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CONSTRUCTION MATERIALS IN DECATUR COUNTY, KANSAS

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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 inventory of construction materials. A field party composed of personnel from the two agencies investigated sources of engineering construction materials in Decatur County in the summer of 1947. This report of the Decatur County investigation is a part of the State-wide materials inventory and a contribution to the geologic mapping and investigation of mineral resources being made in the Missouri River Basin. 1/

The primary objective of the investigation was the accumulation of all field and laboratory data pertaining to the geologic materials in Decatur County that would be of use in the construction of dams, irrigation canals, highways, airports, or 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 construction materials prospects reported in the inventory or for the location of other prospects to meet future engineering needs.

AREA COVERED BY THE INVESTIGATION

Decatur County is in the first tier of Kansas counties south of the Nebraska border and in the third tier east of Colorado (fig. 1). It comprises 25 townships and covers an area of about 900 square miles. The county is bounded by parallels 39°34' and 40°00' north latitude and meridians 100°11' and 100°44½' west longitude. It is bounded on the north by Furnas and Red Willow Counties, Nebraska, and by the following Kansas counties: Norton on the east, Sheridan and Thomas on the south, and Rawlins on the west.

GEOGRAPHY OF THE AREA

Decatur County is in the High Plains section of the Great Plains physiographic province. 2/ The divides are flat-topped or gently rolling. They are cut by the shallow but fairly steepsided valleys of the major streams, which drain toward the east and northeast, and by the shallow valleys of the tributaries to these streams. The area of principal relief is along Sappa Creek. The stream valley is cut 100 to 150 feet below the upland surface, as are the lower portions of the tributary valleys. The topography of the Sappa Creek belt is of the moderately dissected type. A map contoured by Elias 3/ shows that the tops of some of the divides along the western boundary of the county rise more than 2,900 feet above sea level and that the flood plains of the major streams in the eastern part lie below an altitude of 2,500 feet.

Three of the principal streams in the county, Sappa Creek, Beaver Creek, and Prairie Dog Creek, are in the drainage basin of the Republican River. The largest of these is Sappa Creek. Both the North and South Forks of Sappa Creek rise in Sherman County about 60 miles to the southwest. They join at a point several miles southwest of the city of Oberlin, and Sappa Creek leaves the county near the northeastern corner. Beaver Creek rises in eastern Colorado and flows toward the northeast, cutting across the northwestern part of Decatur County. Prairie Dog Creek rises about 45 miles to the southwest in Thomas County and flows toward the northeast across the southern part of Decatur County. The two forks of Prairie Dog Creek join at a point about 5 miles west of the city of Dresden. The only other major stream in the county is the North Fork Solomon River. It rises in Thomas County and flows across the extreme southeastern part of Decatur County. The tributaries to the major streams are relatively short and flow only intermittently. They enter the major streams at nearly right angles.

Three railways serve Decatur County. Oberlin, the county seat and principal city, is the terminus of a branch line of the Chicago, Burlington, & Quincy Railroad. This railroad crosses the central part of the county, and Kanona and Norcatur are located along it. One of the main lines of the Chicago, Rock Island, & Pacific Railroad cuts across the southeastern corner of the county and serves the cities of Leoville, Dresden, and Jennings. A second branch line of the Chicago, Burlington, & Quincy Railroad crosses the northwestern part of the county, and serves the cities of Traer and Cedar Bluffs.

U. S. 36, a major east-west transcontinental highway, extends to the east 2 miles north of the center of the county. U. S. 183, an important north-south highway, extends to the south across the county, 4 miles west of the center. The two highways cross at Oberlin. U. S. 383 parallels the Chicago, Rock Island & Pacific Railroad across the southeastern corner of the county. Kansas Highway 9 starts at Dresden and trends eastward across the county. Kansas Highway 23 starts at Dresden and trends southward to the county line. There is a well-developed system of county and township roads. These roads follow section lines for the most part. Some are metaled, while others are maintained by grading only.

INVESTIGATION PROCEDURE

This report is based on reconnaissance-type field work. The base map (Highway Planning Map, scale 1 inch equals 1 mile) was provided by the State Highway Commission of Kansas. Drainage lines were added to the base map for greater ground control in mapping and were taken from a map (scale 1 inch equals 2 miles) compiled from large-scale aerial photographs by the Soil Conservation Service, United States Department of Agriculture. The areal distribution of the stratigraphic units cropping out in Decatur County was then mapped in the field. The mapped units are those recognized as of 1947 by the United States Geological Survey and the Kansas Geological Survey. Their definitions of the stratigraphic units are accepted with little or no modification, because the principal emphasis of the project is on construction materials. Geologic problems not critically related to the presentation of information on construction materials are considered to be of

[1] Missouri River Basin, 78th Cong., 2d sess., S. Doc. 191, 1944, pp. 94-95, appendix III.
[2] Frye, J. C., High Plains surface in Kansas: Kansas Acad. Sci. Trans., vol. 49, no. 1, pp. 81-82, June 1946.
[3] Elias, M. K., Geology of Rawlins and Decatur Counties: Kansas Geol. Survey Min. Res. Circ. 7, pp. 6, 8, fig. 4, 1937.

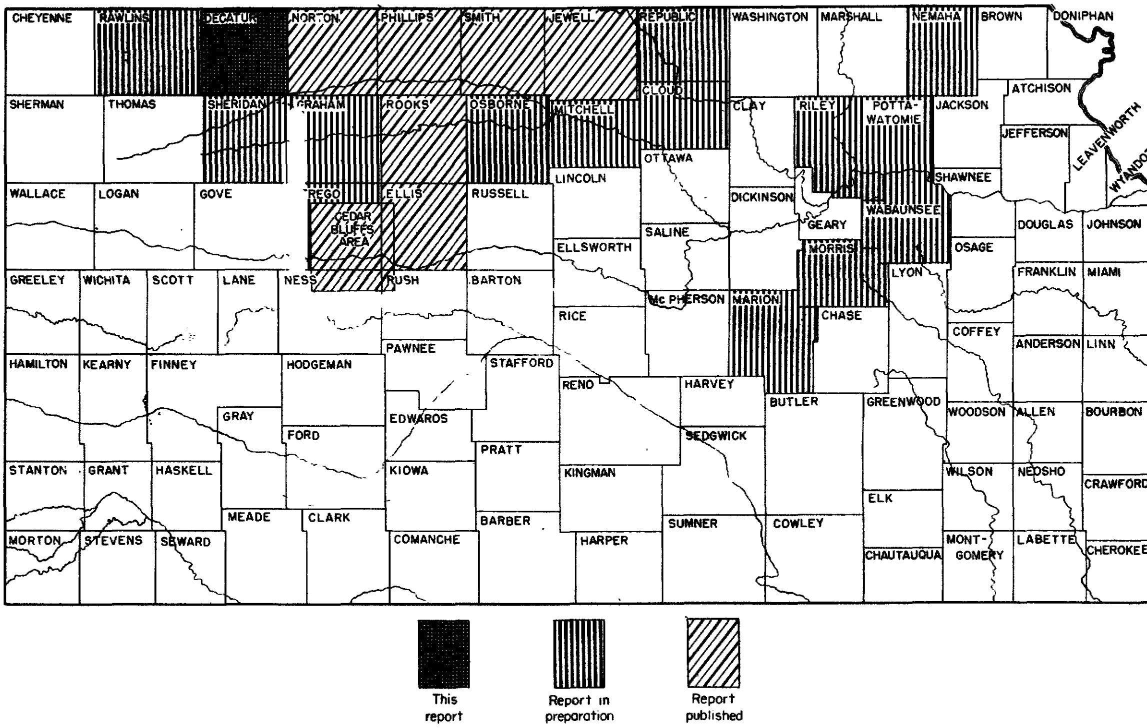
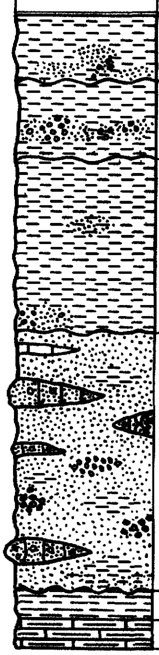


Figure 1.–Index map of Kansas showing areas covered by this report and by other construction materials investigations



Section	Outcrop Thickness (feet)	Stratigraphic units: System	Series	Formations and members	Generslized description	Construction materials
	0-30	Qnaternary	Pleistocene and Recent	Allnvinm	Silt, tan to dark brown; some clay and silty sand; occasional grsvel lenses.	Aggregate Road metal
	0-45	Qnaternary	Pleistocene and Recent	Terrace deposits	Upper part, tan or grny silt, often includes a buried soil zone; basal psrt, occasionally sandy with local gravel lenses included.	Mineral filler Aggregate Road metal
	0-100	Qnaternary	Pleistocene and Recent	Sanborn formation	Silt, tan, gray, or red-brown locally in basal part; one or two baried soil zones often present; columnar structure usually well developed; numerous calcareous nodules or stringers in "B" zone; local lenses of sand and gravel in basal part.	Mineral filler Aggregate Road metal
	0-150	Tertiary	Pliocene	Ogallala formation	Lenticular ledges of grny mortar bed interbedded with lenses of sand, gravel, and silt; hard nodular limestone locally present at or near top; interbedded lenses of light-gray volcanic ash; basal part locally a brown, gray, green, or maroon clay.	Aggregate Road metal Volcanic ash Structural stone
	0-15	a	b	Pierre shale	Thin-bedded dark-gray clay shale; limonite stains along fractures.	
	0-10	a	b	Niobrara formation Smoky Hill Chalk member	Beds of brown silicified chalk separated by thin chalky shales.	

a Cretaceous system.
b Upper Cretaceous series.
Smoky Hill chalk member of Niobrara formation.

secondary importance and are ignored insofar as the validity of the information presented is not affected.

