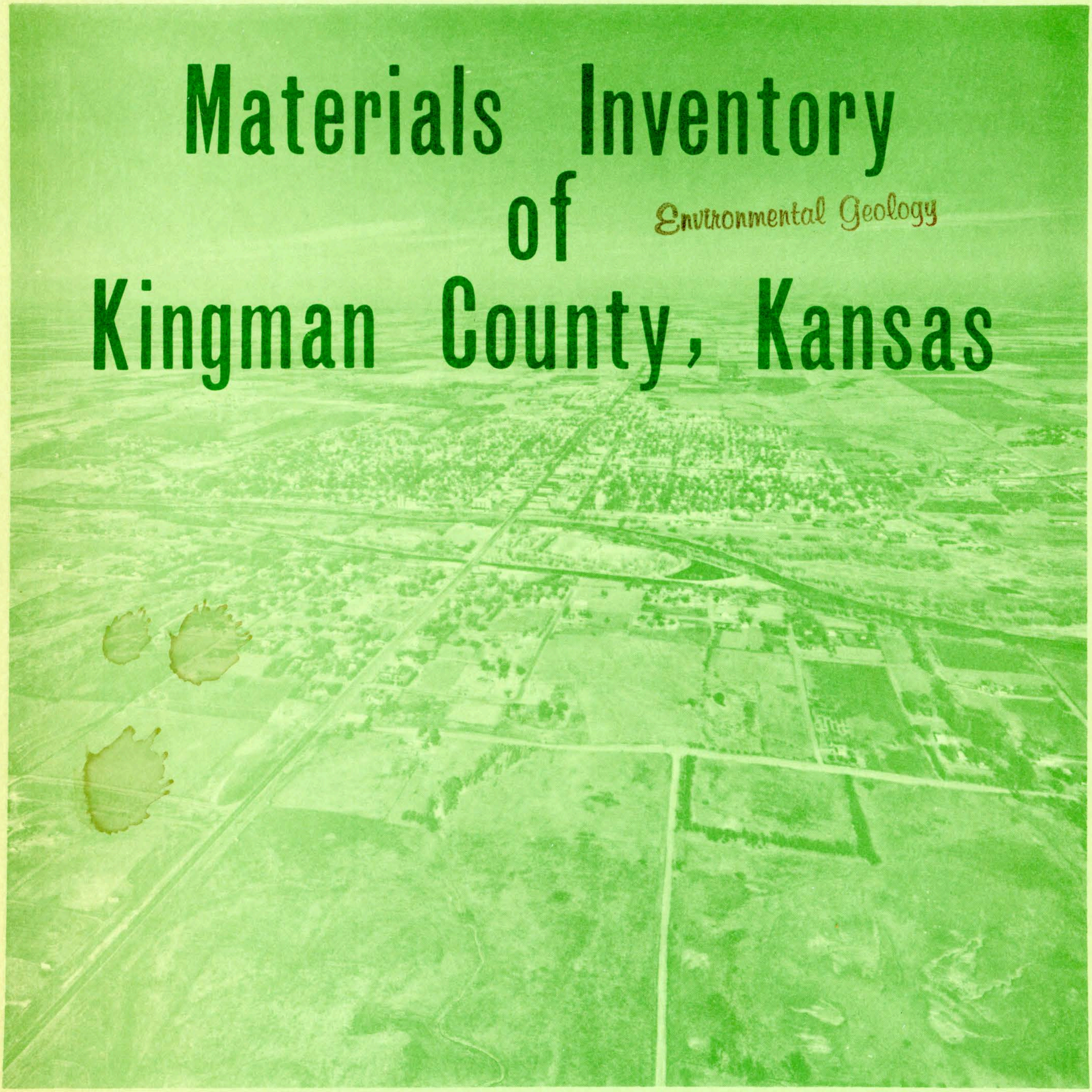
Materials Inventory of Kingman County, Kansas



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 KINGMAN COUNTY, KANSAS

BY

Gerald D. Hargadine, Geologist

Assisted by
Robert L. Kibby
Photogrammetry Section

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

1966

Materials Inventory Report No. 12

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

SUGGESTED USE OF THE REPORT

The *Materials Inventory of Kingman County* is the twelfth report of a series of county materials inventories prepared by the State Highway Commission of Kansas in cooperation with the Bureau of Public Roads. The report includes: 1. an introduction which describes the nature of the report and gives general information concerning Kingman 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. a geo-engineering section to acquaint the engineer with geologic problems which may be encountered in highway construction; 5. county materials maps (plates I through VI) which show the geographic locations where the various source beds can be found in the county, along with the locations of all open and prospective material sites, and 6. appendices I through IV which contain site data forms for each open and prospective materials site. Each site data form has a sketch showing the materials site and surrounding landmarks, the name of the geologic source bed, and a resume' of all test data available for the site.

When this report is used as a guide for planning an exploration program or making an assessment of the material resources of Kingman 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 Material Resources of Kingman County." In this portion of the report, a geologic history of Kingman 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 Kingman County are also inventoried in this portion of the report. A study of the inventory will reveal the type of materials 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 may contain material that will meet his requirements, he should then refer to the county materials maps. From these maps he can find the best areas to look for this material, the locations of sites which have produced material from the source, the locations of prospective sites in the source bed, and references to site data forms for each open and prospective site.

For example, the reader determines from the Construction Materials Inventory that sand and gravel in the Holdrege and Fullerton Formations may fulfill the materials specifications for a project in the north-central part of the county. The materials map (plate I) shows several pits in this area. If the reader is interested in site $\frac{\text{SG+28}}{\text{Qnf}}$, he refers to appendix II where detailed information about this particular site is given on the site data form. This information will enable him to plan his exploration program in a more 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, "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 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 to 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 investigations had been completed in Kingman County; however, two reports of particular usefulness in this project include "Geology and Ground-water Resources of Kingman County, Kansas" (1960) by C. W. Lane and "Pleistocene Geology of Kansas" (1952) by J. C. Frye and A. B. Leonard which were published by the Kansas Geological Survey. 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 which traverse Kingman County; however, available information on materials suitable for construction purposes has been very meager.

Aggregate quality test results, pertinent information pertaining to the materials produced, and some geologic data on Kingman 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 J. D. McNeal, Engineer of Planning and Research; the project leader, R. R. Biege, Jr., Engineer of Aerial Surveys and the Photogrammetry Section; and A. H. Stallard of the Photogrammetry Section. Appreciation is extended to R. E. Fry, Division Materials Engineer, and J. E. Watson, Kingman County Engineer, for verbal information on the material resources of the county.

CONTENTS

ILLUSTRATION INDEX

SITE DATA FORM INDEX

MATERIALS MAP INDEX

ABSTRACT

Kingman County has an area of 864 square miles and had a population of 10,242 in 1966. It is located in south-central Kansas and lies in the High Plains and the Red Hills-Wellington Area physiographic divisions of Kansas. A well developed system of all-weather roads serves the area and nearly all communities are served by a railroad.

Several material source beds are available in Kingman County which include the following map units: Ogallala Formation(?), Holdrege and Fullerton Formations, Grand Island and Sappa Formations, Crete Formation(?), Dune Sand, and Alluvium.

Small amounts of Ogallala(?) sand and gravel have been taken from the northeastern part of Kingman County. It is composed of red-brown calcareous silt, fine to coarse grained sand, and fine to coarse gravel and cobbles. A unique feature of the unit is an abundance of ironstone pebbles. This material has not been used extensively but has been used for light type surfacing material on rural roads in the northeast part of the county.

The Holdrege Formation (Holdrege and Fullerton map unit) is one of the most important sources of sand and gravel in Kingman County. The Holdrege is composed of fine to coarse sand and gravel with some sandy silt and clay. The material from the Holdrege has been used in concrete and bituminous mixes as well as for surfacing material on lightly traveled rural roads. The Fullerton, which overlies the Holdrege, contains abundant clay and sandy silt with some caliche accumulation.

The Grand Island and Sappa Formations have been mapped as one material source unit. The Grand Island, which underlies the Sappa, is composed of fine to coarse sand and gravel with minor amounts of silt and is suitable for concrete and bituminous aggregate as well as light type surfacing material for rural roads. The Sappa is composed of clay, silt, and fine sand with scattered deposits of volcanic ash. The ash is of major significance as a source of mineral filler.

Deposits of silt, sand, and gravel believed to be the Crete Formation(?) are found in northeastern Kingman County. The Crete(?) has not been used for material purposes but is a potential source for light type surfacing material.

Dune Sand is found in several scattered areas in Kingman County. The dunes are composed of fine to medium sand containing some silt. This material may be useful in base course construction as well as mineral filler.

The Alluvium of the major drainage is closely associated with Wisconsinan deposits and, therefore, the two have been included in the Alluvium map unit. The material which comprises these deposits is composed of silt, sand, and fine gravel derived from older

Pleistocene deposits. This material may be useful for bituminous and concrete aggregate as well as for light type surfacing material.

Material derived from some geologic units exposed in Kingman County display unsound engineering properties under certain circumstances. Because these units will be encountered in Kingman County, certain geo-engineering problems can be anticipated in some phases of highway construction. Other problems, which may be of concern, are ground-water problems in road construction and mineralization of water resources when the water is considered for use in Portland Cement concrete.

INTRODUCTION

Purpose and Scope

The purpose of this investigation is to present information concerning the availability, location, and nature of deposits of material for use in highway construction and similar projects in Kingman County. Geologic units which are considered to be potential geo-engineering problems are also mapped and described. The term, "construction material," as used in this report, includes all of the granular material which, in its natural state or through the 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 material source beds are a product of geologic agents, the materials inventory program is based, largely, on the geology of the county being investigated. By adapting geologic nomenclature to materials inventories, a uniform system of material source bed classification is established, although the quality of material that can be produced from a given source bed may vary from one county to another, especially with unconsolidated deposits. In most cases, the geologic name attached to unconsolidated deposits denotes age and not material type; therefore, deposits which were laid down during the same time in different parts of the state may have the same geologic name 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.

