STUDY OF THE "SAND" DEPOSIT BETWEEN MANHATTAN AND WAMEGO, KANSAS

by

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INTRODUCTION

Purpose of the Investigation

The deposits and landscape formed during the Pleistocene and Recent Epochs by the geologic processes operating during these epochs have received much attention in the literature. A great many of the investigations have covered the areas adjacent and to the north of the Kansas River. Much of this work was concerned with the terrace levels, ground water availability, and the geomorphic history of the Kansas River.

The purpose of this work is to describe, in as much detail as possible, one glacio-fluvial deposit. Emphasis is placed on the petrological relationships encountered as a possible aid in determining the source area and geomorphic agent or agents responsible for this deposit. Attention is focused secondarily on the geomorphology and the vertical and areal extent of the deposit.

Geography

The "sand" deposit is about 45 square miles of the southwest corner of Pottawatomie County (Plate I). It extends north from the flood plain of the Kansas River near St. George to Rock Creek and west from the flood plain near Wamego to the flood plain of the Blue River. It is bounded on the northwest by the higher ridges that are underlain by Paleozoic rock.

The major farm crops include corn, wheat, milo, and

soybeans. Most of the upland area is used chiefly for grazing of livestock.

A transcontinental highway, U.S. 24, crosses the area in an east-west direction. State Highway 99 trends north through Wamego. Most sections are accessible by county and township roads that generally parallel the section lines.

The maximum relief of this deposit is 265 feet with the high elevation of 1245 feet at a point one and one-half miles northeast of St. George and the low of 980 feet just south of Wamego. The area is drained by several small creeks that are tributaries of the Kansas River, the Blue River, and Camp and Rock Creeks. The southern half is drained by southwest trending Sand, Plum, Blackjack, and Blood Creeks which are tributaries of the Kansas River. The northern part is drained by Elm Slough Creek and other minor tributaries which drain into Camp and Rock Creeks. These two creeks join and flow into the Vermilion Creek which flows into the Kansas River two and one-half miles east of Wamego.

Previous Investigations

The subdivisions of the Quaternary period and of the Pleistocene Epoch adopted by the U. S. Geological Survey and used in this paper are as follows:

Period	Epoch	Stage	Substage
Quaternary	Recent		
	Pleistocene	Wisconsinan glacial	Mankato Carey Tazewell Iowan
		Sangamonian interglacial Illinoian glacial Yarmouthian interglacial Kansan glacial Aftonian interglacial Nebraskan glacial	

Most authorities generally agree that the only glacial ice to reach this area was that which moved down during the Kansan stage and the only other ice which extended into Kansas was of the Nebraskan stage.

The first recognition of glaciation in Kansas was by Hay (1892), who recognized the existance of true morainic deposits. He recognized the southern limit of the ice advance in Kansas as coinciding with the bluffs on the south side of the Kansas River valley in Wabaunsee County.

Studies of Iowa Point surface exposure (Frye and Leonard, 1949) and samples of subsurface drilling (Frye and Walters, 1950) have shown that the earliest deposits of Pleistocene age in northeastern Kansas are those associated with Nebraskan glaciation.

Smyth (1898) pointed out the existance of several glacial lakes caused by the damming of the Kansas River. The largest of these lakes was Kaw Lake which filled the valley north and west of St. George and extended as far west as Salina.

Todd (1918a) illustrated by the occurrence of chert gravels on ridges that the buried valley west and north of St. George has been occupied by the Pliocene and early Pleistocene Kansas River.

G. R. Scott, et al. (1959), believe this valley was part of a former drainage network of the Kansas River during pre-Kansan time and that the main river valley was about one mile northwest of St. George. This main pre-Kansan Kansas River valley trends northeast to Louisville and continues east and joins the present Kansas River valley, east of Wamego. They conclude that the deposit considered in this study is due to the existance of the pre-Kansan channel of the Kansas River which was filled with outwash by meltwater from the Kansas glacier. Mudge (1955, p. 273) noted another such valley which trends northwest through the Kansas State University campus and then eastward. This was reported by Todd (1918a, p. 197) and described by Beck (1961).

Schoewe (1930) established the line of maximum advance of the Kansan glacier a few miles south of the Kansas River, but the ice front was probably stabilized for the longest period just north of the Kansas River allowing glacial outwash and till to fill many existing stream valleys south of the ice front.

Harned (1940), after studying the mineralogy and grain size analyses of glacial sediments, indicated that physical appearances and field observations alone are insufficient criteria for establishing the origin of parent material of soils.

Later, Lill (1946) reported the clay mineral, illite, in glacial sediments in Marshall and Washington Counties which are located to the north and west of the area of this report.

PROCEDURES

Several methods of presenting mechanical and mineral analysis data have been devised. Many of these have been presented by Krumbein and Pettijohn (1938) and Folk (1961).

Tyrell (1958, p. 189) stated that:

> The principal factors which determine the size of grain in sedimentary rocks are the dominant modes of weathering (decomposition or disintregration), the texture and composition of the pre-existing rocks, and the kind and amount of transport.

Krumbein and Pettijohn (1938, p. 17) said:

> Channel samples tend to mask details, because they furnish no data on the range of sizes in individual beds; they yield composite data made up of several sets of individual data, and furnish no information whatever on the degree of sorting, or mineralogical composition of individual beds.

Folk (1961, p. 4) concluded that:

> Sorting depends on at least three major factors: (1) size range of the material supplied to the environment, (2) the type of deposition -- "bean spreading" versus "city dump", (3) the current characteristics -- time-rate of supply of detritus compared with efficiency of the sorting agent.
>
> Grain size strongly influences sorting. The trend is that the best sorted sediments are usually those with mean sizes of 2 to 3Ø (fine sand). As one measures coarser sediments, sorting worsens until those sediments with a mean size of 0 to 3Ø show the poorest sorting values. From here, sorting improves again into the gravel ranges (-3 to -5Ø). From fine sand into finer sediments, the sorting worsens so that sediments with a mean size of 6 to 8Ø (fine silts have the poorest sorting values, then sorting improves gradually into the pure clay range (10Ø).

Mean size is a function of (1) the size range of available materials, and (2) amount of energy imparted to the sediment which depends on current velocity or turbulence of the transporting medium.

Field Procedures

The field work consisted of collecting samples and making field descriptions of outcrops from which samples were taken. Any irregularities in outcrops were noted and photographed to illustrate to the best advantage exposures of the deposit. Surface features were photographed to illustrate the different geomorphic features.

Thirty five locations, spaced about one per section, were selected for sampling and investigation. This spacing was decided upon after consideration of the type and areal extent of the deposit, and after a reconnaissance of the area had been made. Specific locations were selected on the basis of availability of the kind of material and presence of an undisturbed section exposed in a nearly vertical face.

Thirty two spot samples were taken from the locations. These samples were collected in the manner described by Krumbein and Pettijohn (1938, p. 13) with some modifications. The grid method was modified by the availability of the material studied and a suitable exposure. Care was exercised in sampling in order to keep unrepresentative sampling at a minimum. All samples were collected below the A and B horizons of soil profile in order to keep contamination by organic materials to a minimum.

All samples were collected and numbered. This number was entered into a field book along with the location which was marked and noted on the topographic map. The vertical depth at which the sample was taken below the ground surface was also noted in the field book along with the description of the outcrop and of the surficial features near the location.

Laboratory Procedures

Laboratory research placed primary importance on the mechanical analysis of the samples and secondary importance on the mineralogical analysis.

The mechanical analyses data were obtained by using the Bouyoucos hydrometer method (Bouyoucos, 1930) and the Tyler graded sizing screens.

The samples were first air dried. Each of the samples was thoroughly mixed and split in the Jones sample splitter. Approximately 200 grams of each sample were used for the mechanical and mineral analyses and the remainder of the sample was stored.

The portion of the sample which was used for mechanical analysis was oven dried at 105°C for 24 hours. One hundred grams (50 grams in finer grained samples) were carefully weighed and placed in a 600 milliliter beaker with enough distilled water to cover the sample and then allowed to stand overnight to permit soaking and slacking. Five milliliters of one normal solution of "Calgon" were added as a dispersive agent.

The mixture was then transferred to the sample dispersion cup. Enough distilled water was added to bring the total volume within one inch of the top of the cup. The dispersion cup containing the sample was placed on the mixer and stirred for five minutes. The sample was then transferred into a 1000 milliliter sedimentation cylinder and the total volume increased to 1000 milliliters. The mechanical analyses data were then obtained by using the Bouyoucos hydrometer method of analysis.

The sample was then wet sieved through a 270 mesh sieve. The portion retained on the 270 mesh sieve was dried and sized through a series of Tyler graded screens to obtain the frequency distribution of the particles too large to pass through the 270 mesh sieve. The series of eight inch diameter Tyler screens were arranged in order to have a grade interval of 0.5Ø. Each sample was shaken for fifteen minutes on a Ro-Tap machine. After completion of the shaking, the size fraction retained on each screen was weighed on an analytical balance to the nearest centigram and the values recorded. This set of values was later combined with the values obtained by the Bouyoucos hydrometer method of analysis and curves were plotted from the combined sets of values.

Visual inspection of each sample was accomplished with the aid of a binocular microscope to ascertain the relationship of the rock and mineral grains as to degree of rounding and frosting. Relative size of different mineral grains was also noted.

EXPLANATION OF PLATE I

Index Map of Sample Locations

Sample No.	Location	Elevation[1]	Page[2]
A	SW NW NW 7-10S-9E	1050	25
1	NE SE NE 11-10S-8E	1035	24
2	NW SW NW 6-10S-9E	1075	25
3	SE NE NE 1-10S-8E	1100	25
4	SW NE SE 31-9S-9E	1175	28
5	SE SW SW 28-9S-9E	1135	34
6	SW NW NE 27-9S-9E	1120	37
7	NW NW SE 34-9S-9E	1115	34
8	SW SW SE 35-9S-9E	1150	37
10	SW SE SW 26-9S-9E	1095	37
11	NW NW SW 33-9S-10E	1150	43
12A	SW NW NE 5-10S-10E	1160	40
13	NW SW SE 31-9S-10E	1100	40
14	SE SE SE 25-9S-9E	1100	40
15	SE SE SE 23-9S-9E	1165	37
16	NE SE SW 3-10S-9E	1150	31
17	NE NE SE 3-10S-8E	1080	25
18	SE NW SW 5-10S-9E	1145	28
19	SW SW NE 8-10S-9E	1040	28
20	NE SE SW 8-10S-10E	1000	43
21	NW NW SE 11-10S-9E	1115	31
22	NE SW SW 10-10S-9E	1110	31
23	NE Corner NW 9-10S-9E	1115	31
24	SE SE NE 3-10S-9E	1230	40
25	SW SW NW 6-10S-10E	1170	40
26	SW NW NE 28-9S-10E	1010	43
27	SW NW NE 30-9S-10E	1045	43
28	SE NW SE 33-9S-9E	1115	34
29	SE NE NW 21-9S-9E	1050	37
30	SE NE NW 34-9S-9E	1140	34
31	NE SE SE 33-9S-10E	1000	48
32	SW SE SE 5-10S-10E	1020	43

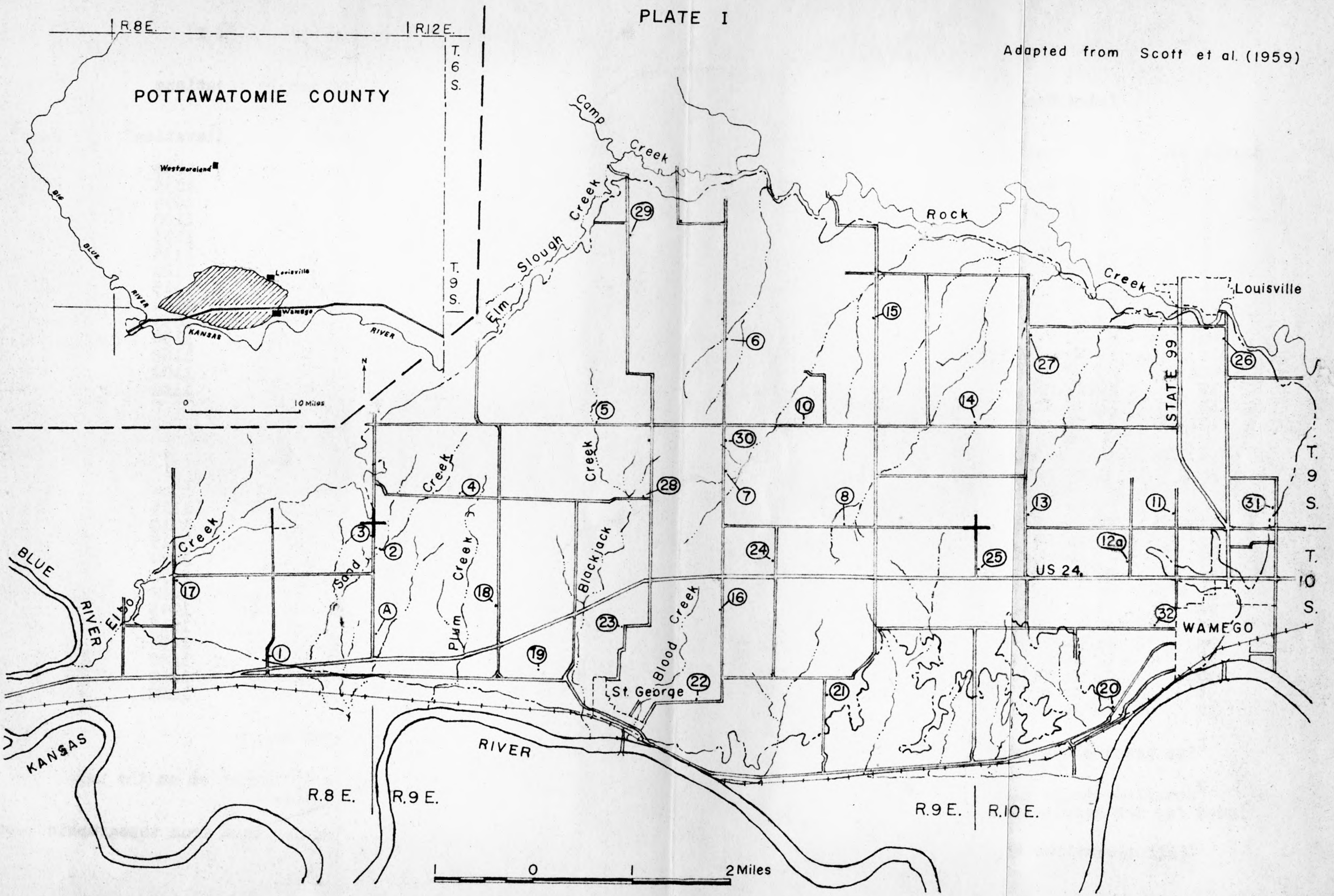
[1]Sea level elevation of sample.

[2]Detailed sample description given on the page listed for the sample location.

(All elevations were obtained from topographic maps.)

