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GEOLOGIC CONSTRUCTION-MATERIAL RESOURCES IN SHERIDAN COUNTY, KANSAS

By

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INTRODUCTION

Purpose of the Investigation

The State Highway Commission of Kansas and the United States Geological Survey are cooperating in the compilation of a State-wide construction materials inventory. A field party composed of personnel from the two cooperating agencies was sent into Sheridan County, Kans., in the summer of 1949 to investigate sources of engineering construction materials. This report of the Sheridan County investigation is a part of the general inventory, and a contribution to the geologic mapping and mineral resource investigation being made in connection with studies of the Missouri River Basin (Cong. doc., 1944).

The primary objective of the investigation was to accumulate all field and laboratory data pertaining to the geologic materials in Sheridan County that would be useful in the construction of dams, highways, railways, airports, and other engineering structures. Additional geologic data are included in this report, but only to the extent of providing information useful in the development of the prospects reported in the inventory, or for the location of other materials required for future engineering needs.

Geography

Area covered by the investigation.--Sheridan County is in the second tier of Kansas counties south of the Nebraska border and in the third tier east of the Colorado border. (See fig. 1.) It comprises 25 townships and covers an area of about 900 square miles. The county is bounded on the north by Decatur County, on the east by Graham County, on the south by Gove County, and on the west by Thomas County.

Topography.--Sheridan County is near the center of the Great Plains physiographic province, and near the western boundary of the Plains Border subdivision of that province. Eastward-flowing streams have dissected the eastern part of the county more than they have the western half. The interstream areas are generally flat and wide. Dissection is most conspicuous in the area between the South Fork Solomon River and the Saline River.

The average altitude of the county is 2500 ft. The lowest point, 2250 ft, is on the South Fork Solomon River at the eastern boundary of the county, and the highest point, 2900 ft. is near the western border of the county in the vicinity of Menlo.

Drainage.--The principal streams in Sheridan County are the South Fork and North Fork Solomon River, and the Saline River. The northward-flowing tributaries of these streams are from 2 to 6 miles long and average 3 miles in length. The southward-flowing tributaries are not as numerous, but average 5 miles in length.

Minor streams are Sand Creek in the west-central part of the county, Bow Creek in the northern part, and Prairie Dog Creek near the northwestern corner.

Climate.--Sheridan County is in an area of continental-type climate in which the summers are relatively long and hot, and the winters short and fairly cold. The mean annual temperature is 53 F; the mean temperature ranges from a low of 29 F in January to a high of 79 F in July. There are 55 cloudy days a year, 110 partly cloudy days, and 200 clear days. The ground is snow-covered 30 days of the year. The normal annual precipitation is 19.35 in. The average date of the first killing frost in the fall is October 11, and that of the last killing frost in the spring is May 1 (Flora, 1948).

Figure 2, a chart showing temperature ranges at Hoxie, Kans., was compiled from Climatological data (U.S. Dept. Commerce, 1937-46), to provide basic data on temperature in relation to engineering construction. The chart indicates, for the 10-year period, the number of days each month in which the maximum daily temperature fell within certain designated ranges arbitrarily based on temperatures important in various phases of engineering construction.

Days in which the maximum temperature does not exceed 32 F occur only from November to March, inclusive, with the maximum incidence of 5.9 days in January. July is the warmest month of the year, with an average of 22.8 days having maximum temperatures above 90 F. The chart also shows the average difference between the daily maximum and mimimum temperatures for each month. The greatest difference in daily temperatures, 26 F, is in October; and the least difference, 20 F, is in January.

Inasmuch as precipitation also conditions the number of working days in engineering construction, figure 3, a chart showing precipitation ranges at Hoxie, Kans., is presented to show the effect of this climate factor. The ranges in precipitation were selected arbitrarily.

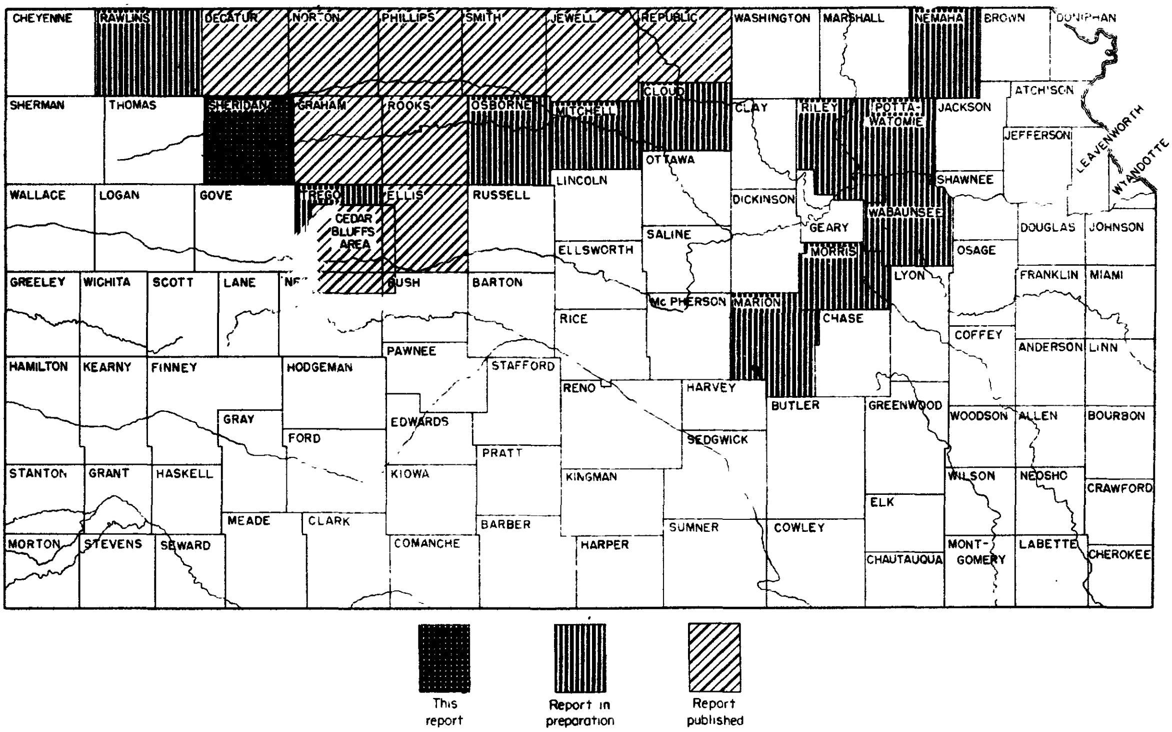
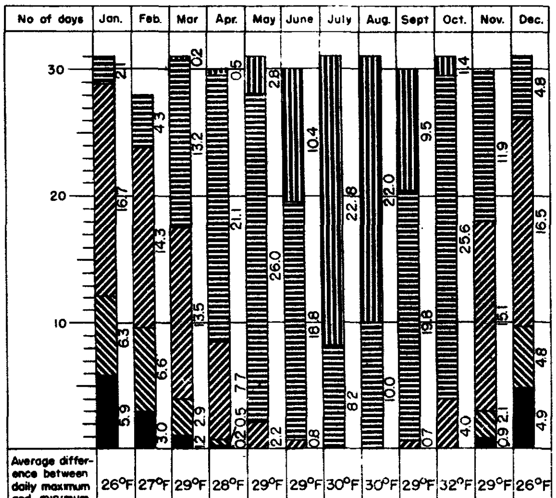


Figure 1.—Index map of Kansas showing areas covered by this report and by other construction materials investigations



EXPLANATION

Days in which maximum temperature was more than 90° F *(no concrete construction)*

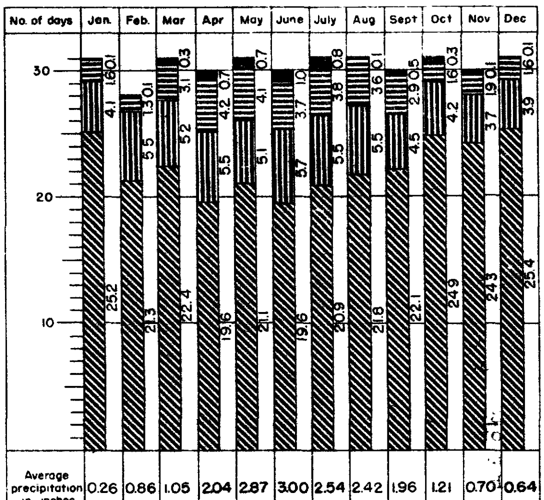
Days in which maximum temperature was between 61°–90° F *(no interference with any type of construction)*

Days in which maximum temperature was between 41°–60° F *(no interference with concrete construction; no bituminous surfacings laid)*

Days in which maximum temperature was between 32°–40° F *(concrete construction requires protection)*

Days in which maximum temperature was less than 32° F *(no concrete construction)*

Figure 2.—Chart showing temperature ranges at Hoxie, Kansas



Data for both charts compiled from Climatological Data Kansas Section for years 1937 to 1946, inclusive. Issued by Weather Bureau United States Department of Commerce

EXPLANATION

Days in which precipitation was more than 1 inch *(no construction activity)*

Days in which precipitation was between 0.11 and 1 inch *(no bituminous surfacings laid)*

Days in which precipitation was between a trace and 0.1 inch *(no interference with construction)*

Days in which there was no precipitation *(no interference with construction)*

Figure 3.—Chart showing precipitation ranges at Hoxie, Kansas

As based on a 10-year average (U.S. Dept. Commerce, 1937-46) there are 19.6 days in June, for example, in which no measurable precipitation fell; 5.7 days in which the precipitation ranged from a trace to 0.1 in.; 3.7 days in which 0.11 to 1 in. of rain fell; and 1 day in which the precipitation was more than 1 in. Continuing rains fall, for the most part, in the late spring and early fall, and other rainfall is generally in the form of showers.

Transportation routes.--Sheridan County is served by two railways, the Union Pacific and the Chicago, Rock Island, and Pacific; three transcontinental highways (U. S. 24, 83, and 383); and two Kansas highways (23 and 123). Kansas Highway 123 is a metaled, all-weather road, the other State and Federal highways are of the black-top type of construction.

County and township roads, for the most part, follow section lines. Some of them are metaled with materials available locally, whereas others are maintained as earth roads.

The locations of the railroads and roads are shown on plate 1.

Investigation Procedure

This report is based on field work of the reconnaissance type. The base map (scale: 1 in. equals 1 mile), including drainage lines, was provided by the State Highway Commission of Kansas. The areal distribution of the stratigraphic units that outcrop in Sheridan County was then mapped in the field. The mapped stratigraphic units are those recognized by the United States Geological Survey (Wilmarth, 1938) and the Kansas Geological Survey (Moore, R.C. Frye, J.C. and Jewett, J.M., 1944). The principal emphasis of this report is on construction materials. Geologic problems not critically related to construction materials, therefore, are considered to be of secondary importance.

An effort was made to accumulate all existing data pertaining to construction materials in the county; these are presented in table 1, a summary of materials tests.