An effort was made to accumulate all existing data pertaining to construction materials in the county. These data, together with their sources, are incorporated in this report. The field party also collected samples of construction materials not reported previously. The samples were brought to the Highway Testing Laboratory of the State Highway Commission in Manhattan, Kans., where they were subjected to routine laboratory tests. A portion of each sample of aggregate material was analyzed under a binocular microscope in the laboratory of the Department of Geology, Kansas State College, and the constituent rock and mineral grains determined. The laboratory tests and mineralogical analyses, together with information from other sources, are presented in table 1.

ACKNOWLEDGMENTS

Generous assistance in the compilation of the areal map and of construction-materials data by the following is appreciated: the State Highway Commission of Kansas at Topeka and Manhattan (S. E. Horner, chief geologist, and R. D. Finney, engineer of materials, and his associates) and the State Geological Survey of Kansas at Lawrence (J. C. Frye, executive director).

This report, in manuscript form, was reviewed critically by members of the State Highway Commission and the United States Geological Survey. Illustrations were prepared by draftsmen of the State Highway Commission and the United States Geological Survey.

CHARACTERISTICS OF THE OUTCROPPING STRATIGRAPHIC UNITS

GENERAL

This part of the report discusses the characteristics of each geologic formation or member cropping out in Decatur County. The discussion emphasizes the areal distribution, general characteristics, and thickness of each stratigraphic unit. A representative section is given for each formation or member where possible or desirable. The measured sections presented in this report are not necessarily intended to be complete; their purpose is to show a typical section of a formation or member as it occurs in the county. The construction materials in each stratigraphic unit are listed also. The principal purpose of this part of the report is to present the geologic information required for the location and the effective development of the construction materials contained in each stratigraphic unit.

A summary of the geologic construction-materials data for each unit is presented in tabular form in figure 2. The relations of the stratigraphic units to one another are indicated in figure 3.

The areal distribution of the local stratigraphic units is shown on plate 1. Each unit is indicated by an identifying symbol, and its outcrop areas are shown by a distinctive pattern. Railroads, roads, and streams are shown to provide a rough basis for evaluating the accessibility of sources of construction materials.

The locations of operated and prospect pits and quarries are shown also 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 feet thick). Symbols shown in vertical letters followed by a number (such as ma 12) are listed in table 1. Symbols shown in italicized letters (such as mb or fa) 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. The numbering is continued in the next tier south, starting with the township in the easternmost range and proceeding to the western boundary of the county, and so on. The construction materials sources within a township are numbered in the same sequence as are the sections.

SMOKY HILL CHALK MEMBER OF THE NIOBRARA FORMATION

Areal distribution.--The Smoky Hill chalk member of the Niobrara formation (fig. 2) is the oldest stratigraphic unit that crops out in Decatur County. It was deposited in marine waters. Only two small outcrops (pl. 1) of this unit were found in Decatur County by the field party. Both are cut banks along Sappa Creek and occur in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 12 and the NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 19, T. 1 S., R. 26 W. Undoubtedly the Smoky Hill chalk underlies the entire area of Decatur County but is concealed elsewhere in the county by younger, overlying formations.

General description.--The two local outcrops of the Smoky Hill chalk undoubtedly are of the upper part of the member. The exposed rock consists of layers of silicified chalk 0.3 to 0.6 foot thick separated by very thin beds of tan chalky shale. The silicified chalk is brown with darker brown streaks throughout. The original calcium carbonate of the chalk beds probably was replaced by silica through the action of silica-rich subsurface waters. The limited outcrops of this unit account for the lack of a complete description of its lithologic and paleontologic characteristics. The outcrops are overlain unconformably (with an intervening erosional break) by terrace deposits. Because of the limited thickness of the exposures of this stratigraphic unit a representative section was not measured.

Thickness.--The individual outcrops are each about 1.5 feet thick. Elias 4/ states that the Niobrara formation (composed of the Smoky Hill chalk member and the underlying Fort Hays limestone member) is only about 300 feet thick in Rawlins and Decatur Counties, as interpreted from local well logs.

Construction materials.--Because of the limited quantity of material available from this stratigraphic unit in Decatur County, it probably cannot be considered a source of construction materials. Silicified chalk, however, has been used in other counties in

[4]Elias, M. K., op. cit., p. 8.

north-central Kansas as riprap, road metal, and structural stone. Additional outcrops of the Smoky Hill chalk might possibly be discovered through intensive exploration of the deeper valleys in the eastern border region of the county.

PIERRE SHALE

Areal distribution.--The Pierre shale (fig. 2) is of marine origin and conformably (without an intervening erosional break) overlies the Smoky Hill chalk member of the Niobrara formation. Only one outcrop of the Pierre shale (pl. 1) was found by the field party in Decatur County. This is an artificial outcrop, because the formation is exposed in a road cut along U. S. Highway 383 in the SW¼ NE¼ sec. 10, T. 4 S., R. 26 W. Material identified by the field party as Pierre shale was encountered in an auger hole drilled in the SW¼ NW¼ sec. 6, T. 4 S., R. 30 W. beneath 7 feet of sand and gravel of Quaternary age.

Elias 5/ reports that the Pierre shale crops out in the valley of Beaver Creek, in some of its tributary valleys, and in the valley of Sappa Creek. An examination of the reported outcrop areas failed to reveal the formation, although a more intensive investigation might prove successful. Undoubtedly the Pierre shale underlies most of Decatur County but is obscured beneath younger Tertiary and Quaternary sediments (fig. 3), from which it is separated by an unconformity.

General description.--The Pierre shale is composed predominantly of a thin bedded to very thin bedded, dark-gray or black clay shale. It weathers light gray. Fracture planes are conspicuously limonite stained. The Pierre shale is so homogeneous in the exposure examined by the field party that a section of it was not measured.

Thickness.--The thickness of the one local outcrop of the Pierre shale examined is about 5 feet. Undoubtedly this is only a small part of the full thickness of the formation, for Elias 6/ reports that 600 feet of the formation was encountered in drilling a well in the vicinity of Kanona and that the formation thickens toward the west to 900 to 1,200 feet in Rawlins County.

Construction materials.--The clay shales of this stratigraphic unit are probably of little or no value as materials for engineering construction.

OGALLALA FORMATION

Areal distribution.--The Ogallala formation (fig. 2) crops out locally along the valley walls of the larger streams and their tributaries in Decatur County (pl. 1). The outcrops are discontinuous, because this formation is generally buried beneath the younger, overlying Sanborn formation. The Ogallala formation undoubtedly underlies all of the larger divide areas in the county but is exposed only where streams have cut through overlying Sanborn formation.

General description.--The Ogallala formation overlies the Smoky Hill chalk member of the Niobrara formation in the eastern part of the county and the Pierre shale throughout the remainder of the county (fig. 3). It is separated by an unconformity from these older stratigraphic units. It is overlain unconformably by the Sanborn formation.

The Ogallala formation includes interbedded lenses of silt, clay, and cross-bedded sands and gravels. The lenses vary in both thickness and extent and thus indicate the stream-deposited origin of much of the formation. The bulk of the material composing the Ogallala was eroded from the Rocky Mountains by streams, which then transported the sediments toward the east and deposited them as a sedimentary layer over the High Plains surface.

