							
9.8'+	Red Eagle Limestone							
15'+	Johnson Shale							
57.5' to 71.5'	Foraker Limestone							
34.0' to 54.0'	Janesville Shale			Admire				
3.3' to 4.4'	Falls City Limestone							
58.8' to 59.7'	Onaga Shale							
25.1'	Wood siding Formation			Wabaunsee	Upper Pennsylvanian	Pennsylvanian		
44.0'+	Root Shale							
22.0'+	Stotler Limestone							
40.0'	Pillsbury Shale							
2.0'	Maple Hill Limestone	Zeandale Limestone	₽t				Light type surfacing. Aggregate when processed suitable for bituminous and concrete construction.	A massive, hard, gray-brown to tan-brown limestone which weathers to a rich brown color and breaks into a large angular blocks.
10.0'+	Wamego Shale							
5.0'+	Tarkio Limestone							
30.0'+	Willard Shale							
42.0'+	Emporia Limestone							
35.0'+	Auburn Shale							
8.0'+	Wakarusa Limestone	Bern Limestone	₽b				Light type surfacing and riprap, limited source of structural stone	Basal member consists of light brown, fossiliferous limestone and interbedded shale. Upper member consists of several limestone beds separated by thin shale partings with the upper unit being a hard, dense blue-gray limestone.
12.0'+	Soldier Creek Shale							
10.0'	Burlingame Limestone							
59.0'	Scranton Shale							

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

logic source bed. The county materials map, Plates I through VI, shows the geographic areas where construction materials source beds are exposed or near the surface.

Figure 7 (Page 19), lists the results of gradation and quality tests performed on samples taken from the various source units in Brown County. Figure 8 (Page 21), contains a tabulation of the different types of material available in the county, the beds from which each type can be produced, and the page number where the characteristics of the separate geologic source units are described.

The Pennsylvanian and Permian limestones in Brown County exhibit, for the most part, undesirable engineering properties. The extensive glacial deposits, although providing sources of sand and gravel, mask the rock units with excessive overburden which frequently precludes economical production from the limestone members. According to Mr. Albert Ross, Brown County Engineer (Personal Communication), Brown County imports most of its construction material from adjacent Doniphan and Atchison Counties. Only two material sites (SE¼ Sec.27,T2S,R17E and SW¼ Sec.15,T3S,R18E) were producing material at the time of this investigation (Sept. 1965). Material from Glacial Drift was being produced and used only for light type surfacing material.

<u>Pennsylvanian System, Wabaunsee Group</u>
<u>Bern Limestone Formation (Map Unit Pb)</u>

The Bern Limestone consists of three members which, in ascending order, are the Burlingame Limestone, Soldier Creek Shale, and the Wakarusa Limestone Members.

The Burlingame, the basal member, consists of several limestones separated by thin beds of shale. Generally the limestone is light brown and fossiliferous, with the uppermost bed encrusted with algae.

Even though good quality material is produced from the Burlingame in counties to the south, quality test results indicate that inferior rock is found in Brown County. The unit is difficult to produce because of the interbedded shale and the variability of the quality of the ledges. Tests completed on samples of the Burlingame taken in Brown County show a wide variation in engineering properties depending upon the horizon sampled (See Figure 7, Page 19), Even though only a limited amount of the Burlingame has been quarried in Brown County for local use, material from the unit can be used for riprap and crushed for aggregate for use as a light type surfacing material.

Exposures are limited, however, to the valley walls of the South Fork of Wolf River in the east-central part of the county. In most instances, a large amount of overburden would have to be removed in order to produce the unit because this part of the county is masked by glacial drift.

The upper member of the Bern Limestone is the Wakarusa which consists of several limestone beds separated by thin shale partings with most outcrops being covered with glacial drift. The Wakarusa is approximately seven feet thick with a 2.7 foot limestone ledge on top. This upper unit is a blue-gray, hard limestone and has been produced on a limited basis for structural stone. The Wakarusa may provide a limited source of good quality rock; however, no quality tests have been completed on this member in Brown County.

Plate IV shows the limited exposures of the Bern Limestone Formation in the county.