Acknowledgments

Appreciation is expressed to the following for their aid in contributing information found useful in the compilation of the geologic map and of construction material data included in this report: the State Highway Commission of Kansas at Topeka and Manhattan, Kans., S. E. Horner, chief geologist, R. D. Finney, engineer of materials, and W. E. Gibson, engineer of tests; the Sheridan County office of the Soil Conservation Service, U. S. Department of Agriculture; and Vernon Huntington, county engineer of Sheridan County.

CHARACTERISTICS OF THE OUTCROPPING STRATIGRAPHIC UNITS

Introduction

This discussion of the outcropping stratigraphic units of Sheridan County emphasizes the areal distribution, general characteristics, thickness, and the construction materials in each formation. This part of the report presents the geological information required for the location and effective development of the construction materials.

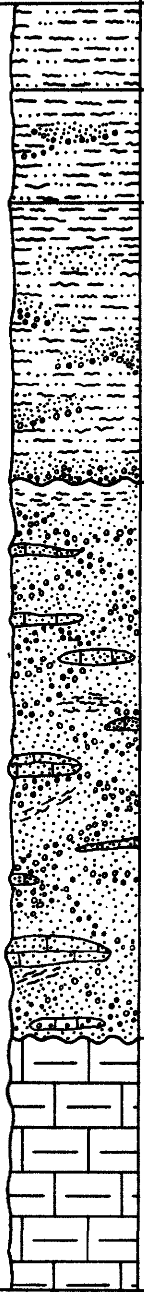
A summary of the data for each geologic formation or member is presented in figure 4, and the relations of the stratigraphic units to one another are illustrated in figure 5, a geologic cross section of the valley of the South Fork Solomon River.

The areal distribution of the local stratigraphic units is shown on plate 1, a map showing construction materials and geology of Sheridan County, Kans. Each unit is indicated by an identifying symbol, and its outcrop areas are shown by a distinctive pattern.

The locations of pits and quarries also are shown on plate 1. The symbols indicate whether the pit or quarry is or has been operated or is a prospect, the type of construction material available at each site, and the quantity of the material (in units of 10,000 cubic yards) that can be removed under no more than moderate overburden (unconsolidated sediments less than 6 ft thick). Most of these sources are listed in table 1. Materials represented on the map by inclined letters have not been tested and are not listed in table 1. All materials sources listed in table 1 are numbered within each materials classification according to the following plan: The numbering starts in the northeasternmost township and continues along the same tier to the western boundary of the county; it is continued in the next tier south starting again with the township in the easternmost range and proceeding to the western boundary of the county, and so on. Within a township the sources are numbered in the same sequence as are the sections of the township.

Niobrara formation of the Smoky Hill Chalk member

Areal distribution.--The Smoky Hill chalk member of the Niobrara formation is the only stratigraphic unit of Cretaceous age that crops out in Sheridan County. (See pl. 1 and fig. 4.) It probably underlies the entire area of the county but is concealed by younger, overlying formations except along stream courses. The outcrops are most numerous along the valley walls of the Saline River in the southeastern part of the county. Several small outcrops are mapped along the South Fork Solomon River.



Outcrop thickness (feet)	System	Series	Formations and members (Stratigraphic units)	Generalized description	Construction materials
0-30	Quaternary	Pleistocene and Recent	Alluvium	Predominantly gray silt with numerous interbedded lenses of sand and sandy gravel.	Aggregate Road metal
0-40	Quaternary	Pleistocene and Recent	Terrace deposits	Gray, light-gray, or tan-gray clayey silt; interbedded lenses of sand and sandy gravel in basal part.	Aggregate Road metal Mineral filler
0-100	Quaternary	Pleistocene and Recent	Sanborn formation	Predominantly tan-gray or red-brown clayey silt in the upper part; local lenses of sand and gravel in the basal part; buried soil present locally; occasional lenses of volcanic ash; fossil snails common.	Mineral filler Aggregate Road metal Volcanic ash
200	Tertiary	Pliocene	Ogallala	Interbedded lenses of sand, gravel, silt, and clay; tan, green, and brown; lenticular ledges of gray mortar bed; lenses of light-gray to white volcanic ash.	Aggregate Road metal Structural stone Volcanic ash Calcareous binder Riprap
100	Cretaceous	Upper Cretaceous	Niobrara formation: Smoky Hill chalk member	Chalky shale interbedded with chalk and shaly chalk; tan, brown, and orange-colored; thin silicified lenses in upper part; interbedded thin layers of bentonite.	Structural stone Calcareous binder Riprap Road metal

Figure 4_Outcropping stratigraphic units in Sheridan County, Kans., and their construction materials.

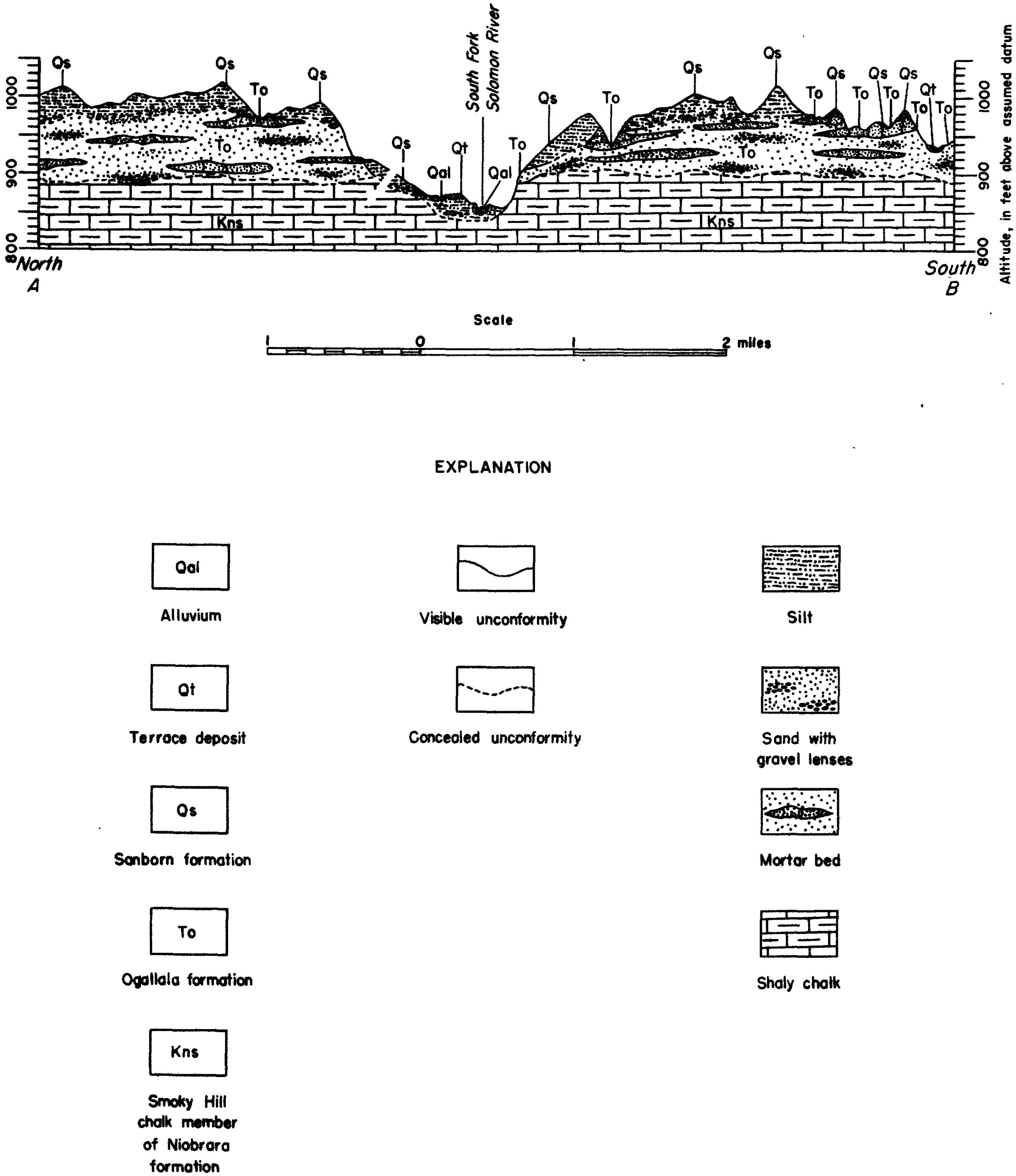


Figure 5.—Geologic cross section of the valley of the South Fork Solomon River along line A–B (line between secs. 1 and 2, T. 8 S., R. 26 W. and secs. 35 and 36, T. 8 S., R. 26 W.)

near the Graham County line, along U. S. Highway 24 just west of Studley, and along the south valley wall of the South Fork Solomon River in the same vicinity. The westernmost outcrop of the unit is in the NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 23, T. 10 S., R. 28 W. where it forms a small nose on the north wall of the valley of the Saline River.

General description.--The Smoky Hill member is the only marine deposit exposed in Sheridan County. Its contact with the underlying Fort Hays limestone member of the same formation is below the present land surface. At one time a still younger Cretaceous formation, the Pierre shale, was present above the Smoky Hill chalk member, but subsequently it was removed except for small remnants which may still exist beneath the younger formations, the Ogallala and Sanborn.

The Smoky Hill consists of interbedded layers of chalky shale and chalky limestone. Some of the chalk beds are massive and may be as much as 6 ft thick, and their color varies markedly over the outcrop area. Near Studley, for example, the chalk includes white, yellow, and bright orange zones. The orange-colored layers are very clayey and softer than the white and yellow beds. The upper few feet of the member in this area are characterized by geodes and veins of calcium carbonate which have been deposited in small openings and fractures.

A prominent bluff on the south side of the South Fork Solomon River in the SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 25, T. 10 S., R. 27 W. exposes the Smoky Hill chalk member capped by a foot-thick bed of the Ogallala formation. The chalk is thin-bedded at this location and more brown than the exposures near Studley. Geodes and veins of calcium carbonate are abundant in the upper 2 ft of the chalk. Chalk that is mottled tan-orange and orange-red is exposed in a stream bank in the SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 21, T. 8 S., R. 26 W.

Lenses in the Smoky Hill chalk member have been silicified, and Frye and Swineford (1946) suggest that the silicification was accomplished by downward-percolating waters which had dissolved silica from stratigraphically higher beds of volcanic ash. An exchange of dissolved silica for some or all of the calcium carbonate in the chalk may have been made as the subsurface waters percolated through this member. The silicified lenses are brown and dark brown with included greenish streaks. The material is hard, very brittle, and occurs in beds from 0.2 to 0.5 ft thick, which seldom persist laterally for more than a few feet.

Thin beds of gray-green and olive-drab bentonite, presumed to be weathered volcanic ash, are numerous in the Smoky Hill chalk member. They are interbedded with the chalky shale, and are best displayed in exposures in the southeastern part of the county.

