PLEISTOCENE GEOLOGY AND GROUND WATER OF KANSAS RIVER VALLEY BETWEEN MANHATTAN AND JUNCTION CITY, KANSAS

by

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INTRODUCTION

Purpose of the Investigation

The geology and ground water resources of the Kansas River Valley have been investigated from the river's junction with the Missouri River at Kansas City, Kansas, to the eastern city limits of Manhattan, Kansas. Most of these investigations have been published by the State Geological Survey in Lawrence. The purpose of this investigation was to determine the geomorphic history of Kansas River Valley and the availability of ground water from Manhattan westward to the junction of the Smoky Hill and Republican Rivers, northeast of Junction City, Kansas. With the aid of a research grant from the Faculty Research Fund, Kansas State University, field work began in the fall of 1961, and was completed in April, 1962.

Area of the Investigation

The area of this investigation extends in an east-west direction from the east city limits of Manhattan to the west city limits of Junction City. The bluffs of the river are cut into limestone and shale of the Council Grove and Chase groups, and form the boundary of the area of investigation on the north and south. The western half of the area is within Geary County and the eastern half in Riley County. The entire area covers approximately 95 square miles. Mapping was extended up the major tributaries to the north and south to determine exact relationships between deposits in the main river valley and the tributaries.

Geography

The Kansas River Valley is in the Osage plains division of the Central Lowlands province according to Frye (1946, p. 72). Sharp bluffs are present to the south and a rolling dissected plain to the north of the river valley. The valley varies in width from seven miles in the Manhattan airport vicinity to less than one mile in the vicinity of Camp Funston on the Fort Riley reservation. The maximum relief in the area is 220 feet but the average is 150 feet. The valley is asymmetrical with the river flowing on the south side of the valley. Numerous meander scars and channel changes are present, some of which occurred as recently as the 1951 flood.

Transportation

The area is accessible by numerous maintained county roads and also highways U. S. 40 and 24, and K-18. The Union Pacific railroad trends east and west through the area, following the route of K-18 from Manhattan through Fort Riley to Junction City. The Chicago, Rock Island, and Pacific Railroad operates from Manhattan in a northwest direction and leaves the area in the Wildcat Creek Valley region.

Climate

The Kansas River Valley in this area lies within a humid-continental type of climatic belt which is characterized by long, hot summers with the average temperatures over 50 degrees F., and cold winters with the average temperature above 32 degrees f. The precipitation is concentrated in the summer months, June through August. The average annual precipitation from January, 1957, through December, 1961, was 36.97 inches, determined from records of the Manhattan recording station located at the Physics department on the campus of Kansas State University. The average temperature from 1958 through 1961 was 53.8 degrees F. The annual average precipitation for this period is higher than an average taken for an eleven-year period beginning January, 1950, through December, 1961, which is 33 inches. This is explained due to the drought period which occurred from late 1951 to 1957.

Land Use

Extensive agriculture is practiced in the river valley; the main crops are alfalfa, corn, and wheat, but very from vegetables to Christmas trees. Irrigation is used extensively in the eastern sector with little in the west due to the military reservation. The Horticulture and Agronomy departments of Kansas State University operate experimental farms on the south side of the river in the vicinity of the Manhattan airport.

Previous Investigations

The majority of the early work done in Kansas concerning glaciation and the Quaternary period is contained in the transactions of the Kansas Academy of Science. Of the recent work done on the Quaternary of the state, most has been published by the State Geological Survey in Lawrence. A mention of the authors and their findings will be presented in chronological order.

Hay (1892) recognized morainic deposits in the Washington County area where glacial erratics rest on the Dakota sandstone of Cretaceous age. The limit of ice advance in the area was recognized by him to be on the south bluff of the Kaw River in Waubaunsee County. Smyth (1898) described a buried moraine along Shunganunga Creek in Shawnee County and pointed out several marginal lakes which developed in Kansas, the largest of which was Kaw lake extending from Waubaunsee westward past Manhattan to Salina. Wooster (1915), in describing the chert gravels of Greenwood, Lyon, and Morris Counties in eastern Kansas, mentions that the gravels are usually smaller than five inches in diameter and possess a Lower Permian fauna. They are found capping the bluffs in the area and also are present in some channels. Numerous articles of an ancient cult, and also the remains of a Quaternary horse, were found in silt material covering the chert gravels. He attempts to explain the chert gravel covered by silt material as a result of drainage changes due to uplift, and advance and retreat of glaciers. In an article by Todd (1918) he describes much of the evidence present in Kansas such as boulder beds, morainic, fluvial, and lacusterine deposits for the proof of glaciation. He has also compiled a Pleistocene history of northeast Kansas, and limits the extent of glacial drift to the Big Blue River on the west and the Kansas River on the south. He mentions that the altitude of glacial drift is 1400 feet where it enters the state at Nebraska and is 1100 feet where it enters Missouri at Kansas City. In another article by Todd (1918a), he states that while traveling west on the Union Pacific railway from St. Mary's, a distinct basin can be seen until we reach Manhattan. This he refers to as Kaw Lake and extends its western limit past Manhattan to Salina. He points to the fact that there is no evidence of glaciation in this basin which would follow his line of reasoning of the presence of a marginal lake in the area. Furthermore, the presence of a chain of red quartzite boulders, similar to those found in Minnesota, forming in a belt-like fashion near Wamego, and extending as far west as the campus of Kansas State University, favors his theory. He explains the presence of chert gravels as the result of stream gradient changes, and also mentions the Pliocene and later course of the Kaw River.