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

Mapping 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 silt, sand, and gravel are very abundant in Kingman County, but are somewhat difficult to map because of their erratic nature; however, some mapping of the unconsolidated deposits can be done on aerial photographs by having a knowledge of the county geology and by interpreting significant terrain features that are discernible on the photographs.

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

General Information

Kingman County has an area of 864 square miles and a population of 10,242 according to figures compiled in 1966 by the Kansas State Board of Agriculture. It lies in the High Plains and the Red Hills-Wellington Area physiographic divisions of Kansas and is bounded by parallels 37° 23' and 37° 44' north latitude and meridians 97° 48' and 98° 28' west longitude. The county is bordered on the north by Reno County, on the east by Sedgwick and Sumner Counties, on the south by Harper and Barber Counties and on the west by Barber and Pratt Counties.

An index map showing the location of Kingman County, along with the location of other counties currently included in the materials inventory program is shown in figure 1.

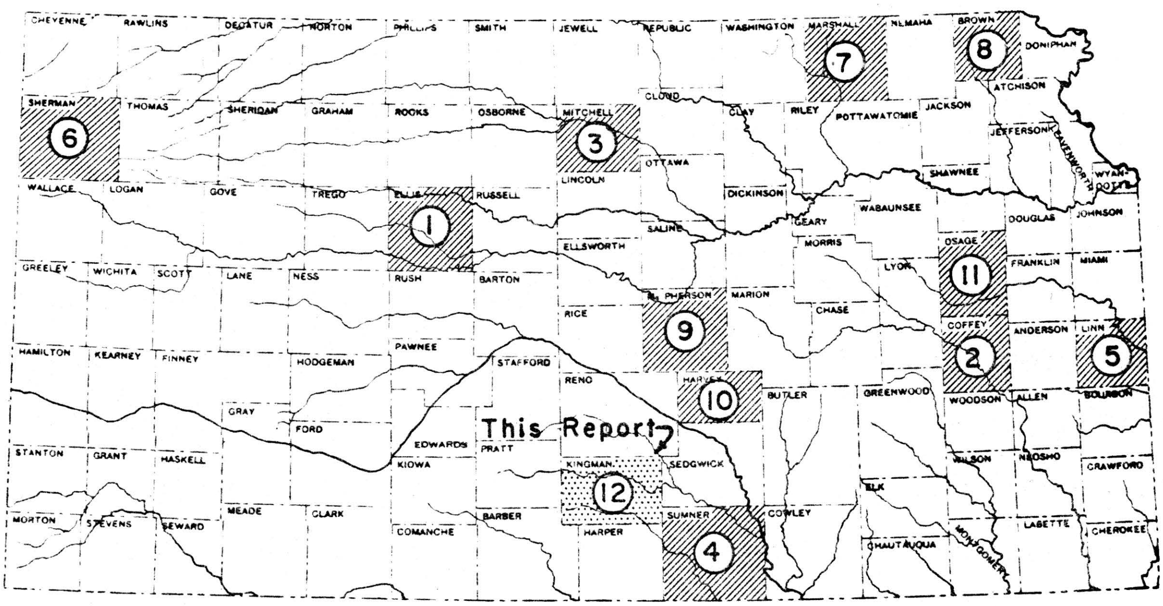


Figure 1. Index map of Kansas showing the location of Kingman County along with the report number and location of counties for which reports are published or are being prepared.

The surface drainage in Kingman County is controlled, basically, by the South Fork Ninnescah River, the Chikaskia River, and their tributaries. A small area in the northeast corner of the county is drained by the North Fork Ninnescah River.

Kingman County is served by two railroad systems, the Atchison, Topeka, and Santa Fe and the Missouri Pacific. All of the towns in the county are served by a railroad except Mt. Vernon, Midway, St. Leo, and Willowdale.

The county is served by more than 100 miles of asphalt and (or) concrete surfaced federal and state highways. U. S. Highway 54 traverses the northern half of the county from east to west, and Kansas Highway 42 crosses the southern half of the county, roughly paralleling

Highway 54. Kansas Highway 14 extends north-south through the center of the county, and Kansas Highway 17 enters the county near the northeast corner and terminates at U. S. Highway 54. The southeast corner of the county is crossed diagonally by Kansas Highway 2.

A well developed system of county and township roads serves the county except in areas of major drainage (where a bridge is necessary for the road to continue). Most of the county roads also have some type of all-weather surfacing.

PROCEDURES

The procedure followed in completing this report is divided into the following four phases: 1. research and review of existing publications, maps and other data; 2. aerial photographic interpretation on a county wide basis; 3. field reconnaissance survey; and 4. report writing and completion of the illustrations. With the exception of the first, the phases of this investigation were not handled as a separate operation but were completed contemporaneously. A detailed discussion of the steps followed in each phase is included in this section of the report.

Phase I Research of Available Information

Available information pertaining to the geology, soils, and construction material resources of Kingman County was reviewed, and the general geology of the county, relative to construction materials, was determined. The results of quality tests, already completed on samples taken in Kingman County, were correlated with the various geologic deposits in the county.

Phase II Aerial Photographic Interpretation

The aerial photography used in this investigation was taken by the State Highway Commission of Kansas, April 8, October 6, and October 12, 1965 at a scale of 1:24,000 (one inch represents 2,000 feet). Figure 2 (page 6), is a photographic coverage map of Kingman County.

The initial investigation involved a study of the entire county on aerial photographs. As the photo interpretation operation proceeded, all open material sites were located on the photographs and transferred to a cronar base map. Distinction was later made as to whether test information was available on the sites and, subsequently, delineation was made between "open sites; sampled" and "open sites; not sampled." Locations which have available test information but have not been opened as a materials site were also plotted on the base map. All material site locations were then correlated with the geology of the county. Figure 3 (page 7) illustrates the photo interpretation procedure.

The aerial photograph shown in figure 3 (page 7) illustrates a portion of the South Fork Ninnescah River and its associated deposits. When this area is viewed stereoscopically, the boundaries between the different deposits can be delineated. The immediate floodplain area is occupied by Recent Alluvium. A distinct break in the terrain marks the division between the Recent Alluvium and the older terrace which is termed the Holdrege and Fullerton Formations. A small area along the south valley wall may contain Permian red beds with variable colluvial cover. Good quality construction material has been produced from the Holdrege and Fullerton in pits along the north side of the river.

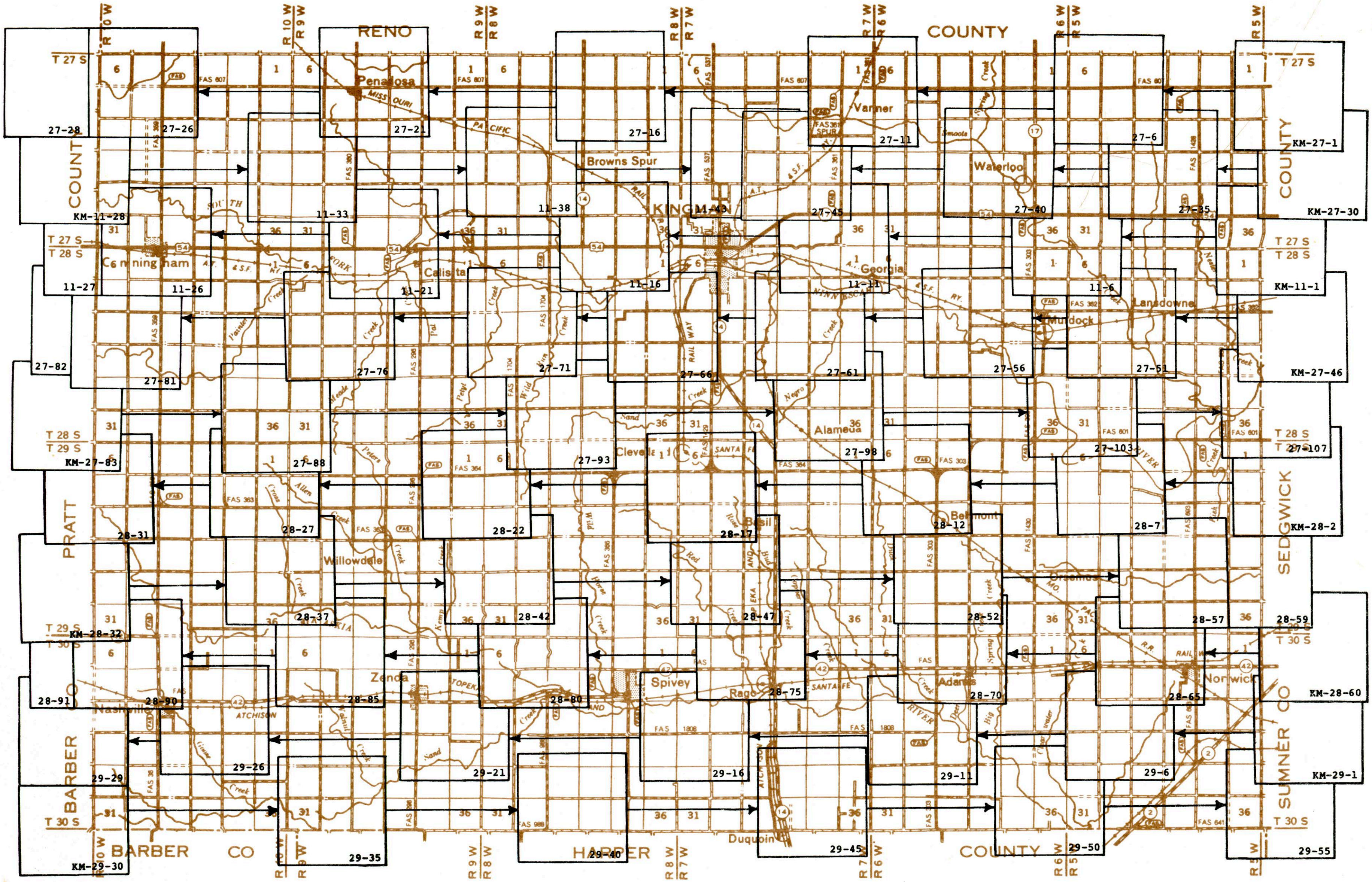


Figure 2. Aerial photographic coverage map of Kingman County. The numbers which are underlined indicate photograph numbers on flights taken by the Photogrammetry Section, State Highway Commission of Kansas, April 8, October 6, and October 12, 1965, at a scale of 1:24,000. Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas

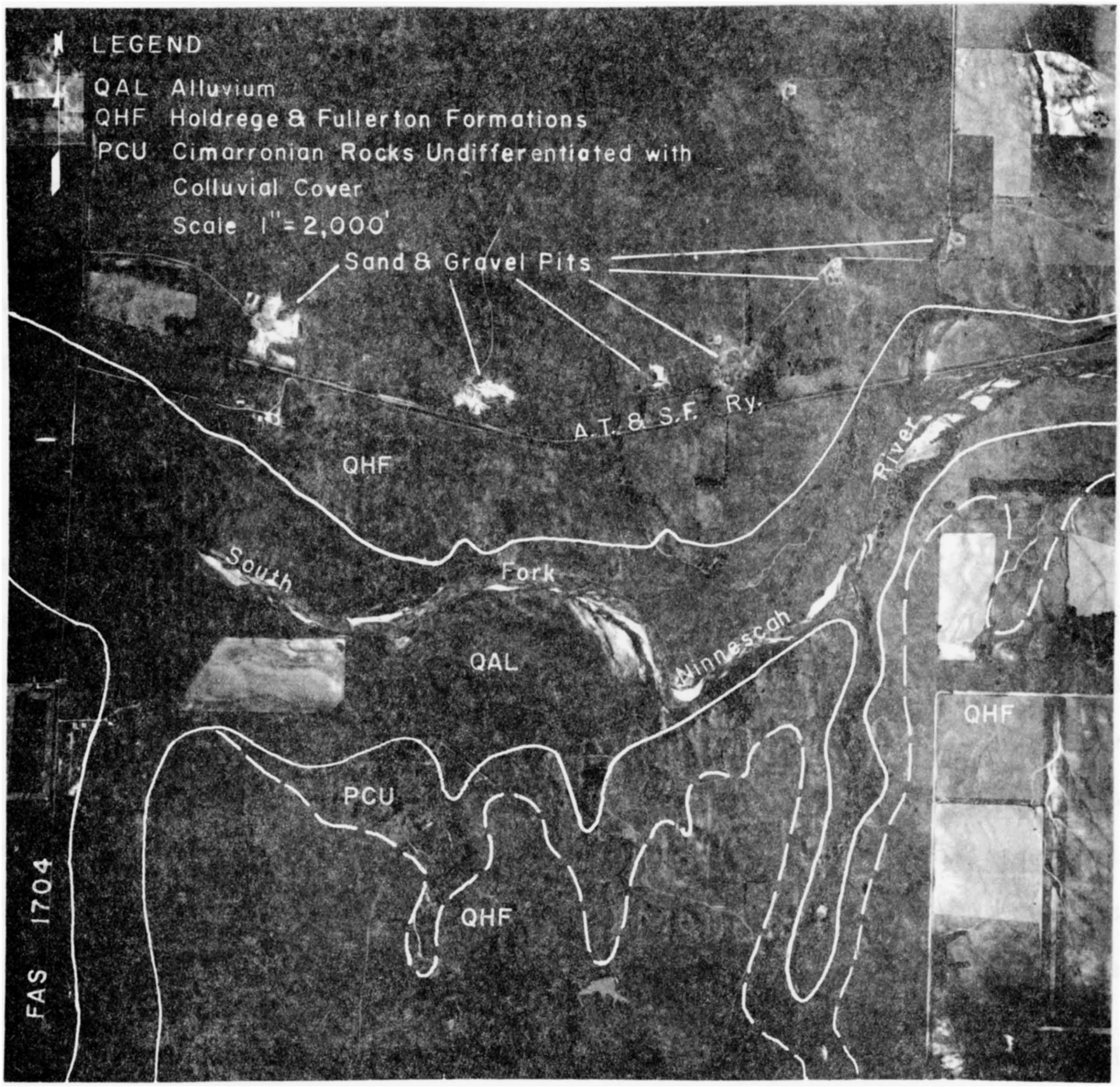


Figure 3. Aerial photograph taken in north-central Kingman County which illustrates the method of delineation between the Alluvium in the river valley and the area occupied by colluvial covered Cimarronian rocks (red beds) and Holdrege and Fullerton Formations.

Photographic interpretation clues indicate that construction material may be available in the area shown at the lower left portion of the photograph. A field investigation confirms the prospective material site.

After the source beds were tentatively mapped and classified on the aerial photographs, the geology of the county was checked in the field. Following this check, the final mapping process was completed, and a detailed description of the geological source units was written. The quality of the material that might be produced from a particular source bed was, in most instances, ascertained by correlating the results of the quality tests with the unit from which the test samples were obtained and by field study of the producing unit.

Phase III <u>Field Reconnaissance</u>

A field reconnaissance of the county was conducted after the first study of the aerial photographs had been completed. This enabled the photo interpreter to examine the material with which he was working, to verify doubtful mapping situations, and to better acquaint himself with the geology of the county. All open sites were inspected to verify the geologic classification. Most prospective areas were surface checked in the field but drilling would be necessary to confirm the materials site.

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

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

All geologic units, which contributed to the construction materials resources of Kingman County, were mapped. The engineering characteristics of the geologic units are fairly consistant; however, some variation in the gradation and quality may be anticipated.

All existing and prospective sites are identified on the county materials map by appropriate designations and symbols. The symbol will indicate the status of the material site to the user of this report, i.e., whether it is a prospective or an open site and whether or not it has been sampled. The pit 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 form for that site, and the geologic age and name of the source bed. The map legend associated with each plate explains all letters and map symbols used in the site designations.

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 information on 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 for each site in appendix II. Appendix III contains data forms for each site shown on the materials map as "prospective sites; not sampled," and appendix IV contains a form for each location depicted on the materials map as a "prospective site; sampled." Test information is also included for each site included in appendix IV.

Additional information is presented on each data 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 for the same source bed are available.

An outline of each site was drawn illustrating major culture features of the immediate site area to help locate the exact field location. Landowner information is included for each material site as it is listed in the Kingman County Treasurers Office.

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

CONSTRUCTION MATERIAL RESOURCES OF KINGMAN COUNTY

Geologic History of Kingman County

The geologic history of Kingman County is presented to provide the reader with a general understanding of the geologic events that were responsible for the deposition of the present day construction material resources. Figure 4 (page 11) 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 on the geologic timetable 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.

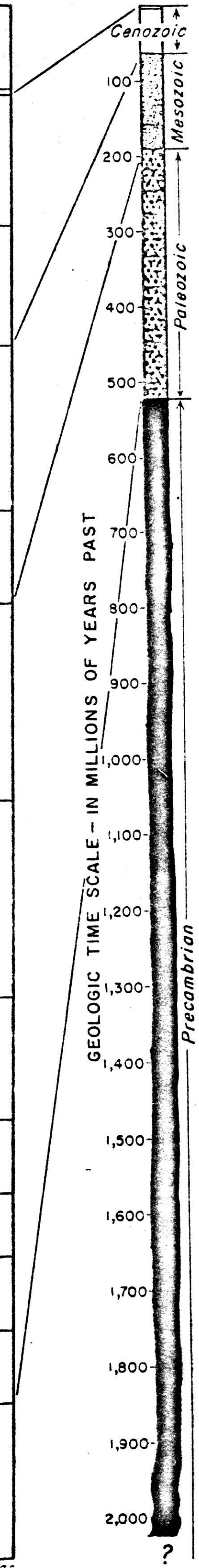
Geologic units exposed in Kingman County total only a few hundred feet in thickness. From these, the geologic history of the near surface deposits may be interpreted; however, the history of the older deposits must be studied through the use of drillhole information or from the surface exposures of the unit found in other areas of the country.

Kingman County is underlain by a "basement complex" of igneous and metamorphic rock of Pre-Cambrian age. In Paleozoic time, marine rocks of Cambrian and Ordovician age were deposited in central Kansas over the basement rocks. During Silurian and Devonian time, sediments

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

(Not scaled for geologic time or thickness of deposits)

*Committee on Measurement of Geologic Time, National Research Council



State Geological Survey of Kansas

Figure 4. Geologic timetable

were probably deposited over the older rocks but were removed, later, by erosion following the uplift of the Central Kansas Arch. Rocks of Mississippian age were deposited over the arch and lie unconformably on Cambrian and Ordovician rocks. Following the deposition of Mississippian rocks, the area was again raised and part of the upper Mississippian strata was eroded. After the Mississippian erosion, the area was submerged, forming the Sedgwick Basin, where approximately 3,500 feet of Pennsylvanian and Permian rocks were deposited (Lane, 1960, p. 17). Following the deposition of Permian units, the area was uplifted and subjected to long periods of erosion.