Representative measured section.--A stream bank in the SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 33, T. 10 S., R. 26 W. shows the following section of the Smoky Hill chalk member:

	Feet
Ogallala formation	10.8
Smoky Hill chalk member of the Niobrara formation:	
Chalk; thin beds of hard, siliceous chalk interbedded with soft chalky shale; chalky shale is yellow orange, siliceous chalk is brown	6.2
Limestone; chalky; massive, soft; tan, weathers gray tan	1.1
Shale, chalky and silty; tan, weathers tan gray	.1
Limestone, chalky; massive, soft; tan, weathers gray tan	.8
Chalk, silicified; brittle, breaks into angular fragments; light brown, weathers brown	.1
Limestone, chalky; massive, soft; tan, weathers gray tan with white and pink streaks	4.6
Bentonite; flaky; gray green, weathers olive drab	.1
Limestone, chalky; massive, soft; tan, weathers brown	.8
Bentonite; flaky; olive drab	.1
Limestone, chalky; massive, soft; tan, weathers brown	1.6
Bentonite; two layers separated by a thin layer of chalk; olive drab	.2
Limestone, chalky; massive, soft; orange tan with white bands, weathers gray tan	2.1
Bentonite; flaky; olive drab	.1
Limestone, chalky; massive, soft; tan, weathers gray tan	1.4
Base covered	19.3

Thickness.--Individual outcrops of the Smoky Hill chalk member are 5 to 35 ft thick. The thickest exposures are along the south wall of the valley of the Saline River near the southeastern corner of the county. The aggregate thickness of the chalk in Sheridan County, as estimated from outcrop width and regional dip, is 600 ft.

Construction materials.--
Calcareous binder.
Road metal.
Structural stone.

Ogallala formation

Areal distribution.--The Ogallala formation of Pliocene age crops out in many places in Sheridan County. (See pl. 1 and fig. 4.) Most of the outcrops are in stream valleys and are the result of present-day streams having cut through the overlying Sanborn formation. The Ogallala formation is best exposed in the valleys of the northward-flowing tributaries of the South Fork Solomon River, Saline River, Sand Creek, and, to a lesser extent, Prairie Dog Creek. Exposures also occur in the main streams, but may not be continuous from one tributary to the next. Undoubtedly the Ogallala formation underlies much of the remainder of the county but is buried to a variable depth by the overlying Sanborn formation. (See fig. 5.)

Certain zones in the Ogallala formation are similar in physical characteristics to zones in the overlying Sanborn formation and in some places only arbitrary contacts can be drawn between the two formations. The contacts, as mapped, are based upon the presence in the Ogallala formation of mortar-bed ledges, beds of clay and clay shale, and thick lenses of sand and gravel. The Sanborn formation is predominantly silty, mortar-bed ledges do not occur in it, clay is not a characteristic material, and its sand and gravel lenses generally are less extensive and thinner than those in the Ogallala formation.

General description. --The Ogallala formation consists of interbedded lenses of sand, gravel, silt, and clay. The bulk of the material composing this formation was eroded by streams that headed in the Rocky Mountains, was transported eastward by these streams, and was deposited as a sedimentary mantle over the surface of the High Plains.

This formation includes lenticular layers of light-gray, massive, lime-cemented sand and sandy gravel. Such layers are termed mortar beds. A mortar bed is harder than other materials in the formation, so that in most places differential erosion causes it to project as a conspicuous hillside ledge. Some ledges are less than one foot thick, but many others are as much as 10 ft thick, such as that exposed in a valley wall in the NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 10, T. 8 S., R. 26 W. Generally the mortar beds are composed of fine sand cemented by lime. A mortar bed composed of gravel-size particles of granite, quartz, feldspar, and basic igneous rocks loosely cemented by calcium carbonate is exposed in a stream bank in the SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 31, T. 3 S., R. 29 W. The exposure shows prominent crossbedding, and is about 15 ft thick.

The Ogallala formation in Sheridan County is composed predominantly of beds of loose sand, gravel, and silt, with occasional lenses cemented to form mortar beds. Because of this variation in composition, a rugged topography has been developed over a large part of the eastern half of the county. In the W$\frac{1}{2}$ sec. 1, T. 9 S., R. 26 W. a rough erosional surface has been developed in the sandy part of the Ogallala and thin layers of mortar bed make ledges at different levels along the hillsides. This feature is found most commonly on the south valley walls of the South Fork Solomon River, and Sand Creek as far west as Hoxie.

Sand and gravel typical of the Ogallala formation are exposed in a pit in the NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 19, T. 9 S., R. 29 W. The constituent particles are granite, feldspar, quartz, chalcedony, and dark-colored igneous rocks. In the upper part of this exposure the sand and gravel are stained greenish. A mortar bed crops out about 30 ft above this pit.

There are lenses of volcanic ash in the Ogallala formation. The volcanic ash is material discharged into the atmosphere during the explosive phase of a volcanic eruption and carried by the wind to be finally deposited in sheltered places on the land surface, as in stream valleys and lake basins. The ash consists of shards of glass-like material, and is white to light gray. The ash sometimes contains extraneous particles of sand, gravel, and silt washed in by streams or slope-wash during the period of ash fall. The beds of ash in the Ogallala formation average 3 ft in thickness. Material from a pit in the SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 12, T. 8 S., R. 27 W. is used locally in the construction of roads of the bituminous-mat type. The ash in this pit is neither extensive nor thick. There are stringers of bentonite throughout the upper part of the deposit, indicating that some alteration has taken place since the time of its deposition.

Representative measured section. --The following section of the Ogallala formation is exposed in an abandoned pit in the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 32, T. 8 S., R. 29 E.:

	Feet
Sanborn formation: Silt	5.5
Ogallala formation:	
Mortar bed; silt and fine sand poorly cemented by calcium carbonate at base, well cemented at top; light tan, weathers tan gray and nodular	3.5
Silt, with fine sand throughout, calcareous with calcium carbonate concretions; brown, weathers tan	3.8
Sand, fine, with silt, clay, and a few gravel particles, calcareous; massive; brown, weathers tan . . .	3.4
Sand and gravel; clean; abundance of basic igneous rock fragments; light tan, weathers light gray . . .	4.4
Clay, with some sand, calcareous; concretions of clay cemented with calcium carbonate in upper 2 ft; thin stringer of carbonaceous matter 1.3 ft from top; mottled olive drab and light gray, weathers tan gray.	3.3
Silt, with sand and clay, calcareous; granular; light gray-green	.8
Sand, fine, with some gravel, clayey, slightly calcareous; loosely compacted; olive drab, weathers light gray	1.4
Sand and gravel; sand in upper part with some clay, coarse near the base; sand poorly sorted and composed of quartz and feldspar; gravel largely granitic fragments; thin layer of carbon-stained sand and gravel 3 ft from top; light tan, weathers light gray.	8.7
Mortar bed; sand and gravel well cemented by calcium carbonate; crossbedded; gray	3.0
Total thickness exposed (base covered)	32.3

Thickness. --The thickness of the Ogallala formation is variable throughout the county, and ranges from a featheredge to a maximum of 200 ft. Average outcrops are 20 ft in thickness.

Construction materials.--
- Volcanic ash.
- Riprap.
- Road metal.
- Aggregate for concrete.
- Calcareous binder.

Sanborn formation

Areal distribution.--The Sanborn formation of Pleistocene and Recent age is the most widely distributed formation outcropping in Sheridan County. (See pl. 1 and fig. 4.) At one time the formation undoubtedly extended over the full area of the county, but it subsequently has been eroded from the courses of many of the streams. The formation caps the interstream areas, principally, where it conceals older stratigraphic units. (See fig. 5.)

General description.--The Sanborn formation is composed of materials deposited by streams, slope-wash, wind, and through the action of gravity. Frye and Fent (1947) have divided the formation into members. It was not feasible to attempt the mapping of these members in the field work on which this report is based. To do so would have required a greatly extended field program, including test drilling. The treatment of the Sanborn formation as an undivided unit seems adequate to serve the purpose of this construction materials inventory.

The upper part of the formation is predominantly silt but scattered throughout are a few particles of sand and gravel size. The color is light gray, tan, or tan gray. There is a prominent soil profile developed at the top of this formation. The A horizon is characteristically rather thin, ranging from 0.5 to 1.1 ft. It is usually dark gray but in places is brown, and has a granular texture. The thick B horizon is characterized by lighter color and secondary calcium carbonate deposited by downward-percolating subsurface water. The calcium carbonate is disseminated throughout the zone or is locally concentrated within the zone in the form of nodules or pipe-like concretionary masses. This zone characteristically stands in vertical banks and develops a crude columnar structure, the result of the intersection of irregular joint planes. A buried (fossil) soil is exposed in a road ditch in the NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 24, T. 8S., R. 29 W. In this exposure the top soil is separated from the buried soil by 0.7 ft of tan-gray silt which is clayey and calcareous. The buried soil is dark-gray silt and clay with calcium carbonate along the fracture surfaces. At this exposure the buried soil is 0.9 ft thick. Fossil snails are found above and below the buried soil zone.

Lenses of sand and sandy gravel are present in the basal part of the formation. They are about 6 ft thick, pinch out laterally within short distances, and contain a small percentage of material derived from the weathering and erosion of the Ogallala formation and the Smoky Hill member. Such lenses are deposits laid down along streams or materials carried from higher levels by slope wash, and are usually markedly cross-bedded.

Several deposits of volcanic ash were found in the basal part of the Sanborn formation. In a pit in the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 34, T. 8 S., R. 28 W., the volcanic ash is white and light gray. The dip of the beds is toward the south. The ash is overlain by coarse silt which contains large irregular masses of fine sand cemented by calcium carbonate. Another deposit of volcanic ash is exposed in the NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 4, T. 6 S., R. 27 W. The ash is exposed in a road ditch, which is about 15 ft thick, and shows horizontal bedding in the lower part. The overburden is 8 ft thick, and is composed of sand and gravel with some reworked ash, all showing crossbedding. The ash is underlain by fine, light-tan sand of the Sanborn formation.

Fossil snails were collected from several outcrops of the formation and were used, in part, for purposes of correlation.

The Sanborn formation occurs in two topographic positions: (1) as a blanket of unconsolidated material covering the interstream areas, and (2) as a relatively thin veneer of material covering the lower part of the valley walls of the larger streams. The deposits are mapped as a single stratigraphic unit because the contact between these two levels of Sanborn deposition has been obscured over much of the county through the action of slope wash. Generally the Sanborn formation is eroded to form a gently undulatory surface. The headward parts of some stream valleys that have been cut into the Sanborn formation, however, exhibit a phenomenon known as "catstep erosion," which is probably the result of gravity sliding of water-saturated silt toward the streams. The "catsteps" are bounded by scarps 1 to 5 ft high and can be traced horizontally for several hundred feet. Bluffs 20 ft high have been formed in the same way on the south wall of the Saline River in the southwestern part of the county. They are composed of silt which has a tendency to stand in vertical banks.