PLATE I

Adapted from Scott et al. (1959)



RESULTS OF INVESTIGATION

Field Observations

Most streams in the area are intermittent and the ones that drain south are shorter and have as much as 60 feet per mile higher gradient than the north draining streams. (Plate I.) The deepest stream cuts are in the southern portion of the deposit. Soil in the eastern and northern parts is more resistant to erosion than that in the southern and western parts, possibly, because the percent of clay present (Plate XV) is higher in the east and north.

Pre-Kansan gravel deposits occur high on ridges northwest of Wamego (Beck, 1959, p. 29). Figure 1 shows a deposit of pre-Kansan gravel at SE¼ SE¼ NE¼ sec. 3, T.10 S., R.9 E. Similar deposits were noted at the SW¼ SW¼ NW¼ sec. 6, T.10 S., R.10 W. and SE¼ SE¼ NE¼ sec. 6, T.10 S., R.10 E. The deposit immediately overlying the gravel was referred to as outwash by Scott, et al. (1959, p. 132). Erratic boulders of granite, quartzite, and greenstone overlie pre-Kansan gravel which in turn, overlies Pennsylvanian limestone in a road cut in the SE¼ SE¼ NE¼ sec. 6, T.10 S., R.10 E. One-half mile east of here, a stone stripe consisting of granite, quartzite, greenstone, chert, quartz, and sandstone boulders is exposed in a road cut (Fig. 2).

Boulder fields are common in the northern part of the area near the SE¼ sec. 22 and the NW¼ sec. 21, T.9 S., R.9 E., and NW corner sec. 22, T.9 S., R.9 E. (Fig. 3).

Figure 9 shows a buried soil profile in a stream cut at

NW corner NE¼ sec. 28, T.9 S., R.9 E. Several buried profiles were noted in that general area. Buried soil profiles also occur at SW¼ SW¼ SE¼ sec. 35, T.9 S., R.9 E., and in Elbo Creek bank at the NW corner NE¼ sec. 10, T.10 S., R.8 E.

A buried soil occurs three feet below the surface in the west road bank at SE¼ NW¼ NE¼ sec. 33, T.9 S., R.9 E. (Fig. 4). A one inch seam of resistant, limonitic, sandy silt, similar to that of Fig. 10, occurs at a depth of approximately four feet immediately to the south of the buried soil and extends northward and down to a depth of two feet below the buried soil.

Figure 8 illustrates what appeared to be sudden changes in deposition. Two dark gray bands appear to contain less clay than the rest of the outcrop. The color of this outcrop is considerably different than other outcrops studied. The gray changes laterally to the characteristic reddish brown in just a few feet. This could possibly be a result of different drainage and degree of oxidation and reduction that had taken place in a very localized environment.

Reddish-brown Kansan sandy silt overlies a ridge of fine-grained, gray, silty mud at the NW corner sec. 22, T.9 S., R.9 E. The same general stratigraphic relationship of the two types of sediment at this location and at SW¼ NW¼ NE¼ sec. 5, T.10 S., R.10 E. were noted. A stone stripe is not present at NW corner sec. 22, T.9 S., R.9 E. but a boulder field is present near this location. It is probable that the stone stripe and boulders of the field serve the same stratigraphic relationship at each location.

EXPLANATION OF PLATE II

Fig. 1. Pre-Kansas gravel deposit in gravel pit overlain by Kansan "outwash" in SE¼ SE¼ NE¼ sec. 3, T.10 S., R.9 E.

Fig. 2. Stone stripe consisting of erratic boulders in a road cut in SW¼ NW¼ NE¼ sec. 5, T.10 S,, R.10 E.

PLATE II

Fig. 1

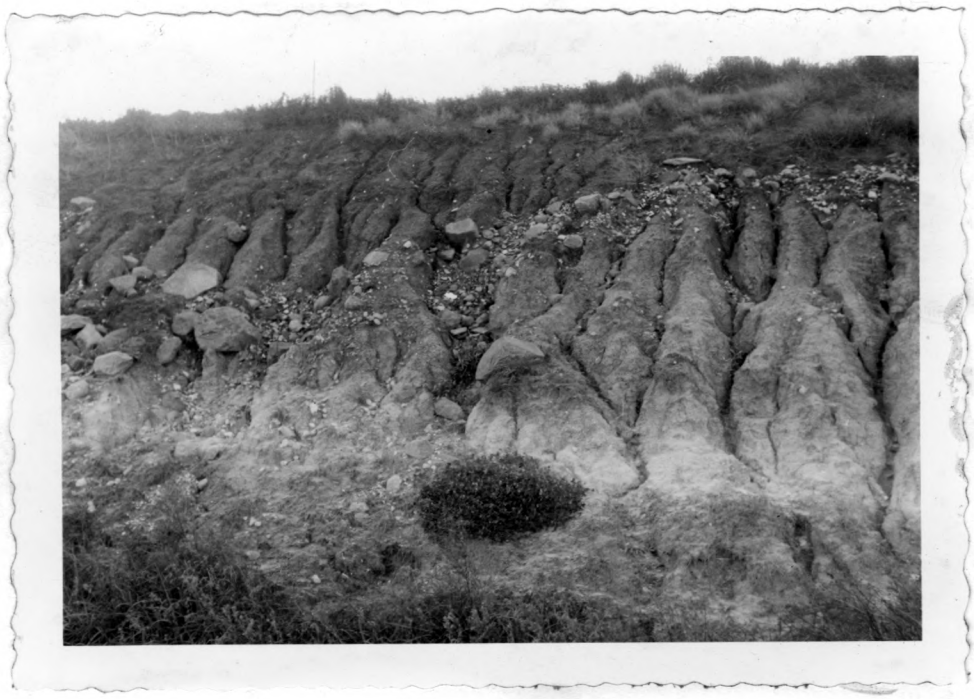


Fig. 2

EXPLANATION OF PLATE III

Fig. 3. A boulder field, looking north from a point about one quarter mile east of NW corner sec. 22, T.9 S., R.9 E.

Fig. 4. A buried soil in road cut in SE¼ NW¼ NE¼ sec. 33, T.9 S., R.9 E.

PLATE III

Fig. 3

Fig. 4

The complexity of the geologic history of the area is best illustrated by a 50 foot section exposed in Blackjack Creek bank 2700 feet north of U.S. 24 in the NW¼ SE¼ NW¼ sec. 4, T.10 S., R.9 E. (Plate IV and Fig. 7). Four distinct depositional changes are evident. D in Fig. 7 shows a ledge of very tight clayey sand overlain by approximately 6 feet of horizontally bedded sand (C in Fig. 6) overlain by approximately 12 feet of deltaic-like, crossbedded sand (B in Fig. 6), in turn, overlain by a non-bedded, silty sand (A in Fig. 5). The non-bedded, silty sand was the one of special interest in this investigation; therefore, no mechanical analysis or special work other than a general description was devoted to the Blackjack Creek section.

Methods of Presentation

Terms and methods used in the presentation of most of the laboratory results were explained by Folk (1961, pp. 32-47). The phi (Ø) scale (Krumbein, 1934) was used in this investigation because of the convenience offered in its use. A brief explanation of the terms and formulas used is given below. Classification was based on the triangular classification of Plate XV (Folk, 1954, p. 349).

Mode = The most frequently occurring particle diameter. It is diameter size at the steepest point on the cumulative curve and the highest point or points on the frequency curve.

M = Median size or the diameter corresponding to the 50 percent mark on the cumulative curve.

EXPLANATION OF PLATE IV

Fig. 5. Non-bedded, silty sand A, crossbedded sand B, horizontally bedded sand C, and ledge of clayey sand D in stream cut on Blackjack Creek in NW¼ SE¼ NW¼ sec. 4, T.10 S., R.9 E.

Fig. 6. Blackjack Creek section showing contacts and bedding variations of non-bedded, silty sand A, crossbedded sand B, horizontally bedded sand C, and tight, clayey sand D.

PLATE IV

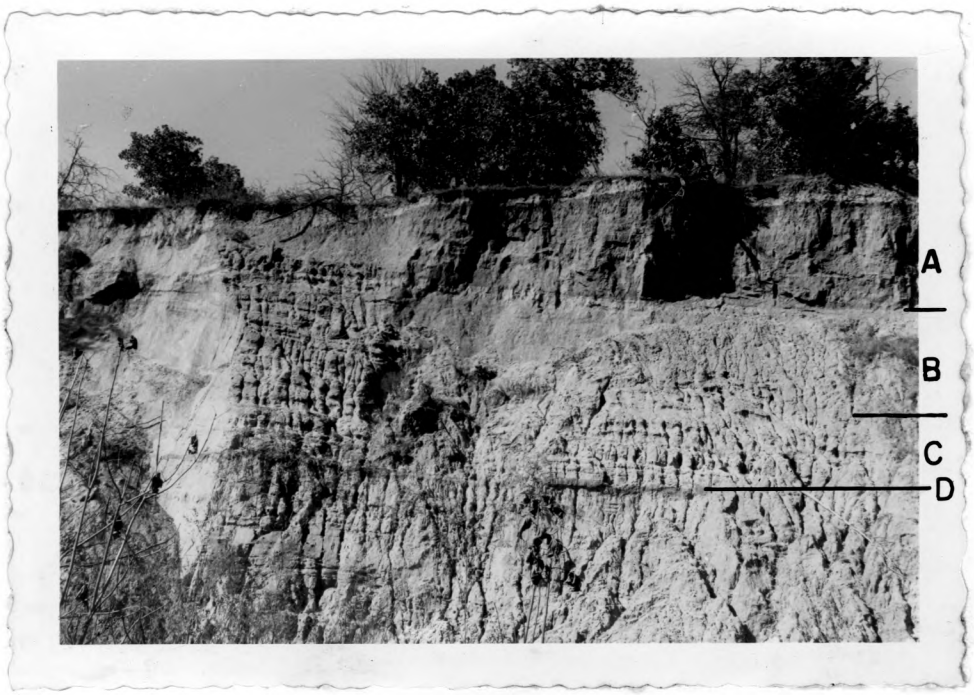


Fig. 5

Fig. 6

EXPLANATION OF PLATE V

Fig. 7. Contact of the lower clayey bed and the horizontally bedded sand of the Blackjack Creek section.

Fig. 8. Dark gray lenses of sand in a gray, muddy sand in road cut in the NE¼ SE¼ SW¼ sec. 3, T.10 S., R.9 E.

PLATE V

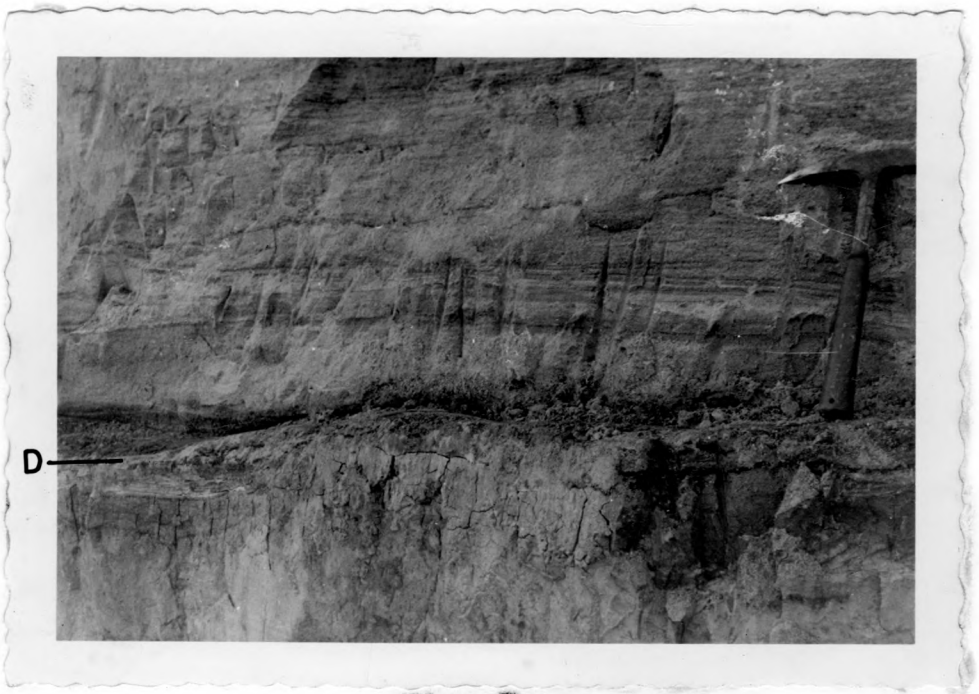


Fig. 7

Fig. 8

EXPLANATION OF PLATE VI

Fig. 9. Buried soil profile in stream cut at NW corner NE¼ sec. 28, T.9 S., R.9 E.

Fig. 10. Leached bands of limonite in SW¼ NW¼ NW¼ sec. 7, T.10 S., R.9 E.

PLATE VI

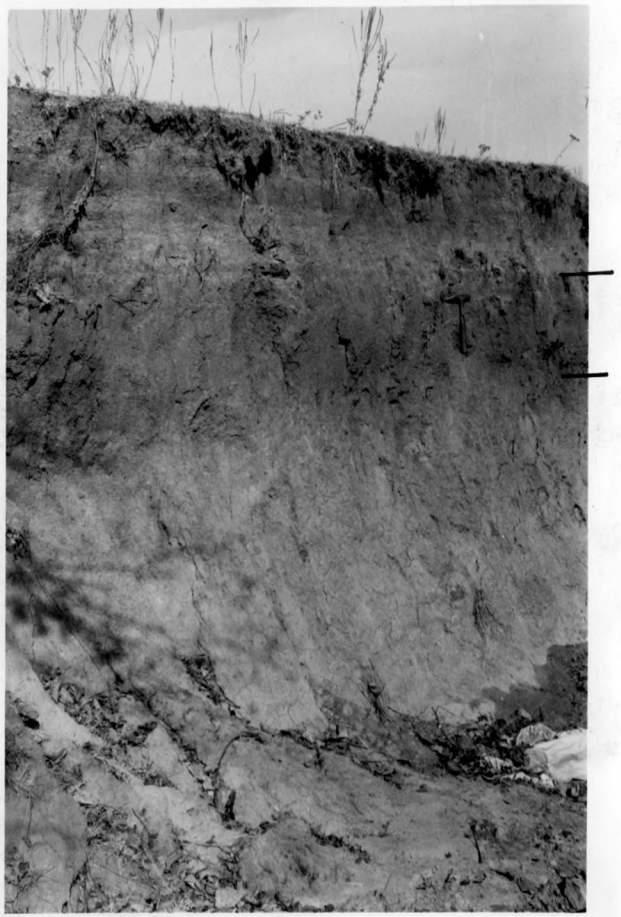


Fig. 9

Fig. 10

M_z = Graphic mean is the best graphic measure for determining overall size of sample (Folk, 1961, p. 44) $\left(\frac{\phi16+\phi50+\phi84}{3}\right)$

σ_I = Inclusive graphic standard deviation is the best measure of sorting because it includes 90 percent of the distribution (Folk, 1961, p. 45). $\left(\frac{\phi84-\phi16}{4}\right) + \left(\frac{\phi95-\phi5}{6.6}\right)$

The verbal classification scale for sorting (Folk, 1961, p. 45).