Some rocks of Mesozoic age are found in Kansas. Central Kansas, including Kingman County, was probably a landmass during the Triassic and Jurassic Periods, inasmuch as, no deposits of this age are known in the area. Deposition continued in the area during Cretaceous time and resulted in the deposition of a considerable thickness of marine shales.

At the close of the Mesozoic Era, uplifting in the Rocky Mountain area and tilting of older rock in bordering areas started a long period of erosion over all of Kansas. This erosion removed all the Cretaceous and a part of the Permian rocks from an area which included Kingman County. Prominent erosion continued until late Tertiary time, when silt, sand, and gravel, termed the Ogallala Formation, were laid down. In Kingman County, this material was derived from Cretaceous and Permian rocks to the west and north. Most material of this age was removed from Kingman County except for a small area in the eastern part of the county.

Following the physical disturbance that marked the end of the Tertiary Period, there was a gradual climatic change in North America which resulted in the formation of great continental glaciers.

Figure 5 (page 14) is a geologic timetable which indicates the divisions of the Quaternary Period and the approximate duration of each. The glacial stages (Nebraskan, Kansan, Illinoisan, and Wisconsinan) represent times of major glacial advancement while the three interglacial stages (Aftonian, Yarmouthian, and Sangamonian) represent times of major glacial recession and stability. Glacial activity in Kansas was restricted to the northeastern portion of the state. Although no glaciers reached Kingman County, the sequence of glaciation which occurred during this time has played a controlling role in the development of Pleistocene nomenclature and the classification of Pleistocene deposits throughout the state. The geologic history of the Pleistocene Epoch, as discussed here, is based, chiefly, on reports by Lane (1960) and Fry and Leonard (1952).

Central Kansas was an area of subdued relief at the beginning of Nebraskan time with broad alluviated valleys joined by alluviated tributaries. The climatic change that accompanied the formation and advance of the Nebraskan ice sheet into the midcontinent brought a cooler and more moist climate to central Kansas. The additional rainfall caused a period of downcutting by streams and, in Kingman County, most of the Tertiary sediments (Ogallala Formation) were removed with the cutting proceeding well into the underlying Permian red beds. When the Nebraskan ice sheet was at its maximum, these streams were probably at base level and had gradients somewhat less than the present major streams. Because of the warmer climate, the Nebraskan ice sheet began to melt, and the deep valleys (cut earlier during this age) began to fill up with sediments. The origin of the valley fill was the Ogallala Formation which had a source of sediment in the headwater regions of the Nebraskan streams. The stream de-

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

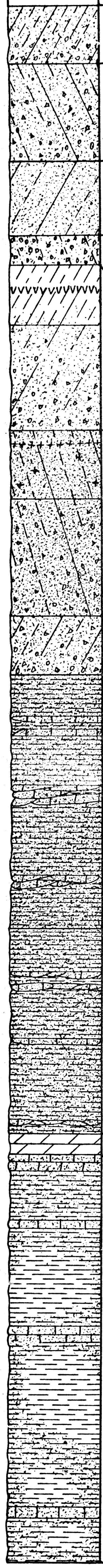
position at this time may have resulted from a decrease in precipitation which, in turn, resulted in a decrease in transporting power of the streams and, coupled with low stream gradients, caused widespread alluviation (Holdrege Formation) of the stream valleys. This alluviation process continued until the valleys were filled, and many former stream divides were buried. When the Nebraskan ice sheet retreated further and further north, a milder climate returned to central Kansas, and the capacity of the stream became less, resulting in deposition of a finer material (Fullerton Formation). As the Nebraskan glacial stage gave way to a period of stability (Aftonian Interglacial stage), the Aftonian soil developed. Remnants of this caliche rich soil may be found in scattered localities in Kingman County today.

As the Aftonian Interglacial stage came to a close, a cooler, moist climate returned, accompanied by the accumulation and advancement of the Kansan ice sheet into the midcontinent region and heavy glaciation of the Rocky Mountain region. An increase in precipitation caused the streams to degrade their channels. In the Kingman County area there is little evidence of pronounced downcutting, but a low stream divide may have covered most of the county between the major stream in the northeast and southwest. A through drainage system by way of the Rocky Mountains was established in south-central Kansas by late Kansan time. This stream, which was heavily laded with outwash, rapidly filled its valley, shifted laterally on its alluvial fill, topped low divides, and spread a thick sheet of alluvial material over much of Kingman County (Grand Island Formation). As the Kansan ice disappeared from the midcontinent and Rocky Mountain areas, streams carried a finer outwash (Sappa Formation) to south-central Kansas due to the reduced amount of water carried by streams. Toward the end of the Kansan Age, milder climates returned to south-central Kansas. The area at this time was, again, a relatively flat plain, sloping gently to the southeast, but at a higher altitude than existed at the close of Nebraskan time. A period of stability followed the Kansan Glacial Age, at which time, the Yarmouthian soil developed. Remnants of this soil are preserved in extreme western Kingman County (Lane, 1960, p. 23).

The return of cooler climates marked the beginning of the Illinoisan Glacial Age. The Illinoisan ice sheet did not extend further south than the northern midcontinent region, but, as in the prior glacial ages, some glacier accumulation occurred in the Rocky

Mountains. The climatic changes which accompanied the continental glaciation were probably far reaching and caused rejuvenation of streams in most of the midcontinent region. Major streams in northern Kansas, once again, deepened their channels; however, in most of south-central Kansas, available evidence does not indicate that an integrated drainage system existed at the beginning of Illinoisan time west of the major stream flowing through the McPherson Valley and the ancestral Arkansas River. During this time, erosion had extended well into Kingman County, establishing the pattern of the present drainage system in that area. The melting of the Illinoisan ice and return to milder climates resulted in outwash (from the Rocky Mountains), being transported into south-central Kansas by a large stream. This stream shifted laterally over an extensive area, depositing a thin sheet of alluvial material over western Kingman County and in areas west of the county. This shifting stream may have been captured by the headwaters of the ancestral Arkansas River, establishing the master stream that is found today. Such a drainage adjustment would have profound effects, inasmuch as, the adjustment of the master stream to an increased volume of water and renewed headwater erosion of its tributaries would result at a time when streams in other parts of the state were alluviating their valleys. This major drainage change could account for some anomalous distribution of sediments tentatively dated as Illinoisan (Crete Formation).

Wisconsinan terrace deposits are the youngest sediments associated with Pleistocene glaciation. Although the Wisconsinan ice sheet advanced no further south than central Iowa and northeastern Nebraska, the accompanying cooler and more moist climate was far reaching. In Kingman County, evidence of this change is prevalent,



Graphic Legend	Thickness	System	Series	Stage	Formations	Generalized Description	Construction Materials
	0-25±				Soil and Colluvium	Brown to mostly red-brown clayey silt and fine sand, but contains some arkosic gravel and pieces of siltstone.	None
	0-80±	Quaternary	Pleistocene	Wisconsinan and Recent	Alluvium and Wisconsinan Terrace Deposits	Tan to red-brown silt, sand, and arkosic gravel. May contain some clay binder.	Aggregate Road Surfacing Material Base Coarse Material Mineral Filler
	0-30'				Dune Sand	Light tan fine sand with varying amounts of silt and clay; cross-bedded.	Base Coarse Material
	0-12'			Illinoisan	Crete Formation(?)	Tan, silt, sand, and arkosic gravel; cross-bedded. May contain same clay binder.	Aggregate Road Surfacing Material Base Coarse Material
	0-150'			Kansan and Yarmouthian	Sappa Formation	Light gray to tan clayey and sandy silt with some zones and nodules of caliche. May contain a volcanic ash zone (Pearlette).	Mineral Filler
					Grand Island Formation	Tan to red-brown silt, sand, and arkosic gravel; cross-bedded, may contain some clay binder.	Aggregate Road Surfacing Material Base Coarse Material
	0-165'			Nebraskan and Aftonian	Fullerton Formation	Tan clayey and sandy silt with zones and nodules of caliche. May contain boulder sized caliche balls in a zone near the top.	None
					Holdrege Formation	Tan to red-brown silt, sand, and arkosic gravel with a few pebbles of sandstone and ironstone; cross-bedded. May contain some clay binder.	Aggregate Road Surfacing Material Base Coarse Material
	0-26'	Tertiary	Pliocene		Ogallala Formation(?)	Tan to red-brown silt, sand, and arkosic gravel with a few cobble sized constituents. Abundant ironstone and sandstone pebbles may be found near the base of the unit.	Road Surfacing Material
	0-265'	Permian	Lower Permian	Cimarronian	Salt Plain Siltstone Formation	Red-brown siltstone and silty shale. May contain some clay binder.	None
	0-210'				Harper Siltstone Formation	Mostly red-brown siltstone and silty shale but may contain a few green bands.	None
	0-1'				Stone Corral Formation	Gray to buff dolomite and reddish dolomitic silty shale.	None
	0-400'±				Ninnescah Shale Formation	Red-brown silty shale and siltstone with a few thin beds of gray-green silty shale.	None

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

inasmuch as, streams deepened their channels in the early Wisconsinan period. Return to milder climates caused retreat of early Wisconsinan ice; thus, streams were no longer able to transport their sediment load. The ice sheets returned to the northern midcontinent region in late Wisconsinan time and resulted in deepening of most Kansas stream valleys. The major streams in Kingman County deepened their valleys slightly below the earlier Wisconsinan stream level. As the Wisconsinan ice sheet retreated with the return of more moderate climate, the streams alluviated their channels. The downcutting and alluviation during this age has resulted in the formation of two terrace levels which may be identified in various regions of Kingman County. Some of the upland divides are covered, in this county, with wind-blown silts (Peoria Formation) the source of which may have been the barren floodplains of the major drainage.