LOCATION	MATERIAL	PERCENT RETAINED 11/2	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: Burlington Limestone Member																					
NE¼,SE¼ Sec.10,T3S,R18E	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.40	-	-	53.8(A)	0.94	-	S.H.C. form 619,No. 7-6
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.32	-	-	58.6(A)	0.42	-	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.30	-	-	59.2(A)	0.95	-	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	-	-	42.0(B)	0.96	-	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.32	2.20	-	46.7(B)	0.94	5.15	
SOURCE OF MATERIAL: Burr Limestone Member																					
SE¼,NE¼ Sec.19,T1S,R15E	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.31	2.19	-	50.0(B)	0.94	5.74	S.H.C. form 619,No. 7-31
NE¼ Sec. 9,T3S,R15E	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.36	2.21	-	35.7(B)	0.90	-	S.H.C. form 619,No. 7-15
NE¼ Sec.10,T3S,R15E	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.42	-	-	35.6(B)	0.92	4.80	S.H.C. form 619,No. 7-14
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.41	-	-	31.7(B)	0.92	5.40	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.36	2.22	-	36.9(B)	0.88	6.51	
SOURCE OF MATERIAL: Neva Limestone Member																					
SE¼,SE¼ Sec.31,T3S,R15E	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.49	-	-	33.4	0.82	3.96	S.H.C. form 619,No. 7-18
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	-	-	35.1	0.78	4.67	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.47	-	-	40.3	0.72	5.47	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	-	-	37.9	0.74	4.79	
	Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	2.40	2.27		37.8	0.87	5.60	
SOURCE OF MATERIAL: Glacial Drift																					
NE¼,NW¼ Sec.18,T1S,R16E	Sand-Gravel	4	10	23	38	54	75	86	89	91	8	4.66	39	17	-	-	-	28.0(A)	0.85	-	S.H.C. form 619,No. Br.Co. 6
SE¼,SW¼ Sec.32,T1S,R17E	Sand-Gravel	-	1	6	14	22	30	45	92	95	4	3.05	-	-	2.61	-	107.3	27.3	0.97	1.01	S.H.C. form 619,No. 7-27
SE¼,NE¼ Sec.27,T1S,R17E	Sand-Gravel	-	1	3	7	14	39	64	77	89	8	2.93	-	-	2.54	-	98.7	-	0.95	1.48	S.H.C. form 619,No. MS 7-9
NW¼,SW¼ Sec.18,T3S,R17E	Sand-Gravel	-	-	-	-	1	3	9	29	71	28	-	-	2	-	-	-	-	-	-	S.H.C. form 619,No. 7-22
NE¼,NE¼ Sec.20,T3S,R17E	Sand-Gravel	-	-	-	-	-	-	4	55	87	11	-	-	2	-	-	-	-	-	-	S.H.C. form 619,No. 7-20
NE¼,SE¼ Sec.11,T3S,R17E	Sand-Gravel	-	-	-	1	2	6	26	59	87	-	-	19	2	-	-	-	-	-	-	S.H.C. form 619,No. 7-1
SW¼,NE¼ Sec.15,T3S,R18E	Sand-Gravel	-	-	1	2	5	13	37	81	96	2	2.35	-	0	-	-	-	-	-	-	
	Sand-Gravel	-	2	12	26	38	51	65	74	78	-	3.46	-	15	-	-	-	-	-	-	
NE¼,NE¼ Sec.31,T4S,R15E	Sand-Gravel	-	-	2	5	10	18	29	52	76	19	-	14	-	-	-	-	-	-	-	S.H.C. form 619,No. 7-13
	Sand-Gravel	-	-	10	20	29	38	52	71	85	11	-	14	1	-	-	-	-	-	-	
NE¼,NW¼ Sec.29,T4S,R15E	Sand-Gravel	-	-	8	16	26	38	57	81	92	6	-	-	0	-	-	-	-	-	-	S.H.C. form 619,No. 7-24
SW¼ Sec.22,T4S,R15E	Sand-Gravel	-	-	4	9	16	33	61	86	93	6	-	-	8	-	-	-	-	-	-	S.H.C. form 619,No. 7-25
SE¼,SE¼ Sec.23,T4S,R15E	Sand-Gravel	-	-	1	4	11	27	61	79	84	15	-	-	23	-	-	-	-	-	-	S.H.C. form 619,No. 7-21
	Sand-Gravel	-	-	2	5	11	30	78	91	92	7	-	-	26	-	-	-	-	-	-	
SOURCE OF MATERIAL: Alluvium																					
SE¼,NE¼ Sec. 9,T3S,R15E	Silt	-	-	-	-	-	-	-	1	3	9	35	14	-	-	-	-	-	-	-	S.H.C. form 619,No. 7-17
	Silt	-	-	-	-	-	-	1	2	6	11	35	15	-	-	-	-	-	-	-	
	Silt	-	-	-	-	-	-	-	-	1	4	35	12	-	-	-	-	-	-	-	
SW¼,SE¼ Sec.10,T3S,R15E	Silt	-	-	-	-	-	-	1	5	11	18	32	11	-	-	-	-	-	-	-	S.H.C. form 619,No. 7-16
	Silt	-	-	-	-	-	-	-	2	5	9	35	13	-	-	-	-	-	-	-	
	Silt	-	-	-	-	-	-	-	1	2	4	34	12	-	-	-	-	-	-	-	

Figure 7. Results of tests completed on samples taken from the various material source units in Brown County.

Material Type	Geologic Source (map unit)	Description	Locality Where Available
Limestone	Bern Limestone (IPb)	Page 17	Very limited source, found in east-central part of county. Plate II and IV.
	Tarkio Limestone (IPt)	Page 22	Very limited source, found in southeastern part of county. Plate VI.
	Grenola Limestone (Pg)	Page 23	Limited source found in western 1/4 of county. Plates I, III, and V.
	Beattie Limestone (Pb)	Page 25	Limited source, found in northwestern 1/4 of the county. Plates I and III.
Chert Gravel	High Terrace Deposits (Tt)	Page 27	Very limited source, found in northwestern 1/4 of county. Plate I.
Fine Sand	Glacial Drift (Qgd)	Page 29	Limited source, found mainly in southern 1/2 of county. Plates III, IV, V and VI.
Sand and Gravel	Glacial Drift (Qgd)	Page 29	County wide but the amount of material available at each site is limited. All Plates.
Limestone Gravel	Alluvium (Qal)	Page 33	Very limited source, found mainly in central part of county. Plate III.
Silt (binder)	Alluvium (Qal)	Page 33	Found in alluvial valleys. All Plates

Figure 8. A summary of the construction materials types and their availability in Brown County.

