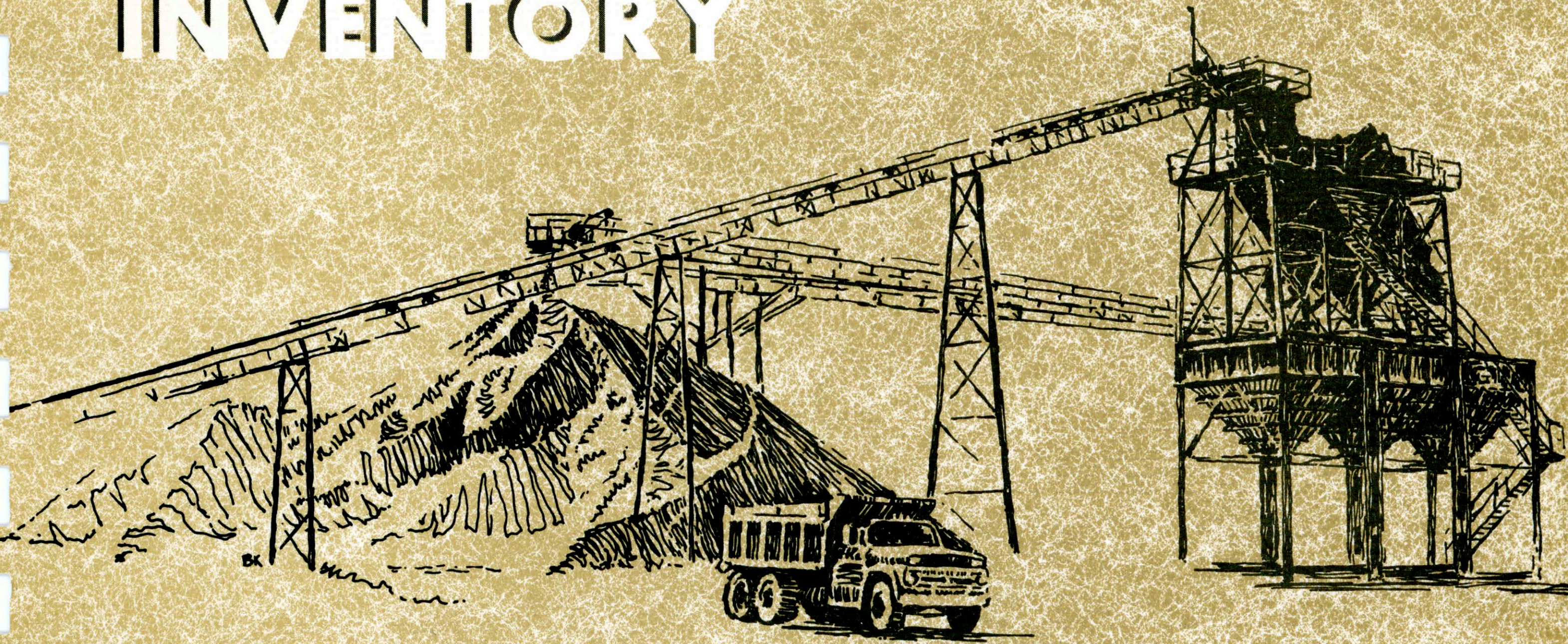
REPORT NO. 31

CONSTRUCTION MATERIALS INVENTORY



OTTAWA COUNTY, KANSAS

DEPARTMENT OF TRANSPORTATION KANSAS

Kansas Department of Transportation
Engineering Services Department
Planning and Development Department

CONSTRUCTION MATERIALS INVENTORY OF OTTAWA COUNTY, KANSAS

by

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

1977

Construction Materials Inventory Report No. 31

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

the **WHY?**

WHAT?

and **HOW?**

of **This REPORT**

This report was compiled for use as a guide for locating construction materials in Ottawa County.

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

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

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

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

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

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

TO LOCATE AND EVALUATE

A MAPPED SITE OF CONSTRUCTION MATERIAL IN OTTAWA COUNTY

TURN TO THE MATERIALS INVENTORY SECTION

See
TABULATION OF CONSTRUCTION MATERIALS
Figure 8, Page 15

for material
BY TYPE
USE COLUMN 1

For Quality Data
See Figure 17
Page 25

for material
BY INTENDED USE
USE COLUMN 2

for **DESCRIPTION** of material

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

for **AVAILABILITY** of material

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

MATERIALS MAP

SEE PINK SHEET, PAGE 27

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

SITE DATA FORMS

OPEN MATERIALS SITES: SAMPLED	GREEN SHEET, PAGE 30
OPEN MATERIALS SITES: NOT SAMPLED	GREEN SHEET, PAGE 50
PROSPECTIVE MATERIALS SITES: SAMPLED	GREEN SHEET, PAGE 104
PROSPECTIVE MATERIALS SITES: NOT SAMPLED	GREEN SHEET, PAGE 110

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

CONTENTS

PREFACE

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

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

Appreciation is extended to Mr. Donald L. Jarboe, Second District Materials Engineer, Mr. Larry Day, Ottawa County Road Supervisor, Mr. Robert Lott, Ottawa County Assessor, and Mr. Robert Robins, owner of Robins Sand and Gravel Company, Minneapolis, Kansas, for verbal information concerning construction materials discussed in this report.

This report was prepared under the guidance of R. R. Jones, P. E., Engineer of Engineering Services, A. H. Stallard, Chief, Environmental Support Section, Engineering Services, L. D. Myers, Geologist III, and members of the Environmental Support and Special Services Sections.

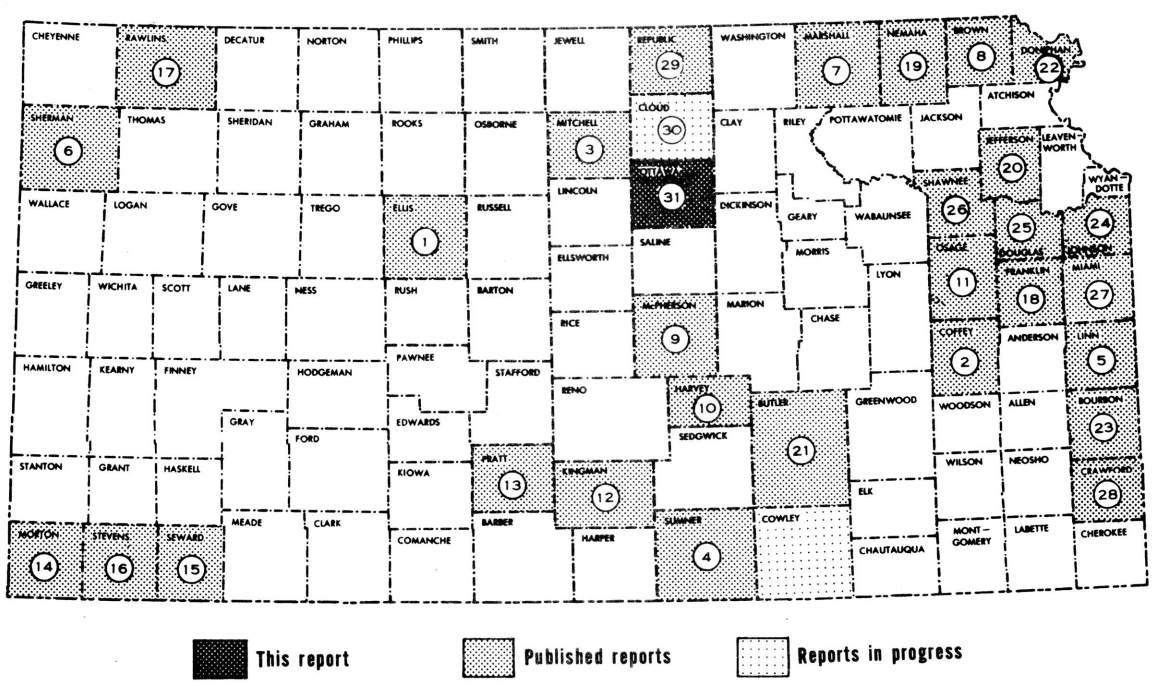


Figure 1. Index map of Kansas showing the location of Ottawa County along with the report numbers and location of counties for which reports have been or are being completed.