The Recent Stage represents the geologic development since the last Wisconsinan ice sheet (last 10,000 years). Major developments include the alluvial floodplain of the major drainage and sand movement in dune areas; however, geomorphic processes have reworked some older deposits. Some undrained depressions have also developed in Kingman County, especially in Dune Sand areas.

Construction Materials Inventory

This portion of the report inventories the construction material resources of Kingman County. Figure 6 (page 17) is a generalized geologic column of the surface geology in Kingman County which shows the relative stratigraphic position of each source bed. The county materials maps (plates I through VI) define the geographic areas where construction material source beds are exposed or near the surface.

A tabulation of test results is shown in figure 7 (page 21) on material taken from the various source units in the county. In general, material with the same basic engineering characteristics can be found throughout each source bed.

Figure 8 (page 22) shows a tabulation of the various types of material available in Kingman County. The source beds from which each material type can be produced are listed along with the page number where the engineering characteristics of each are described. A thorough study of these descriptions may be helpful when making a preliminary assessment of the construction materials resources of the county.

Permian System

Cimarronian Rocks Undifferentiated With Varying Colluvial Cover

Exposed Cimarronian rocks (red beds) include the following formations in Kingman County: 1. Ninnescah Shale, 2. Stone Corral, 3. Harper Siltstone, and 4. Salt Plain Siltstone. Many of these rocks have a varying thickness of colluvial cover some of which may be suitable for binder soil. The rocks are composed of siltstone and silty shale and are generally red-brown in color but may have some green bands and (or) green specks. Figure 9 (page 23) shows an exposure of these rocks in eastern Kingman County. The thickness of the exposed Cimarronian rocks in the county may exceed 600 feet.

Rocks of this age are found mostly in the eastern one-half of Kingman County along stream valleys. The areal distribution of Cimarronian rocks (red beds) is shown on the Kingman County materials maps, primarily, for reference to the geo-engineering information which is discussed in another section of this report. To date this material has not been used in the county for road construction pur-

Location	Material Type	Percent Retained								Wash	G.F.	P.I.	L.L.	Sp.Gr. Sat.	Wt./Cu.Ft.	Wear	Soundness	Absorption	Source of Data
		3/4	3/8	4	8	16	30	50	100										
Source of Material: Ogallala Formation (?)																			
SW¼,SE¼,Sec. 5,T28S,R6W	Sand and Gravel		2	6	11	24	55	87	94	3.0	2.79			2.74	109.6	31.4	0.92	1.5	av. SHC Form 619, No. 48-22
Source of Material: Fullerton and Holdrege Formations																			
SE¼,Sec.11,T28S,R8W	Sand and Gravel		4	10	24	48	84	99	100		3.80			2.61	102.7	35.6	0.95		Hole 8, SHC Form 619, No. 48-10
SW¼,Sec. 1,T28S,R8W	Sand and Gravel	1	7	15	27	46	75	93	97	2.33	3.61			2.60	112.9	36.0	0.99		1 Quality Sample, Lab. No. 73421
NE¼,Sec.22,T28S,R8W	Sand and Gravel		1	4	12	36	72	96	99		3.20			2.57	98.4	36.6	0.94		Hole 12, SHC Form 619, No. 48-13
NW¼,Sec. 9,T28S,R8W	Sand and Gravel	6	13	21	33	51	77	94	98	1.5	3.87			2.61	111.8	30.6	0.98	0.30	av. SHC Form 619, No. 48-18
NW¼,Sec. 7,T28S,R9W	Sand and Gravel		5	13	25				98	1.5				2.62	112.0				1 Quality Sample, Lab. No. 25624
N ½,Sec. 3,T27S,R5W	Sand and Gravel		2	7	19	39	74	95	98	1.05	3.34			2.62	113.62	30.7	0.97	0.80	1 Quality Sample, Lab. No. 16923
NE¼,Sec.10,T28S,R8W	Sand and Gravel	2	6	14	25	41	62	87	94	4.0	3.31			2.60	114.0	32.9	0.98		Hole 35, SHC Form 619, No. 48-3
NE¼,Sec. 1,T28S,R8W	Sand and Gravel		2	10	36	68	88	96	99	0.65	3.99			2.62	113.9	31.8	0.99	0.39	Stockpile SHC Form 619, No. 48-5
NE¼,Sec. 1,T28S,R8W	Sand and Gravel		3	8	16	25	45	86	90	7.0	2.73	20	32	2.60	105.8	37.4	0.99	0.6	Hole 17, SHC Form 619, No. 48-5A
NW¼,Sec.15,T29S,R5W	Sand and Gravel	1	5	20	33	51	74	94	98	1.26	3.76			2.62	110.72	34.0	0.97	0.60	1 Quality Sample, Lab. No. 23532
NW¼,Sec. 6,T28S,R7W	Sand and Gravel	1	3	12	26	41	71	90	97	2.0	3.42			2.60	107.3	32.0	0.97		av. SHC Form 619, No. 48-15
NE¼,Sec. 9,T28S,R8W	Sand and Gravel		3	9	18	32	57	81	89	8.7	2.89			2.56	101.8	34.9	0.98		1 Quality Sample, Lab. No. 36000
Source of Material: Sappa and Grand Island Formations																			
NE¼,Sec. 7,T27S,R10W	Sand and Gravel		5	14	34	58	84	98	100		3.93			2.59	110.9	31.6	0.99		Hole 86, SHC Form 619, No. 48-6
SE¼,Sec.17,T28S,R7W	Sand and Gravel		1	4	13	23	49	78	90	8.9	2.58			2.57	105.9	37.2	0.97	1.11	Hole 6, SHC Form 619, No. 48-17
NE¼,Sec.27,T30S,R10W	Volcanic Ash						2	6	37	53.0			56						Hole 8, SHC Form 619, No. 48-20
NW¼,SW¼,Sec.18,T27S,R10W	Sand and Gravel		1	4	10	20	43	76	92	5.0	2.46			2.58	107.12	38.4	0.99		av. SHC Form 619, No. 48-23
SE¼,Sec. 3,T27S,R10W	Sand and Gravel	1	5	11	23	41	62	89	98	1.0	3.30			2.59	111.6	36.5	0.98	0.40	Stockpile SHC, Form 619, No. 48-24
NE¼,Sec. 3,T27S,R10W	Sand and Gravel		2	9	23	41	61	80	93	4.75	3.09			2.60	113.62	32.7	0.98	1.1	1 Quality Sample, Lab. No. 11055
NW¼,Sec. 5,T30S,R10W	Sand and Gravel	2	6	9	16	32	70	94	98	1.0	3.36			2.58	101.26	30.5	0.96	0.61	av. SHC Form 619, No. 48-21
Source of Material: Colluvium																			
SW¼,Sec.17,T29S,R7W	Binder Soil					4	9	14	16	79.0		9	29						Hole 15, SHC Form 619, No. 48-11
NE¼,Sec. 7,T30S,R8W	Sand and Gravel		2	7	21	48	81	95	99	0.25	3.53			2.61	111.6	32.0	0.98		1 Quality Sample, Lab. No. 94658
Source of Material: Alluvium																			
NW¼,Sec.14,T30S,R8W	Sand and Gravel	2	8	11	18	32	62	90	96	4.0	3.19			2.63	115.0	23.4	0.97		Hole 8, SHC Form 619, No. 48-1
NE¼,Sec.14,T30S,R8W	Sand and Gravel	6	9	13	20	32	53	84	92	6.7	3.09			2.60	109.9	31.1	0.97	0.7	Hole 2, SHC Form 619, No. 48-1A
SE¼,Sec.32,T30S,R10W	Sand and Gravel		3	11	16	33	61	93	99		3.16			2.62	117.0	30.3	0.98		Hole 13, SHC Form 619, No. 48-2
NW¼,Sec.15,T30S,R7W	Sand and Gravel			3	10	26	59	84	90		2.72			2.58	103.79	36.3	0.99		Hole 6, SHC Form 619, No. 48-9C-R
SE¼,Sec.11,T30S,R8W	Sand and Gravel		1	4	23	32	68	89	94	6.0	3.11			2.60	106.4	31.8	0.98	0.9	Hole 5, SHC Form 619, No. 48-16
SE¼,Sec. 4,T28S,R7W	Sand and Gravel		1	3	8	21	54	89	98	1.32	2.74			2.62	103.4	32.4	0.96	0.62	1 Quality Sample, Lab. No. 6680
NE¼,Sec.16,T27S,R7W	Sand and Gravel	2	7	20	49	80	94	97	99	1.06	4.48			2.60	112.3	36.6	0.99		1 Quality Sample, Lab. No. 70559
NE¼,Sec.14,T30S,R7W	Sand and Gravel		1	3	9	20	45	76	89	9.0	2.43	1	17	2.57	107.54	34.6	0.96		Hole 4, SHC Form 619, No. 48-9A-R
NE¼,Sec.15,T30S,R7W	Filler Sand					4	16	88	98	1.0	2.06								Hole 7, SHC Form 619, No. 48-9B
SE¼,Sec.10,T30S,R7W	Sand and Gravel		4	12	26	43	50	89	93	6.20	3.17			2.54	106.6	31.2	0.96		1 Quality Sample, Lab. No. 34770

Figure 7. Results of tests completed on samples of material from several geologic source beds in Kingman County.