Pennsylvanian System, Wabaunsee Group
Tarkio Limestone Member (Map Unit IPt)

The Tarkio is the basal member of the Zeandale Limestone Formation. It is a massive, hard, gray-brown to tan-brown limestone containing a large number of fossils and averages about five feet in thickness in Brown County. It weathers to a rich brown color and breaks into large angular blocks. It has not been quarried in Brown County mainly because of the limited number of exposures and the thick overburden of glacial drift. It has been produced by Concrete Materials Division of Martin-Marietta at a site one mile south of Horton in northern Atchison County; however, the hardness of the ledge is variable, and the rock must be selected in the outcrop in order to avoid soft zones. Figure 9 (Page 22), shows the Tarkio at this site.

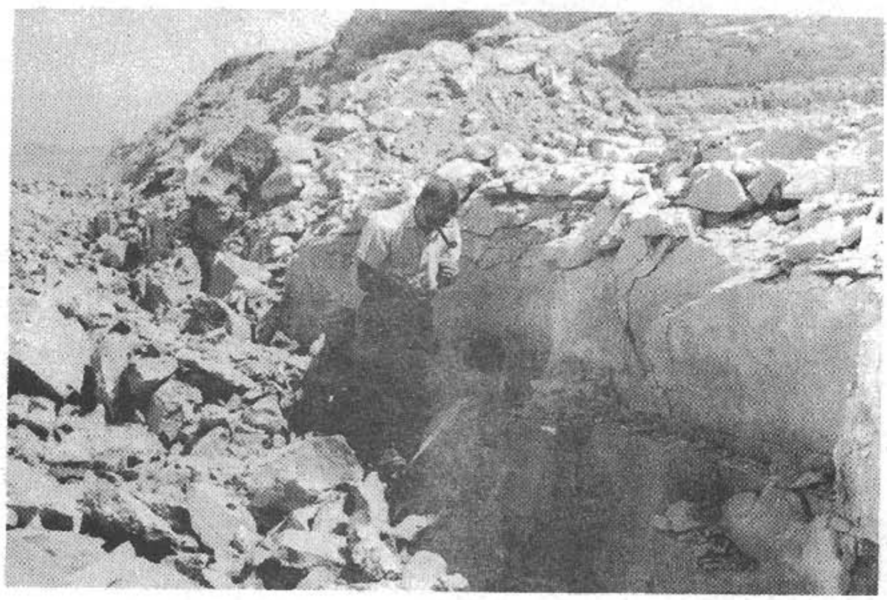


Figure 9. The Tarkio Limestone in a quarry near the south boundary of Brown County.

Test results on samples from this quarry show the following characteristics: specific gravity(saturated) 2.61, specific gravity(dry) 2.52, percent absorption 3.57, and Los Angeles Wear 30.8.

The Tarkio can be used for light type surfacing material and generally will meet specifications for bituminous and concrete construction.

Exposures of the Tarkio are limited to the southeastern corner of Brown County near Horton. (See Plate VI).

Permian Systems, Council Grove Group
Grenola Limestone Formation (Map Unit Pg)

The Grenola Limestone consists of five members which, in ascending order, are the Sallyards Limestone, the Legion Shale, the Burr Limestone, the Salem Point Shale, and the Neva Limestone Members. The Neva is the most widely used member for materials purposes and, therefore, makes up most of this map unit as it is used in this report. Even though the Burr is relative insignificant as a source of large quantities of material, it is included as the basal member of the map unit to help identify the formation in the field.

In adjacent areas, the Burr consists of several limestone units separated by beds of shale; however, only the basal limestone is significant as a source of construction material. This basal unit is a hard, gray, fossiliferous limestone about one foot in thickness, which weathers to a tan-gray color. Several quality tests have been completed on samples taken in Brown County, the results of which are listed in Figure 7 (Page 19).

The Neva Limestone consists of alternating beds of limestone and shale. The upper part of the unit is soft, shaly, tan-gray limestone underlain by fairly massive brownish-gray limestones. The limestone beds in this unit are also fossiliferous and porous. Figure 10 (Page 24), shows a piece of weathered limestone from the