σ_I under	± .35Ø	Very well sorted
± .35 -	± .50Ø	Well sorted
± .50 -	± .71Ø	Moderately well sorted
± .71 -	± 1.0 Ø	Moderately sorted
±1.0 -	± 2.0 Ø	Poorly sorted
±2.0 -	± 4.0 Ø	Very poorly sorted
over	± 4.0 Ø	Extremely poorly sorted

Data obtained from the mechanical analysis were calculated on a percentage basis of the total sample. This data is presented in Table 1 and the cumulative and frequency curves which were plotted on arithmetic graph paper using the phi (Ø) grain size scale devised by Krumbein (1934). A grain size distribution map (Plate XV) was prepared using the percent of sand and the percent of silt to mud obtained from the mechanical analysis data and presented in Table 2.

Sample Descriptions

Sample 1 (Plate VII) was a spot sample collected 10 feet below the ground surface. Despite the apparent absence of a cement, the outcrop is fairly resistant and shows blocky fractures in the C zone. Combined thickness of the A and B zones was 20 inches. Lenses of different grain size of silt and sand were within the parent material. Laboratory analysis

showed the frequency and cumulative curves of the sample to be polymodal with modes of 3.0, 4.0, and 6.8Ø, graphic mean (M_z) 4.38Ø, and an inclusive graphic standard deviation (σ_I) value of $\pm$2.28Ø. This sample is a very poorly sorted sandy silt.

Sample 2 (Plate VII) was a spot sample taken six feet below the surface in a stream cut. The outcrop surface has a tan, mottled appearance with blocky fractures. No significant vertical variation in grain size is evident. Analysis of this sample indicated a bimodal curve having modes of 4.0 and 5.7Ø, M_z - 7.48Ø, and a σ_I value of $\pm$3.35Ø. The sample is a very poorly sorted silty mud.

Sample 3 (Plate VII) was taken 200 feet north of and at an elevation of 20 feet higher than sample 2. Sample 3 was a spot sample collected seven feet below the ground surface from an outcrop that had a mottled tan, non-compact appearance. The plot of the analysis of this sample was represented by a bimodal curve with modes of 3.0 and 5.7Ø, M_z of 5.25Ø, and is a very poorly sorted silty mud with a σ_I value of $\pm$3.48Ø.

Sample 17 (Plate VII) was collected nine feet below the ground surface in a road cut about one-half mile north of Elbo Cemetery. Curves plotted from the mechanical analysis data were polymodal with modes of 2.0, 4.0, and 5.7Ø, showed a M_z of 4.0Ø and σ_I value of $\pm$3.01Ø. The sample is a very poorly sorted, muddy sand.

Sample A (Plate VIII) was taken seven feet below the surface in a road cut. The road cut at SW¼ NW¼ NW¼ sec. 7, T.10 S., R.9 E., contains a one inch thick band of limonite that is more

EXPLANATION OF PLATE VII

Fig. 11. Frequency curves of samples 1, 2, 3, and 17.

Fig. 12. Cumulative curves of samples 1, 2, 3, and 17.

PLATE VII

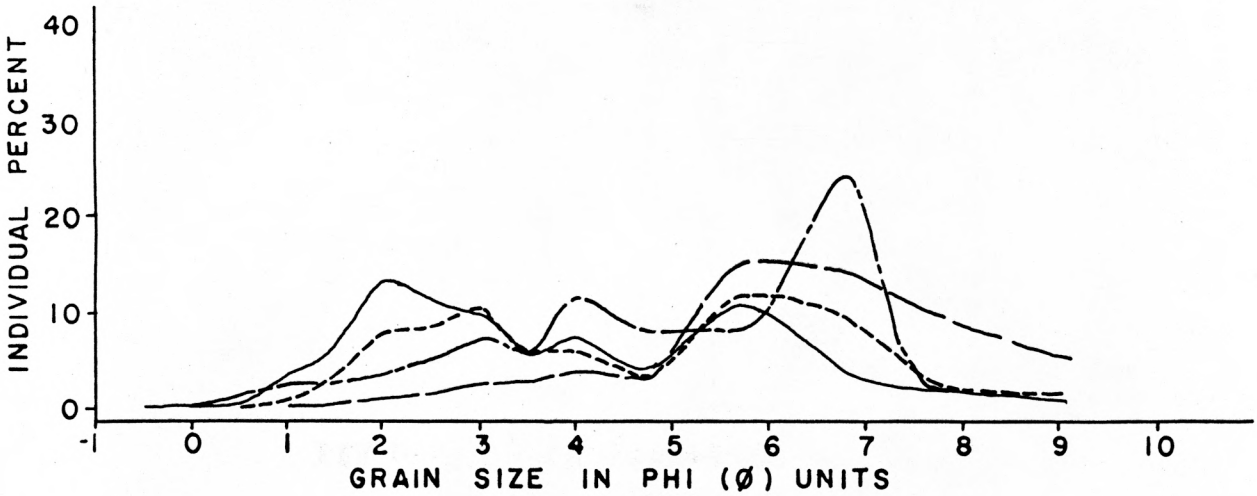


Fig. 11

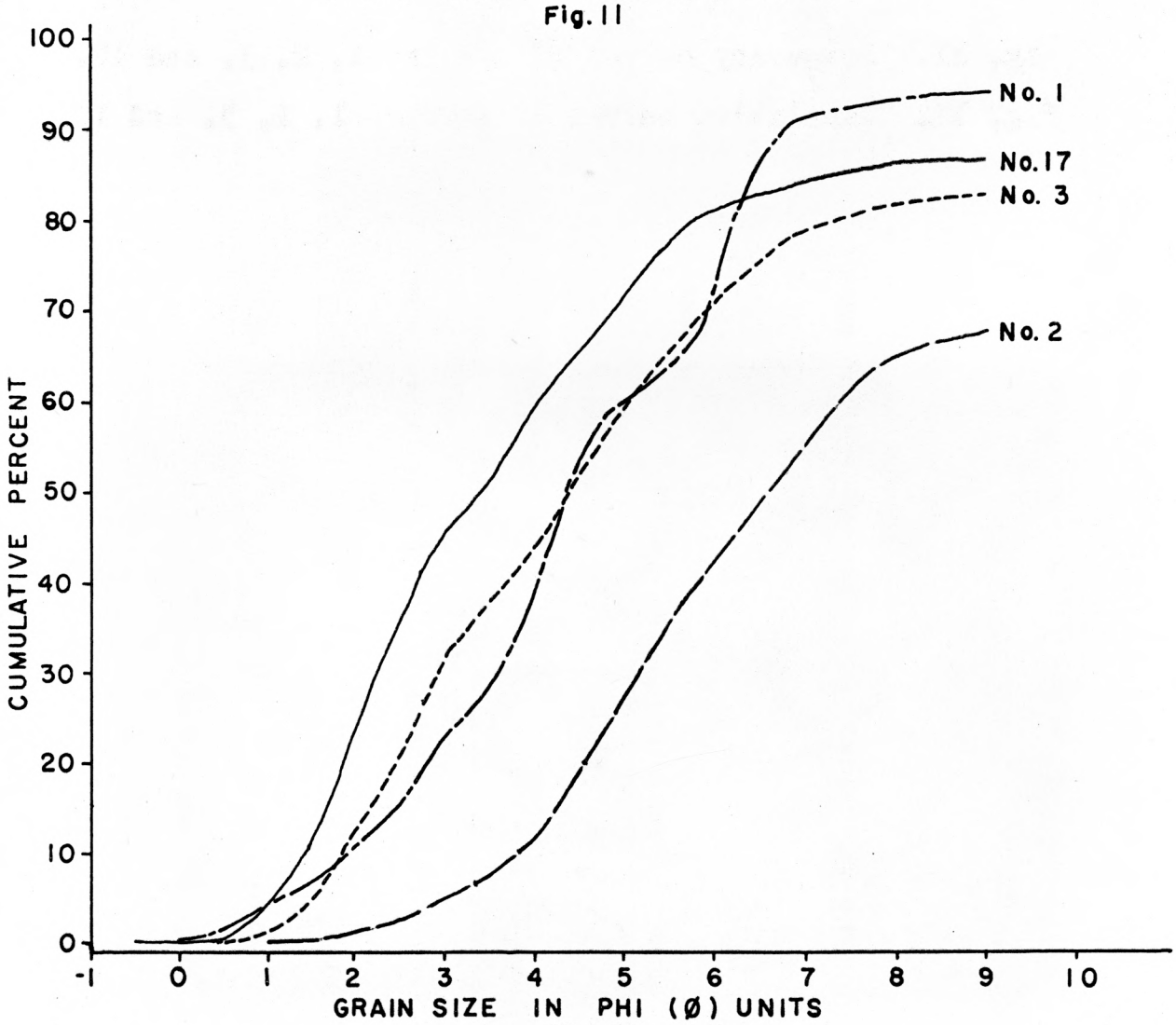


Fig. 12

resistant than the rest of the outcrop five feet below the ground level (Fig. 10). Below this band, there are several thinner limonite stained bands. A sand deposit having the same appearance and located in the NW¼ NE¼ sec. 25, T.9 S., R.9 E. was described by Scott, et al. (1959, p. 133) as follows:

> Limonite has been leached from the upper light-gray part of a soil profile characterized by distinct horizons and concentrated in a one-half inch layer that is itself being leached and reconcentrated in a lower reddish-brown, sandy outwash.

Curves plotted from the mechanical analysis data are polymodal with modes of 3.0, 4.0, and 5.7Ø, M_z of 4.08Ø. Sample A is a very poorly sorted, silty sand with a σ_I value of ±2.25Ø.

Sample 4 was collected four feet below the ground surface in a road cut of apparent homogeneous sand. It was analyzed and classified. The curve produced is bimodal (Plate VIII) with modes of 4.0 and 5.7Ø, M_z of 3.05Ø, and a σ_I value of ±3.Ø. The sample is a very poorly sorted, muddy sand.

Sample 18 (Plate VIII) was a spot sample taken four feet below the ground surface in a road cut. The curve of the analysis is bimodal with a mode of 2.0Ø in the sand size fraction, a mode of 5.8Ø in the silt size fraction, and a M_z of 3.67Ø. The sample is a very poorly sorted, silty sand with a σ_I value of ±2.91Ø.

Sample 19 (Plate VIII) was a spot sample taken about four feet below the surface, in a stream cut at an elevation of 1030 feet, about 1600 feet north of the Kansas River flood plain. The curve of sample 19 is bimodal in character with modes of 3.0 and 5.7Ø, M_z of 2.96Ø, and σ_I value of ±2.22Ø. The sample

EXPLANATION OF PLATE VIII

Fig. 13. Frequency curves of samples A, 4, 18, and 19.

Fig. 14. Cumulative curves of samples A, 4, 18, and 19.

PLATE VIII

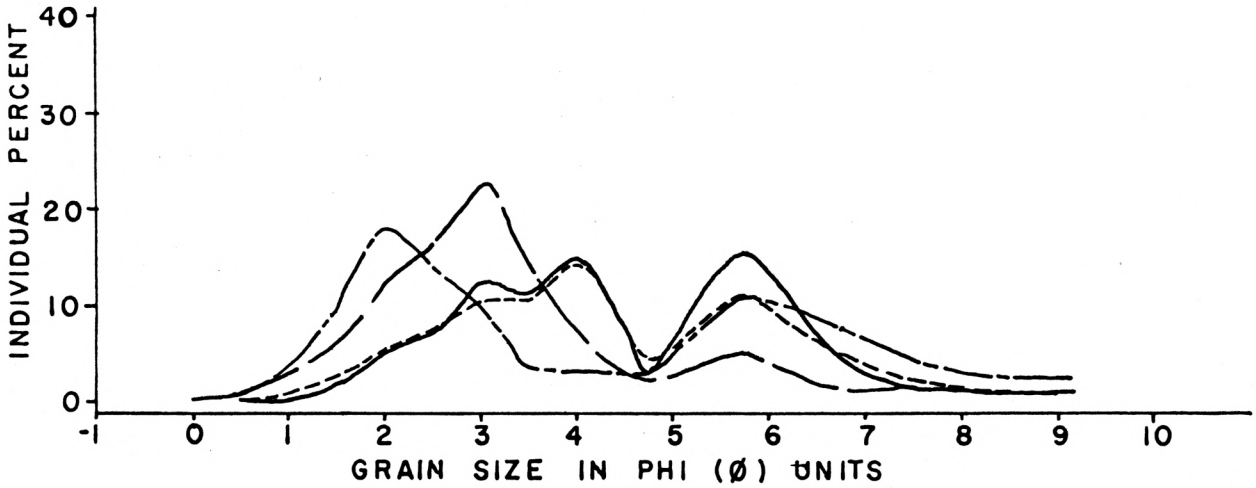


Fig. 13

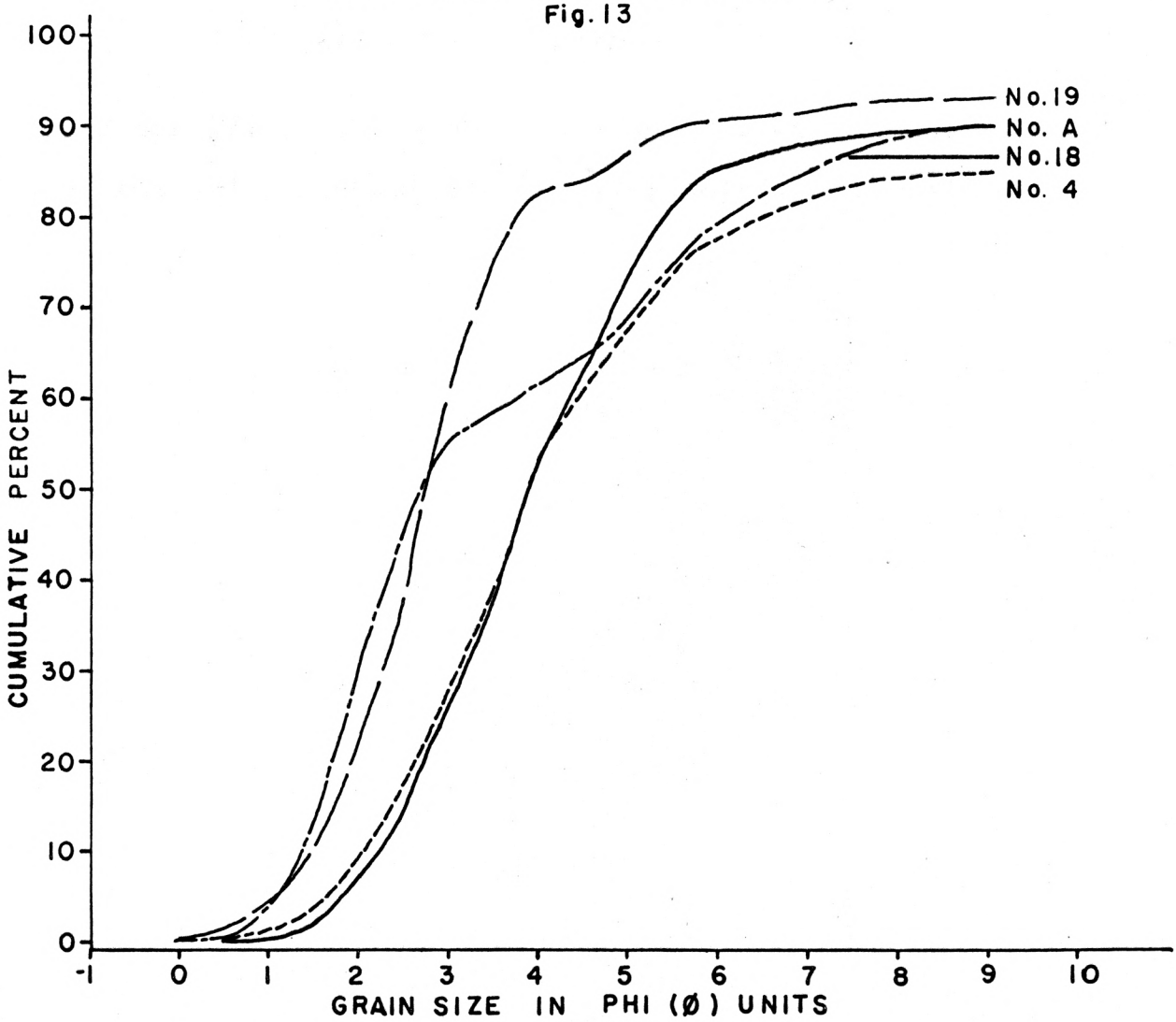


Fig. 14

is classified as a very poorly sorted, muddy sand.