The Ogallala formation in Decatur County is characterized especially by lenticular layers of mortar bed. The mortar bed lenses are light gray and are composed of sand and/or gravel cemented by interstitial deposits of calcium carbonate. The degree of cementation varies and influences the hardness of each mortar bed layer; the most firmly cemented layers are the hardest. Because of their superior hardness, as compared with that of the other materials composing this formation, the mortar beds crop out as conspicuous hillside ledges. So many ledges occur in Decatur County that some hillsides, often as high as 50 feet, appear to be entirely underlain by mortar bed material. Careful examination reveals, however, that even in such situations the mortar beds are interbedded with poorly cemented sands, gravels, and silts and mask the hills only because they are less easily eroded. Individual mortar beds average about 6 feet in thickness, but locally they may be as much as 18 to 20 feet thick. Clay balls are fairly numerous in the mortar beds. The poorly cemented sediments average about 4 feet in thickness.

Fairly thick beds of maroon, green, and brown clays occur in various parts of Decatur County (see representative measured section). Some zones have been sufficiently compacted to form shales. They are either laminated or massive, and they may contain scattered calcareous concretions. It is thought that the clays and the clay shales are a basal phase of the Ogallala formation. Similar materials were found by the field party working in Norton County and have been reported in other northwestern Kansas localities.

The loosely cemented sands and gravels in the Ogallala formation often are hard to distinguish from local sands and gravels in the basal part of the Sanborn formation. This distinction can be made readily if the mortar beds of the Ogallala are in direct association with sand and gravel lenses. Lacking this association, the correlation of such sand and gravel layers is based on topographic position and the presence of certain mineral and rock fragments considered to be indicative of the Sanborn formation. The presence of numerous particles of mortar bed or other typical materials of the Ogallala in the sand and gravel is interpreted as indicating that the deposit is to be classified as Sanborn formation.

A dense nodular massive buff-gray limestone occurs locally in the upper part of the Ogallala formation. It is lighter in color, finer textured, and generally much harder than the mortar beds of the Ogallala. This phase of the Ogallala formation contains only scattered sand grains and is thought to represent a surface or near-surface caliche deposited through the evaporation of subsurface waters heavily

[5] Elias, M. K., op. cit., p. 6.
[6] Elias, M. K., op. cit., p. 8.

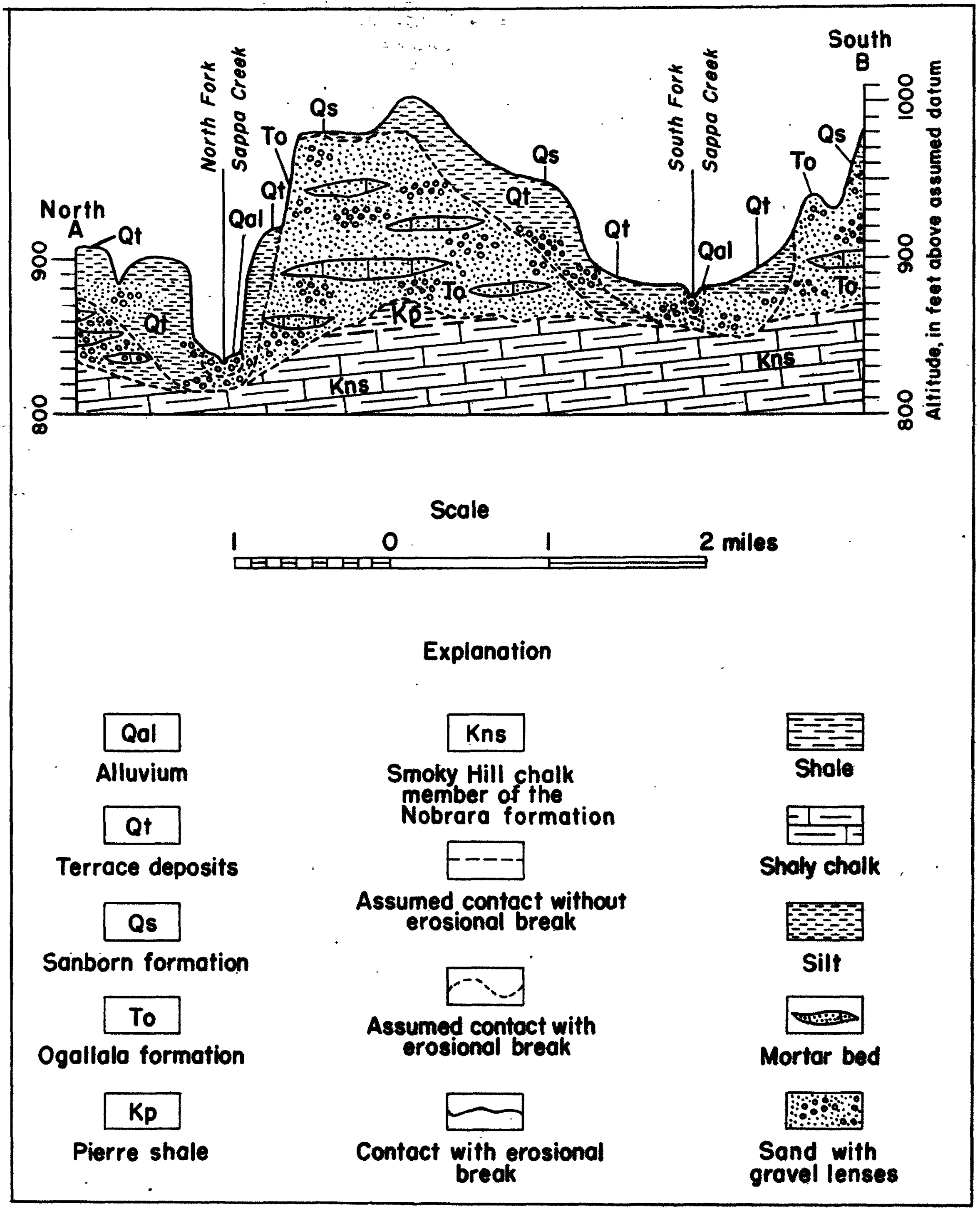


Figure 3.—Geologic cross section through the North and South Fork Valleys of Sappa Creek along the line between secs. 32 and 33, T. 3 S., R. 30 W., and secs. 20 and 21, T. 4 S., R. 30 W.

charged with dissolved calcium carbonate. The limestone was examined in two quarries; in the NE¼ SW¼ sec. 29, T. 4 S., R. 26 W. and in the SW¼ NW¼ sec. 25, T. 1 S., R. 27 W. The beds have an average thickness of about 2 feet.

Two lenses of volcanic ash of Ogallala age were located by the Decatur County field party. The ash is white to light gray, is relatively free of extraneous material, and appears to be somewhat more compacted than the volcanic ash found in younger stratigraphic units. The ash is material discharged into the atmosphere during the explosive phase of a volcanic eruption. It was carried by the wind and deposited in such sheltered places as stream valleys and river basins. The two localities are listed in table 1 (va 1 and 2) and mapped on plate 1.

A fossil plant, Biorbia fossilia, was recognized in this formation in Decatur County. Other types of fossils have been reported in the Ogallala but were not found by the Decatur County field party.

The quartzite lenses so characteristic of the Ogallala formation in other parts of Kansas were not found in Decatur County.

Representative measured section.--A section of the Ogallala formation is exhibited in a cut bank of a Sappa Creek tributary in the NW¼ NW¼ sec. 2, T. 2 S., R. 28 W., as follows:

	Feet
(Overlain by silt of the Sanborn formation)	
Ogallala formation:	
Mortar bed, firmly cemented; two prominent ledges that crop out on hillside; intervening beds covered	18.0
Silt, sandy; gray, weathers light gray	.15
Flintlike bed; hard; somewhat calcareous; light gray	.5
Shale; dark green, weathers light green; contains numerous calcareous concretions	1.3
Zone of calcareous concretions	.15
Shale; laminated; maroon, weathers pink	.55
Clay, silty; laminated; light brown, weathers gray	.1
Shale; maroon, weathers pink; numerous calcareous concretions in basal part	.85
Clay, silty; light brown, weathers grayish green	.15
Shale; maroon, weathers pink	.45
Clay, silty; gray brown, weathers gray green	.15
Shale; maroon, weathers pink; scattered calcareous concretions	2.1
Clay, sandy; brown	.2
Zone of flinty nodules	.1
Sand, very fine; light brown; very thin layers of silt interbedded	.65
Clay; yellow brown, weathers light brown	2.0
Total thickness exposed (base covered)	27.40

Thickness.--The thickness of the Ogallala formation ranges from a feather edge along the valleys of the major streams to an estimated maximum of about 200 feet. The average thickness of the formation is thought to be about 150 feet. Individual outcrops have an average thickness of about 20 feet, although, in the northwestern part of the county, the thickness of the Ogallala formation exposed through the overlying Sanborn formation averages about 50 feet.