MacFarquhar (1938) described the chert gravels in the area from Lawrence to Kansas City. His work was concentrated in Leavenworth County for the most part, and he found the chert to be buff in color, from one to six inches in diameter, and smooth and rounded. These gravels are found on the high slopes from

100 feet to 150 feet above the flood plain. Todd describes them as being fluvial whereas Hayworth thinks they are residual. Glacial erratics in the upper part suggest that part are from streams flowing from the Kansan ice sheet, according to MacFarquhar. An article by Hoover (1936) describes the petrography and distribution of a highly weathered drift in the Kansas River Valley. He analyzed a red clay-like deposit which occurs on terraces, uplands, and in the undissected areas at the heads of tributary valleys. The thickness of this deposit varies with topographic position and reaches a maximum in the terrace levels. He accounts for the origin of this deposit in two ways: the upland phase due to weathered till, and the terrace phase due to fluvial deposits. Lill (1946), in an unpublished master's thesis at Kansas State University, described a possible glaciofluvial terrace in Marshall and Washington Counties. He was concerned with the mineralogical relationships in fixing the age of sediments, with some attention focused on the geomorphology and areal extent. With the use of differential thermal analysis methods, he discovered illite in the glacial sediments. (Flint (1947), in his map of North American glaciation, set the boundaries of ice advance in Kansas to the Kaw River. Beck (1949), in another unpublished master's thesis, mapped and described the Quaternary geology of Riley County, Kansas, with special significance upon construction materials. Both Frye and Leonard (1952), have made tremendous contributions to the study of the Pleistocene epoch in Kansas. Frye, along with others, has worked with all phases of the Pleistocene in the state. Davis

and Carlson (1952) have mapped and described the Quaternary deposits between Lawrence and Topeka, and Beck (1959) did similar work from Topeka to Wamego. Smith (1959) carried this investigation of the geology and ground water resources of the Kansas River Valley from Wamego to Manhattan in an unpublished master's thesis at Kansas State University.

In 1937, a program was initiated by the United States Geological Survey and the State Geological Survey of Kansas in cooperation with the Division of Sanitation of the State Board of Health and the Division of Water Resources of the State Board of Agriculture whose purpose was to investigate the ground water resources of Kansas. To date, information on more than half the counties in Kansas has been published and others are in preparation. This has aided considerably in the compilation of data on the Pleistocene epoch in Kansas.

PROCEDURES

Field Procedures

Field Mapping. Aerial photographs from the United States Department of Agriculture office in Manhattan were consulted, but not used as a method of mapping, since the area was completely accessible. The field map was constructed from a base map used by Beck (1949) for the area in Riley County. For the area covered in Geary County in this report, seven and one-half minute quadrangle sheets, constructed by the United States Geological Survey, of the Junction City and Ogden quadrangles were photographically reduced to correspond with the base map used by Beck. Drainage and culture were drawn from the quadrangle sheets and contacts of the various sediments were then placed on the map. Since the bedrock forming the bluffs on the north and south sides of the river was not considered important in a study of the Quaternary geology, it was divided into the Chase and Council Grove groups of the Wolfcamp series of the Permian system. It was not felt necessary to delineate these groups to formational rank.

The data on the depth to water in the area was compiled by measuring the depth to water in drilled wells, where possible, by the use of a drawdown gauge. In many instances, the wells were unable to be measured and reported depths were used. Water levels, in areas where no wells have been drilled, were determined by the use of a portable auger of the Ground Water division of the United States Geological Survey in Lawrence, Kansas. This instrument played a dual role by serving as a method of sampling and also as a means of collecting ground water data.