Representative measured sections.--(1) The following section is exposed in a road cut in the SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 9, T. 8 S., R. 28 W.:

	Feet
Soil: Silty; poorly developed; gray brown	0.8
Sanborn formation:	
Silt with some clay, calcareous; loosely compacted; quite porous; gray tan, weathers light gray; high-spired snail shells fairly common	5.5
Silt, with some clay, calcareous; loosely compacted; light brown, weathers light gray; snails common	3.4
Silt, with some clay and sand, slightly calcareous with some small calcium carbonate concretions; more compact than the above; gray brown, weathers pinkish tan	1.1

	Feet
Sand, silty with some gravel, calcareous; loosely compacted; reddish tan, weathers pinkish tan	2.6
Silt, clayey and sandy, calcareous; loosely compacted and porous; mottled gray and pinkish tan	3.2
Total thickness exposed (base covered) .	16.6

(2) The following section of the Sanborn formation is exposed in a road cut along U. S. Highway 24 in the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 20, T. 8 S., R. 28 W.:

	Feet
Soil: Silt, clayey, slightly calcareous; gray	0.6
Sanborn formation:	
Silt, clayey, more calcareous than soil, calcium carbonate disseminated throughout; tan, weathers tan gray	4.3
Silt, clayey, calcareous; tan, weathers tan gray; low- and high-spired snail shells	13.2
Silt, clayey, sandy in basal part, very calcareous; tan, weathers light gray	15.5
Silt, some clay, calcareous; massive; large irregular concretions composed of fine sand cemented by calcium carbonate; gray brown, weathers gray	9.4
Silt, with some clay and fine sand; slightly calcareous; friable; tan, weathers light tan gray	5.3
Total thickness exposed (base covered) .	48.3

Thickness.--The formation is variable in its thickness, and has been completely eroded from the valleys of many of the streams. The greatest thickness, about 100 ft, is in the interstream area between Sand Creek and the North Fork Solomon River in the western half of the county. The average thickness is 30 ft.

Construction materials.--
- Mineral filler.
- Volcanic ash.
- Aggregate for concrete.
- Road metal.

Terrace Deposits

Areal distribution.--Terrace deposits are characteristic of the valleys of the major streams in the county. (See pl. 1 and fig. 4.) Narrow extensions of the terraces project into the valleys of streams tributary to these major drainage lines. The width of the terrace deposits changes rapidly within short distances. Those of the Saline River are about 0.6 mile wide in the eastern part of the county but narrow westward to about 0.2 mile. The deposits along the South Fork Solomon River range from 0.7 mile wide in the eastern part of the county to 0.3 mile near the western border. The terraces along the North Fork Solomon River may be as much as a mile wide near the northeastern corner of the county but are less than 0.1 mile in the western part. The terrace deposits along Prairie Dog Creek near the northwestern corner of the county average about 0.2 mile in width. Local evidences of a higher (older) terrace level were observed along the South Fork Solomon River, but because the composition is similar to that of the lower terrace, the two levels are mapped as a single unit on plate 1. The topographic position of the terrace deposits, with respect to other formations in the county, is illustrated in figure 5.

General description.--The terrace deposits are composed of silt with some clay in the upper part, but the lower part is more sandy and includes local lenses of cross-bedded sand and gravel. The silt is tan gray to dark gray, and there is usually a well-developed A soil horizon present in the uppermost part of each outcrop. This horizon is usually dark gray but is brown in places. The underlying B horizon is typically tan gray but may be light brown, and is clayey.

The lenses of sand and sandy gravel that are found in the lower part of the terrace deposits are composed of granitic material (quartz, pink feldspar, and fragments of granite). The largest particles in a pit in the NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 32, T. 10 S., R. 26 W. are fragments of chalk and siliceous chalk of local origin. The source of the sand is the Ogallala formation.

Lumps of black shale are present in an abandoned wet pit in the NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 36, T. 8 S., R. 26 W. These lumps were probably pumped up with the sand and gravel and were derived from nearby outcrops of the Pierre shale of Cretaceous age. The sand and gravel of this pit are composed predominantly of fragments of quartz, feldspar, and granite.

Representative measured sections.--(1) The following section of a terrace deposit was obtained by drilling an auger hole in the valley of the South Fork Solomon River in the SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 17, T. 9 S., R. 30 W.:

	Feet
Soil: Dark gray	0.3
Terrace deposit:	
Silt, some sand, calcareous; brown	2.7
Silt, sand, and some clay, slightly calcareous; loosely compacted; tan gray	1.0
Silt, sandy and clayey, calcareous; very loose; tan	1.0
Silt, very little clay or sand, very calcareous; loose; light tan. . . .	3.0
Silt, clayey, calcareous; loose; light tan	1.0
Sand, silty and clayey, calcareous; tan gray	1.0
Sand, very fine and clean, slightly calcareous; light tan-gray	.3
Silt, very clayey, some sand, calcareous, compact; tan gray	.9

	Feet
Sand and gravel, large amount of silt and clay, calcareous; tan gray	.8
Sand and gravel, clean, slightly calcareous; tan gray	1.0
Total depth of hole	13.0

(2) An auger hole along Sand Creek in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 8 S., R. 28 E. showed the following section of a terrace deposit:

	Feet
Terrace deposit:	
Silt, clayey, calcareous; dark brown.	0.2
Silt, slightly clayey, calcareous; tan gray	2.3
Silt, sandy, some clay, calcareous; tan	4.0
Silt, clayey, calcareous; tan gray	1.0
Total depth of hole	7.5

Thickness.--The height of the terraces above the streams in the county is variable but is greatest in the eastern part of the county. The average difference in elevation is about 10 ft. The full thickness of the terrace deposits is estimated to be 40 ft along the major streams in the eastern part of the county. Extensions of the terrace deposits into the tributary valleys decrease abruptly in thickness away from the junctions with the larger streams.

Construction materials.--
Aggregate for concrete.
Mineral filler.
Road metal.

Alluvium

Areal distribution.--The deposits formed by streams in their present cycles are mapped as alluvium. (See pl. 1 and fig. 4.) They constitute the most recent stratigraphic unit in the county. Alluvium is defined in this report as the material that underlies the present floodplain of a stream. The floodplain is the area adjacent to the stream channel that is covered by water during normal flood stage. (See fig. 5.) Alluvium is mapped along the Saline River and both forks of the Solomon River, but only in the eastern part of the county. Because of the scale of the map, very narrow alluvial deposits along some of the larger tributary streams could not be shown. The width of the alluvium averages 0.15 mile, and is greatest near the eastern border of the county.

General description.--Alluvial deposits of the Saline River are predominantly sand with some gravel but include considerable silt in the western part of the county. The sand is composed largely of quartz and feldspar, and the gravel contains fragments of the Smoky Hill member. The alluvium of the South Fork Solomon River is mostly sand, but includes some gravel and silt in the eastern part of the county, and is more silty in the western part. The alluvial deposits of the North Fork Solomon River are predominantly silt with small lenses of sand and gravel by sand occuring locally. The color of the alluvium reflects, in a general way, the sand content of the material; the zones in which the alluvium is sandy tend to be tan, whereas those composed predominantly of silt tend to be brown or gray.

Representative measured section.--The relief of the alluvium is so low that a representative section could not be measured.

Thickness.--The maximum thickness of the alluvial deposits is estimated to be about 30 ft.

Construction materials.--
Aggregate for concrete.
Road metal.

INVENTORY OF CONSTRUCTION MATERIALS

General

The objectives of this inventory of construction materials in Sheridan County are to define the construction materials as they are classified in this report and to relate the materials to the map units in which they occur.

Whenever available, laboratory test data have been introduced into the report to aid the reader in the evaluation of the materials. The information given in table 1 is based on standard testing procedures of the State Highway Commission of Kansas (1945, Gradation factor, p. 16; Sieve analysis, pp. 333-34; Soundness, pp. 335-36). This information is based also on the procedures of the American Association of State Highway Officials (1947, Absorption, pp. 251-52; Compressive strength, pp. 257-58; Deval abrasion, pp. 235-36; Liquid limit, pp. 198-201; Los Angeles abrasion, pp. 237-39; Plasticity index, pp. 202-04; Specific gravity, pp. 249-50; Toughness, pp. 240-41; Weight per cu ft, pp. 253-54.)

It is expected that prospects listed in this report will be proved by subsequent augering, drilling, or test pitting and that the materials themselves will be subject to laboratory testing prior to production for specific uses.

Although numerous prospect pits and quarries were located, no attempt was made to complete an exhaustive survey of all possible sources of materials. Every effort was made to correlate the construction materials that are available in Sheridan County with the geologic formations mapped on plate 1.

Aggregate for concrete

Engineering and geologic characteristics.--Aggregate for concrete is classified as fine aggregate and mixed aggregate in table 1 and on plate 1. In this report the distinction is an arbitrary one based on the percentage of material retained on a standard No. 4 sieve. The portion of a sample retained on that sieve is designated as the coarse fraction. The material is classified as a mixed aggregate if the coarse fraction is 5 percent or more by weight of the whole sample; as a fine aggregate if the coarse fraction is less than 5 percent. Fine and mixed aggregate will be considered together because of the standard practice of bringing the grading to specifications by sweetening or screening.

The materials reported in this and other classifications are exposed at the surface or are under soft or unconsolidated overburden sufficiently thin that they may be economically developed. Deposits that are overlain by thick or consolidated beds, or that are relatively inaccessible, usually are not included in this inventory because of the additional expense involved in their removal or transportation.

Stratigraphic sources and performance characteristics. --The following stratigraphic units are actual or potential sources of aggregate for concrete:

(1) Ogallala formation. One sample of fine aggregate (fa 1) and 17 samples of mixed aggregate were obtained from this formation. (See table 1.) The principal difference between aggregates of this formation and those of the Sanborn formation is that the Sanborn formation contains a higher percentage of mortar-bed fragments.

(2) Sanborn formation. Two samples of fine aggregate (fa 2 and 3) and 16 samples of mixed aggregate (ma 1 to 4, 7, 9, 11, 13 to 15, 19, 24, 26, 29, 31, 36) were obtained from the Sanborn formation. Sand and gravel of this formation are composed of particles of granite, quartz, feldspar, and a small percentage of quartzite. Basic igneous rocks and mortar bed fragments are also present in these deposits in minor amounts.

Additional supplies of sand and gravel from the Sanborn formation are undoubtedly present in the basal part of the formation. They can best be located by intensive search of the margins of the mapped area of outcrop of the Sanborn formation (see pl. 1), especially in places where streams have cut through the formation into underlying stratigraphic units. However, the sands and gravels occur as lenses of variable extent, generally with only limited quantities of material available.

(3) Terrace deposits. One sample of fine aggregate (fa 4) and one sample of mixed aggregate (ma 28) were taken from the terrace deposits; the sampled localities are mapped on plate 1, and the test characteristics of the samples are given in table 1. Sand and gravel of the terrace deposits consist predominantly of fragments of granite, quartz, and feldspar. Basic igneous rocks and fragments of carbonate minerals occur in minor amounts, and chert also may be present.

The quantity of sand and gravel that can be obtained from terrace deposits is not large inasmuch as the lenses of sand and gravel are small and not numerous. Other deposits are probably present in the eastern part of the county. The overburden is silt and may be removed easily.