Construction materials.--
- Aggregate for concrete.
- Road metal.
- Volcanic ash.
- Structural stone.
- Riprap.

SANBORN FORMATION

Areal distribution.--The Sanborn formation (fig. 2) is the most widely distributed stratigraphic unit cropping out in Decatur County (pl. 1). It occurs as an extensive blanket of silt of variable thickness capping the divides and as a discontinuous deposit of silt part way up the valley walls of some of the larger streams in the county, such as Sappa Creek. The discontinuous phase is not as conspicuously developed in Decatur County as it is in counties to the east. The two phases of the Sanborn formation are mapped as a single stratigraphic unit because their lithologic characters are similar.

General description.--The Sanborn formation is composed of materials deposited by streams, slope wash, and wind and through the action of gravity. Frye and Fent 7/ have subdivided the formation into members. It was not feasible to attempt the mapping of such members in the reconnaissance-type field work on which this report is based. To do so would require a greatly expanded field program, including test drilling. The Sanborn formation as it is here defined and mapped seems adequate to serve the purpose of a construction materials inventory.

The Sanborn formation unconformably overlies all older stratigraphic units with which it is in contact. Silt-size particles predominate in the upper part of the formation. The color is generally light tan but locally may be light gray. The typical silts of the lower part of the formation are dull red. There is a prominent soil profile at the top of the formation, and one or more buried soil zones have been reported by Hibbard, Frye, and Leonard. 8/ The "A" zone of the soil profile varies in thickness from about 0.9 foot to 1.9 feet. The "B" zone is several times as thick and is characterized by secondary calcium carbonate deposited by percolating subsurface waters as nodules, stringers, or impregnations. The amount of calcium carbonate in the "C" zone of the soil profile is relatively negligible. A crude columnar structure is often developed in the upper part of the Sanborn and is the result of the intersection of irregular joint planes. Silts of the Sanborn formation tend to stand in vertical banks.

In addition to the red silt, the basal part of the formation locally includes lenses of cross-bedded silty sand and/or gravel usually from 4 to 6 feet thick. These are channel deposits that pinch out within

[7] Frye, J. C., and Fent, O. S., Late Pleistocene loesses of central Kansas: Kansas Geol. Survey Bull. 70, pt. 3, pp. 41-51, 1947.
[8] Hibbard, C. W., Frye, J. C., and Leonard, A. B., Reconnaissance of Pleistocene deposits in north-central Kansas: Kansas Geol. Survey Bull. 52, pt. 1, p. 13, 1944.

relatively short distances. Weathered and water-rounded particles of the mortar bed of the Ogallala are conspicuous in the gravels.

Fossil shells of gastropods (snails) were collected from several outcrops of the Sanborn formation by the field party. The specimens included both high-spired and low-spired types. Fragments of the skeletons of vertebrate animals are reported to be fairly common in the basal part of the formation.

The Sanborn formation generally erodes to form a gently undulating surface. The gently sloping walls of the headward portions of numerous small tributary valleys exhibit a phenomenon known as "catstep erosion." This is probably the result of gravity sliding of water-saturated silt down toward the tributary streams. The "catsteps" are bounded by scarps a foot or more high, which define slump blocks from several feet to about 20 feet wide. The catsteps may develop in two or more series.

The Sanborn formation is more extensive and is thicker along the north walls of the major stream valleys than it is along the south walls. This causes the north walls to be gently sloping and the south valley walls to be much more steep. Most of the exposures of older stratigraphic units, therefore, occur along the south valley walls.

Representative measured section.--A road cut in the SE¼ SE¼ sec. 9, T. 1 S., R. 30 W. shows the following section of the Sanborn formation:

	Feet
Sanborn formation:	
Soil zone; silty, tan gray	0.5
Silt; brown; well-developed columnar structure	3.4
Silt; light buff; shows crude columnar structure; numerous stringers of calcium carbonate	2.3
Silt; occasional granitic pebbles scattered throughout; light buff; fossil snails in basal part	5.3
Sand, silty; pebbles as much as 0.5 inch in diameter scattered throughout; numerous calcareous nodules	4.6
Silt, very fine; light buff; occasional thin lenses of fine sand interbedded	8.1
Sand; cross-bedded; numerous rounded mortar-bed pebbles in basal part; some irregular lenses of silt interbedded	12.3
Silt, fine; tan	1.5
Total thickness exposed (base covered)	38.0

Thickness.--The thickness of this formation varies greatly over the county. In the vicinity of the stream valleys it may be only a feather edge, but near the tops of the divides it is estimated to be as much as 50 feet thick. The average thickness is about 75 feet.

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

TERRACE DEPOSITS

Areal distribution.--Terrace deposits (fig. 2) are conspicuous features in the valleys of the major streams in Decatur County (pl. 1). Fingerlike extensions of the terrace deposits project into the valleys of the larger tributaries. The terraces of Sappa Creek range from about 0.5 mile to 1.3 miles in width, those of Prairie Dog Creek average about 0.5 mile, those of the Solomon River about 1 mile, and those of Beaver Creek about 1.5 miles in width. Two or more terrace levels are present but are mapped as a single stratigraphic unit because of their lithologic similarity.

General description.--The terrace deposits unconformably overlie older formations (fig. 3) and are composed of materials deposited by present-day streams in earlier gradational cycles. The upper part of a terrace is composed of a tan or gray silt that exhibits many of the characteristics listed for the Sanborn formation. There is a well-developed soil profile, there may be one or more buried soil zones, it often develops columnar structure, and locally it contains the shells of fossil gastropods. There are lenses of cross-bedded sand and gravel in the basal part of the formation. The sand and gravel particles are from local older stratigraphic units that have been reworked by streams in later gradational cycles.

Representative measured section.--The following section of a terrace deposit in the valley of Prairie Dog Creek was measured in a road cut in the SE¼ NE¼ sec. 11, T. 4 S., R. 26 W.:

	Feet
Quaternary terrace deposits:	
Soil zone; dark gray	3.5
Silt, very fine; light brown to buff	2.5
Silt, fine; lime stained; light gray to buff	3.7
Silt, fine; light tan to buff	1.6
Silt, sandy; light buff	1.6
Total thickness exposed (base covered)	12.9

Thickness.--The thickness of the terrace deposits is exceedingly variable and could have been determined accurately only by test drilling. Such data is not available for Decatur County, but it is estimated that the maximum thickness is about 45 feet. The terrace extensions into the smaller tributary valleys probably have an average thickness of no more than 10 to 15 feet.

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

ALLUVIUM

Areal distribution.--The deposits (fig. 2) formed by streams in their present gradational cycles are mapped as alluvium (pl. 1). They constitute the most recent stratigraphic unit in Decatur County. Alluvium is defined in this report as the material underlying the present flood plain of a stream. The flood plain is the area adjacent to the stream channel that is covered by water during a normal flood stage.

Alluvium in the valleys of the Solomon River, Prairie Dog Creek, Sappa Creek, and Beaver Creek is mapped. Alluvial deposits also are present in tributary valleys but are so narrow that they could not be shown on a map scaled to 1 mile to 1 inch. The alluvial deposits along the major streams have an average width of about 0.25 mile.

General description.--The alluvium is composed predominantly of tan or dark-gray silt. Local channel fills in the main mass of the alluvium are composed of sand-size and gravel-size particles. High percentages of local mortar-bed fragments are characteristic of the gravels. Fossil shells of gastropods were collected by the field party from cut banks in the alluvium of Decatur County. It was not possible to measure a section representative of this formation because of the low relief of the alluvium.

Thickness.--The thickness of the alluvium could not be determined because of the absence of test-drilling data. The maximum thickness of the alluvium in the major stream valleys is estimated to be about 30 feet.

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

INVENTORY OF CONSTRUCTION MATERIALS

GENERAL

This part of the report inventories the construction materials in Decatur County. Its objectives are to establish the bases upon which the construction materials are classified and to analyze the relations of the various materials to the stratigraphic units in which they occur.

Laboratory test data have been introduced into the report whenever available to aid in the evaluation of the materials. This information is given in table 1 and is based on standard testing procedures.9/ It is expected that the materials prospects listed in this report will be proved by subsequent augering, drilling, or test pitting and that the materials themselves will be subjected to laboratory testing prior to the development of a site.

Although numerous prospect pits and quarries were located in the field, no attempt was made to complete an exhaustive materials location survey. [The purposes of this report are to inventory the construction materials that occur in Decatur County and to establish the geologic pattern required for the location and development of the materials which future engineering needs may demand.]