Sample 16 was taken six feet below the surface of a stream cut. The curves of the sample were bimodal (Plate IX) with a mode of 3.0Ø in the sand size fraction and a mode of 5.7Ø in the silt size fraction, shows a M_z of 3.05Ø, and a σ_I value of ±2.02Ø. This sample is a very poorly sorted, muddy sand.

Sample 21 was collected four feet below the surface of a stream cut along the east fork of Sand Creek two miles east of St. George. The sand exposed appeared to contain very little cement, but formed a very resistant outcrop. Analysis of sample produced a bimodal curve (Plate IX) with a mode of 2.0Ø in the sand size fraction and a mode of 5.7Ø in the silt size fraction, a M_z of 2.3Ø, and an σ_I value of ±1.38Ø. Sample 21 is a poorly sorted, muddy sand.

Sample 22 (Plate IX) was a spot sample taken 10 feet below the ground surface in a stream cut. In the NE¼ SW¼ SW¼ sec. 10, T.10 S., R.9 E., cross-bedded seams of limonite-stained sand and lenses of sand grains of different sizes and colors are present. Mechanical analysis of sample 22 produced curves with a single mode of 2.0Ø, a M_z of 2.0Ø, and an σ_I value of ±1.38Ø. The sample is a poorly sorted sand.

Sample 23 (Plate IX) was a spot sample taken six feet below the ground surface in a stream cut one mile north of St. George. The curves of the mechanical analysis data from the sample are polymodal and show modes in the sand size fraction of 3.0 and 4.0Ø, a mode of 5.7Ø in the silt size fraction, a M_z of 4.06Ø, and an σ_I value of ±3.06Ø. The sample is a very

EXPLANATION OF PLATE IX

Fig. 15. Frequency curves of samples 16, 21, 22, and 23.

Fig. 16. Cumulative curves of samples 16, 21, 22, and 23.

PLATE IX

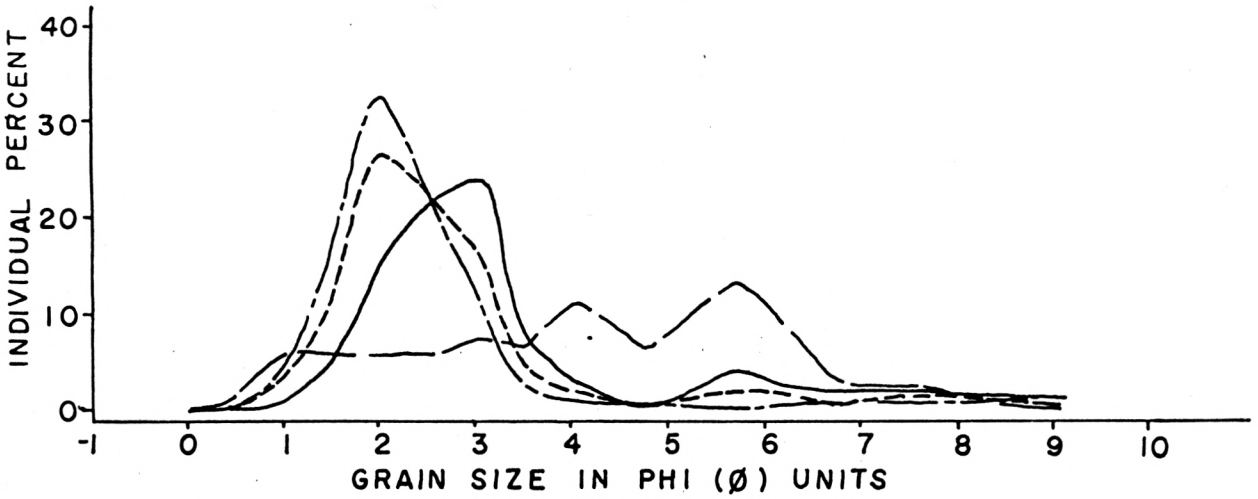


Fig. 15

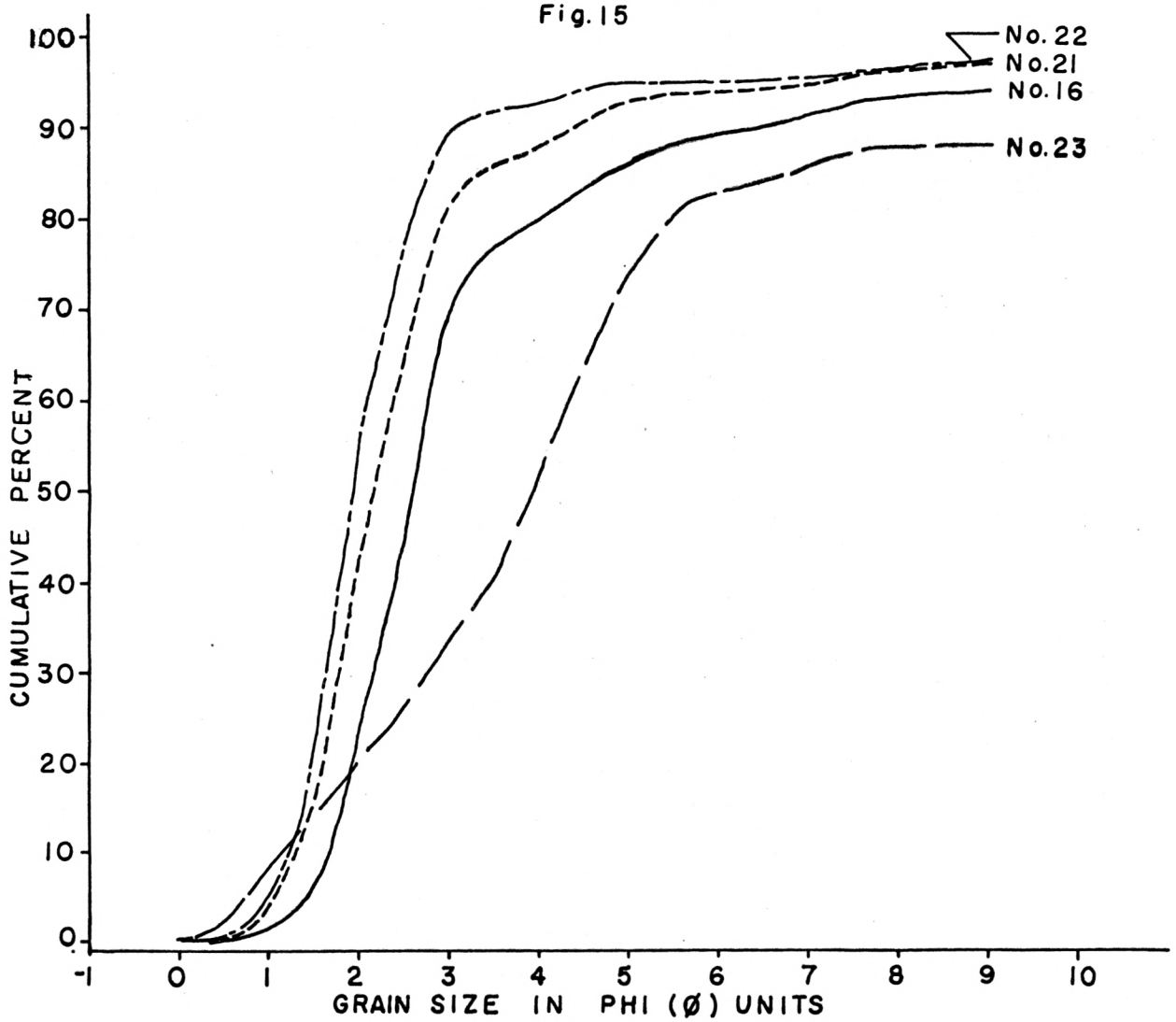


Fig. 16

poorly sorted, silty sand.

Sample 5 was taken five feet below the ground surface. The color of the sand is much lighter brown at SE¼ SW¼ SW¼ sec. 28, T.9 S., R.9 E., and the limonite stain is much less conspicuous than at the other locations examined. The sandy soil near this location is less resistant to erosion than the soils in the vicinity of most of the other samples collected and consequently forms fewer resistant outcrops. The cumulative and frequency curves (Plate X) of sample 5 are bimodal with a mode of 3.0Ø in the sand size fraction and a mode of 4.75Ø in the silt size fraction. The M_z is 3.67Ø and the σ_I value is $\pm$2.22Ø. The sample is a very poorly sorted, muddy sand.

Sample 7 was collected four feet below the ground surface in a road cut. Curves (Plate X) plotted from the analysis data are polymodal with modes of 2.0, 3.0, 4.0, and 5.7Ø. The M_z is 3.92Ø and the σ_I value is $\pm$2.93Ø. The sample is a very poorly sorted, silty sand.

Sample 28 (Plate X) was collected six feet below the ground surface in the SE¼ NW¼ SE¼ sec. 33, T.9 S., R.9 E. Curves plotted from the mechanical analysis data show a mode at 5.7Ø and a σ_I value $\pm$2.28Ø. Sample 28 is a very poorly sorted, sandy silt.

Sample 30 was taken four feet below the ground surface from a zone of light-brown sand in the SE¼ NE¼ NW¼ sec. 34, T.9 S., R.9 E. The curves (Plate X) of sample 30 are bimodal with a mode of 2.0Ø in the sand size fraction and a mode of 5.7Ø in the silt size fraction. The M_z is 2.76Ø and the σ_I value is

EXPLANATION OF PLATE X

Fig. 17. Frequency curves of samples 5, 7, 28, and 30.

Fig. 18. Cumulative curves of samples 5, 7, 28, and 30.