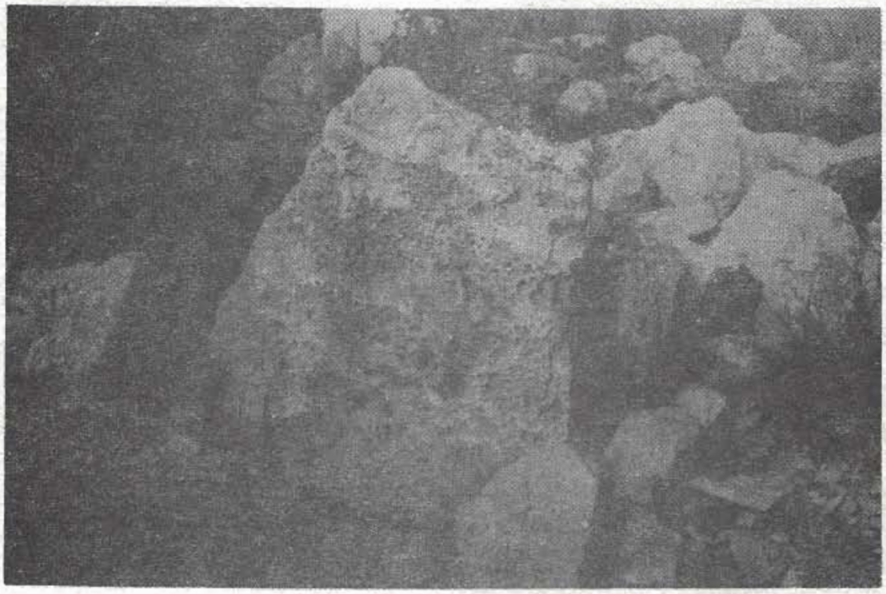


Figure 10. An example of the porous nature of the Neva Limestone in a quarry located in the SE¼ Sec.31, T3S, R15E.

Neva illustrating the porous nature of the rock. Figure 11 (Page 24) shows an outcrop in the basal part of the Neva. Total thickness of the unit is about 13 feet.

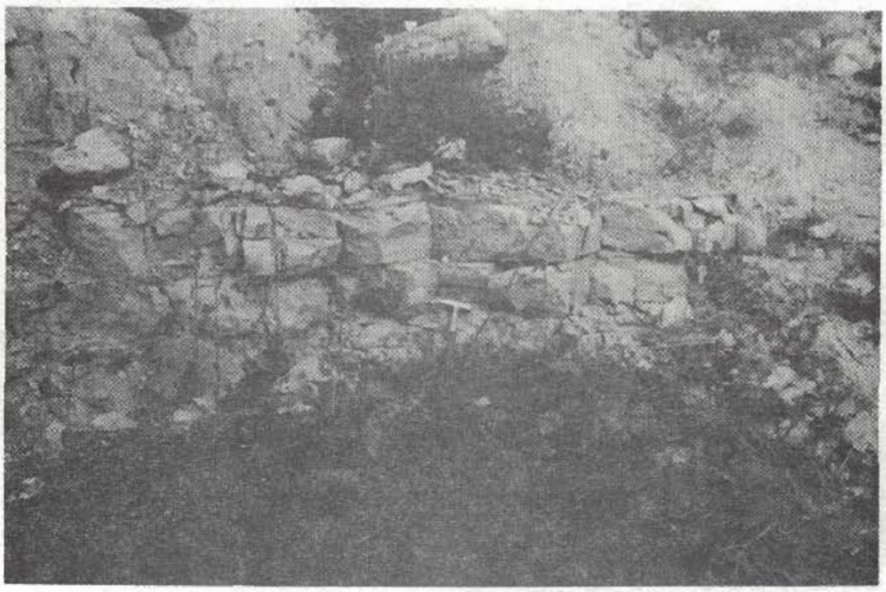


Figure 11. Exposure of the basal portion of the Neva Limestone in an abandoned quarry located in the SE¼ Sec.31, T3S, R15E.

Results of quality tests indicate that the material will not meet most specifications for bituminous and concrete construction but will suffice for light type surfacing material and riprap. Test results are listed in Figure 7 (Page 19).

Exposures of the Grenola are limited to the western part of the county. See Plates I, III, and V for geographic areas where the Grenola is exposed or near surface.

Permian System, Council Grove Group
Beattie Limestone Formation (Map Unit Pb)

The Beattie Limestone consists of three members which, in ascending order, are the Cottonwood Limestone, the Florena Shale, and the Morrill Limestone Members. The total thickness of the formation is about 12 feet.

The Cottonwood, which is the most important member for material purposes, is a light gray massive limestone which is approximately 5.5 feet thick. In Brown County it is characterized by chert nodules and contains abundant fusulinids. Results of quality tests indicate that the Cottonwood is not as hard in northern Kansas as in the central part of the state. Only a very limited amount of the Cottonwood has been quarried in Brown County. No quality tests have been conducted on samples taken in the county but tests results on samples taken in Nemaha County to the west are as follows:

	Specific Gravity (Wet)	Specific Gravity (Dry)	LA Wear	Soundness (25 Cycles)	Absorption
Sample 1	2.36	2.20	51.0%	.69	7.33
Sample 2	2.39	2.28	48.5%	.77	4.89
Sample 3	2.39	2.28	39.0%	.87	4.69
Sample 4	2.47	2.36	46.5%	.78	4.64

In general, the Cottonwood will not meet all specifications for bituminous and concrete construction but could be used as a source of light type surfacing material and riprap. Exposures are limited to the northwestern part of the county. Figure 12 (Page 26), shows the basal part of the Cottonwood Limestone.