[9] State Highway Commission of Kansas, Standard specifications for State road and bridge construction, 1945: Gradation factor, p. 16; Sieve analysis, pp. 333-334; Soundness, pp. 335-336. American Association of State Highway Officials, Standard specifications for highway materials and methods of sampling and testing, pt. 2, 1947: Absorption, pp. 251-252; Compressive strength, pp. 257-258; Deval abrasion, pp. 235-236; Liquid limit, pp. 198-201; Los Angeles abrasion, pp. 237-239; Plastic limit, pp. 202-203; Specific gravity, pp. 249-250; Toughness, pp. 240-241; Weight per cubic foot, pp. 253-254.

AGGREGATE FOR CONCRETE

ENGINEERING AND GEOLOGIC CHARACTERISTICS

Aggregates for concrete are distinguished as "fine aggregates" and "mixed aggregates" in table 1 and on plate 1. 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 the sieve is designated as the coarse fraction. The sample 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 aggregates will be discussed under a single heading, "Aggregate for concrete," because the grading of almost any aggregate material may be changed by sweetening or by screening to conform to required specifications.

Aggregates for concrete consist of sand-size and/or gravel-size fragments of hard, durable minerals and/or rocks. The constituent particles are free from adherent coatings that would interfere with the bonding of cement with the particles. The presence of the following deleterious substances, if in quantities thought to be excessive in a concrete aggregate, is noted under Remarks in table 1: material passing the no. 200 sieve (wash); shaly, soft, or flaky fragments; sticks or other organic debris; clay lumps; and minerals which, because of their chemical composition, may react with the cement to the detriment of the concrete.

The materials reported in this classification are exposed at the surface or are under unconsolidated overburden sufficiently thin for them to be economically developed. Relatively inaccessible deposits and deposits of sand and gravel overlain by thick or consolidated beds usually are not included in this classification because of the added expense in the removal of the overburden; exceptions to this practice are noted in the "Remarks" column of table 1.

The test characteristics of some of the materials included under this heading indicate that they might be acceptable for other uses of aggregate, such as aggregate for bituminous concrete or cover material, even though they are below the standard required of aggregate used in Portland-cement concrete.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

The following stratigraphic units are actual or potential sources of aggregate for concrete in Decatur County:

(1) Ogallala formation.--This formation is probably the most promising source of aggregate for concrete in Decatur County. Nine samples of fine aggregate (fa 2, 3, 5, 8, 9, and 12-15) and 6 samples of mixed aggregate (ma 3, 4, 11, and 15-17) were taken from this stratigraphic unit. Their locations are mapped on plate 1, and their test characteristics are given in table 1. The coarse fractions of both types of aggregate are composed predominantly of quartz and feldspar particles and contain minor amounts of fragments of basic igneous rocks. The fine fractions are composed mainly of quartz grains, but there are numerous feldspar grains and some basic igneous rock and quartzite particles. Quartzite is the only constituent present that might be deleterious in concrete

Table 1.–Summary of materials tests

Location, thickness, source and sieve analysis

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	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 passing no. 200 (wash)
Fine aggregate	fa1	NE	NE	19	2	27	5,000	9	6	Fair	Terrace deposits	SHCK[2] USGS	11-47	1	2	3	11	83	14.7
	fa2	SW	SW	30	2	28	20,000	11	0-5	Good	Ogallala	do	do			0	6	80	3.7
	fa3	SE	NE	33	2	28	50,000	10	0-7	Poor	do	SHCK[3]	3.42	0	2	4	24	92	6.0
	fa4	NW	NW	19	2	30	20,000	15	2-10	Fair	Sanborn	SHCK USGS	12-47		0	1	44	97	1.57
	fa5	NW	NE	4	3	28	5,000	6	0-6	Good	Ogallala	do	do	0	1	4	36	92	4.41
	fa6	NE	NE	32	3	29	15,000		7-10	do	Terrace deposits	do	11-47		0	1	11	93	4.6
	fa7	SE	SE	29	4	27	12,000	5-20	7	do	Sanborn	SHCK	3-42		0	3	34	87	3.5
	fa8	NE	NW	35	4	27	5,000	9	0-6	Good	Ogallala	SHCK USGS	11-47	0	1	3	25	92	6.37
	fa9	SE	NW	11	4	29	5,000	12	3-8	Fair	do	do	do		0	2	18	91	4.5
	fa10	NE	NE	1	4	30	2,000	9	2-4	Good	Terrace deposits	do	do	0	1	2	9	89	7.8
	fa11	NW	SE	6	4	30	2,000	10+	2-6	Poor	do	da	do		0	1	4	90	8.3
	fa12	SW	SE	4	5	29	1,500	12	3	do	Ogallala	do	do	0	1	4	42	95	3.3
	fa13	SE	SE	24	5	29	15,000	3-10	3-10	do	do	SHCK	3-42		0	1	9	92	3.4
	fa14	NW	SW	28	5	29	500	5	3-10	Good	do	SHCK USGS	11-47		0	2	26	86	10.2
	fa15	NW	SE	33	5	29	5,000	20	0-6	do	do	do	do		0	2	12	89	5.6
Mixed aggregate	ma1	NE	SW	9	1	28	3,000	14	0-6	Fair	Sanborn	do	do	1	3	7	33	92	3.4
	ma2	SE	SW	32	2	27	5,000	5	3-6	do	do	do	do	0	2	5	18	87	10.4
	ma3	NW	SW	21	2	28	5,000	10	0-8	Good	Ogallala	da	do	2	5	9	39	89	5.21
	ma4	NW	SE	22	2	28	5,000	20	4	poor	do	do	do	0	2	5	36	96	2.4
	ma5	SW	SW	11	3	29	5,000	5-8	15-20	Good	Terrace deposits	SHCK	4-39	0	2	6	46	98	
	ma6	SW	NE	15	3	29	20,000	15	0-8	do	do	do	3-42	0	2	8	26	89	6.6
	ma7	NE	NW	14	3	30	1,000	7	0-5	Fair	Sanborn	SHCK USGS	12-47	0	1	6	38	90	6.7
	ma8	SW	SW	9	4	26	25,000	10+	10	Good	Alluvium	SHCK	3-42	0	1	5	38	97	2.4
	ma9	SW	SW	17	4	26	1,500	10+	10	Good	do	do	8-40	0	3	9	50	99	0.6
	ma10	NE	NE	19	4	26	3,000	10+	10	do	do	do	1-39	0	1	6	57	97	1.4
	ma11	NE	SE	16	4	29	20,000	15	0-15	Fair	Ogallala	SHCK USGS	11-47	0	2	6	33	93	3.0
	ma12	SE	NW	6	4	30	2,000	9	0-6	Poor	Terrace deposits	da	do	0	3	8	45	96	2.27
	ma13	SW	NE	10	4	30	10,000	5	0-10	Good	do	do	do	0	1	6	45	95	3.24
	ma14	SE	NE	30	4	30	10,000	20	5-10	do	do	do	do	0	3	8	36	96	3.0
	ma15	SE	SE	34	5	29	14,000	10-13	17	Fair	Ogallala	SHCK	3-42	0	4	9	40	92	4.6
	ma16	NW	NW	36	5	29	10,000	8	3-10	Good	do	SHCK USGS	11-47	0	1	5	30	94	3.1
	ma17	NE	NE	26	5	30	10,000	7	3-10	Fair	da	do	do	0	2	5	37	92	4.1
Mineral filler	mf1	NW	NE	3	3	27	2,000	30	1	Good	Sanborn	SHCK	8-41				0	2	86
	mf2	NE	SE	24	4	27	150,000	15	1±2	Good	Terrace deposits	SHCK USGS	8-47				0	4	93
	mf3	NE	NE	36	4	30	150,000	20+	1-2	do	Sanborn	do	1.1-47			0	3		91.6
Volcanic ash	va1	SE	NE	4	3	28	1,500	4-5	0-5	do	Ogallala	do	do				0	17	52.4
	va2	NE	NE	9	5	29	2,000	8	0-8	do	do	do	do						
Mtr. bed	mb1	NW	NW	31	1	29	10,000	15	0-6	Good	do	SHCK USGS	12-47						