ABSTRACT

Ottawa County lies within the Great Plains physiographic province. The county is further divided into the Dissected High Plains and Flint Hills Upland regions with the Dissected High Plains covering all but the southeastern corner. Major topographic features of the county include the gently-sloping upland plains and steep valley walls formed by the erosion of upper Cretaceous limestones and shales in the northwestern part of the county, and the gently-to moderately-rolling land surface formed by the erosion of the Dakota, Kiowa and Wellington Formations.

The Solomon and Saline Rivers and their tributaries drain most of Ottawa County; however, the northeast corner is drained by small streams flowing eastwardly into Clay County.

The primary source of construction materials in Ottawa County is sand and gravel deposits in Quaternary alluvium of the Solomon River. Additional untested deposits of sand and gravel may be found in Illinoisan terrace deposits. Reworked sandstone and limestone gravels of Nebraskan - Kansan age are found in small terrace deposits in the western half of the county. Untested calcite cemented sandstones have been located southwest and north of Tescott and east of Lamar; however, the full extent of these deposits is not known. Volcanic ash deposits of unknown quantity and quality were observed northwest of Ada and northeast of Lamar.

Moderate quantities of water are available in the alluvial and terrace deposits of the Solomon and Saline River valleys; however, the water may be highly mineralized in some areas. No water is produced from the Nebraskan-Kansan terraces, Carlile Shale, Greenhorn Limestone, Kiowa Shale, or Wellington Formation. Consolidated rock aquifers of the Dakota yield minimal quantities which are generally satisfactory only for domestic use.

GENERAL INFORMATION SECTION

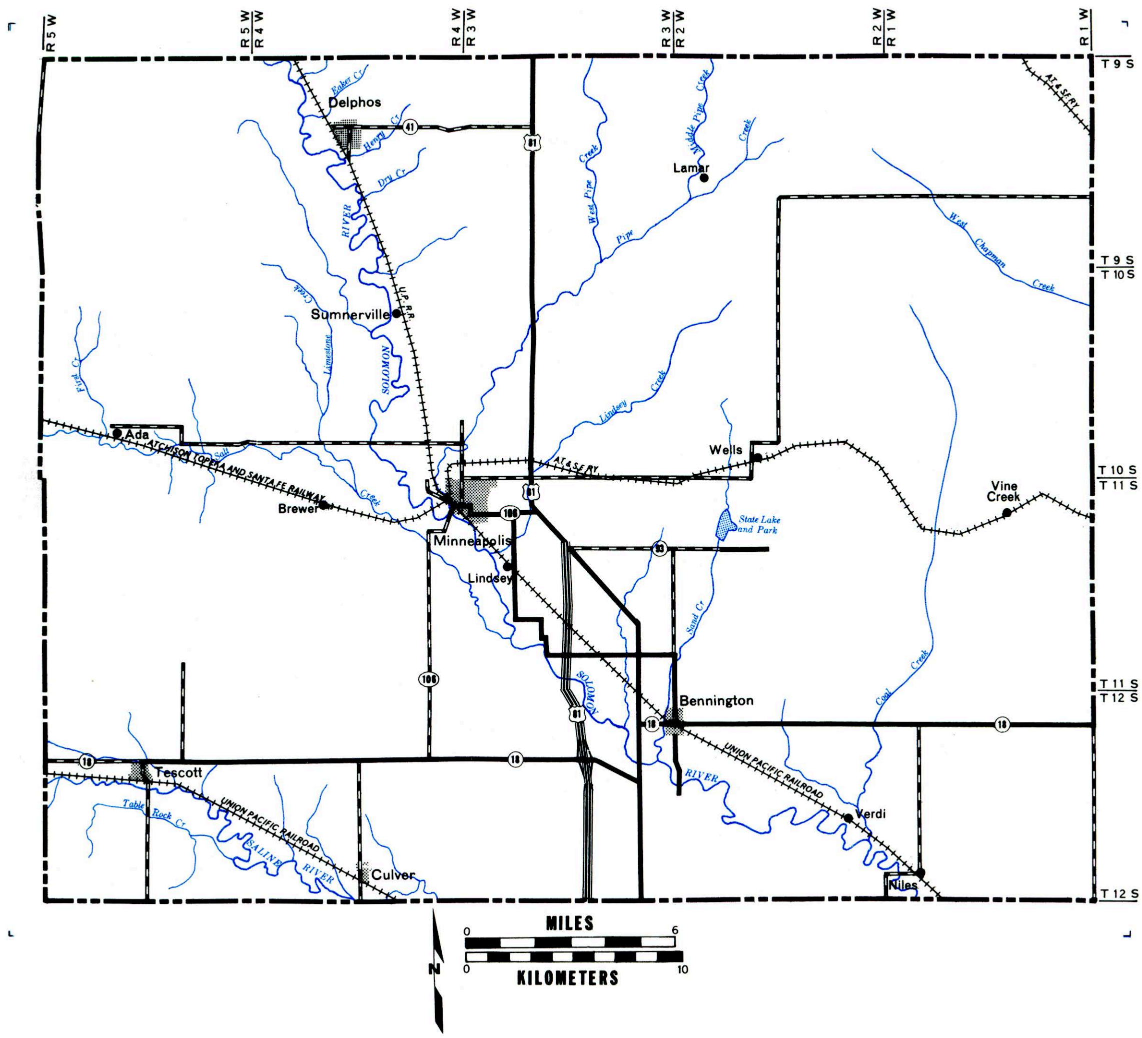


Figure 2. Drainage and major transportation facilities in Ottawa County.

FACTS ABOUT OTTAWA COUNTY

Ottawa County is located in north-central Kansas (figure 1, page v), and has an area of 723 square miles (1872.6 square kilometers) and a population of 6351 according to the 1976 records of the Kansas State Board of Agriculture. Elevation of terrain above mean sea level ranges from a high of 1645 feet (501.4 meters) in sec. 15, T9S, R5W, to a low of 1180 feet (359.7 meters) where the Solomon River leaves the county in sec. 32, T12S, R1W.

A primary road system connects all major communities and a well developed secondary road system provides access to small communities. Figure 2 illustrates major drainage and transportation facilities in the county.

METHODS OF INVESTIGATION

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

Phase One: Relevant information concerning geology, soils, and construction materials of the county was reviewed and the general geology determined. Quality-test results of samples taken in Ottawa County were then correlated with the various geologic units and unconsolidated deposits.

Phase Two: A study and interpretation of aerial photographs taken by the Kansas Department of Transportation at a scale of one inch equals 2,000 feet (1 cm = 240 meters), was accomplished. Figure 3 illustrates aerial photographic coverage of Ottawa County. Geologic source beds and all open materials sites were mapped and classified on aerial photographs. All materials sites were then correlated with the geology of the county.