Material Type	Geologic Source	Page Described	Locality Where Available
Sand and Gravel	Ogallala Formation(?)	23	Northeast 1/4 of the county.
	Holdrege and Fullerton Formations	24	Terraces throughout the county parallel to the major drainage.
	Grand Island and Sappa Formations	26	Covers the upland divides between the major drainage channels in the western 2/3 of the county.
	Crete Formation (?)	28	Mostly in the northeast 1/4 of the county.
	Alluvium	29	Occupies the floodplain of the major drainage channels throughout the county.
Mineral Filler	Sappa Formation	26	Scattered volcanic ash deposits which have been found to date, only, in the southeast 1/4 of the county.
	Cimarronian Rocks Undifferentiated (red beds)	20	Eastern 1/2 of the county along some of the stream valleys.
Binder Soil	Colluvium	20	Eastern 1/3 of the county along the major drainage.
	Dune Sand	28	Extreme western portion of the southwest 1/4 of the county and along the Chikaskia River and north of Smoots Creek in the eastern 1/2 of the county.

Figure 8. A summary of the construction material types and their availability in Kingman County.

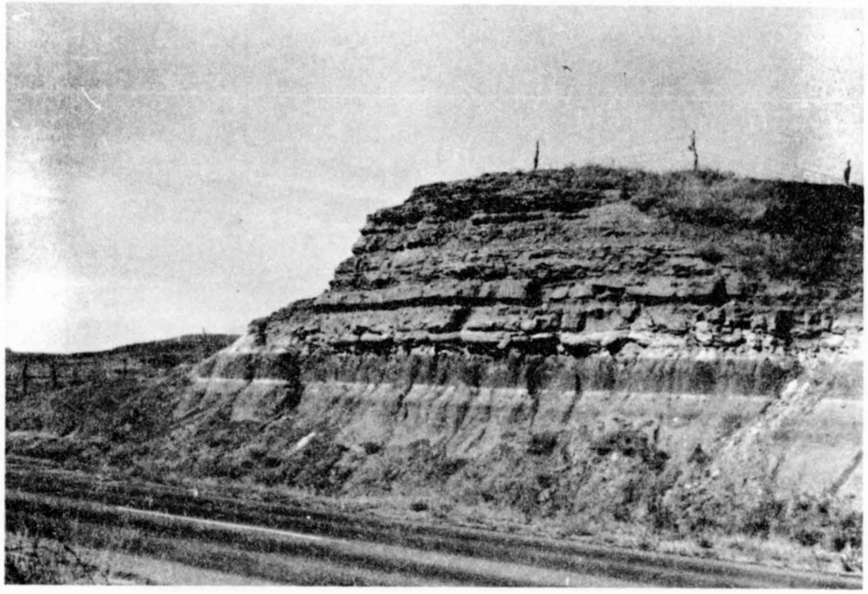


Figure 9. Cimarronian rocks (red beds) undifferentiated in SW¼ sec.27, T27S, R7W.

poses except in the weathered phase as mineral filler for road mixed bituminous surfacing projects; however, it is used in adjacent Sumner County for road surfacing material on some lightly traveled rural roads.

Tertiary System
Ogallala Formation(?)

The Ogallala Formation(?) is composed of tan, brown, and red-brown calcareous silt; fine to coarse grained sand; and fine to coarse gravel. Locally, the gravel is cemented with calcium carbonate. An outstanding feature of the unit is the presence of an abundant supply of dark brown sandstone and ironstone pebbles at some locations. Cross-bedding and a variable sized material at various horizons in each plane are common features. Compared to other units in Kingman County, the Ogallala(?) is relatively thin with a maximum thickness of about 26 feet (Lane, 1960, p. 57).

Quality test results, which were obtained from one sample of the Ogallala(?), indicate that the material is suitable for use in both concrete and bituminous construction as well as for surfacing lightly traveled rural roads. Because of the large percentage of fines, sweetening with coarser material may be necessary in most locations to meet gradation specifications. The test results show the Los Angeles wear to be 31.4 percent, the soundness loss ratio 0.92, and the absorption 1.5 percent. Because the Ogallala(?) occurs on high elements of topography, the water table will probably not be encountered during production operations. Figure 10 illustrates some ironstone gravel in a pit in the Ogallala Formation(?).

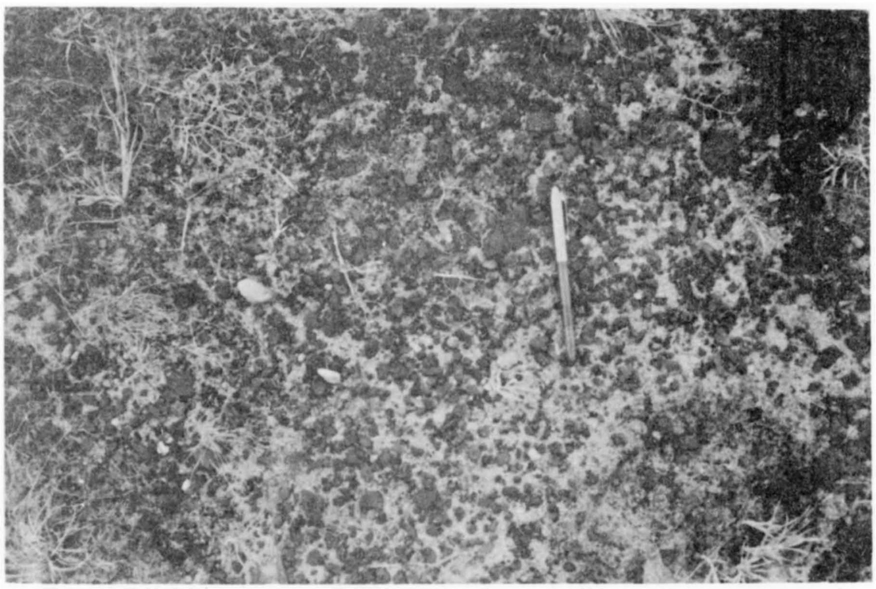


Figure 10. Ironstone gravel in the Ogallala Formation(?), SE¼ sec. 5, T28S, R6W.

Quaternary System
Holdrege and Fullerton Formations

The Holdrege and Fullerton Formations are composed of clay, silt, sand, and gravel. The contact between Holdrege and Fullerton is arbitrarily placed where sand and gravel grades into silt and clay. Since the distinction between the two units is not definite, the two units were mapped as one.

The Holdrege Formation is a major source of granular material, suitable for all phases of road construction purposes. This material is a tan colored arkosic sand and gravel with the fine fraction being more prominent. Lane (1960, p. 57) reports that the gravel found near the base of the formation contains pebbles of ironstone and sandstone. Thin beds of variable sized material is a common characteristic of this unit. Lane (1960, p. 58) reports the thickness of the unit to be as much as 162 feet in Kingman County.

Sand and gravel of the Holdrege Formation is found in a relatively narrow band paralleling the major drainage throughout the area but is more prevalent in the eastern one-half of the county. A materials pit in the Holdrege Formation is shown in figure 11.

Figure 11. *Sand and gravel pit in the Holdrege Formation, NW¼ sec. 9, T28S, R8W.*

Quality tests completed on material from this unit indicates that it is of good quality. The Los Angeles wear ranged from 30.6 to 36.6 percent, the soundness loss ratio from 0.94 to 0.98 and the absorption from 0.30 to 0.60 percent. Because the water table varies with the rainfall, production from this unit may be either dry or by pumping operations.

Grand Island and Sappa Formations

Generally, no distinct contact between the Grand Island and Sappa Formations can be recognized in Kingman County and, therefore, the two formations were mapped as a single unit.

The Grand Island is composed mostly of tan colored, arkosic, fine to coarse sand and fine to coarse gravel with minor amounts of silt. Coarse gravel is common throughout the unit but is most commonly found near the base. Generally, the Grand Island Formation contains coarser material than the Holdrege Formation in Kingman County. Figure 12 illustrates a sand and gravel pit in the Grand Island Formation.

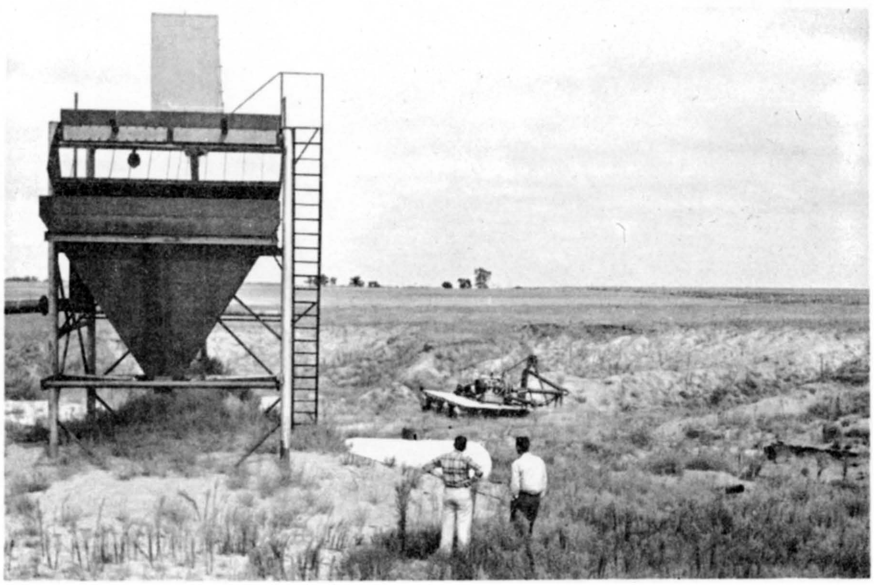


Figure 12. Sand and gravel pit in the Grand Island Formation, SE¼ sec. 3, T27S, R10W.