<u>Sample Collecting</u>. Three methods of sampling were used: (1) channel, (2) spot, and (3) auger. In most cases, spot samples were taken; however, some channel samples were taken where they were deemed necessary, and the portable auger was used in areas where it was necessary to take subsurface samples from depths of ten to sixty feet. In the channel samples, the face of the material was cleaned thoroughly before sampling. A lithologic change determined the depth of samples when using the

portable auger.

Laboratory Procedures

Mechanical Analysis. Mechanical analysis was performed on samples collected in hopes of determining some differentiation in grain size of the particles from the different materials sampled. The standard procedure using the soil hydrometer method was employed. Fifty grams of the material, one hundred grams in the case of sandy deposits, was dried for 24 hours in an oven, and then crushed and placed in a beaker of distilled water with twenty milliliters of a dispersing agent, sodium hexametaphosphate, added. This was allowed to set overnight and then mixed for five minutes and placed in a 1,000 milliliter cylinder, shaken, and readings were taken at the proper time intervals for a period of 24 hours. At the end of this period, the two micron fraction was siphoned off and saved for X-ray analysis. Histograms were prepared to show the relationship of sand, silt, and clay-sized materials from various samples.

X-Ray Analysis. Oriented slides of the remaining clay fraction were prepared to insure basal reflections from X-ray bombardment. This was done by placing a few drops of the clay fraction held in solution upon glass slides and permitting the slide to air dry overnight. In drying, the clay particles align themselves along their basal surfaces, thereby producing the orientation desired. The X-rays were bombarded in an arc from 30 to zero degrees which takes two hours. The slides were then treated with ethylene glycol and exposed once more to the X-rays in an arc from fifteen to zero degrees for a period of one hour. Glycolating was necessary to determine the interlayer relationships between vermiculite, chlorite, and montmorillonite. The slides were then heated to 450 degrees C. for one-half hour and submitted to the X-ray analysis for an arc of fifteen degrees. This procedure was necessary to determine the clay minerals contained; for the crystal lattice of montmorillonite will break down at 450 degrees C., whereas the lattice of vermiculite and chlorite remain intact.

The X-ray patterns of clay-size fractions from three topographic positions are shown in Figure 1. The pattern is of only one sample from each level. Initially, the patterns were thought quite similar and not diagnostic, but when plotted, as on this figure, the montmorillonite peak of the Menoken is suggestive of a possible criterion for distinguishing between the three. More samples could be run to determine if this characteristic is distinctive.

DESCRIPTION OF QUATERNARY SEDIMENTS

Introduction

The Quaternary deposits in this area of the Kansas River Valley rest unconformably on rocks of the Council Grove and Chase groups of the Wolfcamp series of the Permian system. The deposits range from dune sand of Recent age to the Menoken terrace deposits of the Kansan glacial stage. The Quaternary