In counties to the west, the Cottonwood and the Morrill Limestones are sometimes produced from the same quarry. In such cases the intervening shale unit (Florena Shale) is usually less than one foot thick, but it varies from three to six feet in thickness in this county.

The Morrill consists of two limestone units separated by a shale bed. The upper bed is a hard, dense, gray limestone while the lower is soft and shaly. Total thickness is approximately three feet. No samples of the Morrill, taken in Brown County, have been tested.

Figure 12. The basal portion of the Cottonwood Limestone Member in the SW¼ Sec.30, T1S, R15E.

Even though the material from the upper bed may meet most specifications for bituminous and concrete construction, the lower unit would provide a much inferior material.

Material from the Beattie could be used for light type surfacing material and riprap but would probably fail to meet specification for bituminous and concrete construction because of the high percentage of shale and soft limestone.

Exposures of the Beattie, which are restricted to the northwestern part of Brown County (See Plates I and III), are limited and usually covered with thick overburden.

Tertiary System, Pliocene(?) Series
High Terrace Deposits (Map Unit Tt)

Scattered Pliocene(?) terrace deposits cap the high terrain in northwestern Brown County. These terraces are composed of clay bound chert gravel and are usually less than ten feet in thickness. Figure 13 (Page 28), shows a pit from which chert gravel has been produced, and Figure 14 (Page 28), illustrates the textural aspects of these deposits.

Limited sampling and testing indicates that these deposits have a high percentage retained on the one inch and three-quarter inch sieves (10 to 20 percent). Approximately 15 to 20 percent of the material passed the number 200 sieve and had a plastic index that ranged from 17 to 36. No quality tests (Los Angeles Wear, absorption, or soundness) were performed. Washing would undoubtedly increase the material usefulness of these gravels; however, limited sources of water in the areas where the gravels are found restricts such a process. These deposits provide a good, but limited source of light type surfacing material. Several sites have been depleted, but other localities in the general area will

Figure 13. A chert gravel pit in High Terrace Deposits, SW¼ Sec.8, T1S, R15E.

Figure 14. An exposure of chert gravel in High Terrace Deposits illustrating the coarse fraction of the material, SW¼ Sec.8, T1S, R15E.

provide a similar material; however, overburden thickness may be a problem in some localities.

Prospective areas were selected on the basis of topographic position, drainage characteristics, and proximity of open sites and are depicted on Plate I.

Quaternary System, Pleistocene Series
Glacial Drift (Map Unit Qgd)

This map unit represents material that has been deposited by the various glacial processes. The unit is wide spread, covering all of the county except along major drainage channels and in the northwestern corner. It consists mostly of clay and silt size particles with zones of fine and coarse sand, gravel, and various sized boulders. The sand and gravel are predominantly siliceous, however, other igneous and metamorphic rocks are present. Glacial drift in Brown County may have a thickness of at least 115 feet with various types of construction material present at any horizon; however, only a few of the granular deposits can be traced over a large area. One such area is located in the southeastern corner of the county about one mile west of the town of Everest. According to Bayne and Schoewe, an old drainage channel, which was active during Kansan time, trends north-south and may extend north and northwest to an area about one mile northeast of the community of Baker where outwash gravel is exposed in several pits. Drill logs obtained from the Kansas State Geological Survey indicate 16 feet of overburden was encountered along the south boundary of Section 36, T4S, R17E and Section 31, T4S, R18E (Plate VI) with 30 to 45 feet of moderately well sorted quartz sand with some granitic and metamorphic rocks present. Two miles north in the southwest corner of Section 19, T4S, R18E, 30 feet of overburden and 36 feet of granular material were encountered. To the north and northeast the amount of overburden increases; however, in the northwestern corner of Section 19, T4S, R18E, only 16 feet of overburden was encountered because of the erosive action of a tributary of the Delaware River. Fine and coarse sand is being pumped from the buried channel two miles south of the town of Everest in northern Atchison County. Figure 15 (Page 30), is a ground photograph of this site. Notwithstanding the overburden, this buried channel is the best source of construction material in Brown County.