Description of the material

Number on plate 1	Fraction[1]	Quartz	Feldspars	Acid rocks	Basic rocks	Mortar bed	Carbonate minerals	Chalk	Silicified chalk	Quartzite	Chert and/or chalcedony	Limonite nodules
fa1	C	40	20		10	30						
	F	80	10		5	5						
fa2	C	50	25		10	15						
	F	70	20					10				
fa3	(4)											
fa4	C	60	20		15	5					Tr	
	F	70	20		10	Tr[5]					Tr	
fa5	C	50	25		15	10						
	F	75	15		10							
fa6	C	50	20		Tr	30		Tr		Tr		Tr
	F	65	20		5	10		Tr		Tr		
fa7												
fa8	C	65	20		Tr	Tr	15	Tr		Tr		
	F	80	15		Tr		5					
fa9	C	75	20		5					Tr		
	F	80	20		Tr					Tr		
fa10	C	50	25		Tr	10		10		Tr		
	F	65	20		Tr	7		8		Tr		
fa11	C	55	25		Tr	10		5		Tr		
	F	55	25		Tr	10		5		5		
fa12	C	70	30		Tr					Tr		
	F	80	20		Tr					Tr		
fa13												
fa14	C	70	20	5						5		
	F	70	20							10		
fa15	C	70	20		10					Tr		
	F	80	15		5							
ma1	C	45	20		10	25						
	F	60	15		10	15						
ma2	C	52	20		8	20						
	F	65	20		5	10						
ma3	C	50	30		5			15				
	F	75	20		5			Tr				
ma4	C	50	25		5		15					
	F	65	15		5		10			Tr	5	
ma5	Clean granitic sand.											
ma6	Siliceous and calcareous.											
ma7	C	45	25		5	20						
	F	60	20		5	15						
ma8	Siliceous and calcareous.											
ma9	Siliceous sand gravel.											
ma10	Granitic with some mortar bed material.											
ma11	C	50	40		10							
	F	70	20		10							
ma12	C	55	35		5			5				
	F	60	35		5			Tr				
ma13	C	60	25		7	8						
	F	70	20		5	5						
ma14	C	50	25		10	15						
	F	50	30		10	10						
ma15	Siliceous and calcareous.											
ma16	C	60	30		5					5		
	F	70	20		10					Tr		
ma17	C	60	30		10						Tr	
	F	80	15		5						Tr	
mf1	Light-yellow silty clay.											
mf2	Chocolate-brown silt.											
mf3	Buff-colored silt and clay.											
va1												
va2	White volcanic ash.											
mb1	Lime-cemented cross-bedded somewhat conglomeratic sandy mortar bed.											

Laboratory test data

Number on plate 1	Weight per cubic foot (dry)	Specific gravity (saturated)	Gradation factor	Compressive strength ratio: 1 day	Compressive strength ratio: 3 days	Los Angeles Percent loss	Soundness (25 cycles)	Toughness	Cementation	Absorption	Liquid limit	Plasticity index	Color[6]	Remarks
fa1	102.6	2.58	1.97	0.77	0.82								cl	High percentage of wash; low compressive strength.
fa2	82.9	2.49	1.28	0.21	0.24								cl	Very low compressive strength.
fa3	106	2.53	2.68	1.08	1.02									
fa4	113.7	2.60	3.13	1.82	1.45								lt st	
fa5	105.3	2.61	3.00	1.10	1.07								cl	Some large clay balls.
fa6	107.3	2.60	2.23	1.09	1.16								cl	
fa7	102	2.54	2.74	1.05	1.03		0.89							In tongue of Sanborn formation projecting toward south across road.
fa8	103.7	2.56	2.79	1.21	1.32								cl	Overburden is Sanborn formation.
fa9	106.8	2.60	2.41	1.05	1.15								cl	Overburden is Sanborn formation; trace of magnetite.
fa10	101.9	2.56	2.02	1.01	1.12								lt st	Silty overburden, occasional large fragments of shale.
fa11	104.0	2.53	1.78	0.83	1.16									Fairly high percentage of wash; overburden is silt of the Sanborn formation.
fa12	106.9	2.58	3.18	1.41	1.40									Overburden is silt of the Sanborn formation.
fa13	109	2.59	2.12	0.91	0.96									
fa14	110.2	2.58	2.50	1.18	1.20								cl	Overburden is silt of the Sanborn formation; high percentages of wash and quartzite particles.
fa15	102.4	2.57	1.85	0.68	0.75								cl	Low compressive strength.
ma1	107.9	2.54	2.90	1.21	1.14								cl	
ma2	107.6	2.59	2.36	1.00	0.97								cl	High percentage of wash.
ma3	107.9	2.53	2.95	0.61	0.64								lt st	Low compressive strength; moderate percentage of soft chalk fragments in coarse fraction.
ma4	109.9	2.58	3.03	1.22	1.12								lt st	Some chert particles in fine fraction.
ma5			3.42	1.31	1.04									
ma6	114	2.58	2.66	1.10	1.18									
ma7	111.0	2.54	2.84	1.31	1.21								cl	
ma8	108	2.58	3.18	1.26	1.22	31.6								Some mud balls.
ma9	110	2.62	3.62											
ma10	108	2.59	3.59	1.45	1.19									Occasional mud balls.
ma11	113.5	2.62	2.86	1.22	1.25		0.98						cl	Overburden is silt of the Sanborn formation; trace of magnetite in fine fraction.
ma12	111.0	2.61	3.39	1.54	1.40								cl	Some soft chalk fragments in coarse fraction.
ma13	113.2	2.59	3.20	1.64	1.64								cl	
ma14	110.7	2.60	3.09	1.47	1.35								cl	
ma15	111.6	2.56	3.10	1.11	1.06	28.4								Overburden is silt of the Sanborn formation.
ma16	108.0	2.59	2.84	1.20	1.28								cl	Overburden is silt of the Sanborn formation.
ma17	109.1	2.59	2.99	1.10	1.28								cl	Overburden is silt of the Sanborn formation.
mf1									77					Cementation factor high.
mf2	82.7	2.60							80					Cementation factor high.
mf3	74.2	2.61							100+					Cementation factor very high.
va1	60.9	2.45							30					Overburden is silt of the Sanborn formation.
va2	45.4	2.37							1					
mb1							34.1 (10)							Overburden is silt of the Sanborn formation.

[1] Fraction: C, coarse fraction (retained on no. 4 sieve); F, fine fraction (passed no. 4 sieve).
[2] Sieve analysis and laboratory tests by State Highway Commission of Kansas; sample collection, determination of geologic formation or member, and material description by the U.S. Geological Survey.
[3] All data by State Highway Commission of Kansas except determination of geologic formation or member.
[4] Blank space indicates data not available.
[5] Tr trace.
[6] Color: cl, clear; lt. st, light straw.

aggregate, but it occurs in such small amounts as to be negligible.

Laboratory test data indicate that some of the sands and gravels of the Ogallala formation may be acceptable as aggregate for concrete. The average specific gravity of the samples tested is about 2.6; the gradation factors are usually satisfactory; the compressive strength ratios are generally within acceptable limits, but those of samples fa 2, 13, 15 and ma 3 are substandard; and the one sample (ma 11) tested for soundness indicates that sands and gravels of the Ogallala probably are sound. The percentage of wash is fairly high in most samples and is very high in fa 14. Engineers consulted in Decatur County seem to be of the opinion that all local sources, including the Ogallala formation, provide only inferior aggregate for use in Portland-cement concrete.

Additional sources of aggregate occur in the Ogallala formation essentially throughout the area of its outcrop. In many places, however, the sand and gravel lenses are under an overburden of relatively hard mortar bed, and their development would not be economical.

(2) Sanborn formation.--Two samples of fine aggregate (fa 4 and 7) and 3 of mixed aggregate (ma 1, 2, and 7) were collected from the Sanborn formation. Mineral analyses indicate that both coarse and fine fractions are composed predominantly of quartz particles, with minor amounts of feldspar, basic igneous rock, and mortar-bed fragments also present. The three mixed aggregates tested contained 20 percent or more of mortar-bed fragments. Such fragments in the gravels of the Sanborn are relatively hard and durable and are not considered to be deleterious.

The test characteristics of sands and gravels of the Sanborn formation indicate that some of them may be acceptable as aggregate for concrete. Their average specific gravity is between 2.5 and 2.6, the gradation factor is within specified limits or only slightly below the minimum, and the compressive strength ratios are satisfactory. In one sample tested, ma 2, the percentage of wash (10.4) probably is excessive.

Intensive exploration of the basal part of the Sanborn formation undoubtedly would result in the discovery of additional channel fills of sand and gravel. Exploration probably would be most productive in areas where tributary streams have cut deep into the formation. Because of the lenticular character of the channel fills it is likely that they will yield aggregate materials in limited quantities only.

(3) Terrace deposits.--The terrace deposits constitute another potential source of aggregate for concrete in Decatur County. Four samples of fine aggregate (fa 1, 6, 10, and 11) and five samples of mixed aggregate (ma 5, 6, and 12-14) were obtained from this formation. The sample locations are mapped on plate 1 and the mineral and test characteristics are given in table 1.