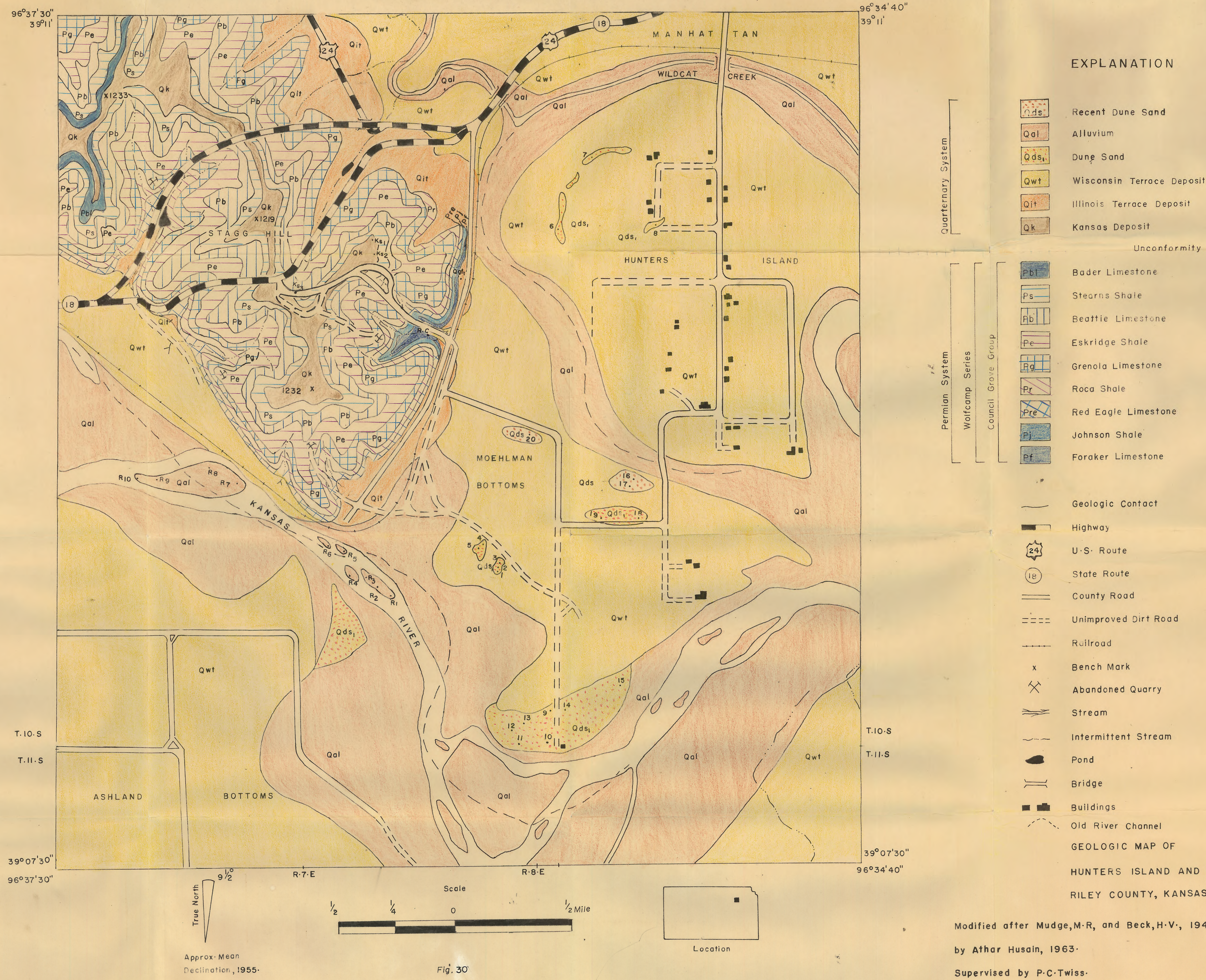

Fig. 30

GEOLOGIC MAP OF HUNTERS ISLAND AND VICINITY RILEY COUNTY, KANSAS.

Modified after Mudge, M.R, and Beck, H.V., 1948-49.

by Athar Husain, 1963.

Supervised by P.C. Twiss.

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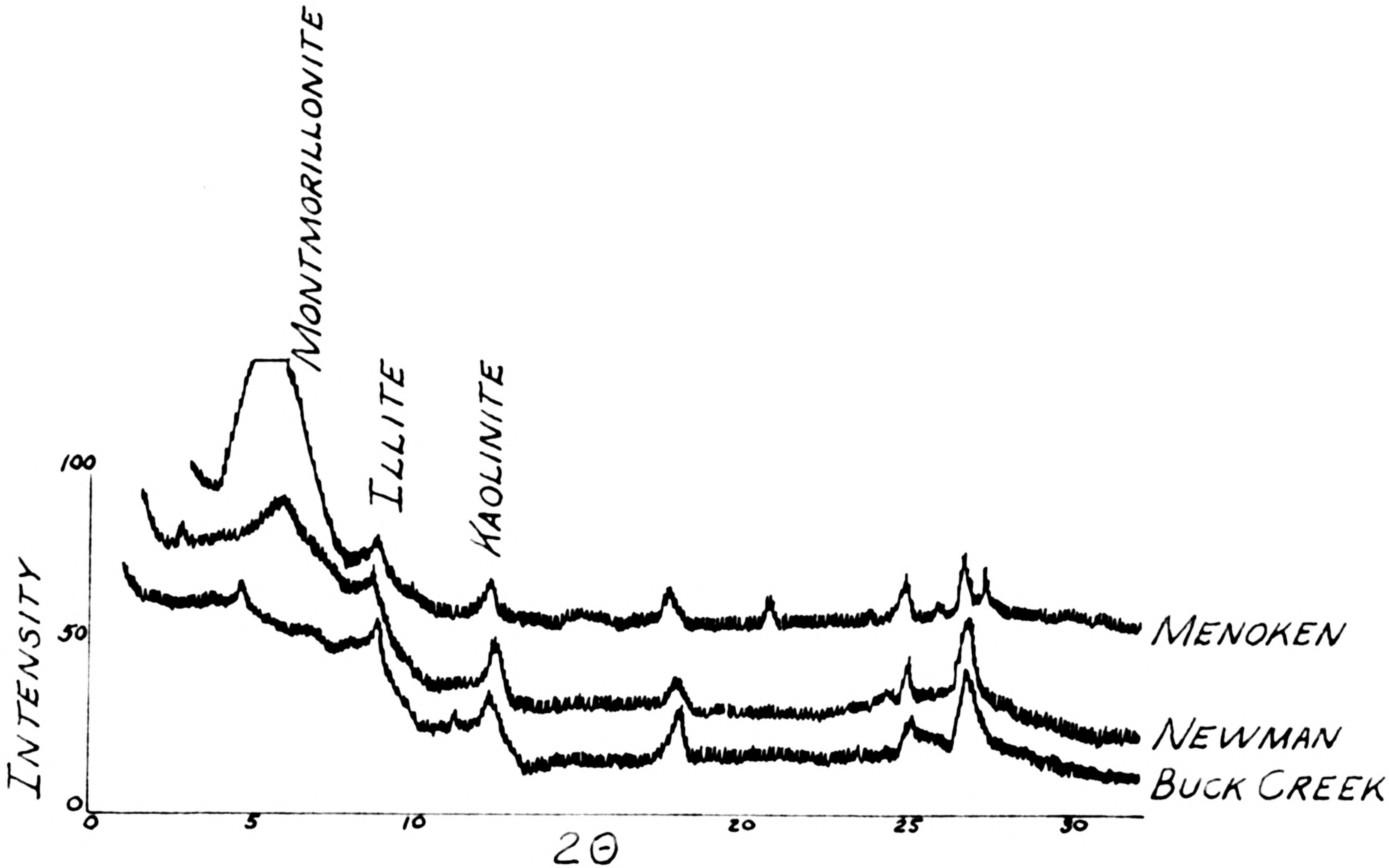