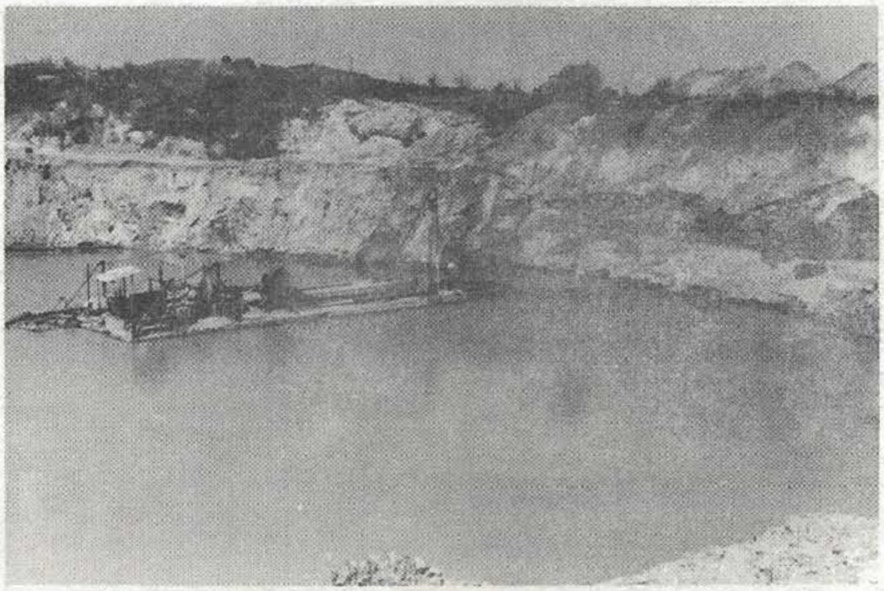


Figure 15. Sand and gravel being produced from Glacial Drift by pumping operations in northern Atchison County.

Elsewhere in the county a large variety, but somewhat limited amount, of construction materials have been encountered. In general, fine sand has been produced in the south-central part, sand and gravel with some larger erratics in the southwestern, central and east-central parts, and sand and gravel with some limestone gravel in the northeastern part of the county; however, the gradation and quality of the material are highly variable from one site to another. Test results on samples taken from several sites are listed in Figure 7 (Page 19). Figure 16 (Page 32), shows a pit located in glacial drift, while Figure 17 (Page 32), illustrates a change in material texture which is typical of such sites.

Because of the heterogeneous and inconsistent nature of the glacial drift, extension of ground data was impossible, and deposits could not be correlated from one area to another; however, some of the more promising areas have been mapped on the basis of drainage characteristics, photographic tone and color, conditions observed that are similar to those where known deposits are located, topography, and information obtained from the Brown County soil conservation maps compiled by the United States Department of Agriculture. Some prospective areas were drilled during this investigation by the State Highway Commission First Division Materials Engineer, during which time some of the clues were proven to be useful; however, the information extracted from such clues was limited to the possible location of granular material and did not reveal the quality of material that might be present. For example, in some areas extensive seeps in the drift were used to locate prospective granular material sites. Because other geologic factors were involved, the size of the seep was not an indication of the type or the amount of granular material that might be present. Subsequent field investigation and drilling of two seep areas revealed that 20 feet of clay-bound fine sand was carrying water at one location while at the other, seepage was caused by a foot of good quality sand and gravel; therefore, the prospective areas depicted on Plates I through VI should not be

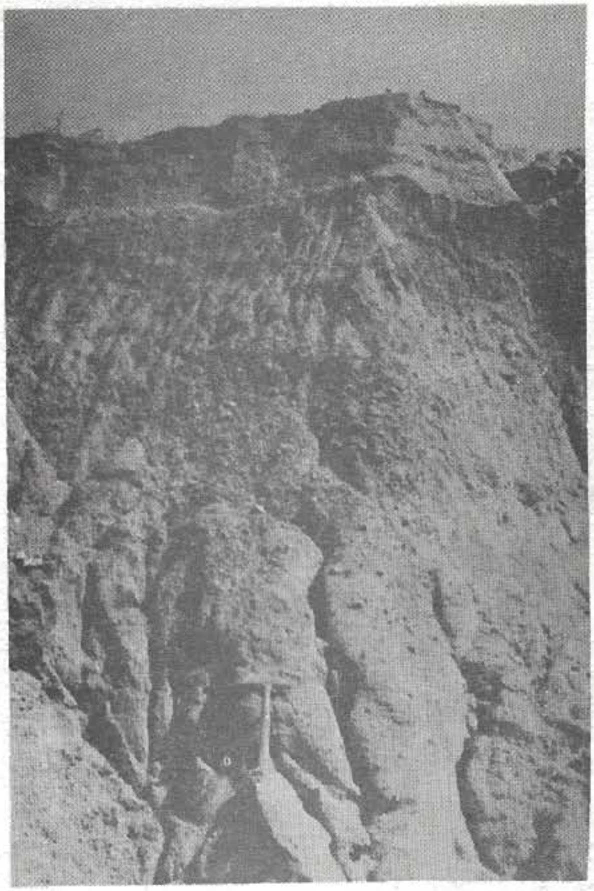


Figure 16. Sand and gravel pit in Glacial Drift, SW¼ Sec.32, T1S, R17E.

Figure 17. An illustration of material textural change in Glacial Drift in the SW¼ Sec.32, T1S, R17E.

interpreted as meaning that a particular type or quantity of material is present, but rather as an area which has characteristics similar to those where known deposits of granular material are located. Exploratory drilling will have to be completed in order to obtain information concerning the quality and quantity of material that may be present.

Most of the test holes drilled during this investigation encountered material similar to that exposed in the open pits (i.e. fine sand to gravel, highly contaminated with silt and clay). Even though most of the open sites have been abandoned in Brown County, they have been shown on the Brown County materials map because exposures of the various types of material can be observed in the field at these localities, and some of the sites may be expanded in the future.

Material from glacial drift has been used primarily for light type surfacing. If properly processed and washed, some of this material would meet specifications for most phases of construction; however, in most cases a large volume of material would have to be processed in order to obtain a feasible amount of useable aggregate. A limited supply of water for washing purposes also restricts such a process.