(4) Alluvium. The alluvial deposits of this county were not sampled by the field party. These deposits would have to be pumped directly from the streams, and there was no facility available to obtain samples. The alluvial deposits of the South Fork Solomon River have been used locally in concrete and serve satisfactorily in small structures. There is a small percentage of fragments of soft, porous chalk and, locally, a high percentage of silt in these deposits. The alluvial deposits of the Saline River contain a high percentage of chalk and mortar-bed fragments.

Road Metal

Engineering and geologic characteristics. --Road metal, known also as surfacing material, crushed stone, and aggregate, is defined in this report as any material that may be applied to a road to improve the performance characteristics of that road. Many geologic materials fulfill this requirement, and the list of such materials will differ from one area to another. The following materials are available in Sheridan County for use as road metal:

(1) Aggregate for concrete.

(2) Indurated rocks that are available in Sheridan County for use as road metal are: (a) chalky limestone, a compact, massive layer of calcareous material, variable in its hardness; (b) mortar bed, a compact, massive, layer of sand and/or gravel firmly cemented by calcium carbonate; (c) silicified chalk, a calcareous rock that has been altered to silica by the action of percolating subsurface waters.

The materials included here under crushed rock are listed in table 1 and mapped on plate 1 under the more specific designations of limestone and mortar bed because, in addition to their use as road metal, they may be used as structural stone and riprap.

Stratigraphic sources and performance characteristics. --

(1) Sources of aggregate for concrete. The materials listed in the section on aggregate for concrete have been used in Sheridan County as road metal on light-traffic roads or as base-course material in roads of the black-top type of construction. Field observation indicates that they are adequate for these purposes. Their sources have been discussed under Aggregate for concrete.

(2) Crushed rock.

(a) Smoky Hill chalk member of the Niobrara formation. The Smoky Hill has not been used in this county as road metal, but the more chalky limestones in this unit have been quarried in other counties in northcentral Kansas, crushed, and applied to light-traffic roads.

(b) Mortar bed of the Ogallala formation. Mortar beds are numerous in the eastern part of the county and are a potential source of crushed rock for road metal. This use of the mortar bed was not observed in Sheridan County. Field observations in other counties indicate that performance characteristics of this material are satisfactory. The sand and gravel particles in the mortar bed are bound by the calcium carbonate cement to form a low-grade traffic-bound macadam. One sample (mb 1) that was considered characteristic of the material has been tested and the location of its source is mapped on plate 1.

Mineral filler

Engineering and geologic characteristics.--Material composed predominantly of silt-size mineral particles (50 percent or more of the material passing the No. 200 sieve) is classified in this report as mineral filler. It has no more than a trace of sticks or other organic debris, but may contain minor amounts of fine sand or clay. W. E. Gibson of the Road Materials Laboratory of the State Highway Commission of Kansas states (personal communication) that material will qualify for mineral filler only if laboratory tests indicate a low coefficient of cementation.

Stratigraphic sources and performance characteristics.-- The following stratigraphic units are actual or potential sources of mineral filler:

(1) Sanborn formation. Two samples of silt from the Sanborn formation (mf 1 and mf 3) were tested for possible use as mineral filler.

(2) Terrace deposits. One sample of material classed as mineral filler was collected from the terrace deposits (mf 2). The test data for this sample are listed in table 1 and the locality is mapped on plate 1.

Volcanic ash

Engineering and geologic characteristics.--Volcanic ash is sometimes classified as mineral filler but in the area covered by this report it is suitable for certain uses for which the usual silty filler is not suited. Volcanic ash consists predominantly of the fine, glass-like shards ejected during the explosive phase of a volcanic eruption. The deposits may include silt-size particles of other origins and occasional thin seams of gravel and sand.

Stratigraphic sources and performance characteristics.--

(1) Ogallala formation. One deposit of volcanic ash of this formation was inspected by the field party. The material at this site is limited in quantity and the site is not easily accessible. The ash contains stringers of bentonitic clay. Other deposits of volcanic ash undoubtedly can be located within the mapped outcrop areas of the formation.

(2) Sanborn formation. One sample (va 1) of volcanic ash of this formation was collected and tested. Test characteristics of this material indicate that it is apparently suitable for use as mineral filler. Material from this pit was used in the bituminous-mat construction of Kansas Highway 23 south of Hoxie.

Other small lenses of volcanic ash undoubtedly occur in the basal part of the Sanborn formation in other parts of Sheridan County. It is probable that exploration for additional deposits should first be made in areas near the heads of tributary streams that have cut well down into the basal part of this formation.

Riprap

Engineering and geologic characteristics.--Riprap, as defined in this report, is any material suitable for protecting earthen fills from erosion. To be acceptable for this use the material must be relatively sound and free from cracks and other structural defects or impurities that would cause it to disintegrate through erosion, slaking, or freeze-and-thaw. It is desirable that the material be in blocks having approximately rectangular faces 7 in. or more in width and that the specific gravity be 2.0 or higher.

Stratigraphic sources and performance characteristics.--

(1) Smoky Hill chalk member of the Niobrara formation. Samples from two localities were tested and the results of the tests are presented in table 1 (ls 1 and 2). The service history of this material used in other counties indicates that the material disintegrates almost completely in a short time. The silicified beds in this member, if extensive enough, would be more desirable for this use.

(2) Ogallala formation. Rock from the ledge-forming mortar beds of the Ogallala formation has been used as riprap in other Kansas counties but its performance is unpredictable and is generally unsatisfactory. Mortar bed is the most wide-spread potential riprap material in Sheridan County for ledges outcrop in nearly all parts of the county.

Structural stone

Engineering and geologic characteristics.--Structural stone, as defined in this report, is any hard, dense rock material that can be quarried and produced to desired size and shape. Materials fulfilling these requirements occur in the Smoky Hill chalk member of the Niobrara formation and in the Ogallala formation.

Stratigraphic source and performance characteristics.--

(1) Smoky Hill chalk member of the Niobrara formation.--Occasional structural use of the massive beds of chalk in the Smoky Hill chalk member was observed in Sheridan County. Field

observations indicate that the material is satisfactory for this purpose. The building housing the general store in Studley is constructed, in part, of this material, and the chalk has stood up well. The building was constructed in 1898 of chalk and mortar bed, and a natural lime cement from Graham County was used. The bond between the cement and chalk is still good. Some cracks have developed in the blocks of chalk, but these are probably the result of foundation settling.

(2) Ogallala formation. Use of ledge-forming mortar beds of the Ogallala formation as structural stone was observed in Sheridan County. The store at Studley, already mentioned, is constructed in part of this material. The mortar bed shows little sign of deterioration in this structure. Mortar bed is also used as foundation stone in farm buildings although in such a use the stone shows signs of deterioration possibly because of the moist ground in contact with it which causes slaking during the rainy season and freeze-and-thaw during the winter months.

The test characteristics of mortar bed (table 1) indicate that it is acceptable for use as structural stone; however, field observations reveal that the mortar-bed ledges are not uniformly hard. The appearance of finished structures built of this material may be marred by the differential weathering of some of the blocks.

Calcareous binder

Engineering and geologic characteristics.--To be classified as calcareous binder the material must be composed essentially of calcium carbonate and must be soft and easily pulverized. A variety of geologic materials is included in this classification. Two local stratigraphic units are sources or potential sources of calcareous binder.

Stratigraphic sources and performance characteristics.--

(1) Smoky Hill chalk member of the Niobrara formation. The Smoky Hill has been accepted by the State Highway Commission of Kansas as a potential source of material suitable for use as calcareous binder. The member contains numerous beds of chalky limestone which are soft, easily pulverized, and free from deleterious substances. This material can be obtained from most of the mapped outcrop areas of the Smoky Hill chalk member in the county.

(2) Ogallala formation. Mortar bed in the Ogallala formation has been accepted as calcareous binder by the State Highway Commission of Kansas, and those in Sheridan County are thought to be suitable for this use. Some of the ledges contain coarse sand and gravel which might affect their acceptability.