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

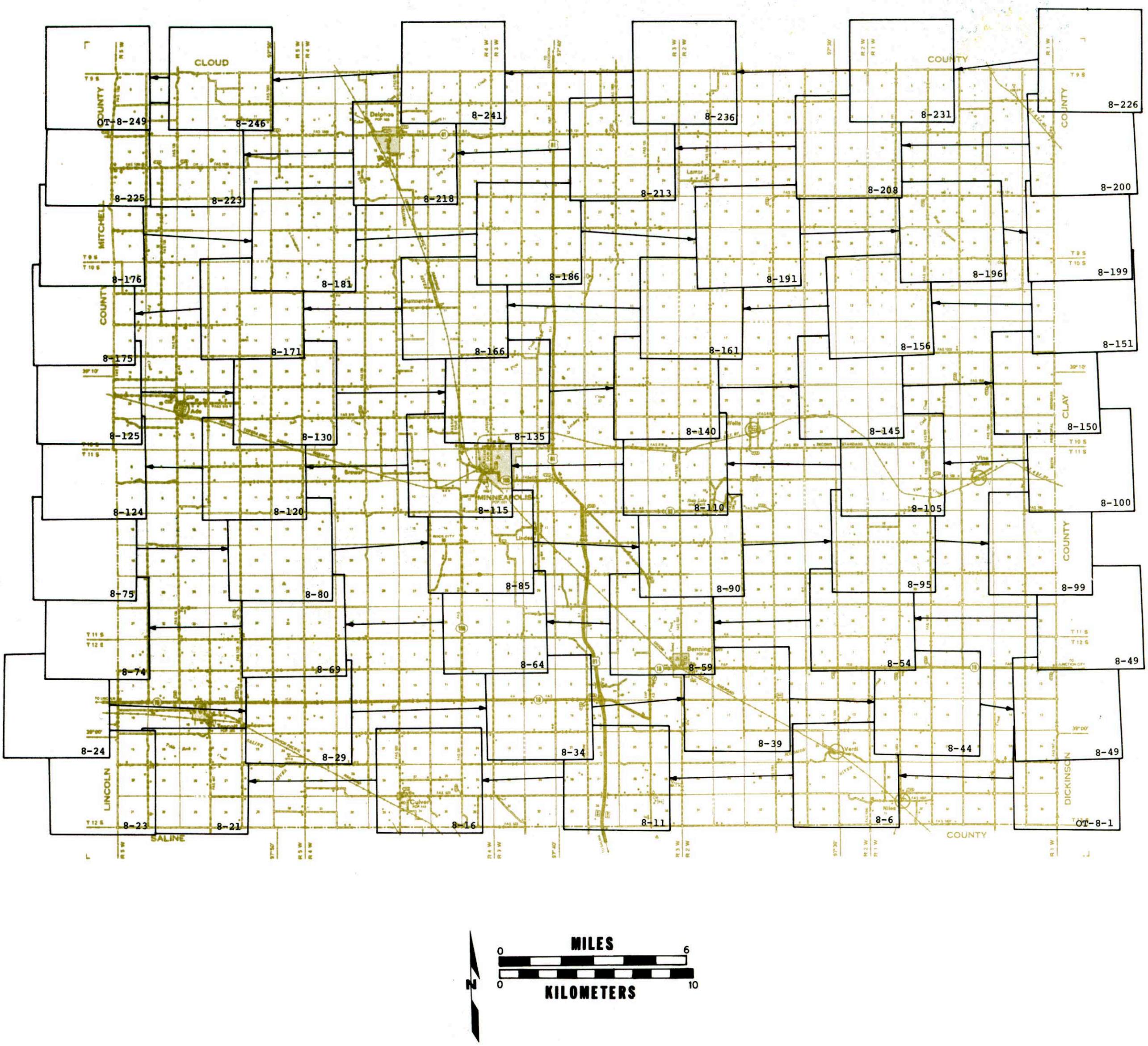
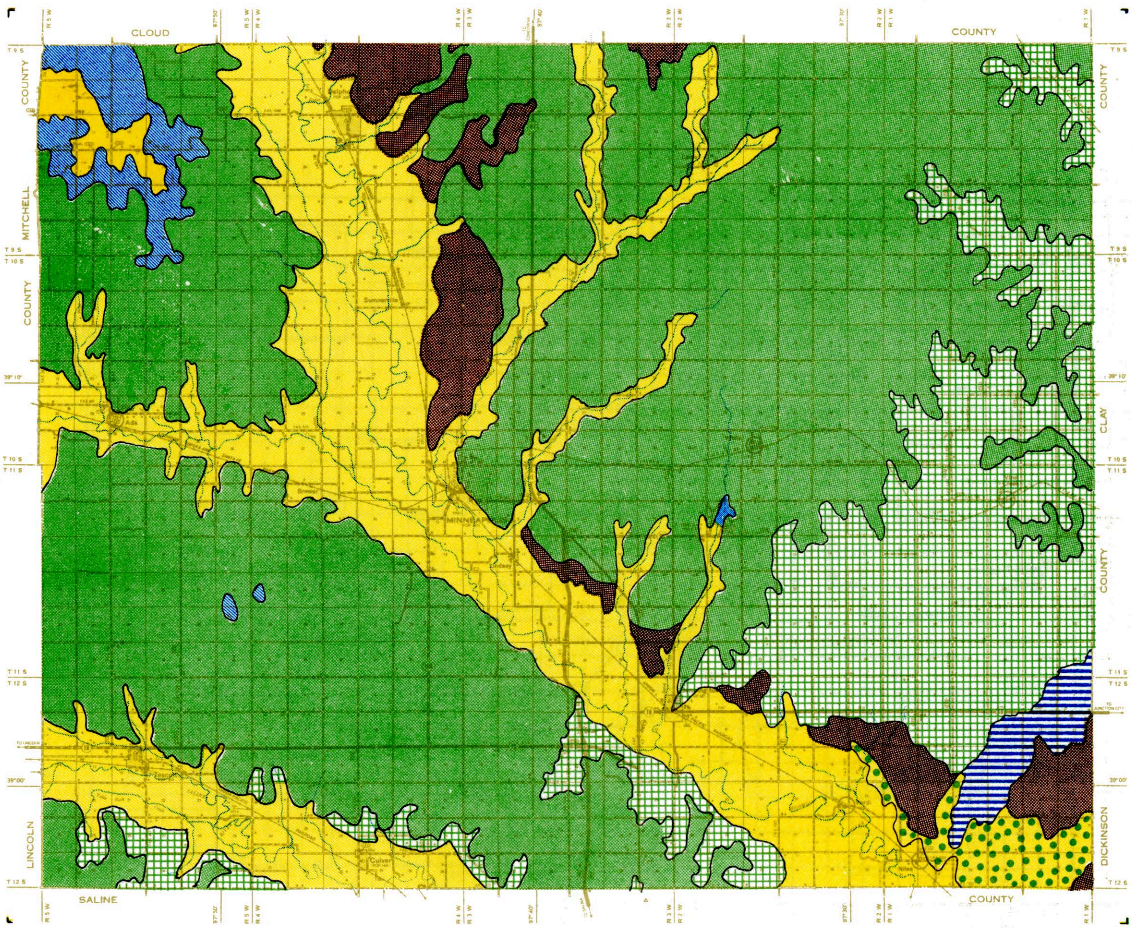
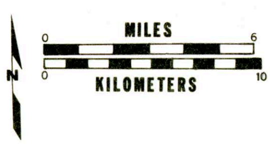


Figure 3. AERIAL PHOTOGRAPHIC COVERAGE MAP for Ottawa County. The numbers refer to photographs taken by the Photogrammetry Section, Kansas Department of Transportation on 4-24-62 at a scale of 1" = 2000' (1cm = 240 meters). Aerial photographs are on file in the Photogrammetry Laboratory, State Office Building, Topeka, Kansas.

GEOLOGY SECTION





LEGEND

- Alluvium
- Loess
- Kansan Terrace
- Carlile Shale
- Greenhorn Limestone Fm.
- Dakota Formation
- Kiowa Shale
- Sumner Group

GENERAL GEOLOGY

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

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

This report is based primarily on information obtained from the State Geological Survey of Kansas, Bulletin 154, "Geology and Ground-Water Resources of Ottawa County, Kansas," by Leslie E. Mack, 1962, 145 pp. Additional information was obtained from Kansas Geological Survey publications relating to Ottawa and surrounding counties, reports compiled by the Geology Section of the Kansas Department of Transportation and field observations by the author. The geologic timetable, figure 4, shows in graphic form the major time periods and the approximate duration of each. Figure 5, page 7, illustrates the surface geology and stratigraphic position of each material source unit in Ottawa County. Divisions of the Quaternary Period are illustrated in figure 6, page 9.