X-RAY PATTERNS OF CLAY MINERAL CONSTITUENTS OF VARIOUS TERRACE DEPOSITS

FIGURE 1

deposits are extensive in this area, and are economically important both for agricultural and ground water reasons.

Pleistocene Series

Recent Dune Sand. Distribution. Fine sand and silt-sized particles on the surface of alluvium have been reworked by the action of wind, and deposited as dune sand on the flood plain at several locations in the river valley. Three prominent dune areas are: (1) NW¼, NE¼ sec. 35, T. 10 S., R. 7 E; (2) south of the river, SW¼, NE¼ sec. 33, T. 10 S., R. 7 E., and (3) SW¼, NE¼ sec. 36, T. 10 S., R. 7 E. north of the river. All are recent dunes since they are deposited on the flood plain or possibly on a Late Wisconsinan terrace level. The largest, SW¼, NE¼ sec. 33, T. 10 S., R. 7 E., on the southeastern edge of the Manhattan airport, is somewhat more than one-half mile square in area. The others are approximately a quarter to half mile square in area. These dune areas produce a hummocky topography and have a maximum relief of 25 feet. Some small dune areas are present south of Ogden in the SW¼, NW¼ sec. 18, T. 11 S., R. 7 E., but are limited in areal extent and were not mapped as such.

Description. The dune sands are composed primarily of sand-sized material with minor amounts of silt and practically no clay. The sand is medium to fine, light gray to light tan in color, and the grains are well-rounded. Vegetation is present in all three areas; however, the area south of the river in the NW¼, NE¼ sec. 35, T. 10 S., R. 7 E., is not as abundantly populated.

Thickness. The thickness of dune deposits ranges from a feather-edge to 30 feet, with a decrease in thickness as distance from the river increases, as would be expected in the deflation of the material.

Mechanical Analysis. One sample of dune sand was collected in the SW¼, NE¼ sec. 36, T. 10 S., R. 7 E., on Hunter's Island and a mechanical analysis was performed. This was done mainly to determine the ratio of sand, silt, and clay, and not to compare with other samples, since the lithologic characteristics of the dune material remained constant throughout the valley. The results showed a composition of 78.7% sand, 18.2% silt, and 3.1% clay. The silt fraction was confined to the .039 millimeter size, and the clay fraction was negligible.