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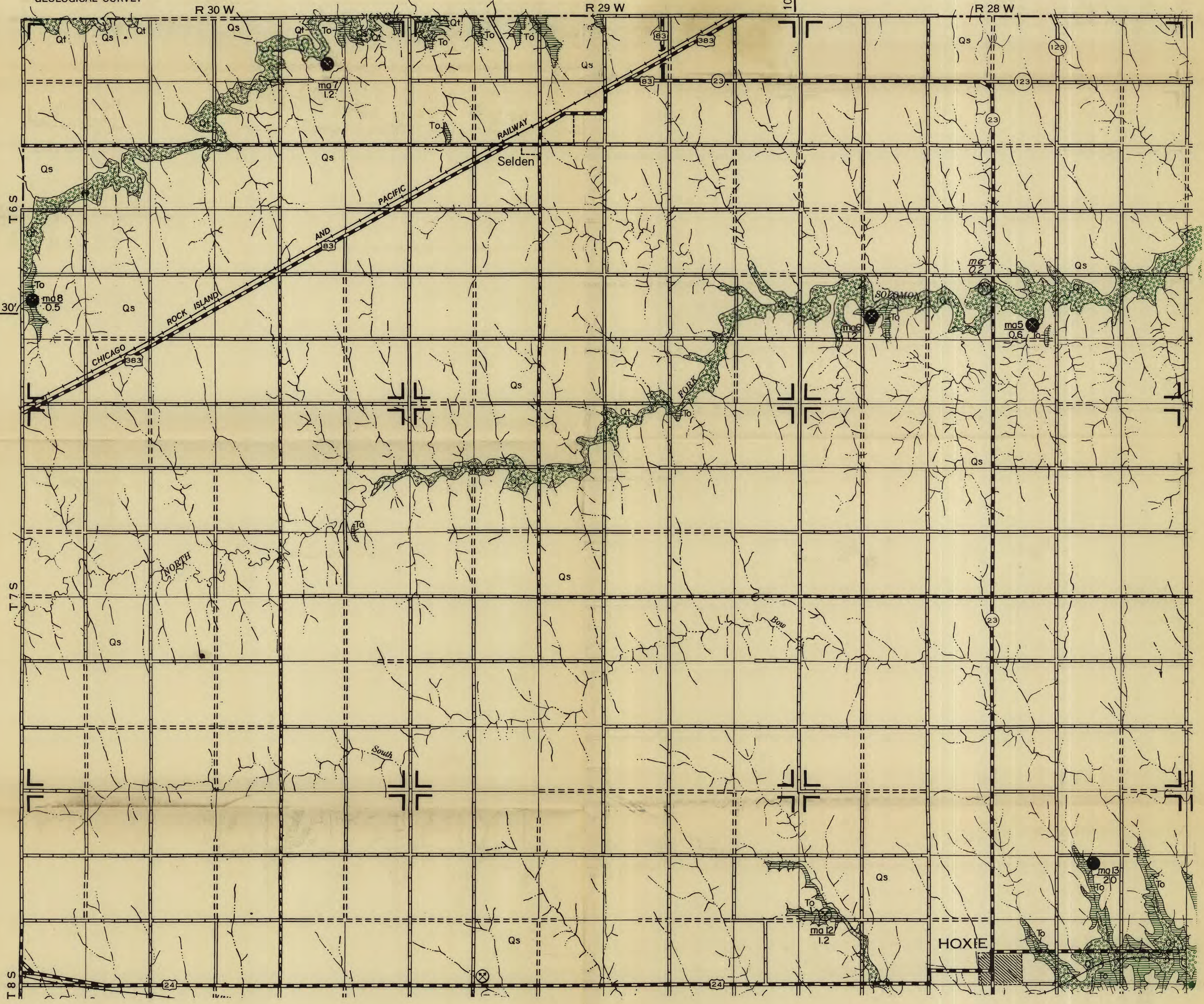
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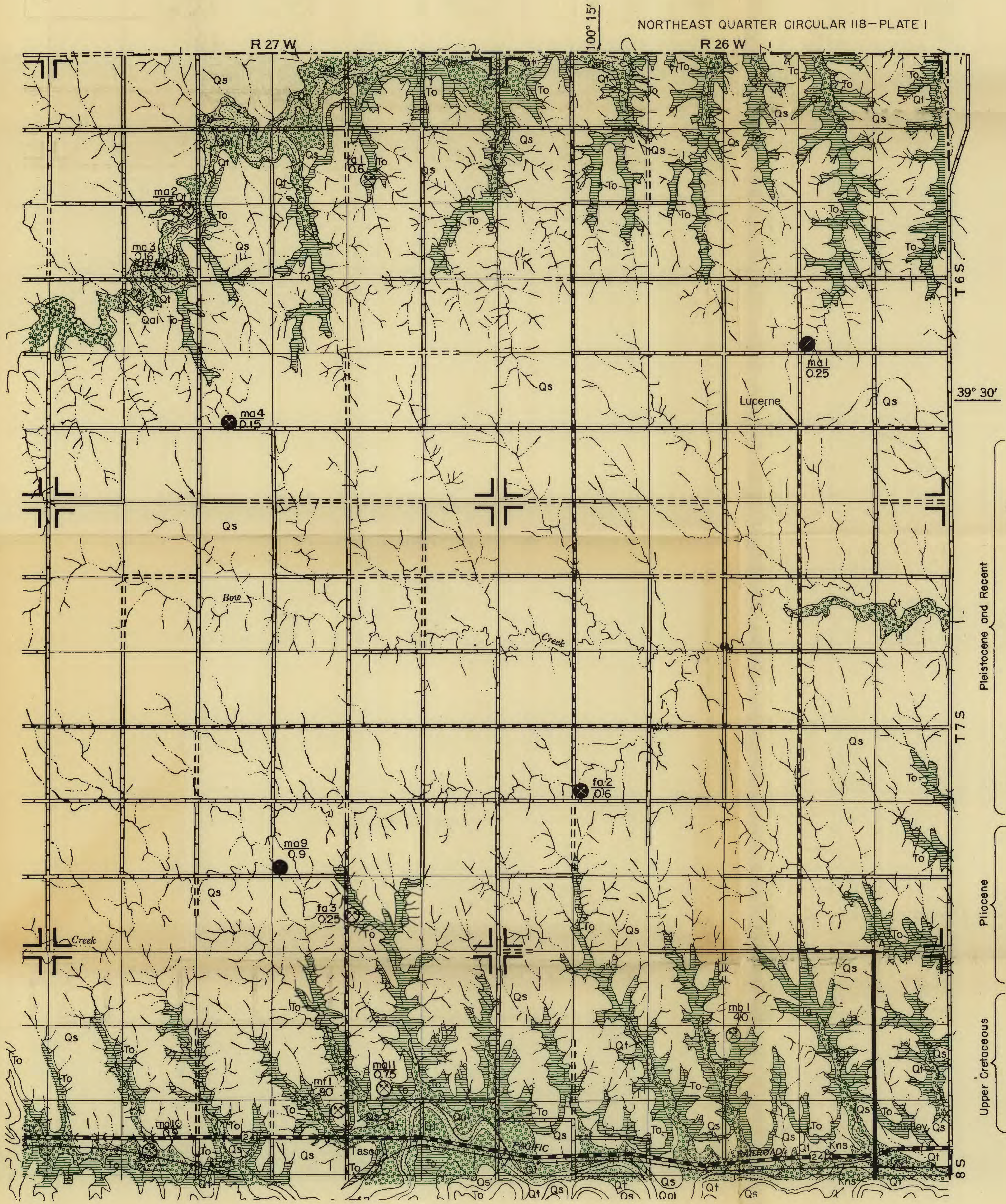


EXPLANATION

QUATERNARY — Pleistocene and Recent

Qal

Alluvium

Gray silt with numerous interbedded lenses of sand and sandy gravel. Source or potential source of: aggregate and road metal.

Qt

Terrace deposits

Gray, light-gray, or tan-gray clayey silt; interbedded lenses of sand and sandy gravel in lower part. Source or potential source of: aggregate, road metal, and mineral filler.

Qs

Sanborn formation

Tan-gray or red-brown clayey silt; buried soil zone in upper part in some places; lenses of volcanic ash, sand, and sandy gravel occur locally in lower part; fossil snails common. Source or potential source of: aggregate, road metal, mineral filler, and volcanic ash.

TERTIARY — Pliocene

To

Ogallala formation

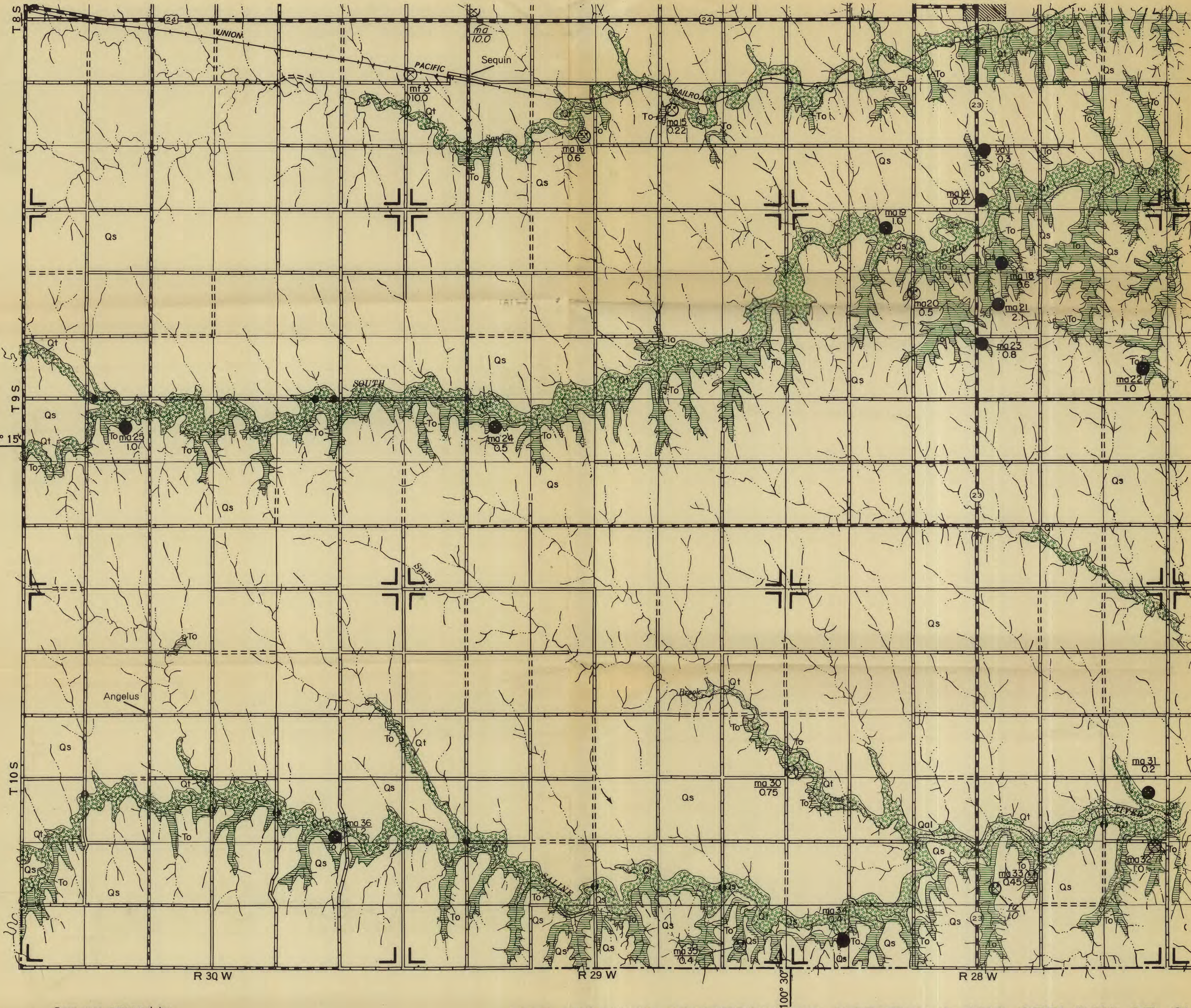
Interbedded lenses of sand, gravel, silt, and clay; tan, green, or brown; numerous lenticular layers of gray mortar bed which make conspicuous hillside outcrops; occasional lenses of white or light-gray volcanic ash. Source or potential source of: aggregate, road metal, riprap, structural stone, volcanic ash, and calcareous binder.

CRETACEOUS — Upper Cretaceous

Kns

Smoky Hill chalk member of the Niobrara formation

Chalky shale interbedded with chalk and shaly chalk; tan, brown, or orange-colored; silicified lenses in upper part in some places; interbedded thin seams of bentonite. Source or potential source of: road metal, riprap, and structural stone.