The constituent mineral grains are predominantly quartz and feldspar. Minor amounts of particles of basic igneous rock, mortar bed, and chalk are also present. Traces of quartzite particles occur in some of the samples analyzed but not in sufficient abundance to be considered deleterious. The percentage of wash, however, is rather high, as in samples fa 1, 10, and 11. Otherwise the test data indicate the terrace deposits may yield acceptable aggregates for concrete. The average specific gravity of the samples tested is about 2.6, and the compressive strength ratios for most samples are generally within required limits.

Intensive exploration of the basal part of the terrace deposits undoubtedly would yield additional sources of sand and gravel. The beds, however, are lenticular, and the quantities of material available necessarily would be rather limited.

(4) Alluvium.--The three samples of alluvium tested (ma 8-10) are classified as mixed aggregate. Mineral analyses were not made for these samples inasmuch as they had been collected prior to the 1947 field season. The materials descriptions indicate, however, that the most numerous particles are probably quartz and feldspar but with minor amounts of calcareous rock fragments, as perhaps mortar bed and chalk, also present. The test characteristics of alluvial samples are all within acceptable limits. Two samples, ma 8 and 10, contain minor amounts of mud balls.

The alluvial sands and gravels occur in lenticular channel deposits in the flood plains of the larger streams in the county. Additional sources may be located by exploring the alluvial deposits. The sand and gravel channel fills are relatively narrow but fairly long lenses in the silt that composes the bulk of the alluvium.

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 vary from one area to the next. The following materials have been used in Decatur County, or are available for use, as road metal:

(1) Aggregate for concrete.

(2) Crushed rock.--Indurated rocks are available in Decatur County for use as crushed stone in road construction or as railway ballast. The rocks are:

(a) Limestone, a compact massive layer of calcareous material, variable in its hardness.

(b) Silicified chalk, a compact massive layer of material originally calcareous but more or less completely replaced by silica. The known deposits of silicified chalk in Decatur County are not mapped on plate 1 because of the limited quantities of material available in them.

(c) Mortar bed, a massive compact rock of variable hardness composed of sand and/or gravel particles more or less firmly cemented by interstitial calcium carbonate.

These materials are mapped on plate 1 as limestone and mortar bed. The test characteristics for mortar bed are given in table 1. In addition to their uses as road metal or ballast, they may be used as structural stone and riprap.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

(1) Aggregate for concrete.--The materials discussed previously as aggregate for concrete have also been used in the construction of bituminous mat roads and as surfacing material on many light-traffic roads within the county. Local sources of information indicate that the bulk of the aggregates so used in Decatur County have been shipped in from Nebraska.

(2) Crushed rock.--

(a) Smoky Hill chalk member of the Niobrara formation. Beds of silicified chalk in the Smoky Hill chalk member are sources of crushed rock used in road construction in other north-central and northwestern Kansas counties. Field examination of this material exposed in Decatur County indicated that it is acceptable for this use. The limited quantity of material available, however, suggests that the local supply is inadequate. It is possible that intensive exploration of the deeper valleys in the eastern part of Decatur County might reveal additional sources of silicified chalk not found by the field party.

(b) Ogallala formation. Two types of material occur in the Ogallala formation that might be used as crushed rock for road construction. The dense, compact, hard nodular limestone in the upper part of the formation has been used for this purpose elsewhere in north-central Kansas but not in Decatur County. Field examination of such uses indicates that the material is acceptable. The amount of this material available locally appears to be rather limited, but additional sources of it may be discovered by intensive prospecting of the upper part of the Ogallala formation. Two quarries opened in beds of nodular limestone are mapped on plate 1, in the SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 25, T. 1 S., R. 27 W., and in the NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 29, T. 4 S., R. 26 W.

Mortar-bed ledges in the Ogallala formation have been quarried and the material crushed and applied to light-traffic roads in other counties in north-central Kansas. The calcium carbonate in the mortar bed serves as a binder for the particles of sand and gravel, and the crushed mortar-bed material is compacted by traffic into a type of macadam. The quantity of mortar-bed material in Decatur County is essentially unlimited. Numerous operated and prospect quarry sites are mapped on plate 1, but additional quarries could be opened at convenient places in nearly all parts of the county.

MINERAL FILLER

ENGINEERING AND GEOLOGIC CHARACTERISTICS

Material composed predominantly of silt-size mineral particles, 50 percent or more of which pass 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 and/or clay. The State Highway Commission of Kansas 10/ states that the material will qualify for mineral filler only if laboratory tests indicate a low coefficient of cementation. Deficiencies of the tested samples in this respect are noted under Remarks in table 1. Failure of the material to pulverize easily, a factor of cementation, increases the difficulty of obtaining its uniform distribution throughout the mix ture,

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

(1) Sanborn formation.--Two samples of mineral filler (mf 1 and 3) were obtained from the Sanborn formation, and the test data are included in table 1. The sample locations are mapped on plate 1. Sieve analyses indicate that the material is acceptable for this use, but the cementation factor for each one is probably excessive. In all probability, the samples were taken from the "B" zone of the soil profile, for the high cementation is undoubtedly a factor of impregnation of the material with calcium carbonate deposited through the action of percolating subsurface waters. Silt in the Sanborn taken from below the "B" zone very likely will have a cementation factor within acceptable limits. This stratigraphic unit is the principal source of mineral filler in Decatur County, and because of the widespread availability of the material it was not thought necessary to map any more than these two prospects. Pits can be opened in the formation wherever its use in engineering construction is desired. It is recommended that, prior to development of a site, the material be laboratory tested and its cementation factor determined.

(2) Terrace deposits.--One sample of silt from a terrace deposit (mf 2) was tested, and the data are included in table 1. The sample location is mapped on plate 1. The test characteristics of this sample are very similar to those of the mineral filler samples from the Sanborn. The cementation factor (80) again is high and may be excessive. Laboratory testing prior to development of any one materials site is recommended.

VOLCANIC ASH

ENGINEERING AND GEOLOGIC CHARACTERISTICS

Volcanic ash is sometimes classified as mineral filler, but in this report it is distinguished as a special type of mineral filler, because it is suitable for certain uses that the usual silty filler is not. Volcanic ash consists predominantly of the fine glass-like shards ejected during the explosive phase of a volcanic eruption. The material may include clay-size or silt-size particles of other origins and occasional thin seams of gravel and sand.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

Two samples of volcanic ash (va 1 and 2) were collected by the field party and tested in the Highway Materials Laboratory. The test data are included in table 1, and the sample locations are mapped on plate 1. Volcanic ash in Decatur County was found in commercial quantities in the Ogallala formation only.

[10] Horner, S. E., chief geologist, State Highway Commission of Kansas, letter dated January 4, 1947.

Thin lenses of impure ash occur in the basal part of the Sanborn formation, but the field party found none in commercial quantity. The test characteristics indicate that the volcanic ash of the Ogallala is satisfactory for use in engineering construction.

Other lenses of volcanic ash undoubtedly occur in the Ogallala formation and may be discovered by intensive field exploration of the mapped outcrop areas. It is entirely likely that commercial quantities of volcanic ash may be located in the basal part of the Sanborn formation, for in other Kansas counties this stratigraphic unit is an important source of volcanic ash.

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 abrasion, slaking, or freeze-and-thaw. It is desirable that the material be in blocks having approximately rectangular faces 7 inches or more in width and that the specific gravity be 2 or higher.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

(1) Smoky Hill chalk member of the Niobrara formation.--The silicified chalk beds of this stratigraphic unit, which have been described previously, appear acceptable as riprap for earthen structures. The outcrops were not sampled because they did not contain material in commercial quantity.

(2) Ogallala formation.--Two of the sedimentary materials included in the Ogallala formation might prove acceptable as riprap. The dense nodular limestone described as occurring in the upper part of the formation has been used elsewhere in Kansas as riprap. Field examination indicates that it is satisfactory for this use. No local deposits of the limestone known at present occur in adequate quantities, but additional deposits may be discovered through the intensive exploration of the outcrop areas of the Ogallala.

Certain of the mortar-bed ledges in the Ogallala formation are unusually firmly cemented and approach the average limestone in hardness. The test characteristics of one mortar-bed ledge (mb 1) are given in table 1, and the sample location is mapped on plate 1. The soundness factor of this one sample is relatively low, but, judged by field comparison with other ledges in Decatur County, more satisfactory mortar-bed materials are available locally. The calcareous nature of all mortar beds, however, indicates that this material is less acceptable as riprap for earthen dams than siliceous rocks such as silicified chalk and quartzite. Before any one mortar bed is accepted for this use it is recommended that it be laboratory tested for soundness, abrasion loss, and slaking coefficient. Field experience indicates, too, that any one mortar-bed ledge is variable in its test properties over relatively short distances.