Subsurface rocks in Ottawa County range in age from Precambrian to Permian. Precambrian rocks are marine sedimentary and granitic (Merriam, 1963). Red clastic Precambrian sediments were encountered at a depth of 4008 feet (1221.6 meters) in the SE ¼, sec. 7, T10S, R2W (Cole & Ebanks, 1974). Paleozoic sediments composed of limestones, dolomites, sandstones, and shales and ranging in age from Cambrian to Permian overlie the Precambrian basement rocks. Exposed Palezoic rocks are limited to small outcrops of the Wellington Formation in the southeastern part of the county.

At the close of Paleozoic time, the seas withdrew and the area was gently tilted towards the Hugoton Embayment located to the southwest. Triassic and Jurassic sediments are absent in the county, indicating a prolonged period of uplift and erosion. During early Cretaceous time, the sea began an advance from the south that eventually inundated the land surface of the mid-continent area. The oldest Cretaceous sediments exposed in the county are small outcrops of Kiowa Shale which lie uncomformably on the Permian sediments. In the western part of the county sediments of the Dakota Formation lie directly on the Permian sediments indicating an extended hiatus between the deposition of the Permian and Dakota sediments. During the desposition of Dakota sediments, the sea is thought to have advanced and retreated numerous times throughout the midcontinent area (Twenhofel, 1920). Plummer and Romary (1942) describe the depositional environment of Dakota time as comparable to the existing Mississippi Delta. Mack (1962) places an erosional unconformity between the top of the Kiowa Shale and the base of the Dakota Formation. Erosional channels in the Kiowa Shale as in sec. 14, T10S, R1W, are filled with Dakota sediments.

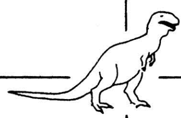
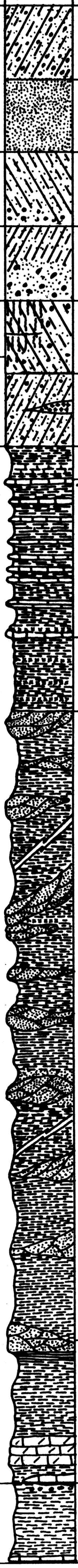
ERAS	PERIODS	ESTIMATED LENGTH IN YEARS	TYPE OF ROCK IN KANSAS	PRINCIPAL MINERAL RESOURCES
CENOZOIC	QUATERNARY (PLEISTOCENE) 	1,800,000	Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.	Sand and gravel; volcanic ash; agricultural soils; water.
	TERTIARY 	63,500,000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

Figure 4, Geologic Timetable.



System	Series	Stage or Group	Graphic Legend	Formations and Members	Map Symbols	Thickness	General Description	Construction Materials
Quaternary	Pleistocene	Recent		**Alluvium**	Qal	0-40'+ (0-12m)	Silt, clay, sand and gravel. Sand and gravel composed of quartz, chert, with some limestone gravel.	Concrete and bituminous aggregate and light type surfacing.
Quaternary	Pleistocene	Recent		**Dune Sand**	Qds	0-20'+ (0-6m)	Cross-bedded tan to gray, fine grained, quartzitic material.	Mortar sand, light type surfacing.
Quaternary	Pleistocene	Wisconsinan		**Wisconsinan Terrace**	Qtw	0-70'+ (0-21m)	Silt, clay, and scattered lenses of sand and gravel.	Light type surfacing.
Quaternary	Pleistocene	Illinoisan		**Illinoisan Terrace**	Qti	0-70'+ (0-21m)	Silt, clay, and scattered thin to thick lenses of sand and gravel.	Concrete and bituminous aggregate, and light type surfacing.
Quaternary	Pleistocene	?		**Undifferentiated Pleistocene Terrace**		0-70' (0-21m)	Silt, clay, rounded limestone and sandstone fragments. Erratic sorting and highly variable in thickness and areal extent. Some scattered volcanic ash deposits in northern half of county.	Mineral filler, light type surfacing.
Quaternary	Pleistocene	Nebraskan-Kansan		**Nebraskan-Kansan Terrace**	Qtn	0-15'+ (0-5m)		
Cretaceous	Upper Cretaceous			**Carlile Shale**		0-15'+ (0-5m)		
Cretaceous	Upper Cretaceous			"Fencepost ls Bed" **Greenhorn Limestone**	Kg	0-75'+ (0-23m)	Alternating thick calcareous shales and thin limestones with scattered seams of bentonite. Tan to gray with abundant fossil clams.	Light type surfacing and building stone
Cretaceous	Upper Cretaceous			**Graneros Shale**		0-38' (0-12m)		
Cretaceous	Lower Cretaceous			**Dakota Formation**	Kd	0-350'+ (0-107m)	Kaolinitic Shale with thin to massive layers of cross-bedded sandstone. Sandstone is tan to tan gray, brown, and reddish brown with iron or calcite cementation.	Concrete and bituminous aggregate, light type surfacing, and riprap from calcite cemented sandstones.
Cretaceous	Lower Cretaceous			**Kiowa Formation**		0-80'+ (0-24m)		
Permian	Middle Permian			**Wellington Formation**		0-50'+ (0-15m)		

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

Although fossils are very scarce in the Dakota in Ottawa County, characteristics of the sediments such as cross-bedding and sorting are indicative of a near shore or coastal plain environment characterized by sand bars, swampy areas, and lagoons. Mack (1962) compares this ancient environment with those in existance today along the Texas Gulf Coast. The presence of the fossil remains of an ankylosaur, family Nodosauridae (an armored dinosaur) in the Dakota Formation of northeast Ottawa County indicates a warm, temperate deciduous forest existed during at least one part of this period (Eaton, 1960).

As the seas gradually transgressed at the close of Dakota time, deposition of the non-calcareous black shales of the Graneros was initiated. The depositional environment continued to change and the chalky Greenhorn Limestone and Carlile Shale Formations were laid down.

At the close of the Cretaceous, the seas retreated to the south and a prolonged period of erosion followed. The only Tertiary sediments in the county are a 3 to 4 inch (7.6-10.2 cm) bed of "Algal" limestone regarded as the uppermost portion of the Ogallala Formation (Mack, 1962).

The Quaternary (figure 6) marked a time of both degradational and aggradational cycles which were the result of a sequence of glaciers advancing and retreating.

Divisions of the Quaternary Period

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

Figure 6. Geologic timetable of the Quaternary Period.

During Nebraskan time, many of the drainage channels flowed southward, including the Solomon River which joined the Smoky Hill River. Using a common channel, both rivers flowed southward thru the McPherson valley into the Arkansas River. The Kansan ice sheet advanced from the northeast where it blocked the Blue and Kansas Rivers and forced major drainages to develop to the south and west.

According to Mack (1962), the present Saline River valley in southern Ottawa County may have formed during this period. As the glaciers retreated for the final time, the degradation process accelerated, which incised the present day drainage pattern into the topography. During Quaternary time, a period of volcanic activity to the west of Kansas brought about several "falls" of volcanic ash over much of the midwest including Ottawa County. Remnants of one or more of these ash falls can be found northwest of Ada and northeast of Lamar.

GEO-ENGINEERING

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

Geo-engineering problems in Ottawa County, which are described in the following paragraphs, are associated with alluvial and terrace deposits of the major drainage channels, sandstone and shale outcrops along valley walls, and in limited areas where limestones and dune sand are located.

The alluvial and terrace deposits encountered in the valleys of the Solomon and Saline Rivers and their tributaries are composed of silt and clay with lenses of sand and gravel. Cut-off meanders containing unconsolidated and organic material are located in the flood plains and terraces. Fill sections will require detailed study to determine construction procedures that will minimize the effect of differential consolidation. The need for borrow for fill construction in alluvium will require exploration to acquire sufficient material above the water table. Alluvial deposits are susceptible to seasonal flooding and terraces of Illinoisan and Wisconsinan age may be inundated during periods of major flooding. Generally, soils present in the alluvium and terraces have a low shear strength and a high shrink-swell potential.