PLATE X

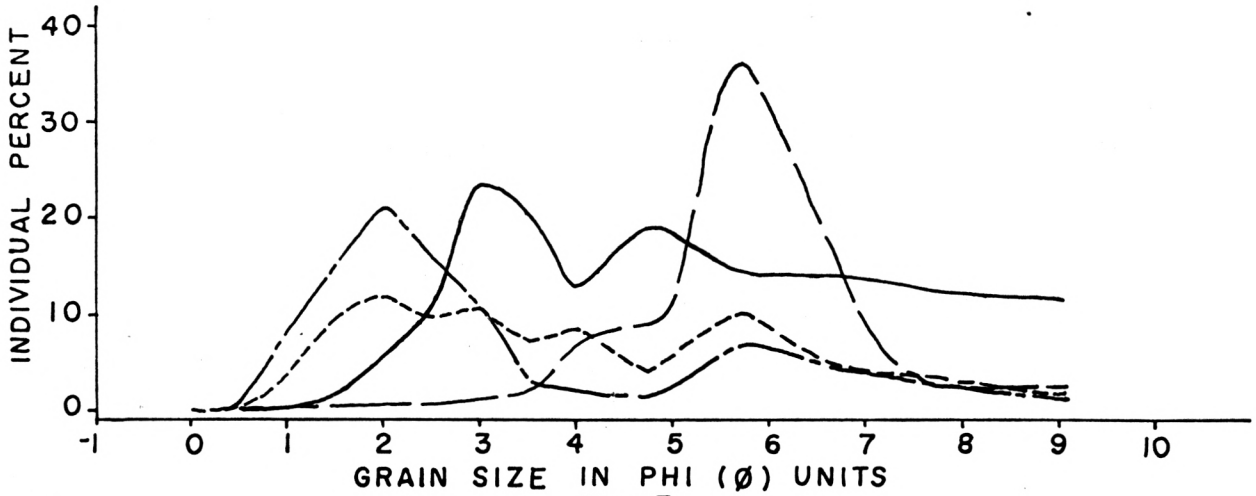


Fig.17

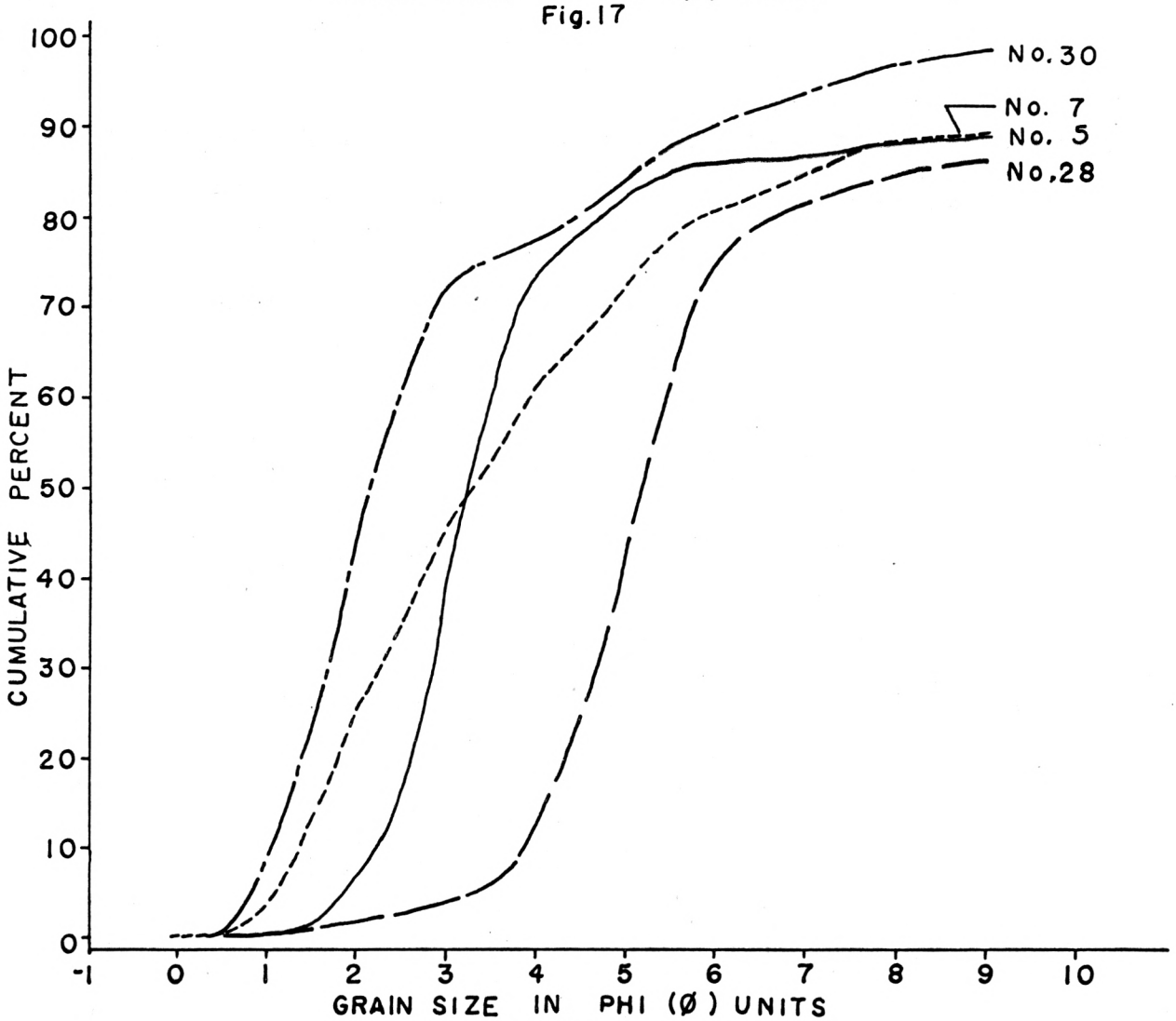


Fig.18

$\pm$2.06Ø. The sample is a very poorly sorted sand.

Sample 6 was taken eight feet below the ground surface from a road cut in an area overlain by glacial erratics. Curves plotted (Plate XI), using the mechanical analysis data obtained of sample, indicate a single mode in the silt size fraction of 5.7Ø, a M_z of 6.38Ø, and a σ_I value of $\pm$2.56Ø. Sample 6 is a very poorly sorted silt.

Sample 10 (Plate XI) was a spot sample taken four feet below the ground surface and also below a zone containing pebbles of chert, quartz, quartzite, greenstone, and limonite concretions. Curves plotted show the sample to be bimodal with modes of 3.0 and 4.0Ø in the sand size fraction and modes of 5.7 and 7.65Ø in the silt size fraction, a M_z of 3.98Ø, and a σ_I value of $\pm$2.77Ø. Sample is of a very poorly sorted, muddy sand.

Sample 15 (Plate XI) was collected five feet below the ground surface. Curves plotted from the mechanical analysis data of sample show a single mode of 2.0Ø in the sand size range, a M_z of 2.03Ø, and an σ_I value of $\pm$1.50Ø. Sample 15 is poorly sorted, muddy sand.

Sample 29 (Plate XI) was collected four feet below the ground surface SE¼ NE¼ NW¼ sec. 21, T.9 S., R.9 E. Material of sample is overlain by quartzite and chert erratics segregated one foot below the surface. Curves plotted of the sample illustrate a single mode of 5.7Ø, a M_z of 5.93Ø, and a σ_I value of $\pm$2.37Ø. The sample is a very poorly sorted silt.

Sample 8 (Plate XII) was taken as a spot sample from a

EXPLANATION OF PLATE XI

Fig. 19. Frequency curves of samples 6, 10, 15, and 29.

Fig. 20. Cumulative curves of samples 6, 10, 15, and 29.

PLATE XI

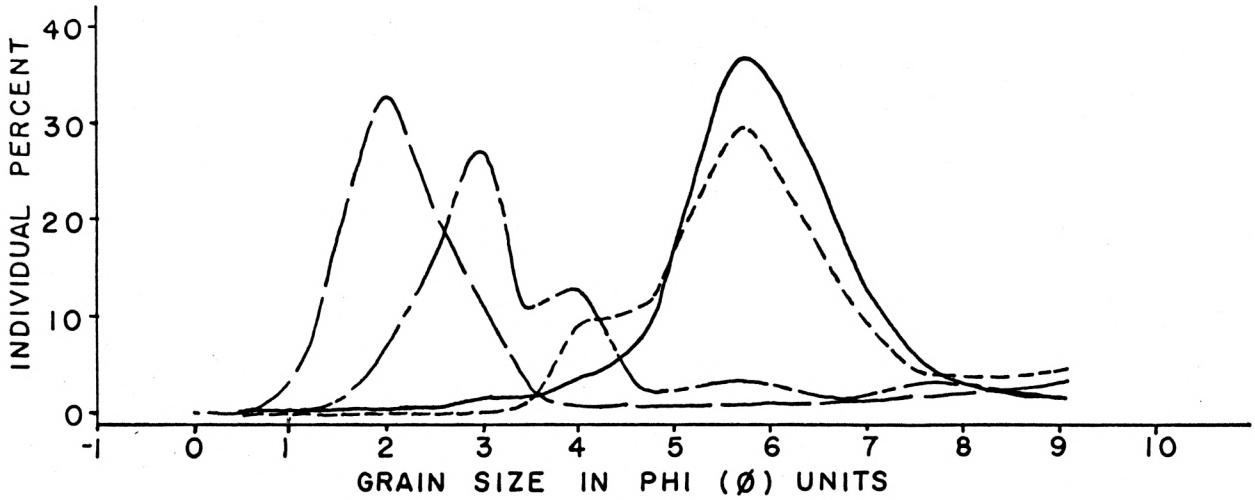


Fig. 19

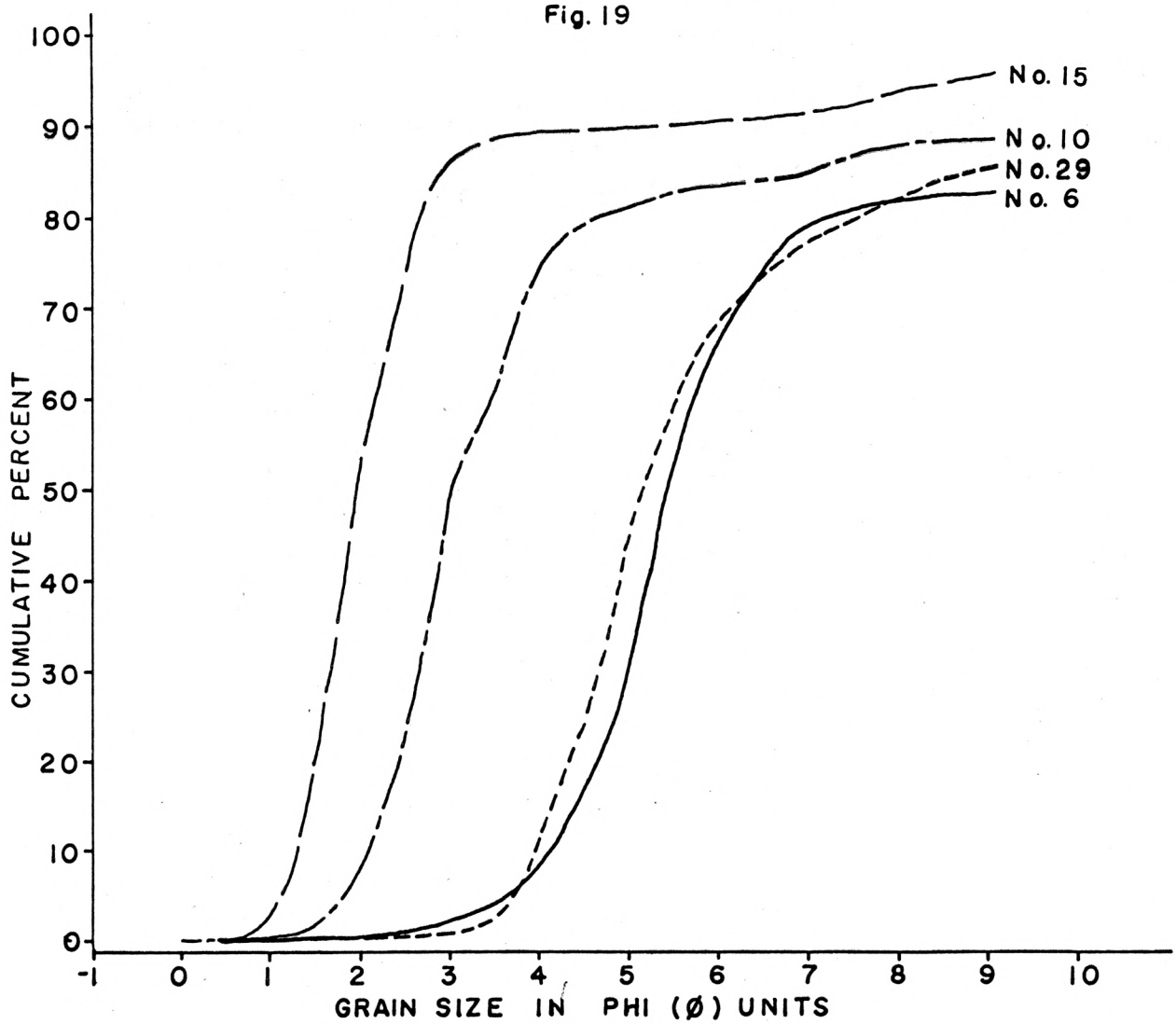


Fig. 20

highly oxidized reddish-brown silt four feet below the ground surface. Curves of the analysis show a single mode of 5.7Ø in the silt size fraction, a M_z of 6.58Ø, and a σ_I value of ±2.87Ø. The sample is classed as a very poorly sorted silt.

Sample 14 (Plate XII) was collected from a zone containing reddish-tan mottling four feet below the ground surface. Curves plotted from data obtained are bimodal with a mode of 3.0Ø in the sand fraction and a mode of 5.7Ø in the silt fraction, a M_z of 5.59Ø, and σ_I of ±3.53Ø. The sample 14 is a very poorly sorted, silty mud.

Sample 24 (Plate XII) was taken two and one-half feet below the ground surface and one foot above the pre-Kansan gravel deposit (Fig. 1). Curves plotted from data obtained by mechanical analysis of sample are bimodal with a mode of 3.0Ø and one of 5.7Ø, show a M_z of 5.88Ø, and a σ_I of ±3.91Ø. Sample is a very poorly sorted, silty mud.

Sample 25 (Plate XII) was taken just above the deposit of pre-Kansan gravel. Plots of the analysis of the sample show bimodal curves having modes of 2.0Ø in the sand size fraction and 5.7Ø in the silt size fraction, a M_z of 5.0Ø and a σ_I of ±3.75Ø. Sample is a very poorly sorted, muddy sand.

Sample 12A (Plate XIII) was taken at SW¼ NW¼ NE¼ sec. 5, T.10 S., R.10 E., just above the stone stripe (Fig. 2). Bimodal curves with modes of 4.0 and 5.7Ø, a M_z of 6.82Ø, and σ_I of ±3.64Ø are plotted. Sample is a very poorly sorted, silty mud.

Sample 13 (Plate XIII) was collected eight feet below the ground surface. Curves plotted from the analysis data are

EXPLANATION OF PLATE XII

Fig. 21. Frequency curves of samples 8, 14, 24, and 25.

Fig. 22. Cumulative curves of samples 8, 14, 24, and 25.