The Sappa Formation overlies the Grand Island and is composed of tan-brown silt. A heavy zone of caliche which is the remnants of the old Yarmouth soil profile, occurs near the top of the Sappa in extreme western Kingman County. Volcanic ash (Pearlette) which is found in the Sappa is of particular importance from the materials aspect. At the time this report was being prepared (1966) volcanic ash was being produced at one site in southwestern Kingman County for mineral filler. Although other deposits of ash may exist, they are very difficult to find by ordinary surface investigation methods. Figure 13 illustrates volcanic ash in the Sappa Formation.

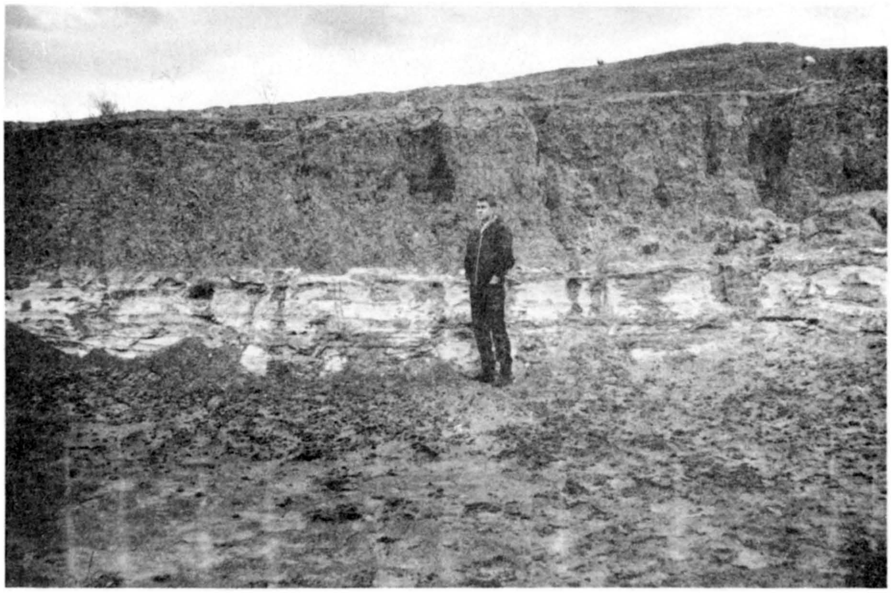


Figure 13. Volcanic ash (Pearlette) in the Sappa Formation, NE¼ sec.21, T30S, R10W.

The Grand Island and Sappa Formations cap most of the stream divides in central and western Kingman County. The abundance of granular material, comprising this source unit, is illustrated by the fact that most of the farm crops are grown in sand and gravel.

Aggregate produced from the Grand Island has been used in concrete and bituminous construction as well as for surfacing lightly traveled rural roads. However, because of the abundance of fine material, sweetening with a coarser material may be necessary to meet gradation specifications. Available test information indicates the Los Angeles wear ranges from 30.5 to 38.4 percent, the soundness loss ratio from 0.96 to 0.99 and the absorption from 0.40 to 1.11 percent. According to Lane (1960), p. 63) the thickness of the Grand Island and Sappa Formations may be as much as 150 feet.

Crete Formation(?)

Deposits of silt, sand, and gravel, believed to be the Crete Formation(?), form terraces adjacent to Smoots Creek in the northeastern part of the county and occupy a buried valley in the east-central portion of this area. Although the Crete Formation(?) may form a thin veneer over much of western Kingman County, only areas where considerable accumulation of material exist were mapped. According to Lane (1960, p. 64) the thickness of the unit may be as much as 50 feet.

No quality test information is available on the Crete Formation(?) in the county, but the material should be useful for the various phases of road construction. Inasmuch as the original source of material for the Crete is the same as the older granular beds (Holdrege and Grand Island), a comparable quality material can be anticipated. No pits were found to exist in this unit, but a prospective site was located where good granular material appeared at the surface. Production of this material would, normally, be by dry site methods.

Dune Sand

The Dune Sand in Kingman County, as in other Kansas areas, is composed, mostly, of fine sand with minor amounts of silt and clay. The dunes exhibit prominent cross-lamination, a typical feature of eolian deposits. The maximum thickness of the dunes, probably, does not exceed 30 feet.

Dune Sand is especially prominent in a narrow band to the north of the Chikaskia River in the southeastern portion of the county, at scattered areas east of Smoots Creek in the northeastern portion, and in southwestern Kingman County between Sand Creek and the Chikaskia River. Figure 14 (page 29) illustrates typical sand dunes along the

Figure 14. Sand dunes along the Chikaskia River in southeastern Kingman County.

Chikaskia River in southeastern Kingman County.

No quality data are available for Dune Sand in Kingman County and, to the authors' knowledge, no pits have been opened in the dunes for material purposes. In other counties (e.g. Harvey County) material from this source has been used as base course material and probably could be used for such a purpose here.

Alluvium

The Wisconsinan Terraces and Recent Alluvium are closely associated deposits and, thus, were mapped as a single map unit (Alluvium). The material is composed of arkosic fine to coarse sand and fine to coarse gravel with a variable gradation. The thickness of the units does not usually exceed 60 feet.

Material of this age occupies the narrow floodplain of the major drainage (Smoots Creek, South Fork Ninnescah River, Chikaskia River, and Sand Creek) in Kingman County, and some deposits extend a short distance into the tributaries of these streams. Figure 15 illustrates a sand and gravel pit in the alluvial floodplain of the Chikaskia River.

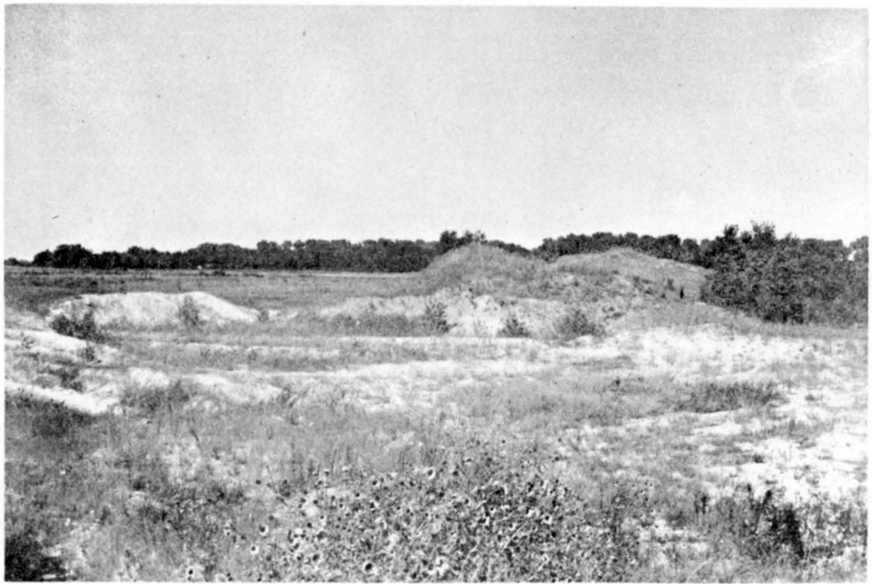


Figure 15. Sand and gravel pit in the Alluvium of the Chikaskia River, SE¼ sec.11, T30S, R8W.

The quality of material obtained from this source is relatively good. The material can be used in concrete and bituminous construction as well as a surfacing material on lightly traveled rural roads. A relatively large amount of fine material will probably necessitate the screening of large quantities of material to obtain the desired gradation. Figure 7 (page 21) illustrates available quality test results on the Alluvium in Kingman County. These results indicate the Los Angeles wear ranges from 23.4 to 36.3 percent, the soundness loss ratio from 0.96 to 0.99, and the absorption from about 0.6 to 0.9 percent. Material from this source is produced by both wet and dry site methods. In most cases, wet site methods are carried out by dredging the material out of the stream bed with a dragline (as opposed to sand pumping method). However, the material could be obtained with a sand pump if conditions require such a method.

Geo-Engineering

The purpose of this section of the investigation is to list and briefly describe the geologic units exposed in Kingman County that, through past experience, may present problems when encountered during construction or when used as a construction material. A general discussion is also presented pertaining to possible ground-water problems that may occur during road construction and the quality of water available for concrete mix purposes.

Material Usage in Road Construction

The usage of material is considered from three points of view: 1. embankment and subgrade construction, 2. backslope steepness and stabilization, and 3. bridge foundation support.

Embankment and Subgrade Construction

It is probable that all the exposed geologic units in Kingman County have been used at some time in the construction of highway embankments and subgrades; however, any of the highly plastic soils or clay lenses in the unconsolidated geologic units are not recommended for subgrade or shoulder construction due to their shrinkage and swell characteristics, although some plastic material may be beneficial if the development of a turf is desired. If used for embankment construction, plastic material should be placed in the lower portion if possible; however, consideration must also be given to the height of the fill to insure that the shear strength of the material is not exceeded.

A material such as fine, silty sand with low swell shrinkage properties is desirable for backfill purposes. In Kingman County the location of this type of material is not a problem, inasmuch as, a large percent of the county is covered by terrace deposits of sand and gravel. Such material in its natural state is desirable for embankment and subgrade construction; however, due to its extreme granular nature, erosion by wind and water may be excessive if the slopes are not protected by a more plastic material (i.e. clay).

The oldest rocks exposed in Kingman County are the red shales and siltstones of the Cimarronian Stage (red beds). Rocks of this age are exposed at scattered localities along the major drainage in central and eastern Kingman County. Material from this source should be usable as embankment material, but, probably, should be avoided in the subgrade unless broken into its uncemented components. Because these red beds do not support vegetation readily, excessive erosion on the slope faces of embankments may be anticipated unless protected by a more plastic material. The amount of erosion will depend upon the degree to which the red beds are broken up since the finer material is highly susceptible to erosional processes.