<u>Alluvium</u>. Distribution. The material mapped as Quaternary alluvium (Qal) on Plate I consists of sand, gravel, silt, and clay which has recently been deposited by the depositional action of the Kansas River and its major tributaries. Alluvium was mapped in the present channel of the Kansas River, on the flood plain which rises to a maximum height of 10 to 12 feet above the present channel, on the meander scars in the valley and in the channels of the major tributaries. The deposits are most extensive in the Hunter's Island area which is one and one-half miles south of Manhattan and north of the Kansas River,

and southeast of the junction of the Smoky Hill and Republican Rivers in the Marshall Field area. The total width of the alluvium in these two areas is approximately three miles. In most of the valley, however, the width does not exceed one quarter to one half mile on the average. In the tributary valleys, the width is from one-sixteenth to one-eighth of a mile. Wildcat Creek, which enters from the northwest, has the most extensive alluvial deposits. The maximum width in this area is one-quarter of a mile. Seven Mile, Clarke, and McDowell Creeks have extensive deposits of alluvium, but the material is restricted to the present channel of the stream and the outcrop pattern is narrow. The flood plains of these three tributary streams are very narrow also.

Description. The alluvium of the Kansas River Valley consists predominantly of sand and gravel-sized material with some silt and clay-sized fractions present. The alluvium grades downward from silt, clay, and very fine sand, to coarse sand and medium to coarse gravel. A minor zone of soil has developed, possibly an A horizon, but much of the soil was eroded away by the 1951 flood, which devastated a considerable area of the valley. The sand and gravel fraction consists mostly of fragments of quartz, feldspar, and igneous rock. Chert is present in small amounts as are limestone fragments, where local tributaries enter the valley. An extensive soil profile is developed in the tributary valleys since they were not as affected by the flood as was the Kansas River Valley. In the major tributary valleys, where the streams have incised, the fine fraction tends to interlock, somewhat in the manner of loess, and consequently, the banks of the streams are vertical, indicating some entrenchment by the streams in recent time. The sand and gravel fragments are well-rounded to sub-rounded in most cases. In contrast to this, the locally derived chert and limestone fragments are subangular to jagged. A possible Late Wisconsinan terrace development is evident in some places, such as on Hunter's Island and in the area of Marshall Field on the Fort Riley Reservation, but because of the lack of sufficient evidence such as a prominent terrace surface or lithologic change, areas such as this were grouped with the alluvium. Some Late Wisconsinan scars in the valley may possibly be formed on an Early Wisconsinan terrace, but because of inconclusive findings they were mapped along with the alluvium.

Thickness. The thickness of the alluvium east of the Manhattan airport area in NW¼, NE¼ sec. 34, T. 10 S., R. 7 E., is 57 feet. This thickness was determined by the depth to bedrock for three irrigation wells on the Kansas State University Horticulture and Agronomy farms. In most of the alluvial area, however, water for domestic use is obtained by the use of a sand point driven in the basement of the residence to a depth of 17 to 20 feet, and consequently, data is insufficient to determine the true thickness of the alluvial material in the area. However, irrigation wells which rest on bedrock in the area vary from 54 feet to 70 feet in depth.

Wisconsinan Terrace Deposits. Distribution. The Wisconsinan terraces deposits, referred to as the Newman from a well-developed terrace deposit of Wisconsinan age near Newman, Kansas (Davis & Carlson, 1952), is quite extensive in this area. Its total areal distribution from Manhattan to Junction City is more than one-third of the valley proper. The Newman terrace is present on both the north and south sides of the river; and is most extensive on the north side of the river in the area of the Manhattan airport, and the Kansas State University Horticulture and Agronomy farms on the south side of the river. In places, the river has eroded sharply into its south bluff, consequently leaving little or no evidence for the presence of the Newman terrace level in such areas. This is noticeable in the SW¼, NW¼ sec. 9, T. 11 S., R. 7 E., southeast of Ogden, and in the NW¼, NW¼ sec. 34, T. 11 S., R. 6 E., southeast of Marshall Airfield.

Description. The Newman terrace deposit is relatively young and its scarp, which was formed by lateral erosion of the river in Late Wisconsinan, is void of any dissection as a rule. In places, gullies formed by headward erosion are noticeable, but in general erosion has not affected the scarp. The scarp ranges from five to ten feet in height above the flood plain, and is very prominent in the NE¼, SW¼ sec. 28, T. 10 S., R. 7 E., on the north side of the river, and in the NE¼, NE¼ sec. 34, T. 10 S., R. 7 E., on the south side of the river. The terrace level is predominantly flat in most of its expanse with a slight gradient eastward, as indicated by contours on topographic maps of this area. The material grades from a dark to medium gray silty clay soil at the surface, to a light gray to tan fine sand and gravel at its base. The mineralogical composition of the sands and gravels is quartz, feldspar, and granitic fragments, with very little or no limestone fragments. Chert fragments are rare in the Newman, which is a means of differentiating between these and various other terrace deposits. Because of the small amount of dissection that has taken place, good exposures of the Newman terrace are poor; however, the entrenched tributaries do expose the upper part where they enter the main valley.