Rock excavation can be expected in areas where calcite and iron cemented sandstones of the Dakota are encountered. The sandstones tend to case harden upon exposure which will cause difficulty in their removal.

Shales of the Dakota, Graneros, and Greenhorn Formations contain thin seams of bentonite which vary in thickness from .01 to .5 feet (.3 cm to 15.2 cm). Failure to remove bentonite seams may result in slope failure as observed in sec. 14, T9S, R5W (figure 7). These failures occur when the bentonite hydrates and expands.

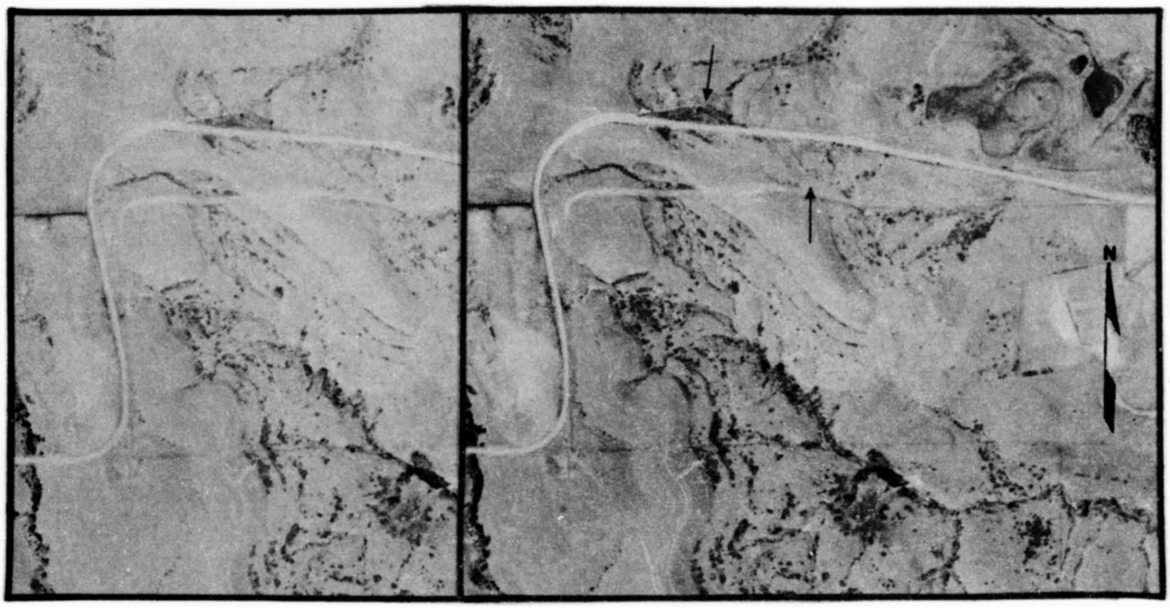


Figure 7. Stereogram of slope failures in Graneros Shale located in sec. 14, T9S, R5W, Ottawa County, Kansas.

Greenhorn Limestone outcrops are found in the northwestern portion of the county with a few outliers located southwest of Minneapolis. These outcrops are composed of alternating thin limestones, thick limy shale beds, shale beds and scattered seams of bentonite. Moderate amounts of rock excavation can be expected in areas where the limestones and shales outcrop.

Sand dunes located east of Bennington (Plate VI and IX) may require special construction techniques to prevent wind erosion when vegetation is removed. Binder material such as soil or asphalt may be needed to provide a stable subgrade for vehicular construction traffic.

Soils overlying the Kiowa and Wellington Formations in the southeastern corner of Ottawa County are clayey and exhibit high shrink and swell characteristics. Soil material covering the Dakota Formation displays moderate to high shrink and swell characteristics, low bearing capacity and low shear strength. These soils are generally stony, thin soils. Thin soils having low shear strength, low bearing capacity and moderate to high shrink and swell potential overlie the area to the northwest of the Greenhorn outcrop line shown on plates I and IV.

Hydrology problems of a limited nature can be anticipated along bentonite seams, limestones, bedrock-soil mantle contacts and buried soil profiles. Similar problems will be encountered in some sandstones of the Dakota Formation; however, due to the complexity of the Formation, these areas will have to be determined by on-site inspection.

Water supplies from less than 1 gpm (.1 l/s) to several hundred gpm (l/s) are available from aquifers in Ottawa County. The principle aquifers are found in deposits of Pleistocene age and in sandstones of the Dakota Formation. Yields from the Dakota vary from less than 5 to more than 145 gpm (.3 - 9.1 l/s) and generally are "hard" due to a high iron concentration and in some cases a high sulfate content. Water from terrace deposits of Illinoisan and Wisconsinan age may yield in excess of 1000 gpm (63.1 l/s). This water usually contains much bicarbonate and locally may have heavy concentrations of iron. There were no observed wells in the alluvial material but moderately large yields of water with some mineral content may be expected (Mack, 1962). Water from surface streams may contain a high chloride content during periods of low flow.

MATERIALS INVENTORY SECTION

GENERAL INFORMATION

Sand and gravel deposits of Quaternary age make up the major portion of the available construction materials of Ottawa County. Scattered deposits of silt found in the alluvial and terrace deposits of the major drainage systems have a low plasticity index which permits their use as mineral filler.

Limestones of Cretaceous age are found in the county; however, the thin nature of the limestone units within the Greenhorn Formation limits their use to light type surfacing and as a minor source of building stone. Deposits of calcite cemented sandstone of the Dakota Formation are found to the north and to the southwest of Tescott and east of Lamar. Quality tests have not been run on the material at the time this report was written; however, field observations indicate the material might be suitable as construction aggregate. The full extent of these deposits has not yet been defined. Volcanic ash of undetermined quality and quantity was observed in two localities; however, the full extent of these deposits is presently unknown.

Construction materials types, their uses, and availability are tabulated in figure 8. Test results from a limited amount of sampling and testing are presented in figure 17, page 25.

CONTENTS
MATERIALS INVENTORY SECTION

TYPE material and Geologic Source	USE	Page	Availability
SANDSTONE Dakota Formation	Calcite cemented sandstone suitable for concrete and bituminous aggregate, light type surfacing, riprap.	16	Moderate source in south-western part of county and limited in north central part. Plate II, IV and VII.
LIMESTONE Greenhorn Formation	Limited to local use for light type surfacing.	18	Limited source in north-western part of county. Plates I and IV.
SAND AND GRAVEL Nebraskan - Kansan Terrace	Light type surfacing.	19	Limited source. All plates.
Illinoisan Terrace	Concrete and bituminous aggregate and light type surfacing. Sweetner may be needed.	20	Moderate source. All plates.
Wisconsinan Terrace	Light type surfacing	21	Limited source. All plates.
Dune Sand	Mortar sand, light type surfacing for local use.	21	Limited source in south central part of county. Plates V and VII.
Quaternary Alluvium	Concrete and bituminous aggregate and light type surfacing. Sweetner may be needed.	21	Moderate source. Plates I, II, IV, V, VI, VII, VIII, IX.
MINERAL FILLER Volcanic Ash	Mineral Filler	22	Very limited sources in western and northern part of county. Plates II and IV.

Figure 8. Tabulation of the construction materials types and their availability in Ottawa County.

DESCRIPTION OF CONSTRUCTION MATERIALS

Sandstone

Dakota Formation

The Dakota Formation of early Cretaceous age lies unconformably on the Wellington and Kiowa Formations in the southeastern part of the county and is overlain conformably by the Graneros Shale in the northwest corner. The Dakota forms a highly variable topography over a major part of the county. In areas where the Graneros caps the Dakota, the thickness of the formation is approximately 350 feet (106 meters); however, the thickness is variable due to the basal unconformity (Mack, 1962).

According to Mack, the Dakota Formation in Ottawa County consists of three primary intergrading units. The upper one-third and lower one-third of the formation are massive lenticular sandstones with intermittent lenses of silt and clay. The middle third is silt and clay interbedded with lenticular sand bodies. Correlation of the beds over more than a short distance is not possible due to the erratic nature of the deposits.