PLATE XII

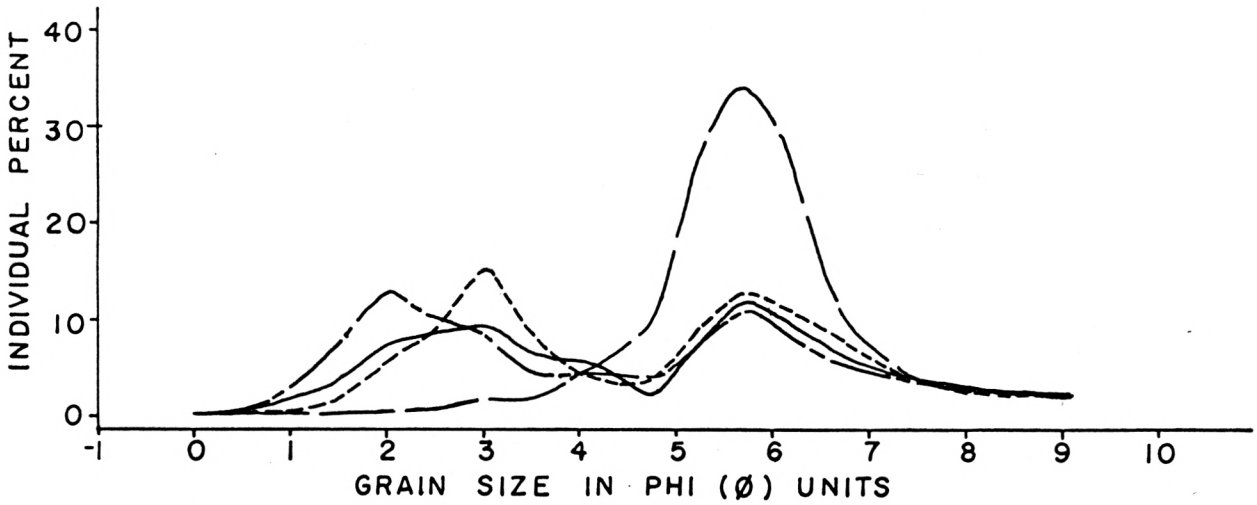


Fig. 21

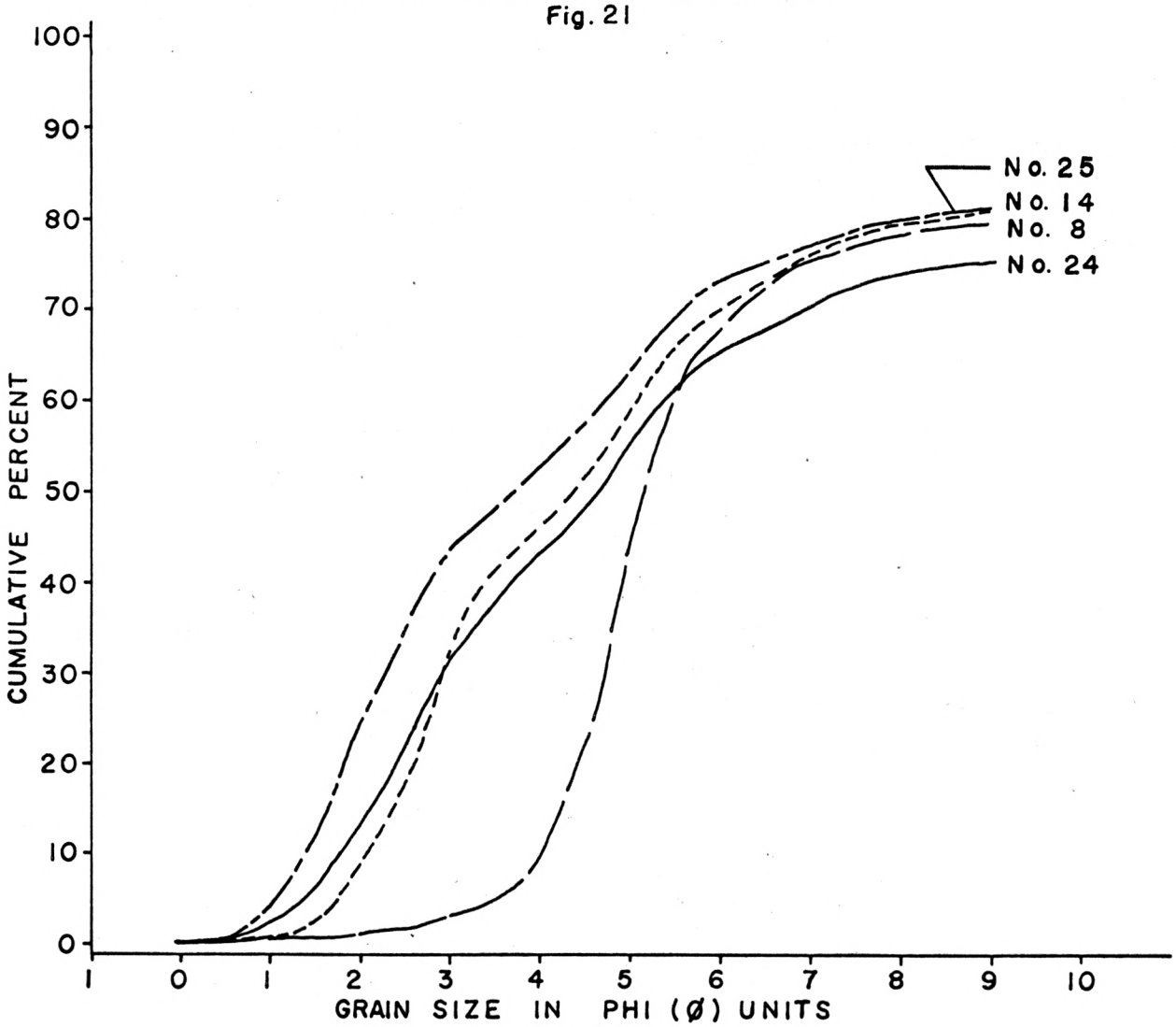


Fig. 22

bimodal with a mode of 2.0Ø in the sand size fraction and a mode of 7.65Ø in the silt size fraction, have a M_z of 2.32Ø, and a σ_I of ±1.96Ø. The sample is a poorly sorted, muddy sand.

Sample 20 (Plate XIII) was taken three feet below ground surface at NE¼ SE¼ SW¼ sec. 8, T.10 S., R.10 E. Curves of the mechanical analysis data are polymodal with modes of 2.0, 4.0, and 5.7Ø, have a M_z value of 6.09Ø, and an σ_I of ±3.34Ø. Sample is a very poorly sorted, silty mud.

Sample 32 (Plate XIII) was taken just west of the city limits of Wamego. Curves of the mechanical analysis data indicate two modes of 4.0 and 5.7Ø, a M_z of 6.75Ø, and a σ_I of 3.19Ø. Sample is a very poorly sorted, silty mud.

Sample 11 (Plate XIV) was taken three feet below ground surface about one mile northwest of Wamego. The soil was eroded much less in that vicinity (NW¼ NW¼ SW¼ sec. 33, T.9 S., R.10 E.) than in the southern and western parts of the area. Curves of the data obtained of sample 11 indicate a polymodal size distribution with modes of 2.0, 4.0, and 5.7Ø, a M_z of 6.45Ø, and σ_I value of 3.60Ø. The sample is a very poorly sorted, silty mud.

Sample 26 (Plate XIV) was collected from a road cut at a depth of five feet below the ground surface, approximately 2000 feet south of Louisville. Analysis provided data used to plot polymodal curves with modes of 2.0, 3.0, and 5.7Ø, M_z of 6.42Ø, and a σ_I value of ±3.82Ø. Sample 26 is a very poorly sorted, silty mud.

Sample 27 (Plate XIV) was a spot sample taken from the

EXPLANATION OF PLATE XIII

Fig. 23. Frequency curves of samples 12A, 13, 20, and 32.

Fig. 24. Cumulative curves of samples 12A, 13, 20, and 32.

PLATE XIII

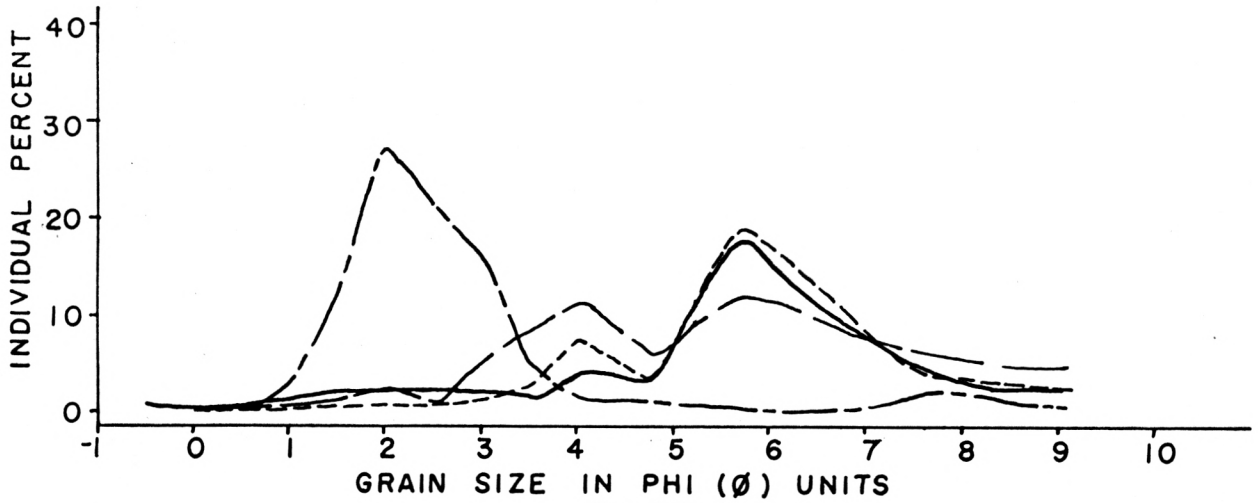


Fig. 23

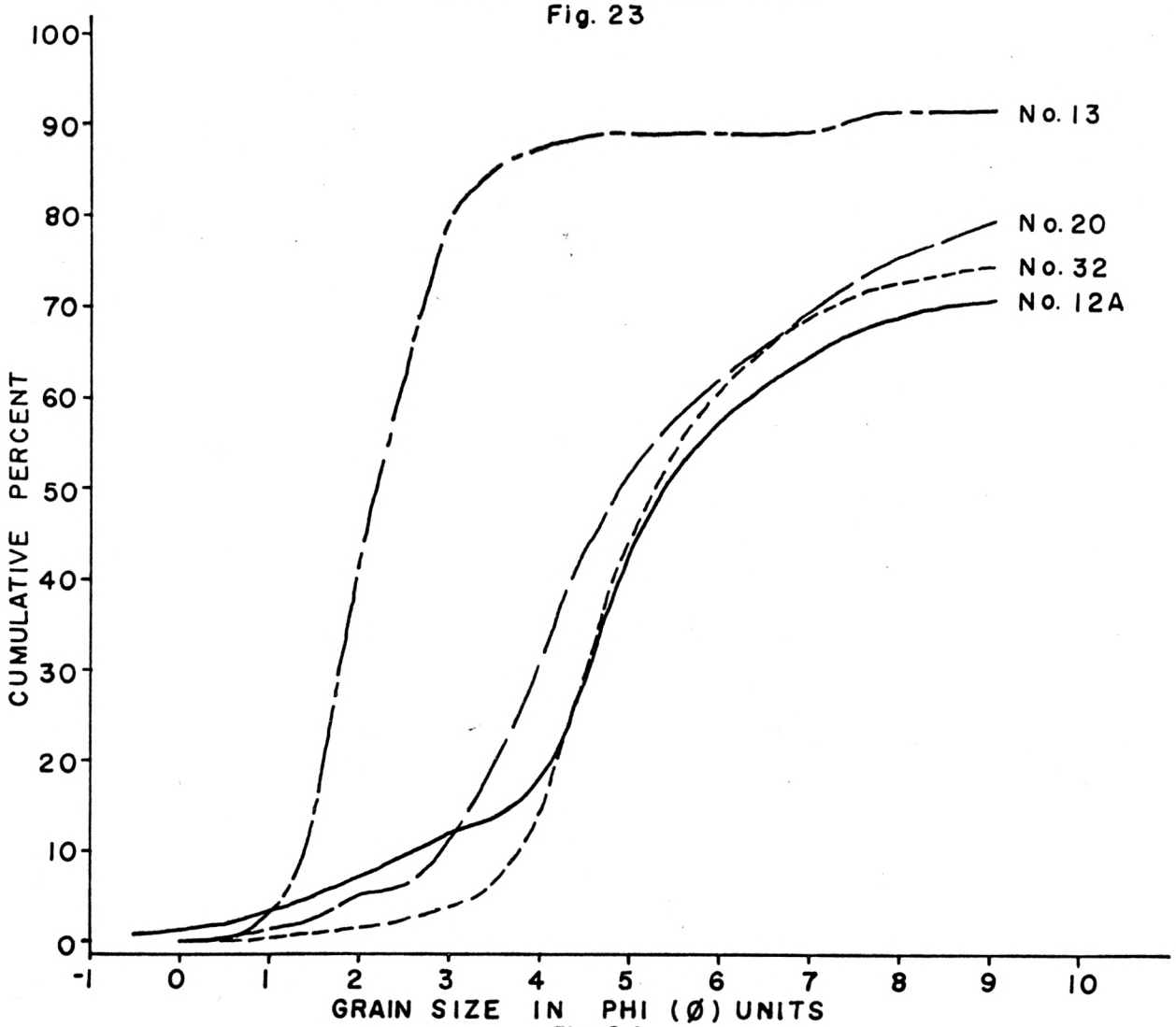


Fig. 24

EXPLANATION OF PLATE XIV

Fig. 25. Frequency curves of samples 11, 26, 27, and 31.

Fig. 26. Cumulative curves of samples 11, 26, 27, and 31.

PLATE XIV

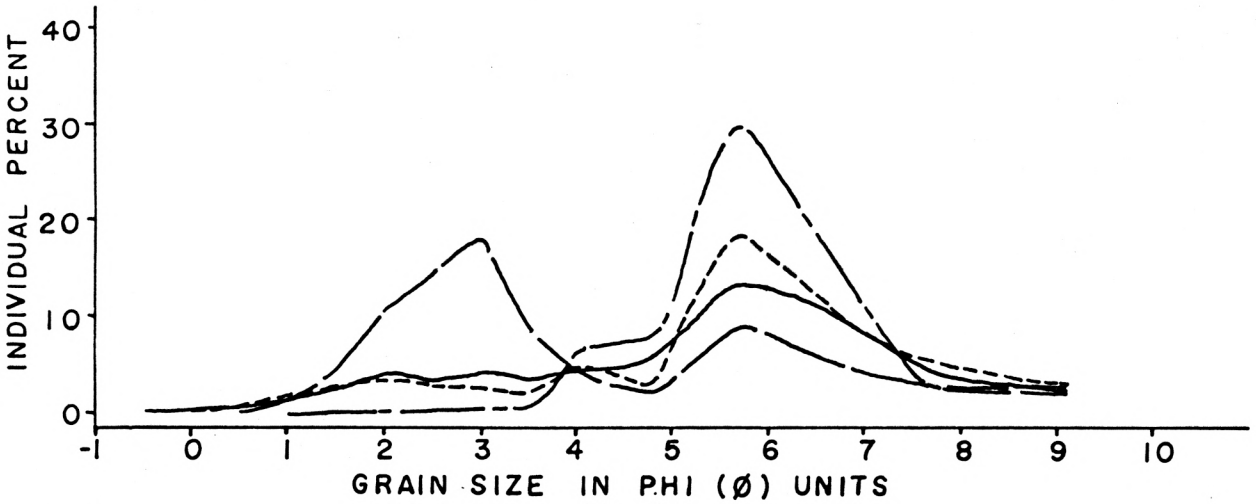


Fig. 25

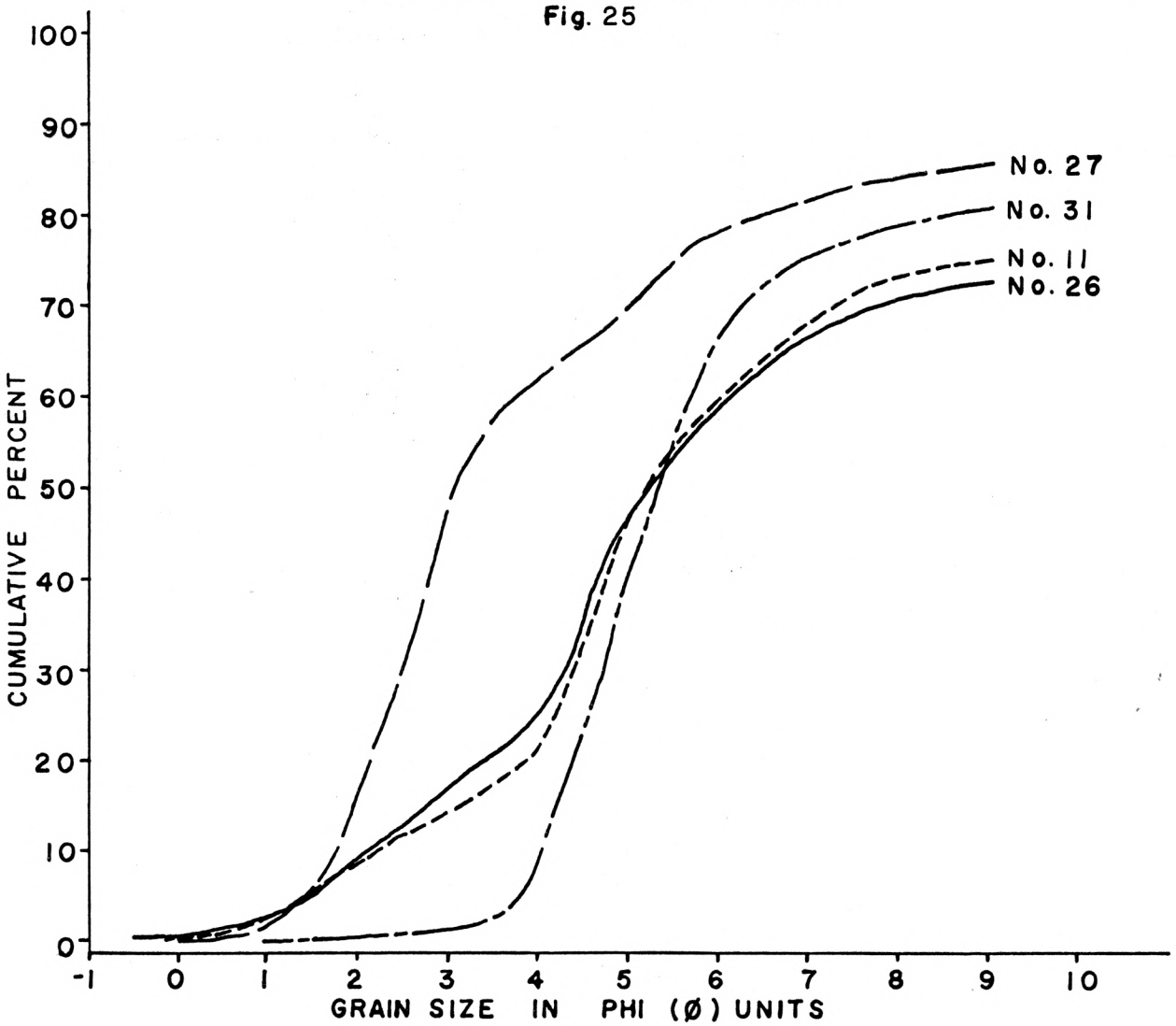


Fig. 26

grader ditch three feet below the ground surface. Analysis data, after being graphed, show bimodal curves with modes of 3.0Ø in the sand fraction and 5.7Ø in the silt fraction, a M_z of 4.34Ø, and a σ_I value of ±3.16Ø. The sample is a very poorly sorted, muddy sand.