Thickness. Records from various irrigation wells drilled into the Newman terrace indicate an approximate thickness of 57 feet (at Junction City) for the deposit. The deepest well measured is located in the NW¼, SE¼ sec. 4, T. 11 S., R. 6 E., and is 58 feet deep. A test hole using a power auger was drilled into the Newman terrace deposit in the SE¼, SW¼ sec. 32, T. 10 S., R. 7 E., southwest of Manhattan Airport, and to a depth of 47 feet, where bedrock was encountered. The location of the test hole was east of the drilled well of 58 feet.

<u>Illinoisan Terrace Deposits</u>. Distribution. The Buck Creek terrace deposit in the Kansas River Valley lies at a higher topographic position than does the Newman terrace deposit. As in SW¼, NE¼, sec. 29, T. 10 S., R. 7 E, on the average,

the surface is 40 to 50 feet above the flood plain of the Kansas River, but this is variable. The terrace is extensive and covers 15 to 20 percent of the area between Manhattan and Junction City. It is found in the valleys of the major tributary streams, and is most extensive in an area west of the Manhattan Airport and within the boundaries of the Fort Riley Military Reservation. In some places on the south side of the river, noticeably in the NW¼, NW¼ sec. 3, T. 12 S., R. 6 E., and the SW¼, SE¼ sec. 33, T. 10 S., R. 7 E., where the river has cut sharply into the south bluff and where resistant material is exposed, the Buck Creek terrace deposit is absent, resulting from erosional action of the Kansas River during post-Illinoisan downcutting. A major drainage change occurred during this time when the Kansas River, which was flowing northwest of the University grounds, changed course and flowed south of Manhattan to its present course.

Description. The Buck Creek terrace deposits have been subjected to erosional processes for a long period and consequently are dissected. Exact locations of a scarp formed by the river on this terrace level are difficult to determine, and in most cases must be inferred. A marked topographic difference exists, however, and this is the main tool used in differentiating these two terrace levels. Several test holes were drilled on the Fort Riley Military Reservation in order to determine the lithology and thickness of Buck Creek terrace deposits (Plate II). The material is a distinctive brown to brownishred color, because of oxidation, and grades from silty clay to a very fine sand and silt to a medium sand, with numerous chert gravel layers throughout. The reddish color persists to a depth of 60 feet, which was the maximum depth augered. The chert nodules are somewhat stained and are subangular to blocky, indicating a local rather than regional source area. The lithology is consistant throughout the Kansas River Valley and the major tributary valleys.

Thickness. In all test holes drilled to 60 feet, the lithology did not change considerably nor was the depth to bedrock reached. The thickness was determined primarily by data accumulated from well inventories. An irrigation well drilled to bedrock through the Buck Creek terrace deposit in the NW¼, NW¼ sec. 29, T. 10 S., R. 7 E., indicates a thickness of 67 feet. However, the maximum depth may be as much as 70 or 75 feet.

Mechanical Analysis. Analysis was made on a sample of Buck Creek terrace deposit from the NE¼, SE¼ sec. 19, T. 10 S., R. 7 E., on the Fort Riley Military Reservation, and the results were: sand, 16.8%, silt, 51.8%, and clay, 21.4%. Bedause of the similarity of lithologic characteristics throughout the valley for the Buck Creek terrace deposit, further mechanical analysis was not considered necessary.