The sandstone lenses are light to tan gray, yellowish brown to brown, and sometimes reddish brown to red in color. The thickness varies from a few inches (centimeters) to many feet (meters) with a highly irregular exposure pattern. They are generally composed of fine to medium, well sorted quartz grains. Cross-bedding is prominent in most of the sandstone lenses.

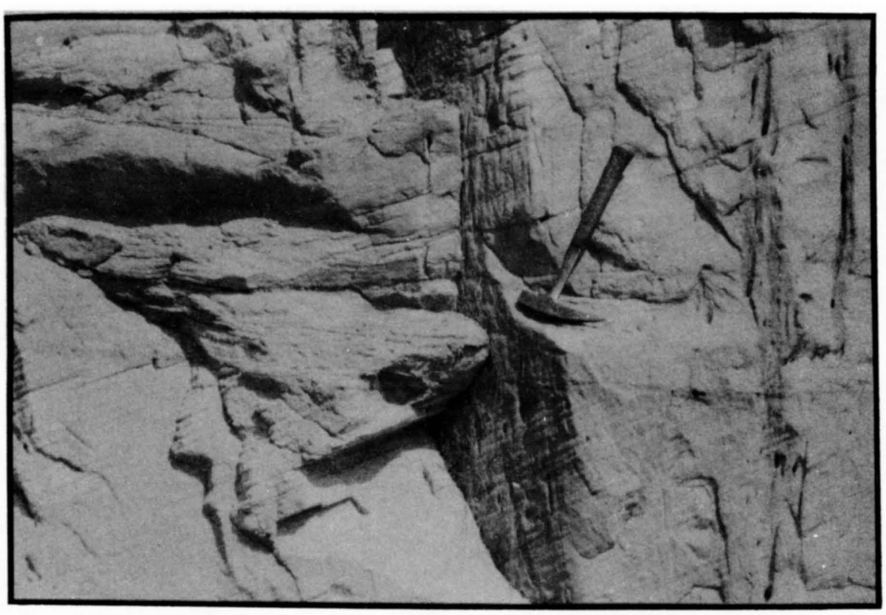


Figure 9. Cross-bedding in Dakota Sandstone exposed in north side of road cut in the SE ¼, sec. 24, T12S, R6W.

The sand grains are cemented together with iron oxide, calcium carbonate and in some cases silica. The degree of cementation ranges from loose sand to a very dense, hard, cemented sandstone (quartz arenite).

Iron cemented sandstones have been used as light type surfacing in the county; however, due to poor durability of the stone, it is not suitable as a construction aggregate. Calcite cemented sandstone, found southwest of Tescott (SS + 85), southwest of Minneapolis at Rock City, and east of Lamar (SS + 76) appears to be acceptable as construction aggregate. Field observations indicate this material is similar to that produced by the Quartzite Stone Co. near Lincoln, Kansas, which has been tested and found to be acceptable as construction aggregate. The quartz arenite produced generally has soundness values of .98 or higher, absorption of less than 1%, specific gravity values (dry) near 2.60 and (wet) 2.65 and Los Angeles wear values from 29 to 45%.

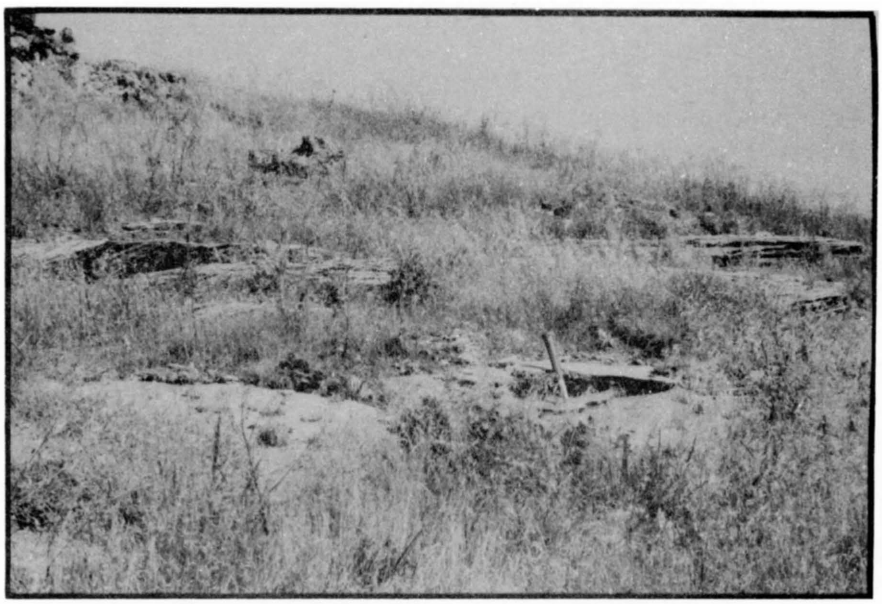


Figure 10. Calcite cemented sandstone of the Dakota Formation outcropping in the SW ¼, sec. 5, T12S, R5W.

The amount of producible aggregate varies from location to location. Test drilling will be needed to delineate the areal extent and thickness of each deposit of sedimentary quartzite (quartz arenite). Quality tests should also be completed on the material before use due to the highly variable nature of the Dakota Formation.

Due to the erratic nature of the sandstone deposits and the fact that much of the Dakota is covered by loess, alluvium, and terrace deposits, the Dakota was not mapped. Specific prospective materials sites are located on plates II, III, IV, and VII.

Limestone

Greenhorn Limestone Formation

The Greenhorn Limestone Formation is exposed in the northwest corner of the county and as small outliers five miles (8 kilometers) southwest of Minneapolis. Its maximum thickness in Ottawa County is approximately 75 feet (22.9 meters) west of the city of Delphos where the overlying Carlile Shale is present.

The Greenhorn is composed of four members which are, in ascending order, the Lincoln Limestone, Hartland Shale, Jetmore Chalk, and Pfeifer Shale. Due to its limited value as construction aggregate, the formation is mapped as one unit and is shown on plates I and IV.

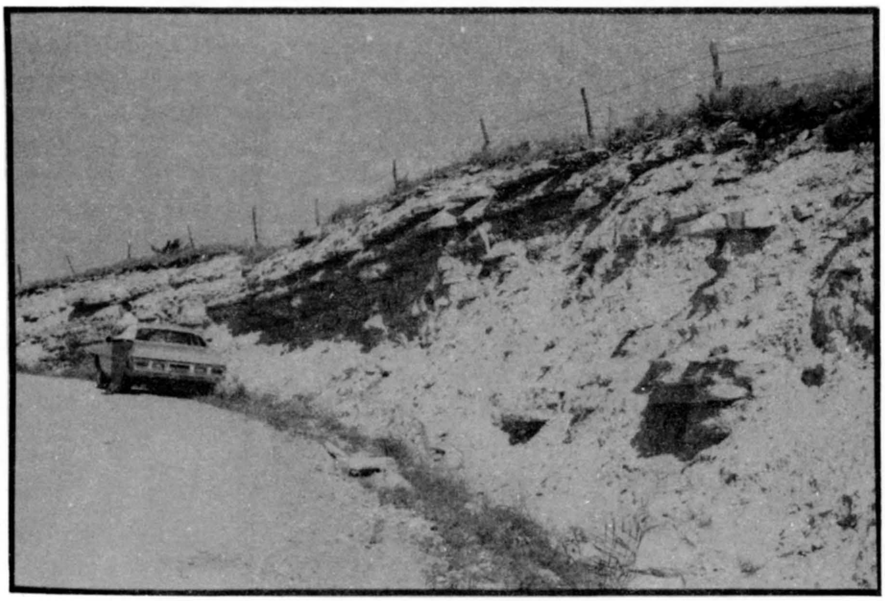


Figure 11. Exposure of a portion of Greenhorn Limestone Formation, SW ¼, sec. 14, T9S, R5W.