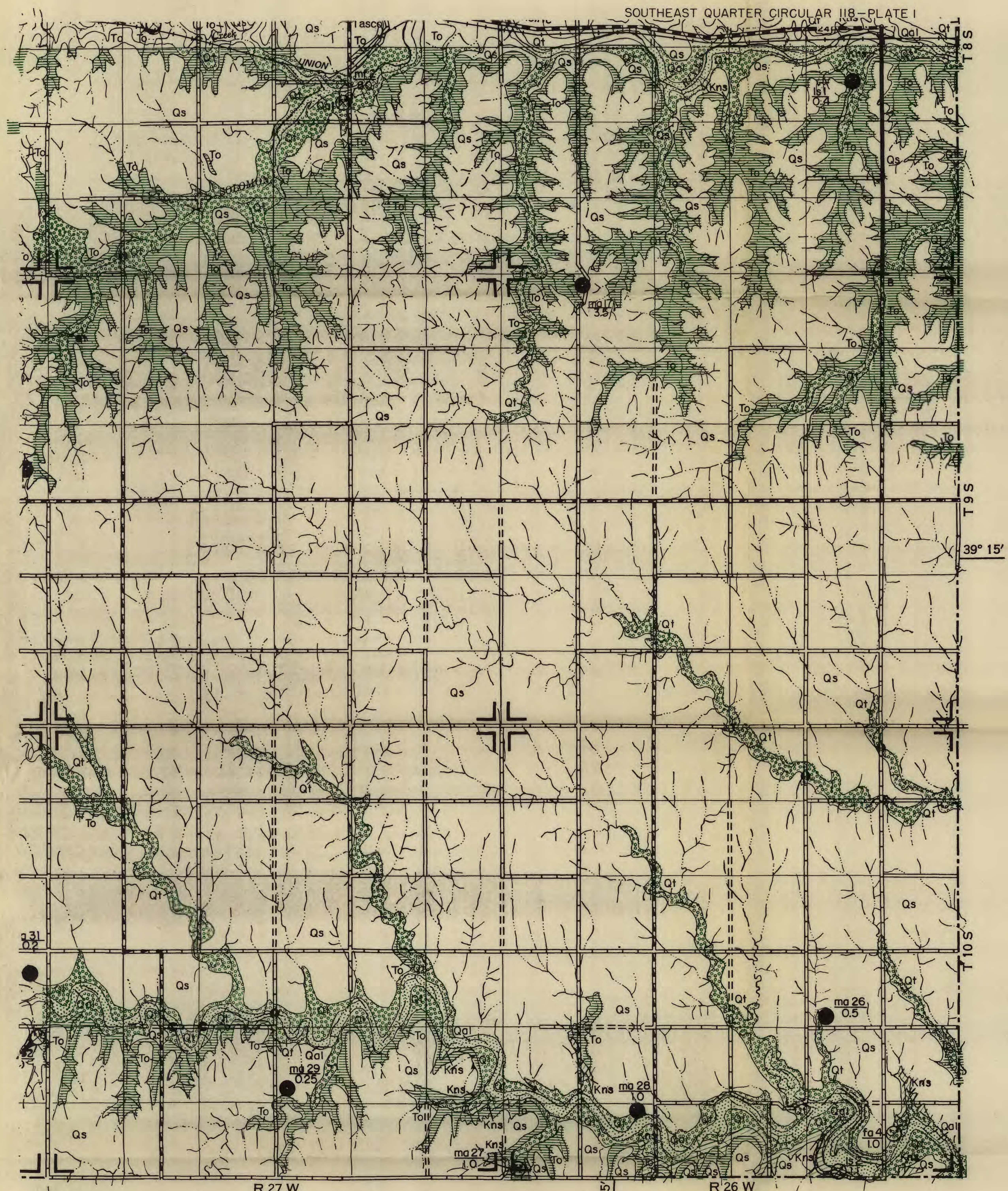
Base map prepared by
State Highway Commission of Kansas

MAP SHOWING CONSTRUCTION MATERIALS AND GEOLOGY OF S

Scale
1 0 1 2 3 4 miles

1951

SOUTHEAST QUARTER CIRCULAR 118—PLATE I



Geologic contact

Operated pit or quarry

Prospect pit or quarry

ls
Limestone

mb
Mortar bed

fa
Fine aggregate

ma
Mixed aggregate

mf
Mineral filler

va
Volcanic ash

ma
Inclined letters indicate materials not tested

ma 1
Vertical letters indicate materials listed in table 1 and their sample numbers

1.0
Quantity of material available (in units of 10,000 cubic yards)

24
Federal (US) highway

23
State highway

Other roads, all classes

Railroad

City

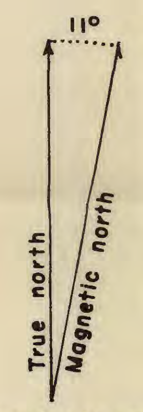
Section line

Township corner

Stream, permanent

Stream, intermittent

A B
Line of cross section, figure 5 (along line between secs. 1 and 2, T. 8 S., R. 26 W., and secs. 35 and 36, T. 8 S., R. 26 W.)



Approximate mean declination, 1951

SHERIDAN COUNTY, KANS.

Geology by H.V. Beck and Robert K. McCormack
Geology drafted by V.L. Stallbaumer and H.M. Lay, U.S. Geological Survey

Table 1. Summary of material tests

(Blank spaces indicate data not available)

Classification of the material	Number on plate[1]	Location: 1/4 fraction	Location: 1/4 section	Location: Section	Location: Township (S)	Location: Range (W)	Estimated quantity of material (cubic yards)	Average thickness: Material (feet)	Average thickness: Overburden (feet)	Accessibility	Geologic formation or member	Authority for test data[1]	Date of test	Sieve analysis: Percent on 3/4 inch	Percent on 3/8 inch	Percent on No. 4	Percent on No. 16	Percent on No. 100	Percent passed No. 200 (wash)
Fine aggregate	fa 1	NE	SW	11	6	27	6,000	9	6	Poor	Ogallala	USGS	1949	0	1	4	28	91	6.41
	fa 2	SW	SW	20	7	26	6,000	6	4	Good	Sanborn	USGS	1949	0	0	3	25	94	4.10
	fa 3	NW	SW	35	7	27	2,500	6	3	Good	Sanborn	USGS	1949	0	0	4	37	92	5.44
	fa 4	NW	SW	36	10	26	10,000	.6	2	Good	Terrace deposit	USGS	1949	0	2	3	16	97	1.87
Mixed aggregate	ma 1	SW	SW	23	6	26	2,500	5	4	Fair	Sanborn	USGS	1949	1	3	9	39	91	4.9
	ma 2	NE	NE	17	6	27	25,000	12	4	Good	Sanborn	USGS	1949	0	1	6	39	95	3.69
	ma 3	SW	SE	17	6	27	1,600	6	4	Good	Terrace deposit	SHCK	1941	0	3	9	45	98	0.7
	ma 4	SE	SW	28	6	27	1,500	8	5	Fair	Sanborn	SHCK	1946	0	3	14	65	95	2.73
	ma 5	SW	SE	27	6	28	6,000	6	4	Good	Ogallala	USGS	1949	0	1	6	43	96	3.06
	ma 8	NW	SW	29	6	28	12,000	6	3	Fair	Ogallala	USGS	1949	1	3	7	41	97	1.88
	ma 7	NW	SE	2	6	30	12,000	12	10	Fair	Sanborn	USGS	1949	2	8	15	41	94	3.62
	ma 8	SW	NW	30	6	30	5,000	6	5	Good	Ogallala	USGS	1949	0	3	10	43	95	3.11
	ma 9	SW	SW	27	7	27	9,000	12	5	Fair	Sanborn	USGS	1949	1	3	5	23	94	3.62
	ma 10	NE	SW	17	8	27	9,000	9	3	Good	Ogallala	USGS	1949	0	3	8	39	92	6.27
	ma 11	SW	SE	11	8	27	7,500	6	1	Fair	Sanborn	USGS	1949	0	1	7	48	95	3.53
	ma 12	SE	SW	7	8	28	12,000	6	2	Good	Ogallala	USGS	1949	0	4	10	45	95	2.69
	ma 13	NE	NW	11	8	28	20,000	6	3	Good	Sanborn	SHCK	1946	1	3	9	43	96	2.67
	ma 14	SW	SW	34	8	28	2,000	6	4	Good	Sanborn	SHCK	1948	0	2	8	50	95	
	ma 15	SW	NW	26	8	29	2,200	6	4	Fair	Sanborn	USGS	1949	1	2	6	29	92	3.97
	ma 16	SE	SE	28	8	29	6,000	6	2	Good	Ogallala	USGS	1949	1	3	5	23	95	1.90
	ma 17	NW	NW	5	9	26	35,000	15	4	Good	Ogallala	USGS	1949	0	3	9	47	97	1.32
	ma 18	SE	SW	3	9	28	6,000	6	4	Good	Ogallala	SHCK	1948	0	2	5	29	94	3.57
	ma 19	SW	NE	5	9	28	10,000	9	5	Fair	Sanborn	USGS	1949	0	2	7	48	96	3.47
	ma 20	SW	NW	9	9	28	5,000	6	2	Good	Ogallala	USGS	1949	0	1	5	25	96	1.66
	ma 21	NE	SW	10	9	28	21,000	9	2	Fair	Ogallala	SHCK	1940	1	5	15	54	98	0.6
	ma 22	NW	SE	13	9	28	10,000	10	2	Good	Ogallala	USGS	1949	0	2	5	32	95	2.44
	ma 23	NW	NW	15	9	28	8,000	6	2	Good	Ogallala	USGS	1949	3	6	10	35	98	1.40
	ma 24	SE	NW	20	9	29	5,000	8	4	Good	Sanborn	USGS	1949	1	4	7	34	97	0.79
	ma 25	SW	NE	20	9	30	10,000	6	3	Fair	Ogallala	SHCK	1942	4	9	15	48	96	
	ma 26	SW	SW	23	10	26	5,000	6	5	Fair	Sanborn	USGS	1949	0	2	7	32	95	4.13
	ma 27	SW	SW	31	10	26	10,000	12	1	Good	Ogallala	USGS	1949	0	1	9	39	94	5.48
	ma 28	NE	NE	32	10	26	10,000	6	2	Good	Terrace deposit	USGS	1949	0	2	6	33	98	1.37
	ma 29	SW	SW	27	10	27	2,500	5	5	Good	Sanborn	USGS	1949	0	5	11	41	92	6.11
	ma 30	SW	SW	18	10	28	7,500	9	2	Good	Ogallala	USGS	1949	0	3	7	38	97	2.07
	ma 31	SW	NE	24	10	28	2,000	5	3	Fair	Sanborn	SHCK	1942						
	ma 32	NE	NE	25	10	28	10,000	12	3	Good	Ogallala	SHCK	1942	0	1	5	46	93	5.6
	ma 33	NE	SE	27	10	28	4,500	9	6	Good	Ogallala	USGS	1949	0	1	5	36	96	2.38
	ma 34	NE	SE	31	10	28	4,000	6	3	Fair	Ogallala	SHCK	1942	4	6	11	43	96	2.4
	ma 35	C	SW	36	10	29	4,000	6	1	Fair	Ogallala	SHCK	1942	2	4	8	28	97	2.0
Volcanic ash	ma 36	SE	SE	23	10	30	12,000	9	4	Good	Sanborn	USGS	1949	0	3	10	38	93	4.33
	va 1	NW	NW	34	8	28	3,000	6	8	Good	Sanborn	USGS	1949	0	0	0	0	3	86.6
Mineral filler	mf 1	NE	NE	15	8	27	90,000	15	1	Good	Sanborn	USGS	1949				0	0	99
	mf 2	NE	SE	22	8	27	80,000	12	2	Good	Terrace deposit	USGS	1949			0	1	4	91
	mf 3	SW	SW	19	8	29	100,000	15	2	Good	Sanborn	USGS	1949					0	99
Limestone	ls 1	SW	NE	23	8	26	4,000	12	5	Fair	Smoky Hill	USGS	1949						
	ls 2	SE	SW	35	10	26	11,000	15	2	Good	Smoky Hill	USGS	1949						
Mtr. bed	mb 1	NW	NW	10	8	26	40,000	8	4	Fair	Ogallala	SHCK	1937						