<u>Quaternary System, Wisconsinan and Recent Series</u>
<u>Alluvium (Map Unit Qal)</u>

The valleys of the major drainage channels in Brown County are filled with alluvium deposited during the Wisconsinan and Recent Stages. This material, which has a maximum thickness of 55 feet, is composed, essentially, of clay and silt with local concentrations of sand and gravel. Most of the coarser material is limestone gravel with small amounts of siliceous sand. Figure 18 (Page 34)

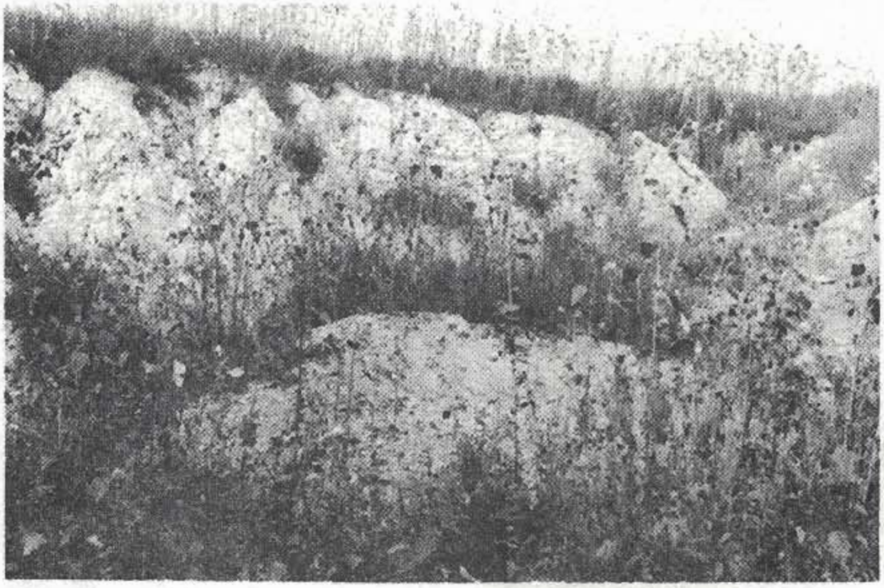


Figure 18. A limestone gravel pit in the Alluvium which has been abandoned because of the high percent of clay and silt size particles, NE¼ Sec.32, T2S, R16E.

shows an abandoned pit in this source unit illustrating the high percentage of fine material.

The use of this material for construction purposes is limited to light type surfacing material because of its soft nature and the presence of a high percent of silt and clay. Even though deposits of this age are present in all parts of the county, the main concentration of granular material suitable for construction purposes is located in the west-central part of the county in Spring Creek valley. Open sites and prospective areas are shown on Plate III.

Geo-Engineering

This section of the report discusses the quality of material available in Brown County for normal or selected embankment purposes and for subgrade construction. Ground-water problems that may be encountered on construction projects and the availability of water suitable for concrete mixing purposes are also briefly reviewed.

The geo-engineering problems facing highway engineers in Brown County are typical of those to be found in other glaciated areas of northeastern Kansas. The prime objective of this section of the report is to provide the reader with a general familiarization with some of the adverse field conditions to be expected and the engineering properties of the material that may be encountered in the county. Detailed field investigations will be required to ascertain the severity of specific problems and to make recommendations concerning design and construction procedures.

Material Usage Considerations

Virtually all highway construction in Brown County will contact glacial till or drift. This material is characterized by high swell properties, excessive liquid limits, and plasticity indices that range from 11 to 54. Soil Survey Reports indicate an average plastic index of 26 on samples of this glacial material. The samples were classified, with respect to the Kansas State Highway system of nomenclature, as silty clay, silty clay loam, clay loam, and clay which correspond to the American Association of State Highway Officals classifications of A-6 and A-7, based on liquid limits and plasticity indices.

Loess deposits are found capping the high terrain of central Brown County, and thick deposits (maximum of 86 feet) generally blanket the northeastern portion of the county. Laboratory results and field observations indicate that the plasticity index will generally exceed the specified maximum for use as mineral filler. The material should, however, provide selected borrow for embankment and subgrade construction.

Highly plastic shales may be encountered in highway construction in the northwestern part of the county and, possibly, near the Delaware River and other major drainages. These units will generally display unsound engineering properties which will make their use in shoulder and subgrade construction undesirable. These plastic clays and shales may be utilized for slope protection because of their resistance to erosion; however, if development of a turf is desired, it is recommended that the stripped topsoil be stockpiled and used where feasible.

Where high embankments are required, sheer strength tests should be conducted on the material being utilized in the lower portions to insure that its capabilities will not be exceeded by the dead load of the overlying fill.

Possible Hydrology Problems in Road Construction

In the field of construction untold numbers of costly failures have developed through the improper control of the water movement or the lack of respect for the extreme pressure and force that water can exert in its various physical states.

This portion of the geo-engineering section of the report is intended to acquaint the reader with adverse situations which either do or may exist in Brown County.