The Greenhorn Formation is composed of chalky shales, thin bedded limestones and scattered, thin beds of bentonite. The basal Lincoln Limestone beds are often distinguishable by the petroliferous odor given off on a freshly broken surface. The Lincoln Limestone should not be confused with the term "Lincoln Quartzite" which is a calcite cemented sandstone of the Dakota Formation. The Jetmore Chalk consists of chalky shale and thin beds of limestone including the "Shellrock bed" which contains abundant fossils (Inoceramus labiatus), clams that lived in the Cretaceous seas.

The uppermost Pfeifer Shale member also consists of thin alternating beds of chalky shale and thinner beds of limestone. The uppermost bed of the Pfeifer is the "Fencepost Limestone bed" which serves as the boundary between the Greenhorn and Carlile Formations. The "Fencepost" has been quarried for building stone and fenceposts throughout its outcrop area.

Limited amounts of aggregate for local use can be obtained from the outcrop area of the Greenhorn Formation; however, due to its soft nature, the material will not meet specifications for construction aggregate.

Sand and Gravel

Nebraskan - Kansan Terraces.

Remnants of terraces of Nebraskan and Kansan age are found over much of Ottawa County; however, the majority are located in an area bounded by the Solomon and Saline Rivers, Salt Creek and the Lincoln - Ottawa County line. Those areas can be seen on plates I, IV and VII.

These deposits vary from 0 to 15 feet (0 - 4.6 meters) in thickness and are generally composed of sand and ironstone fragments from the Dakota Formation.

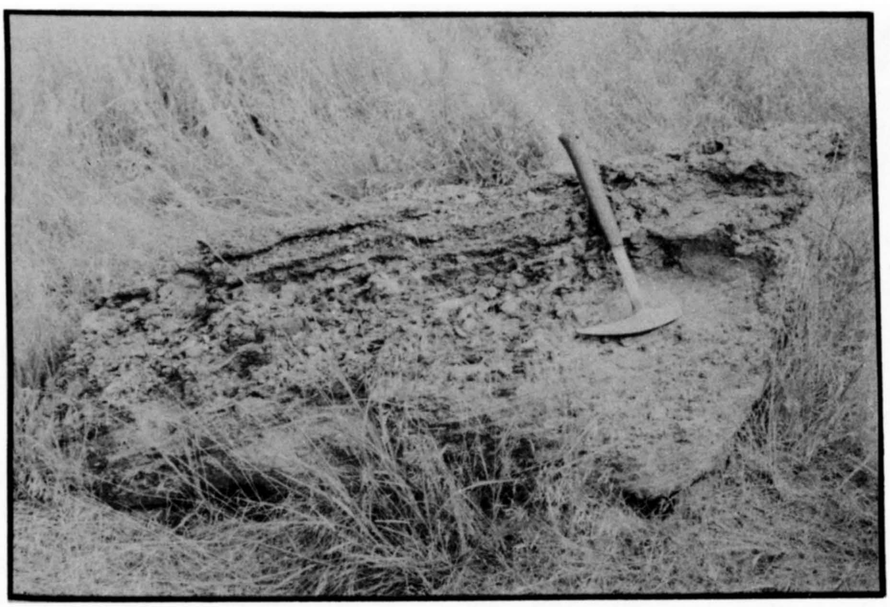


Figure 12. Partially cemented reworked Dakota gravel in a Nebraskan - Kansan Terrace deposit in sec. 20, R4W, T12S.

A large terrace deposit located north of Ada in sec. 8, T10S, R5W, is composed primarily of limestone fragments from the Greenhorn Formation.

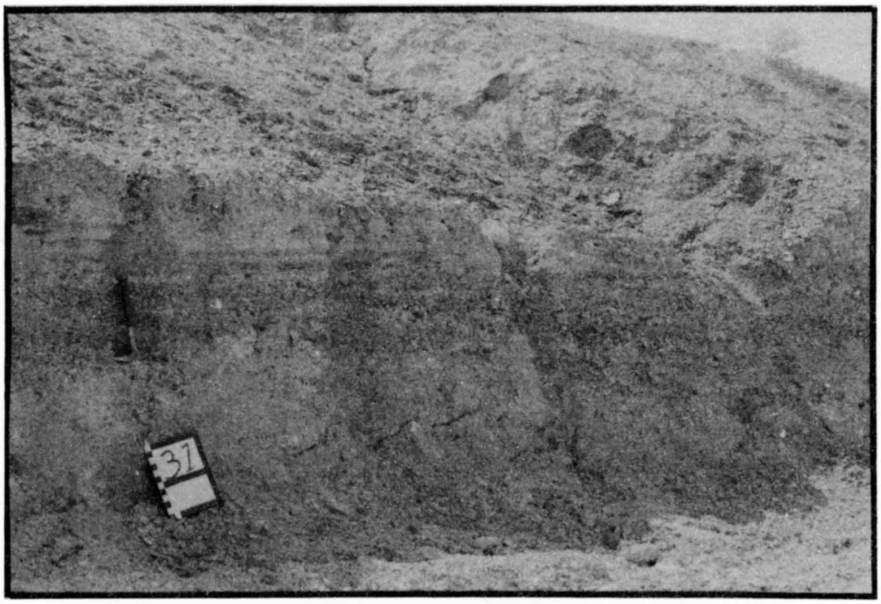


Figure 13. Limestone gravel deposit in a Nebraskan - Kansan age terrace deposit, W ½ sec. 8, T10S, R5W.

Fossils are rarely found in the terrace deposits. These terraces are characterized by poor sorting with scattered lenses of clay matrix occuring in some areas. These deposits generally lie above the water table. A limited amount of construction aggregate can be obtained from many of the terraces; however, they should be tested prior to production. Terrace deposits are shown on all plates.

Illinoisan Terrace

Terrace deposits of Illinoisan age are found alongside most of the major drainage valleys in the county. The height of the terraces above the flood plain range from a few feet (meters) to 20 feet (6.1 meters) (Mack, 1962) and they have a thickness ranging up to 68 feet (20.7 meters). The upper material in the terrace deposits is composed of silt and clay sized material while more granular material of sand and gravel size is found in the lower portion of the deposits. A test hole at site SG + 75 penetrated 44 feet (13.4 meters) of sand and gravel; however, this thickness is above average. The sand and gravel is composed of quartz, feldspar, magnetite, tourmaline and other igneous material (Mack, 1962). These igneous sediments are comprised of reworked material from the Ogallala Formation located to the west of Ottawa County. The Illinoisan terrace deposits are mapped on all plates.

Wisconsinan Terrace

Terrace deposits of the Wisconsinan stage occupy most of the larger stream valleys in Ottawa County. The width of these deposits varies from a few feet (meters) in the smaller tributaries to more than two miles (3.2 kilometers) along the Solomon River and the thickness varies from 0 to more than 70 feet (21.3 meters). Wisconsinan terraces are composed primarily of silt and clay sized material with thin lenticular sand deposits near the base. The sand is composed primarily of quartz with some feldspars and minor amounts of heavy minerals also present (Mack, 1962).

The small lenses of sand have very limited value for local use as light type surfacing material. The extent of the terrace deposits can be seen on all plates.

Dune Sand

Sand dunes are found east of Bennington and are shown on plates VI and IX. They are composed primarily of fine quartz grains with varying amounts of silt and clay. The dunes are tan-colored, cross-bedded, and were well covered with vegetation at the time of this study. Usually their thickness will not exceed 15 to 20 feet (4.6 - 6.1 meters). The fine dune sand can generally be used as a mortar sand; however, tests should be run before use from any location.