Sample 31 (Plate XIV) was collected four feet below the ground surface at NE¼ SE¼ SE¼ sec. 33, T.9 S., R.10 E. Sample 31 was the eastern-most sample collected. Curves of the analysis data show a single mode at 5.7Ø, a M_z of 6.47Ø, and a σ_I value of 2.75Ø. Sample 31 is a very poorly sorted silt.

SUMMARY OF DATA

All samples were found to have a σ_I value ranging from ±1.96 to ±3.82Ø and are poorly sorted and very poorly sorted by the verbal classification scale suggested by Folk (1961, p. 45).

Contours showing the percent of sand on Plate XV indicate an east-west trend with a "low" about one mile north of St. George. This low fans out as it nears Wamego. A "high" trending north-eastward is present approximately two miles northwest of Wamego. "Highs" are also present in the west portion of the area in the SW¼ NE¼ SE¼ sec. 31, T.9 S., R.9 E., and in the south, near St. George. A "high" sand percent trend is also present on each side of and paralleling the east-west "low" sand percent trend north of St. George. The sediments of these trends have graphic mean values ranging from 1.5 to 4.0Ø and generally delineate the previously proposed main stream channel

of the pre-Kansan Kansas River (Todd, 1918a).

Silt to mud ratio contour values on Plate XV show highs in the northwest, central, and extreme eastern parts of the area. Field observations indicated this by the type and degree of dissection at these different locations.

The contours of the graphic mean values on Plate XVI also indicate an east-west trend of fine-grained, silty mud and sandy mud about one mile north of St. George that also fans out in the eastern part of the area as the sand percent contours disclose. "Fines" are also present in the northern part of the area in the SE¼ NE¼ NW¼ sec. 21, T.9 S., R.9 E.

The contours of the degree of sorting (Plate XVII) using σ_I values, show four general locations in which the samples were poorly sorted ($\pm$1.0 to $\pm$2.0Ø). At two locations, the samples possessed a σ_I value greater than $\pm$3.5Ø. The samples having a σ_I value of $\pm$1.0 to $\pm$2.0Ø were located northwest of Wamego in the NW¼ SW¼ SE¼ sec. 31, T.9 S., R.10 E., near St. George, at the extreme north of the area near the NW corner, sec. 22, T.9 S., R.9 E. and three miles north of St. George in the SE¼ SW¼ SW¼ sec. 28, T.9 S., R.9 E. The samples having σ_I values greater than $\pm$ 3.5Ø were located two miles northeast of St. George in the SW¼ SW¼ SE¼ sec. 35, T.9 S., R.9 E., and in a zone north and northwest of Wamego in the SW¼ NW¼ NE¼ sec. 5, T.10 S., R.10 E.

Explanation of the agreement or disagreement of the graphic mean contours of Plate XVI and the sorting contours of Plate XVII may be by the size of the particles. The sorting improves

as the graphic mean values decrease or the average particle size increases to 1.5Ø and at locations containing fine silt (4 to 7Ø) the sorting is poorer. Folk (1961, p. 5) explained three basic detrital grain populations and gave reasons that any sediment with mean sizes in the range of granule-coarse sand (0 to -2Ø) particles and fine silt (6 to 8Ø) must be a mixture of sand and pebbles, or sand, or coarse silt and clay bedause of the scarcity in nature of these two size ranges. The mixtures cause the sample to be poorer sorted than a sample made up of any one of the end members of clay (10Ø), fine sand (2 to 3Ø), or gravel (-3 to -5Ø).

The mineralogical relationships offered little aid in interpreting the history of the area. Quartz grains generally were better rounded than feldspar, hornblende, pyroxene, and other cleavable mineral grains. This is to be expected because of the tendency for minerals having cleavage to form grains having sides generally parallel to the cleavage faces.

The deposit is composed predominately of well-rounded, quartz grains which are larger in size than the feldspar and mafic minerals. There is an apparent difference in size of the quartz and other mineral grains because of relative hardness of the different minerals. Minerals such as apatite and iron ores have the tendency to be less common and form smaller grains because of the availability of these minerals from the parent rock and also their susceptability to weathering (Williams, et al., 1958, p. 272).

It was hoped that approaching the problem of the origin of

this "sand" deposit on the basis of sedimentary petrology with emphasis placed on grain size, sorting, and silt-sand-clay ratio, some light would be shed on the source of the deposit. The deposit contained so many variables of such a complex nature that to make any broad statement of fact regarding the origin would be dangerous.

Many complex problems that were encountered in this study remain unsolved. Much information concerning statistical parameters was obtained and recorded. One of the major problems is vertical control of sampling. The "t" test explained by Folk (1961, p. 56) was used to find the confidence limits of the graphic mean of the samples and to establish confidence in sampling. The average graphic mean of the samples was 4.76Ø and a chosen confidence level of 95 percent was used. The results of the "t" test lead to a belief that the "true" formation was sampled 19 times out of every 20 samples and it is 95 percent definite that the formation graphic mean lies between 3.78 and 5.74Ø. The "t" test partially answers the question of sampling but this question will never be answered completely until the whole formation is analyzed.

One explanation of the "high" east-west sand percent trend (Plate XV) two miles north of St. George may be given in the following manner if the theory of the existance of an ancient Kaw Lake by previous investigators is valid (Todd, 1918a; Mudge, 1955; and Scott, et.al., 1959). The turbidity currents were acting on the finer silts and clays, while still in suspension, within the Kaw Lake and carried them southwestward along the

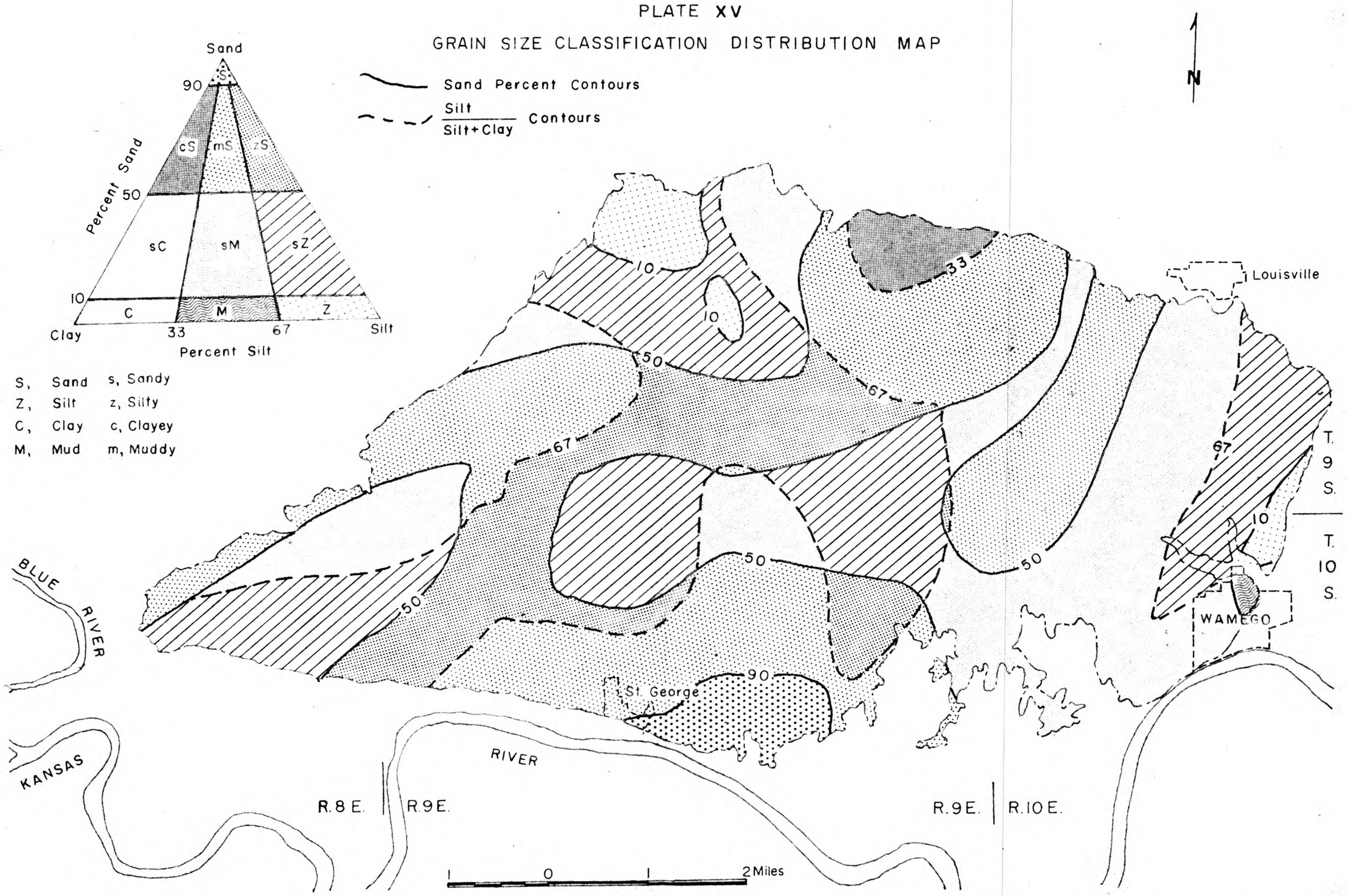
route of the pre-Kansan Kansas River following the damming of the river to the east by the Kansan ice sheet and backing up of the river. South and southwestward drainage continued up to the time of the retreating of the ice sheet which allowed some drainage through the spillway southeast of St. George. Further retreating of the ice sheet allowed the lake to drain into Rock Creek to the northwest of Louisville.

EXPLANATION OF PLATE XV

Grain Size Classification Diagram (Folk, 1954, p. 349) and Grain Size Classification Distribution Map of the area of investigation. Solid lines are contours of the 10, 50, and 90 percent sand content. Dashed lines are contours of the 33 and 67 percent silt to silt plus clay or mud.

PLATE XV

GRAIN SIZE CLASSIFICATION DISTRIBUTION MAP



EXPLANATION OF PLATE XVI

Contour Map of Grain Size

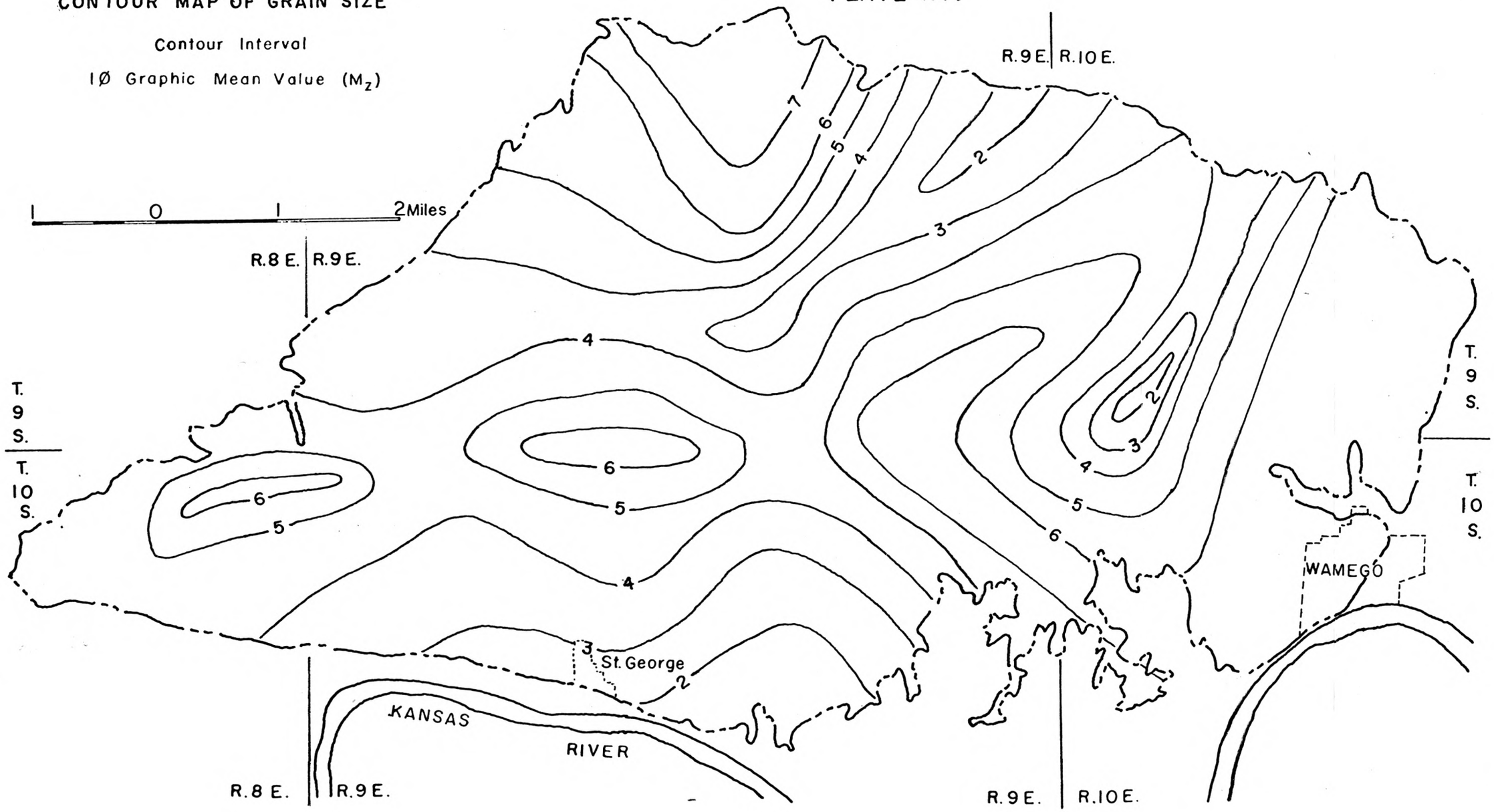
Contour interval is 1 phi (Ø) unit Graphic Mean Value. Each contour value is in terms of phi (Ø) units. Large numbers represent smaller particle size and smaller numbers represent larger particle size.