Terrace sand and gravel, represented by the Ogallala Formation(?), Holdrege and Fullerton Formations, Grand Island and Sappa Formations, and Crete Formation(?) may contain material in the natural state which is desirable for use in both embankment and subgrade construction. However, near the top of the Fullerton and the top of the Sappa Formations, remnants of a buried soil profile may be found. These soils may have a high plastic index and, thus, may be undesirable for embankment and subgrade. Dune Sand will make a desirable subgrade and embankment, but if a stable turf is not developed quickly, severe erosion by both wind and water may result.

The alluvial material found in the floodplain of the major drainage is composed of sand and gravel with varying amounts of silt and clay. Most material from this source would be desirable for subgrade construction. However, due to low topographic position, its need for embankment material is minimized. Caution should be exercised in the alluvial floodplains of the South Fork Ninnescah River, Chikaskia River, Sand Creek, Smoots Creek, and other perennial streams in Kingman County, inasmuch as, the streams have very shallow banks, and the water table is very close to the surface. In some low areas on the alluvial plains, water may stand, perennially, as a result of the depression being below the water table. As a result of the high water table, roads built over the Alluvium may be affected by unstable conditions from below, or some of the ground-water may saturate the subgrade and cause road failure. Because the streams have very shallow banks, flood water may spill out of the stream and temporarily saturate the subgrade of roads built through such an area unless adequate precautionary measures are taken.

Backslope Steepness and Stabilization

The type of material encountered on a road construction project in the county will determine the steepness of the backslope along with the procedure necessary for stabilization. The red, silty shale and siltstone of the Cimarronian Stage should be cut on a slope of approximately 1/4 to 1. A flatter slope may be necessary if the material is weathered. Ancient granular deposits, Ogallala Formation(?) Holdrege Formation, Grand Island and Sappa Formations, and Crete Formation(?), which cover much of the county, should be placed on a 3 to 1 or flatter slope. Alluvium and Wisconsinan Terraces (composed of clay, silt, sand, and gravel) and Dune Sand should be handled in a similar manner. Because of the granular nature, seeding with relatively heavy foliage plants may be necessary to prevent erosion.

Bridge Foundation Support

The type of foundation support necessary to support a bridge in Kingman County will vary with the depth of bedrock below the ground surface. A bridge constructed where the mantle thickness is 20 feet or less will probably require a spread footing support. Bedrock surfaces, deeper than 20 feet, will probably require piling support; however, if stream scour is anticipated, spread footings may be set on bedrock surfaces deeper than 20 feet. Some of the upland areas of the county are thickly mantled, and bedrock will be too deep for consideration of support. In such cases, frictional type piling will be necessary to provide support.

Firm support can be anticipated from the red, silty shales and siltstones of the Cimarronian Stage. Bridges across the major drainage (except possibly in the extreme western section) will be supported mostly by pile penetrating the Alluvium and into the red beds or by spread footings keyed into them.

The State Highway Commission of Kansas relies on information gained through core drilling operations and a No. 2 McKiernan-Terry Air Hammer to help determine the type of structural support required and to estimate the elevation at which a given bearing can be reached. The use of the air hammer has proved especially useful when frictional bearing will be the case inasmuch as relatively accurate estimates of pile tip elevations have been predicted. However, due to variation in composition of unconsolidated deposits, some deviation from the estimated value can be anticipated.

Hydrology Problems in Road Construction

All of the geologic units exposed in Kingman County have properties which could contribute to some sort of ground-water problem in road construction when encountered under adverse conditions. It is beyond the scope of this report to make specific recommendations; however, the undesirable ground-water characteristics of certain formations are briefly discussed to familiarize the reader with their existence. Detailed surface investigations should be conducted with these facts in mind to ascertain the extent and severity of ground-water problems in any area where a construction project is planned.

The red, silty shale and siltstone of the Cimarronian Stage are not generally a problem in road construction since they are, generally, impervious except when weathered. Some slight seepage was noted in the county; thus, adequate precaution should be taken. However, some problems may exist when a road cut intercepts the contact between unconsolidated Quaternary deposits and the Cimarronian rocks. In such cases, water may percolate downward through the unconsolidated material and travel along the top of the nearly impervious red beds. When a contact such as this is intercepted in road construction, water may bleed out and saturate the subgrade unless precautionary measures are taken.

Unconsolidated deposits found in Kingman County consist of varying amounts of clay, silt, sand, and gravel. In some instances, lenses of silt and clay may prevent the downward percolation of water and result in a perched water table.

Mineralization of Water Resources

Engineering problems pertaining to ground-water are discussed here, mainly, on the basis of information reported by Lane (1960).

The major consideration is given to the main source of water and the degree of mineralization which can generally be expected from the various aquifers. Special emphasis is placed on the degree of sulfate and (or) chloride ion concentration in water with reference to specifications for Portland Cement concrete.

The red, silty shale and siltstone (red beds) of the Cimarronian Stage produce very little water, and that produced, is thought to come only from the weathered portion of the rock. Production from this unit is necessary only in the eastern part of the county since a better water source exists in the remainder of the county. It is also probable that adequate supplies of water for construction purposes will not be produced from this unit. One sample of water obtained from the red beds indicated a relatively high sulfate content (Lane, 1960, p. 43). However, it should meet the specifications for concrete mix water.

The Ogallala Formation is relatively thin and limited in areal extent to a small area in northeastern Kingman County. Because of these limitations, only a few water wells exist in the unit and most are used for livestock. No test information is available on water from the unit, but it should be adequate in quality for concrete mix water if found in sufficient quantities.

Most of the water in Kingman County is produced from the area mapped as the Holdrege and Fullerton map unit. The production of water comes from the Holdrege Formation since the granular material is contained in this unit. The quantity of water which may be produced is somewhat variable, but in some parts of Kingman County supplies are adequate for municipal, irrigation, and industrial use. Under normal circumstances, the water should be pure enough for use in Portland Cement concrete; however, caution should be exercised to prevent the possible contamination by salt brine from oil wells.

The area mapped as the Grand Island and Sappa Formations map unit generally lies above the water table except in the western part of the county. Of the two units, only the Grand Island Formation contains suitable granular material for the production of groundwater; however, water produced is relatively low in dissolved solids and should be desirable for use in Portland Cement concrete. Like the Holdrege, proper caution should be exercised with regard to possible contamination from oil field brine.

The area mapped as the Crete Formation(?) generally lies above the water table and does not yield large supplies of water. Test results as acquired by Lane (1960, p. 42) indicate that the water produced from the unit would meet specifications for Portland Cement concrete.

Several areas of Dune Sand, roughly, parallel the major drainage in Kingman County. These dunes do not ordinarily yield water; however, undrained depressions frequently are found which may hold water for weeks and months after heavy rains. If water is obtained from an undrained depression for concrete mix water purposes, the water should be tested to insure against excessive sulfate and chloride contamination.

The Alluvium of the major drainage contains adequate water for yielding large quantities; however, periodic flood water can be anticipated. Water from this source may contain a relatively high chloride content but not high enough to preclude its use in concrete. Tests on such water should be made to insure adequate quality.

GLOSSARY OF SIGNIFICANT TERMS

Absorption: Determined by tests performed in accordance with A.A.S.H.O. (American Association of State Highway Officials) designation T 85.

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

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

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

Colluvium: Heterogenous mixture of material resulting from the transportation action of gravity (i.e. talus at the base of a slope).

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

Cross-bedding: Sedimentary deposits which show oblique layering, extending diagonally across the individual beds.

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

Geologic units: This term is used in this report to denote: 1. a geologic formation; 2. a geologic member, and 3. an unconsolidated deposit of Pleistocene age.

Gradation factor: The value obtained by adding the percentage 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.

Igneous rocks: Rocks formed under conditions involving great heat; as rocks 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.

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

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

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

Pleistocene Series: Deposits laid down during the Quaternary Perio

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

Soundness: Determined by tests performed in accordance with sectio 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 dimensions.

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

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

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

Weight per cubic foot: Determined by tests performed in accordance with A.A.S.H.O. designation T 19-45.

SELECTED REFERENCES

1. American Association of State Highway Officials (1961) Standard specifications for highway materials and methods of sampling and testing: pt. I, 8th ed., 401 p.

2. --- (1961) Standard specifications for highway materials and methods of sampling and testing: pt. II, 8th ed., 617 p.

3. Bayne, C. K. (1956) Geology and ground-water resources of Reno County, Kansas: Kansas Geol. Survey Bull. 120, 130 p.

4. Bayne, C. K. (1960) Geology and ground-water resources of Harper County, Kansas: Kansas Geol. Survey Bull. 143, 183 p.

5. Frye, J. C. and Leonard, A. B. (1952) Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99, 230 p.

6. Lane, C. W. (1960) Geology and ground-water resources of Kingman County, Kansas: Kansas Geol. Survey Bull. 144, 174 p.

7. Moore, R. C. (1920) Geology of Kansas: Kansas Geol. Survey Bull. 6, 98 p.

8. Moore, R. C. (1940) Ground-water of Kansas: Kansas Geol. Survey Bull. 27, 112 p.

9. Norton, G. H. (1939) Permian red beds of Kansas: American Assoc. Petroleum Geologist Bull. vol. p. 1751-1819.

10. State Highway Commission of Kansas (1966) Standard specifications for state road and bridge construction, 888 p.

11. Walters, K. L. (1961) Geology and ground-water resources of Sumner County, Kansas: Kansas Geol. Survey: Kansas Geol. Survey Bull. 151, 193 p.

12. Williams, C. C. and Lohman, S. W. (1949) Geology and ground-water resources of a part of south-central Kansas with special reference to the Wichita Municipal Water Supply: Kansas Geol. Survey Bull. 79, 455 p.