STRUCTURAL STONE

ENGINEERING AND GEOLOGIC CHARACTERISTICS

Structural stone, as defined in this report, is any hard, dense rock material that can be quarried and cut to desired size and shape. Materials fulfilling these requirements occur in the Ogallala formation in Decatur County.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

Two materials from the Ogallala formation have been used as structural stone in Decatur County. The Community Building at Jennings was constructed of the dense nodular limestone that occurs in the upper part of the formation. It was built in 1939, and examination in 1947 indicates that it has not weathered appreciably nor has it reacted with the cement of the mortar. The stone was taken from a quarry in the NW¼ SW¼ sec. 29, T. 4 S., R. 26 W.

Mortar bed was used in 1938 in the construction of a grade school building at Traer. The stone has not changed color through weathering, and there is no indication of mortar reaction with the rock. On the north side of the building, however, some of the stones are weathering fairly rapidly, as indicated by excessive pitting of their external surfaces. This probably is due to the weathering of the calcareous cement. The stone was quarried in the NW¼ SE¼ sec. 4, T. 2 S., R. 30 W.

Field observation indicates that both the mortar bed and the dense nodular limestone are acceptable as structural stone. Laboratory testing of all such materials is recommended before the stone is developed from any one site. Rapid changes of quality in short distances must also be considered.

CALCAREOUS BINDER

ENGINEERING AND GEOLOGIC CHARACTERISTICS

To be classified as calcareous binder a material must be composed essentially of calcium carbonate and must be soft and easily pulverized.

STRATIGRAPHIC SOURCES AND PERFORMANCE CHARACTERISTICS

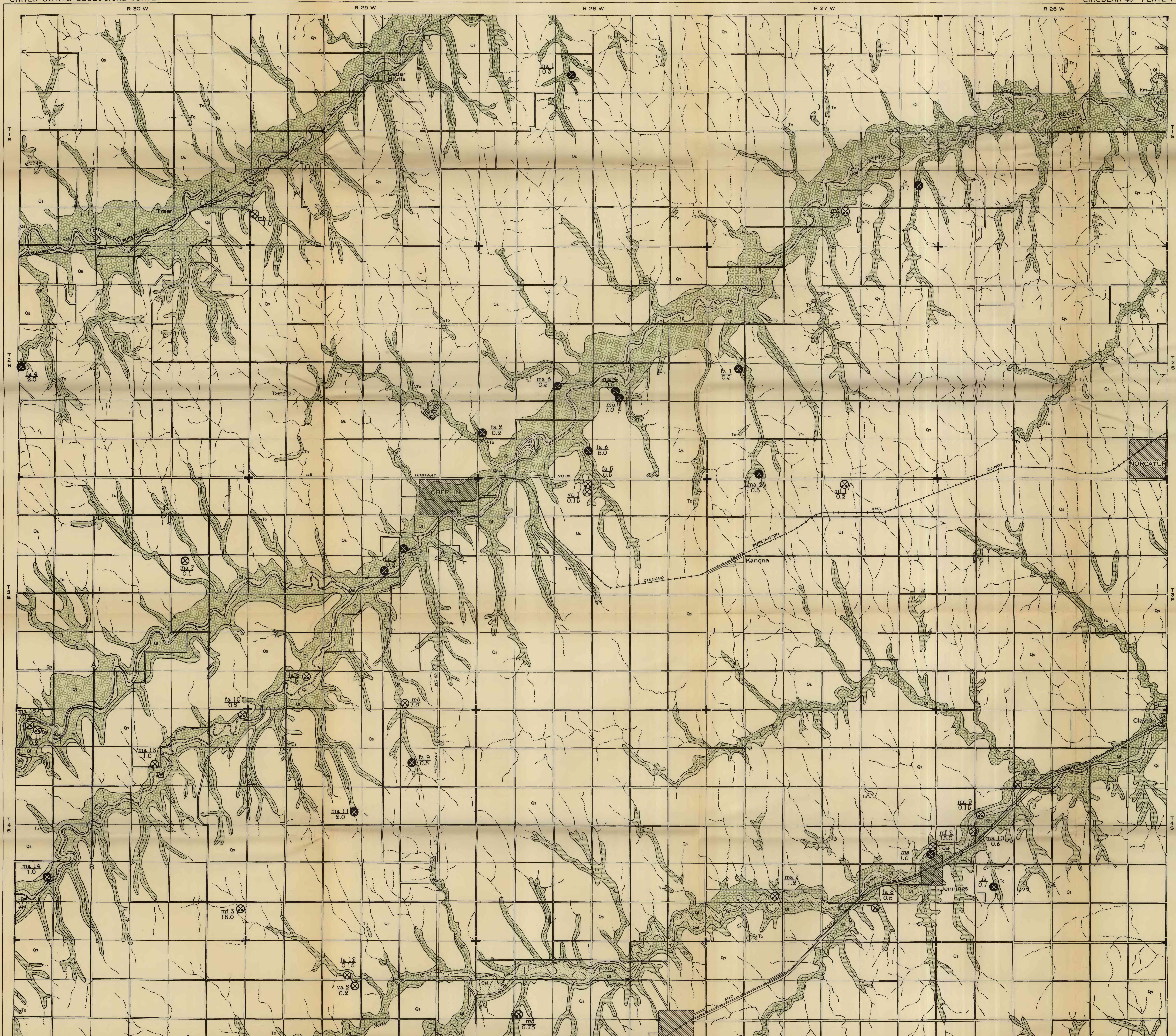
Mortar beds of the Ogallala formation in other Kansas counties have been accepted by the State Highway Commission as calcareous binder. Although no one of them in Decatur County was tested for this use, field observation indicates that many of them probably would prove acceptable. The mortar beds contain a very high percentage of calcium carbonate, and some of them are soft enough to be pulverized easily. This material can be obtained from practically all parts of the county where outcrops of the Ogallala formation are shown.

Interior—Duplicating Section, Washington, D. C.
79971

PLATE 1

MAP SHOWING CONSTRUCTION MATERIALS AND GEOLOGY OF DECATUR COUNTY, KANSAS

1950



EXPLANATION

QUATERNARY — *Pleistocene and Recent*

Qal — **Alluvium**
Tan to dark-brown silt; some clay and silty sand; occasional lenses of gravel. Source or potential source of aggregate, and road metal.

Qt — **Terrace deposits**
Tan or gray silt in upper part, often with a buried soil zone; occasional sand and gravel lenses in lower part. Source or potential source of mineral filler, aggregate, and road metal.

Qs — **Sanborn formation**
Tan or gray silt locally red-brown in basal part; one or more buried soil zones often present; numerous calcareous nodules or stringers in "B" zone; columnar structure usually well-developed; local lenses of sand and gravel in basal part. Source or potential source of mineral filler, aggregate, and road metal.

TERTIARY — *Pliocene*

To — **Ogallala formation**
Lenticular ledges of mortar bed interbedded with lenses of sand, gravel, and silt; hard nodular limestone locally present in upper part; some lenses of volcanic ash; basal part locally a brown, gray, green, or maroon clay. Source or potential source of aggregate, road metal, volcanic ash, structural stone, and riprap.

CRETACEOUS — *Upper Cretaceous*

Kp — **Pierre shale**
Thin-bedded dark-gray clay shale; limonite-stained along fractures.

Kns — **Smoky Hill chalk member of the Niobrara formation**
Beds of brown silicified chalk separated by thin chalky shales.

Geologic boundary

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 2 — 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)

Federal US Highways

Other roads, all classes

Railroad

City

Section line

Township corner

Stream, permanent

Stream, intermittent

Lake

A —— B — Line of cross section, figure 3 (along line between secs. 32 and 33, T. 3 S., R. 30 W., and secs. 20 and 21, T. 4 S., R. 30 W.)

APPROXIMATE MEAN DECLINATION, 1947

Base adapted from maps provided by the State Highway Commission of Kansas. Drainage adapted from maps compiled by the Soil Conservation Service, U. S. Department of Agriculture

Geology by Charles H. Bearman and Claude W. Matthews

MAP SHOWING CONSTRUCTION MATERIALS AND GEOLOGY OF DECATUR COUNTY, KANSAS

Scale: 1 0 1 2 3 4 Miles

1950

GPO D FSO—A. B. Hirschfeld Press, Denver, Colo.