PLATE XVI

CONTOUR MAP OF GRAIN SIZE

Contour Interval

1Ø Graphic Mean Value (M_z)



EXPLANATION OF PLATE XVII

Contour Map of Sorting Values

Contour interval is $\pm .5$ phi (Ø) Inclusive Graphic Standard Deviation (σ_I). Each contour value is in terms of σ_IØ units. Smaller numbers represent better sorted sediment and larger numbers represent poorer sorting.

CONTOUR MAP OF SORTING VALUES

PLATE XVII

Contour Interval

±.5Ø Inclusive Graphic Standard Deviation (σ_I)

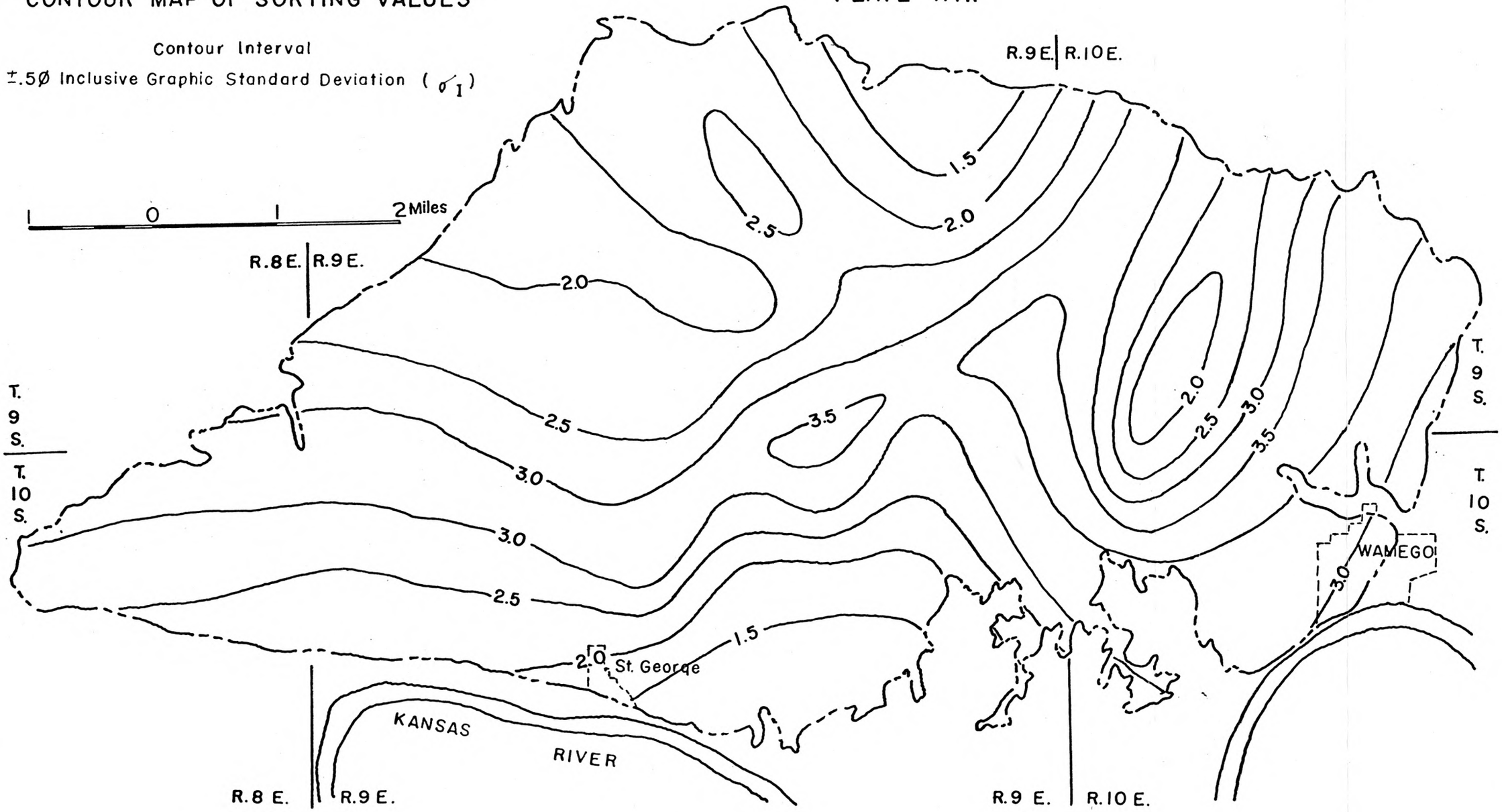


Table 1. Grain size data acquired from samples by means of mechanical analysis.

Plate number		7				8			
Sample number		1	2	3	17	A	4	18	19
Grain size Millimeter	Phi Ø Units	Cumulative weights in grams							
1.41	-0.5	-	-	-	-	-	-	-	-
1.00	0.0	.13	-	-	0.09	-	-	0.03	0.18
0.71	0.5	.85	-	0.16	0.68	0.03	0.13	0.52	1.36
0.50	1.0	2.20	0.04	1.39	4.45	0.37	1.16	4.43	4.56
0.35	1.5	3.57	0.18	5.14	11.41	2.14	3.86	14.28	10.74
0.25	2.0	5.55	0.67	13.27	24.61	7.21	9.54	32.14	23.22
0.177	2.5	8.11	1.39	21.99	35.95	14.36	17.47	46.09	39.73
0.125	3.0	11.77	2.58	32.72	45.88	26.80	28.28	55.77	62.25
0.088	3.5	14.74	3.86	38.76	51.70	38.06	39.33	58.90	75.55
0.0625	4.0	20.48	5.71	44.94	59.38	53.12	53.86	61.97	82.66
0.037	4.75	29.20	11.70	56.70	68.47	68.00	64.80	66.70	85.20
0.019	5.7	33.20	19.20	68.70	79,47	83.50	76.30	77.20	90.20
0.009	6.8	45.20	26.20	78.20	83.47	87.50	81.30	84.20	91.20
0.005	7.65	46.30	31.20	81.20	85.47	88.80	83.70	87.70	92.50
0.002	9.0	47.00	33.80	83.00	86.47	90.00	85.00	90.00	93.00
<.002	<9.0	50.00	50.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 1. (cont.)

Plate number		9				10			
Sample number		16	21	22	23	5	7	28	30
Grain size Millimeter	Phi Ø Units	Cumulative weights in grams							
1.41	-0.5	-	-	-	-	-	-	-	-
1.00	0.0	-	-	0.02	-	-	0.03	-	-
0.71	0.5	0.04	0.32	0.50	2.10	0.03	0.39	0.06	1.02
0.50	1.0	1.07	4.08	5.41	8.37	0.26	4.48	0.21	9.77
0.35	1.5	6.43	16.03	23.41	14.28	1.75	14.10	0.52	25.16
0.25	2.0	23.08	42.61	55.85	20.24	7.41	26.07	0.99	46.29
0.177	2.5	44.97	64.72	77.64	26.03	17.63	35.80	1.43	62.05
0.125	3.0	69.05	81.15	89.54	33.47	40.84	46.20	2.10	72.60
0.088	3.5	76.82	85.71	91.88	40.38	60.95	53.26	3.11	75.59
0.0625	4.0	79.89	87.78	92.63	51.63	73.81	61.58	6.64	77.62
0.037	4.75	84.50	91.70	94.70	68.30	80.20	69.20	16.40	82.30
0.019	5.7	88.50	93.70	94.70	81.80	85.70	79.20	34.40	89.30
0.009	6.8	90.50	94.20	95.20	84.80	86.20	83.70	40.40	93.30
0.005	7.65	92.50	95.70	95.70	87.20	87.70	87.40	41.80	96.20
0.002	9.0	93.80	96.50	97.00	87.50	88.70	89.00	43.10	97.50
<.002	<9.0	100.00	100.00	100.00	100.00	100.00	100.00	50.00	100.00

Table 1. (cont.)

Plate number		11				12			
Sample number		6	10	15	29	8	14	24	25
Grain size Millimeter	Phi Ø Units	Cumulative weights in grams							
1.41	-0.5	-	-	-	-	-	-	-	-
1.00	0.0	-	0.01	-	-	0.03	0.08	0.14	0.10
0.71	0.5	0.03	0.04	0.08	0.02	0.05	0.22	0.69	0.78
0.50	1.0	0.05	0.32	3.53	0.04	0.08	0.71	2.38	4.10
0.35	1.5	0.11	1.50	21.62	0.10	0.19	2.63	6.03	11.84
0.25	2.0	0.31	8.27	54.61	0.16	0.40	8.54	13.57	24.84
0.177	2.5	0.58	23.49	75.11	0.22	0.68	17.58	22.00	35.03
0.125	3.0	1.35	50.68	86.52	0.41	1.43	32.76	31.35	43.69
0.088	3.5	2.19	61.31	88.68	1.26	2.16	41.40	37.78	48.22
0.0625	4.0	4.09	74.23	89.13	6.10	4.33	45.87	43.38	52.70
0.037	4.75	11.46	80.20	89.70	17.20	15.00	54.30	51.20	60.20
0.019	5.7	29.96	83.20	90.20	32.20	32.00	67.30	63.20	71.20
0.009	6.8	38.46	84.20	91.20	38.20	37.00	74.80	69.20	76.20
0.005	7.65	40.76	87.00	92.80	40.30	38.50	78.20	73.00	79.30
0.002	9.0	41.46	88.30	95.80	42.80	39.50	80.50	75.30	81.30
<.002	<9.0	50.00	100.00	100.00	50.00	50.00	100.00	100.00	100.00

Table 1. (concl.)

Plate number		13				14			
Sample number		12A	13	20	32	11	26	27	31
Grain size Millimeter	Phi Ø Units	Cumulative weights in grams							
1.41	-0.5	0.86	-	-	-	-	0.10	-	-
1.00	0.0	1.17	-	0.07	0.03	0.11	0.43	-	-
0.71	0.5	1.77	0.28	0.25	0.13	0.66	1.08	0.13	-
0.50	1.0	3.17	3.76	0.63	0.44	2.49	2.51	1.41	0.04
0.35	1.5	5.19	16.21	1.36	1.01	5.36	5.11	5.95	0.13
0.25	2.0	7.52	43.63	2.59	1.74	8.74	9.27	16.63	0.32
0.177	2.5	9.72	64.85	3.06	2.63	11.47	12.68	30.66	0.50
0.125	3.0	12.04	80.78	5.87	4.08	14.02	16.95	48.66	0.81
0.088	3.5	13.76	85.62	10.13	6.65	16.02	20.51	57.61	1.30
0.0625	4.0	17.94	87.05	15.84	14.44	20.59	25.04	62.02	4.55
0.037	4.75	36.30	89.20	24.00	38.50	38.50	42.30	67.53	15.20
0.019	5.7	54.30	89.20	30.00	57.50	56.70	55.80	76.53	30.20
0.009	6.8	63.30	89.20	34.00	68.00	66.50	65.30	81.03	37.20
0.005	7.65	67.70	91.30	37.00	72.00	72.00	69.70	83.53	38.80
0.002	9.0	70.50	91.90	39.30	74.50	75.10	72.50	85.53	40.30
<.002	<9.0	100.00	100.00	50.00	100.00	100.00	100.00	100.00	50.00

Table 2. Percent of sand, silt, and clay size fractions in samples.

Sample number	Sand	Silt	Clay	Sample number	Sand	Silt	Clay
A	53.12	35.68	11.20	17	59.38	26.42	14.50
1	40.96	51.64	7.40	18	61.97	25.73	12.30
2	11.42	50.94	37.60	19	82.66	9.84	7.50
3	44.94	36.26	18.80	20	31.68	42.32	26.00
4	53.86	29.84	16.30	21	87.78	7.92	4.30
5	73.81	13.89	12.30	22	92.63	3.07	4.30
6	8.18	78.42	13.40	23	51.63	35.57	12.80
7	61.58	25.82	12.60	24	43.38	29.62	27.00
8	8.66	68.34	23.00	25	52.70	26.50	20.70
10	74.23	12.77	13.00	26	25.04	44.66	30.30
11	20.59	51.41	28.00	27	62.02	21.48	16.50
12A	17.94	49.76	32.30	28	13.28	70.22	16.50
13	87.05	4.25	8.70	29	12.20	78.40	19.40
14	45.87	32.43	21.80	30	77.62	18.58	3.80
15	89.13	3.67	7.20	31	9.10	68.50	22.40
16	79.89	12.61	7.50	32	14.44	57.56	28.00

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STUDY OF THE "SAND" DEPOSIT BETWEEN MANHATTAN AND WAMEGO, KANSAS

by

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AN ABSTRACT OF A THESIS

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A deposit of "sand" in southwestern Pottawatomie County between Manhattan and Wamego and comprising approximately 45 square miles is described. Emphasis is placed upon grain size, sorting, and sand-silt-clay ratios in an attempt to solve the problem of origin of the deposit.

Relief of the deposit is 265 feet and streams drain to the northeast and to the southwest in the area and eventually into the Kansas River.

Previous investigations have placed the ancient Kaw Lake and the pre-Kansan Kansas River valley in the general vicinity of the deposit and attributed the deposit to glacial outwash from the Kansan ice sheet which stagnated a few miles to the northeast.

Mechanical analyses were run on spot samples collected approximately one to every section. Data were tabulated and graphs and maps plotted in an attempt to best interpret and present the results of the tests. Methods of presentation are fairly new but are convenient to use because of the ease in computation and understanding. The phi (Ø) scale, a logarithimetric transformation of Wentworth particle grain size classification scale, was used in all calculations and presentations.

Maps of size distribution, graphic mean, and inclusive graphic standard deviation were used and all tend to show definite east-west trends of the sediment characteristics. These trends tend to delineate the previously proposed pre-Kansan Kansas River channel north of St. George eastward toward Louisville. The "t" test was made to check the accuracy of sampling.

This test gives a 95 percent assurance that the graphic mean of the "true" formation ranges between 3.78 and 5.74Ø and there is one chance in twenty that this might be wrong.