The most widespread source of ground-water is the glacial drift which blankets most of Brown County. It is difficult to predict the occurrence of water in this material because of the erratic nature of its lithology. A specific situation often found in Brown County is the occurrence in the glacial drift of isolated sand pockets which usually carry ground-water.

Many of the shale units yield water from their included sandy and limy zones. The Roca Shale Formation of the Council Grove Group has a porous limestone which is an important aquifer in northwest Brown County. This bed thins to the south, and little or no water is produced.

When hydrology problems are encountered, it will be necessary to determine the severity of the situation and to provide appropriate drainage schemes to insure that the structure is protected from ground-water and surface runoff. In the case of the above mentioned sand pockets, it may be possible to cope with given problem areas by excavating special ditches or installing drains to intercept the water before it can enter the road structure.

Individual hydrological conditions will display their own peculiarities which will require field evaluation. This discussion is meant only to emphasize the importance of thorough investigations, and not to propose specific corrective measures.

Pollution of Water Resources

The utilization of ground-water for public, domestic, and industrial purposes is largely governed by the degree of mineralization. In this discussion, concern is with the availability of water in Brown County which is suitable for use in Portland Cement concrete. Water approved for domestic use is normally acceptable, but not in all cases. The sulfate ion, for instance, is difficult and expensive to remove, and because the human body can rapidly develop a tolerance to it, water with concentrations exceeding those recommended for concrete is sometimes allowed for domestic consumption.

In northwestern Brown County, water high in sulfate content is obtained from the Long Creek Limestone, Grenola Limestone, and Roca Shale.

Chlorides are not a problem at the depths reached by most wells in the county. Concentrations are generally low in the glacial drift and alluvial aquifers. Relatively shallow wells producing from a given bedrock unit may show low chloride content, while water from the same unit obtained from a well of greater depth may exhibit a marked increase in chloride concentration. Test results on a sample of water being produced from the Zeandale Limestone and Pillsbury Shale, at a depth of 125 feet, showed a chloride content of 4,275 parts per million. The only other samples tested from this horizon exhibited a chloride concentration of 49 parts per million, at a depth of 22 feet. Excluding the first result mentioned, the next highest was taken from glacial drift at a depth of 35 feet.

Most of the water resources of Brown County will be suitable for use in concrete mixes; however, it is recommended that chemical analyses be conducted to insure that the mineralization is within specified limits.

GLOSSARY OF SIGNIFICANT TERMS

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

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

Aquifer: Geologic formations of units that are water-bearing.

Coarse sand: An aggregation of unconsolidated mineral or rock particles the dimension of which are usually considered to be less than two millimeters and more than five tenths of a millimeter. The term refers to size of grain and not composition; however, since most sands are composed of quartz and is used without qualification, a siliceous composition is implied.

Fine sand: An aggregation of unconsolidated mineral or rock particles the dimension of which are usually considered to be less than five tenths of a millimeter and greater than five hundredths of a millimeter. The term refers to size of grain and not composition; however, since most sands are composed of quartz and is used without qualification, a siliceous composition is implied.

Geologic era: Largest unit of geologic time. Paleozoic, Mesozoic and Cenozoic are examples of eras.

Geologic period: A unit of geological time, smaller than an era and larger than an epoch. Cambrian, Cretaceous, and Tertiary are examples of periods.

Geologic system: A term that refers to rocks or deposits that were laid down during a particular geologic period.

Geologic unit: A term used in this report to denote a geologic formation, a geologic member, or an unconsolidated deposit of Pleistocene age.

Glacial drift: A general term for all rock debris which has been transported and deposited either directly by the ice or from the accompanying meltwater of the glacier.

Glaciolacustrine: A term applied to deposits made in lakes whose borders were affected by glacial ice or by water flowing directly from glaciers.

Gradation factor: Sometimes referred to as the fineness modules, the value obtained by adding the percentages of material retained on the 1½", 3/4", 3/8", 4, 8, 16, 30, 50, and 100 sieves respectively and dividing the sum by 100.

Granitic rocks: A term applied to igneous rocks that have essentially a coarse texture and a relatively high percent of silica.

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

Kansan Stage: Deposits that were laid down during the time that the Kansan glacier was active.

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

Liquid limit: Determined by tests performed in accordance with Section Y-4 of the State Highway Commission of Kansas Standard Specifications, 1960 edition.

Lithology: Physical properties such as grain size, mineral content, color, etc.

Metamorphic rocks: Rocks derived from the alteration of preexisting rocks due to heat and pressure.

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

Outwash: Material that is carried by glaciers and, subsequently, transported and deposited by glacial meltwater.

Plastic index: Determined by tests performed in accordance with Section Y-4 of the State Highway Commission of Kansas Standard Specifications, 1960 edition.

Pleistocene Series: Deposits laid down during the Pleistocene Epoch.

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 Y-15 of the State Highway Commission of Kansas Standard Specifications, 1960 edition.

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

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

Strength Ratio: Determined by tests performed in accordance with A.A.S.H.O. Designation T 71.

Terrace: An elevated plain of sediments deposited by a stream in the earlier geologic history of that stream.

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 19-45.

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