Quaternary Alluvium

The alluvium found along the perennial streams of the county is composed of unconsolidated sand, gravel, silt and clay sized material. The thickness of the alluvial deposits varies from 20 to 54 feet (6.1 to 16.5 meters). Granular material composed of quartz and feldspar is generally found in the lower part of the deposit. The silt and clay overburden overlying the granular material reaches a thickness of 22 feet (6.7 meters) in the W ½, sec. 34, T10S, R4W. The granular aggregate at this location has a thickness of 32 feet (9.8 meters). Removal of the silt and clay allows the granular material to be produced by pumping operations such as shown in figure 14.

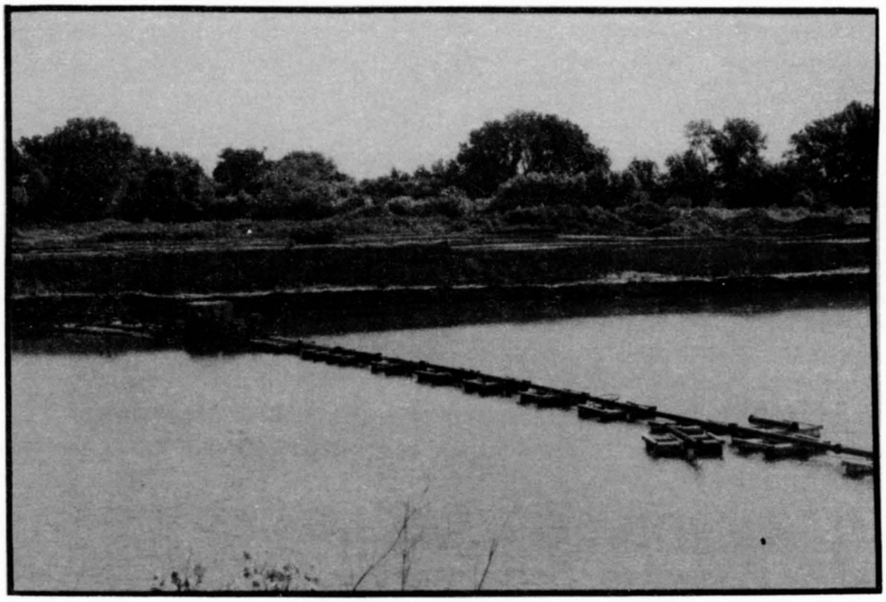


Figure 14. Sand and gravel pumping operation located in the W ½, sec. 34, T10S, R4W.

Siliceous granular material from the lower part of the alluvium present in the Solomon River valley comprises an important source of aggregate in Ottawa County. Sweetner may be added to meet gradational requirements for construction aggregate. Alluvial material, predominately of silt and clay sized particles, is present in many of the smaller stream valleys but cannot be portrayed on 1" = 1 mile (1 cm = .634 kilometers) maps. Alluvial material is mapped on all plates.

Mineral Filler

Volcanic Ash

Volcanic ash identified as Pearlette Ash of Kansan age (Swineford and Frye, 1946) is found in the NE ¼, SW ¼, sec. 9, T10S, R5W. It has a thickness which varies from 2 to 6 feet (0.6 - 1.8 meters) and a lateral exposure of 100 feet (30.5 meters) in the south bank of a small creek. The outcrop was covered with green lichens but was white on a fresh exposure when the ash was examined (figure 15). When the ash was examined under a petrographic microscope, little weathering was detected and no trace of contamination from other materials was noted. The overburden at this location is approximately 14 feet (4.3 meters).

Figure 15. Volcanic ash exposed in a creek bank in the NE ¼, SW ¼, sec. 29, T10S, R5W.

An ash deposit of undetermined age is located in the SE ¼, SW ¼, sec. 3, T9S, R2W. The observed thickness was 2 feet (0.6 meters) with an unknown lateral extent. This ash was also white on a fresh exposure.

Figure 16. Volcanic ash located in the SE ¼, SW ¼, sec. 3, T9S, R2W.

The volcanic ash deposits in Ottawa County had not been tested at the time of this study; however, they will probably meet specifications for mineral filler.

A "fission track" dating method is being used by some geologists to re-evaluate the age of ash falls in the mid-continent area. According to data presented in the *Guidebook to the 24th Annual Meeting of the Midwest Friends of the Pleistocene,* there were at least six ash falls during the Pleistocene. Boellstorff states that the concept of a single Pearlette ash of late Kansan age in the Great Plains area is no longer valid (Bayne, Boellstorff, and Miller, 1976). The ash located in sec. 29, T10S, R5W, in Ottawa County was previously classified as Pearlette by Frye, Swineford and Leonard (1948); however, due to this new dating concept, the ash may be re-examined and subsequently re-classified.

Site Data Form No.	Material Type	Date of Test	Percent Retained 3/4	3/8	4	8	16	30	50	100	Wash	G.F.	SP.GR. SAT.	SP.GR. DRY	%Wear	%Soundness	%Absorption	Source of Data SHC Lab. No.
Source of Material: Aluvium - Qal																		
Si + 9	Silt	4-06-65							0	2	89							
FS + 15	Fine Sand &						0	1	4	7	87.6	.12						
	Silt	5-21-68				0	2	15	49	61	33.2	1.27						
						0	1	1	3	15	69.1	.20						
FS + 16	Sand, Fine							0	1	2	95.2	.03						
	Sand & Silt	5-21-68				0	1	1	3	20	64.4	0.25						
								0	1	6	83.9	.07						
FS + 17	Fine Sand				0	1	1	2	26	64	30.6							
							0	1	44	88	6.3							
							0	3	44	80	15.7							
FS + 18	Blow Sand									74	85							
										77	83							
Source of Material: Nebraskan-Kansan Terrace - Qtn																		
SG + 1	Limestone	12-75	8	21	33	42	47	49	51	53	40.1		2.56		34	0.9	3.7	75-157
SG + 2	Limestone	2-75	3	6	13	20	26	31	41	53	36.6		2.64				1.7	
			12	29	48	62	69	73	76	79	17.9							
			6	17	30	43	52	58	64	71	25.2							
SG + 3		1-76	7	15	25	32	38	43	48	56	34.7		2.55		35	0.87	6.1	76-82
			2	15	34	50	61	67	78	84	12.3		2.66				4.1	
			2	18	38	50	57	60	66	74	18.5							
SG + 4	Sand & Sand																	
	Gravel		2	10	20	27	31	34	44	67	26.5	2.35						
			6	11	17	22	26	31	56	81	13.3	2.50						
			7	20	31	39	44	50	61	77	17.4	3.29						
SG + 5	Fine Sand,						0	1	32	82	8.7	1.15						
	Sand			0	5	8	10	12	22	40	38.5	.97						
			0	4	9	14	22	30	45	65	20.8	1.89						
SG + 6	Silt & Sand							0	2	13	71.6	.15	2.55				2.60	
	Gravel	7-31-73					0	1	2	6	86.1	.09	2.60		28	.94	0.30	73-1918
							0	1	2	6	85.4	.09						
SG + 7	Clay Gravel	12-12-67	1	8	18	28	36	42	51	65	26.1	2.49						
			5	11	21	35	47	55	74	87	8.7	3.35						
			1	7	18	29	37	42	54	67	25.1	2.55						
SG + 8	Silt & Sand Gravel	2-26-69	0	1	5	16	38	78	95	97			2.60		34.2	.94	.40	69-430 Production
			0	2	8	20	44	79	95	97								
Si - 13	Binder Soil	2-54								27	61							
FS + 11	Fine Sand	9-07-66					0	1	22	81	11	1.04						
					0	1	1	1	15	52	35	.70						
					0	1	1	2	28	69	21	1.01						
								0	21	84	8	1.05						
FS +12	Fine Sand	9-08-66				0	1	1	6	38	47	.46						
								0	22	70	22	.92						
								0	8	45	38							
FS -14	Blow Sand	2-54			0	1	1	2	7	17	60.5	.28						
FS + 10	Fine Sand	5-21-68	1	3	5	11	36	77	87	89	9.7	3.14						
						0	1	1	4	49	28.7	.55						

Figure 17. Results of tests completed on samples of material from the various geologic source beds in Ottawa County.