Description of the material[2]

Number on plate	Fraction	Granite	Quartz	Feldspar	Syenite	Acid igneous rocks	Basic igneous rocks	Quartzite	Chert and chalcedony	Mortar bed	Sandstone
fa 1	C F	85 35	 55	5 5		10 		 5	Tr 		 Tr
fa 2	C F	70 35	 50	15 10				15 5			
fa 3	C F	90 40	 30	 20		1 	5 5	 5		4 	
fa 4	C F	90 5	 80	 10						10 5	
ma 1	C F	70 30	 50	10 15		10 Tr	5 5	5 Tr	 Tr	 Tr	
ma 2	C F	85 45	3 30	5 20		Tr 5	5 Tr	 Tr	2 	 Tr	
ma 3	C F										
ma 4	C F	65 30	5 35	15 5			 5	15 5			
ma 5	C F	75 40	10 50	5 5			7 Tr	2 5			1 Tr
ma 8	C F	90 15	 60	 20			10 	 5	Tr Tr		
ma 7	C F	80 40	5 40	2 15				10 5		3 Tr	
ma 8	C F	90 50	 40	 10		3 Tr	5 	2 Tr			
ma 9	C F	75 40	10 50	Tr 10		 Tr	5 Tr	10 Tr		 Tr	
ma 10	C F	85 15	 60	 20	5 	 Tr	5 	5 5	 Tr		
ma 11	C F	85 30	10 50	 20			 Tr	 Tr	5 		
ma 12	C F	85 15	 45	 30				5 10	5 Tr	5 	
ma 13	C F	80 40	3 40	5 15			1 Tr	 5	1 	10 Tr	
ma 14	C F	85 40	 60	 Tr			10 	5 Tr			
ma 15	C F	70 35	2 60	2 5		2 Tr	 Tr	2 Tr	 Tr	20 Tr	2
ma 16	C F	75 25	5 70	 5		5 Tr	15 Tr				Tr
ma 17	C F	90 50	5 50	 Tr			 Tr	Tr Tr			5
ma 18	C F	75 30	 40	3 30	 Tr	5 	10 	5 	2 		
ma 19	C F	85 50	5 40	2 5			3 5	5 	 Tr	 Tr	
ma 20	C F	85 40	 50	5 5		3 	5 5	2 Tr	 Tr		
ma 21	C F	90 50	 40	 5				5 5		 Tr	5
ma 22	C F	80 30	 50	 15	5 Tr		3 	2 Tr	 Tr	10 5	
ma 23	C F	65 15	 50	 25		5 	5 	25 10	 Tr		
ma 24	C F	90 50	5 40	Tr 5				5 5			
ma 25	C F	85 40	 40	 10			10 5	5 5			
ma 26	C F	65 15	20 70	 15		2 	 Tr	10 Tr	3 Tr		
ma 27	C F	90 50	3 35	Tr 10		Tr 	2 Tr	5 5		 Tr	 Tr
ma 28	C F	65 20	 50	 25		2 	 Tr	3 5	5 	25 Tr	
ma 29	C F	60 25	5 50	 15			 Tr	 Tr	 Tr	30 10	5
ma 30	C F	70 40	10 40	10 15		5 	 Tr	 3			5 2
ma 31	C F	80 30	10 50	5 20		 Tr	 Tr	1 Tr	2 	2 	
ma 32	C F	80 40	 35	Tr 20			10 Tr	10 5		Tr Tr	
ma 33	C F	80 40	10 50	3 10	 Tr		6 	1 Tr			 Tr
ma 34	C F	90 20	 50	 25		1 5	5 	1 Tr	3 		
ma 35	C F	80 30	 50	5 15			5 	5 Tr	5 		Tr 5
ma 36	C F	100 35	 50	 10		 Tr	 Tr	 5			
va 1											
mf 1	Light-brown silty clay										
mf 2	Light-brown silty clay										
mf 3	Light-brown silty clay										
ls 1	Yellow and brown limestone and some chert.										
ls 2	Yellowish gray and brown limestone and some brown chert.										
mb 1	Fine sand cemented with calcium carbonate; gray. Commonly called mortar bed.										

Laboratory test data

Number on plate	Weight per cubic foot (dry)	Specific gravity (dry)	Gradation factor	Compressive strength ratio: 1 day	Compressive strength ratio: 3 days	Los Angeles percent loss	Soundness[3] (25 cycles)	Toughness	Cementation	Absorption	Color[4]	Laboratory No.	Remarks
fa 1	98.1	2.56	2.69	1.3	1.02						cl	63765	Somewhat plastic when wet.
fa 2	103.7	2.56	2.59	0.91	0.98	C 29.6	0.98				cl	63769	
fa 3	106.9	2.56	2.93	1.59	1.31	D 26.0	0.96				cl	63761	Overburden well compacted.
fa 4	103.4	2.58	2.40	1.33	1.10							63773	Occasional clay balls.
ma 1	106.7	2.56	2.96	1.60	1.18	D 29.3	0.96				cl	63772	Occasional clay balls.
ma 2	98.1	2.59	3.13	1.63	1.57	C 30.0	0.97				cl	63785	
ma 3	111.0	2.62	3.46	1.22	1.16						st	42776	Acceptable under Sec. 67, Kans. Highway Stand. Spec. (ed. 1937).
ma 4	109.9	2.56	3.87	1.35	1.35						st	50759	Acceptable under Sec. 106, Kans. Highway Stand. Spec. (ed. 1945).
ma 5	103.6	2.60	3.26	1.31	1.28	C 28.4	0.99				cl	64071	Clayey in basal part.
ma 8	105.1	2.60	3.23	1.22	1.24	C 31.2	0.98				cl	64069	Limonite stains in upper part.
ma 7	107.3	2.57	3.30	1.39	1.25	C 27.6					cl	63784	Lenses of silt and clay in lower part.
ma 8	108.0	2.59	3.24	1.11	1.22	C 28.0	0.97				cl	64070	
ma 9	102.1	2.56	2.69	1.05	1.09	A 32.4	0.99				cl	63760	Overburden is sandy silt.
ma 10	105.5	2.60	3.10	2.10	1.67	C 36.0	0.97				cl	63778	Overburden is sandy.
ma 11	108.4	2.60	3.36	1.54	1.40	29.0	0.96				cl	63767	Some gravel particles coated with lime.
ma 12	108.2	2.60	3.33	1.55	1.47	30.2	0.98				cl	64068	Gravel concentrated in upper part of deposit.
ma 13	109.6	2.60	3.29	1.29	1.26						st	50734	Overburden is somewhat silty. Acceptable under Sec. 106, Kans. Highway Stand. Spec. (ed. 1945).
ma 14	104.4	2.61	3.48	1.33	1.40	28.0	0.98					59195	
ma 15	109.6	2.60	2.78	1.43	1.15	27.7	0.97				cl	63771	Overburden is silt.
ma 16	105.0	2.60	2.56	0.84	1.01	30.6	0.97				lt st	64067	Particles well rounded.
ma 17	110.5	2.60	3.36	1.56	1.42	28.6	0.97					63777	
ma 18	107.7	2.60	2.82	1.42	1.35	28.2	0.99				cl	59196	
ma 19	107.5	2.50	3.39	1.98	1.58	29.4	0.96				cl	63774	Upper 4 feet well compacted; clay lens 1 foot thick near base
ma 20	108.2	2.60	2.67	0.95	1.04	27.0	0.98				cl	63761	
ma 21			3.72	1.14	1.10						st	39440	Acceptable under Sec. 67, Kans. Highway Stand. Spec. (ed. 1937).
ma 22	109.5	2.60	2.93	1.31	1.25	31.0	0.99				cl	63764	
ma 23	107.9	2.60	3.34	1.66	1.52	35.4					cl	63783	
ma 24	111.4	2.61	3.04	1.71	1.38	28.0	0.98				st	64066	Overburden is loose silt, sand, and gravel.
ma 25	114.9	2.61	3.56	1.32	1.20	25.0	0.48					44923	Acceptable under Secs. 65, 67, 69, 71, 73, and 75, Kans. Highway Stand. Spec. (ed. 1937).
ma 26	108.0	2.50	2.95	1.50	1.22	28.4	0.98				cl	63766	Overburden is clayey silt.
ma 27	103.7	2.59	3.19	1.15	1.11	31.2	0.98				cl	63762	Contains thin seams of mortar bed and some clay balls.
ma 28	104.6	2.59	3.23	1.77	1.40	33.5	0.94				cl	63776	Contains large particles of chalk, siliceous chalk, and mortar bed fragments.
ma 29	103.5	2.60	3.18	1.27	1.27	33.2	0.91				cl	63759	Overburden of silt, sand, and gravel. Contains calcareous concretions and some clay balls.
ma 30	104.6	2.59	3.16	1.25	1.24	36.0	0.98				st	64064	Limonite (brown) stain throughout.
ma 31	107.6	2.58	3.58	1.15	1.12	28.8	0.94					44924	Some large mortar bed fragments and small clay balls. Acceptable under Secs. 65, 67, 69, 71, 73 and 75, Kans. Highway Stand. Spec. (ed. 1937).
ma 32	107.8	2.54	3.20	1.15	0.99	27.8	0.97				cl	44925	Acceptable under Secs. 65, 67, 69, 71, 73, and 75, Kans. Highway Stand. Spec. (ed. 1937).
ma 33	107.6	2.60	2.94	1.67	1.37	31.3					cl	63770	
ma 34	109.6	2.55	3.43	1.20	1.26	30.2	0.99				cl	44927	Acceptable under Secs. 65, 67, 69, 71, 73, and 75, Kans. Highway Stand. Spec. (ed. 1937).
ma 35	109.1	2.57	3.06	1.06	1.17	28.0	0.98				cl	44928	Acceptable under Secs. 65, 67, 69, 71, 73, and 75, Kans. Highway Stand. Spec. (ed. 1937).
ma 36	104.0	2.58	3.09	1.25	1.12	32.0	0.99				st	64065	
va 1	56.0	2.32							1			63763	
mf 1	74.0								100+			66910	Plasticity index = 2; liquid limit = 31. Cementation factor excessive
mf 2	86.0								90			66906	Plasticity index = 8; liquid limit = 29. Cementation factor high.
mf 3	72.0								100+			66909	Plasticity index = 11; liquid limit = 34. Cementation factor excessive.
ls 1		1.54				86.0	0.31			25.45		63782	
ls 2		1.72				58.2	0.50			18.22		63775	
mb 1		2.11				30.3	not sound	4				32499	

1. SHCK, State Highway Commission of Kansas: sieve analysis and laboratory tests by SHCK, USGS, U.S. Geological Survey: sample collection and description of material by USGS.
2. C, coarse fraction, retained on No. 4 sieve; F, fine fraction, passed through No. 4 sieve; Tr, trace.
3. Loss ratio.
4. cl, clear; st, straw; lt st, light straw.