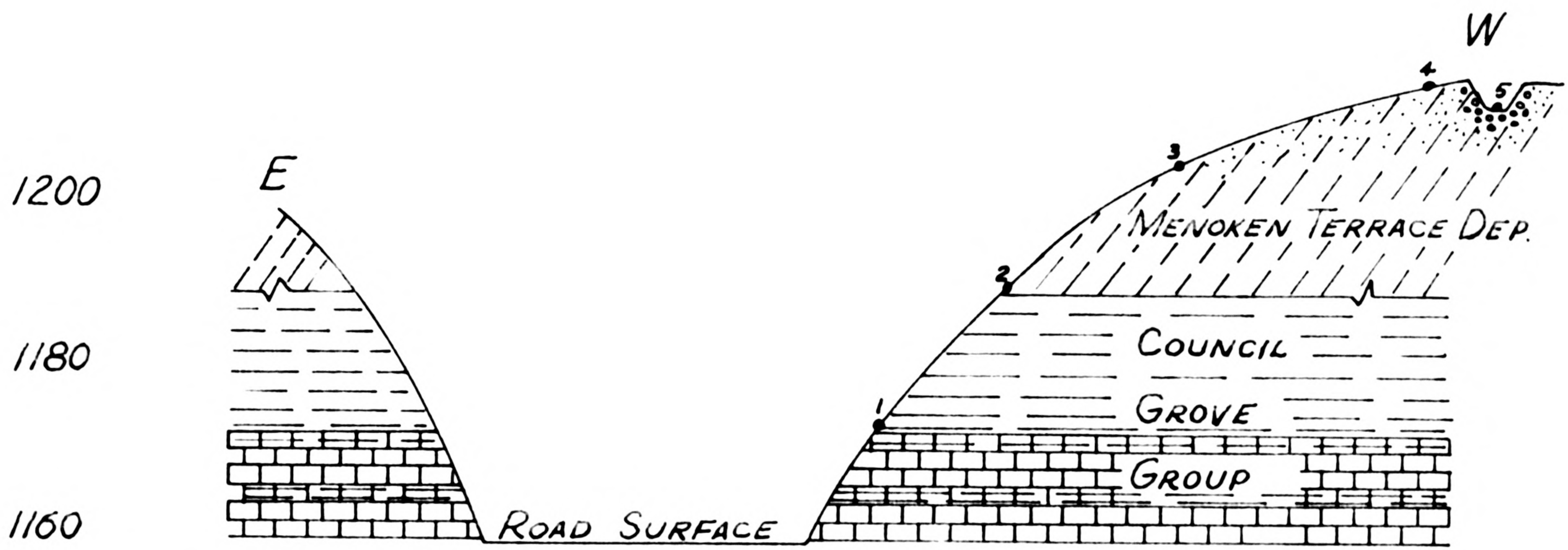
<u>Kansan Terrace Deposits</u>. Distribution. Material quite similar in color and lithology to that of the Buck Creek terrace deposits overlies bedrock in most of the divides in the

area. As can be seen in NE¼, SW¼ sec. 26, T. 11 S., R. 6 E., because of slight differences in lithologic character and physiographic position, these deposits have been named Menoken terrace deposits rather than Buck Creek terrace deposits. The base of these beds lies approximately 150 feet above the flood plain surface; which is contrasted with the Menoken terrace deposits in the Topeka vicinity, which range 20 to 40 feet above the flood plain (Beck, 1959). In previous work, this material was included in the Sanborn formation (Beck, 1949), and has a wide outcrop belt not only in the Kansas River Valley, but also in Riley County. The terrace is extensive, but not as extensive as the Buck Creek and Newman terrace deposits. It is present also on both the north and south sides of the river.

Description. The material is tan-red to brown-red, and grades from silty clay to fine sand and silt with some chert gravels. The entire section is composed of silt-sized particles, closely resembling loess in some places where the material is exposed. In other places, however, the material is a mixture of medium to fine sand, well sorted and rounded, with some silt-size material. In the NE¼, NW¼ sec. 26, T. 11 S., R. 6 E., there is an exposure with prominent vertical weathering of the material composed almost entirely of light tan silt-sized material resting on rocks of the Chase group. A caliche zone is present in the same exposure three to four feet below the B horizon of the soil, and is undulatory and inconsistant. A detailed study shows the material to be thin bedded or laminated, and sand lenses from three to eight inches long are present throughout the unit. A new road cut on state highway 18 in the SE¼, NE¼ sec. 23, T. 10 S., R. 7 E., exposes this material, and it lies directly above the rocks of the Council Grove group. The material is light tan to tan in places, and weathers to a light yellow brown. The material grades upward from a silty clay to silt material near the base resting on the Council Grove group to a medium to coarse rounded sand with some silt present. Some chert fragments are present as gravels. This differentiation in material occurs within 15 to 20 feet. Extreme dissection has taken place, and the Menoken is void of any scarp in this area.

Thickness. The Menoken terrace deposit is extremely variable, ranging from 10 to 30 feet thick. The thickness may exceed 30 feet in places, but because of insufficient well data and hand auger samples, it could not be determined.

Mechanical analysis. Samples from five different levels in ascending order were analyzed from the SE¼, NE¼ sec. 23, T. 10 S., R. 7 E. Spots were chosen from directly above a limestone member of the Council Grove group and samples were then selected at random every two to three feet where a lithologic break seemed to be present (Fig. 2). Histograms were prepared and are shown in Figure 3. A high percentage of clay is present immediately above the limestone, and the clay content gradually decreases toward the top of the section. The sand and silt

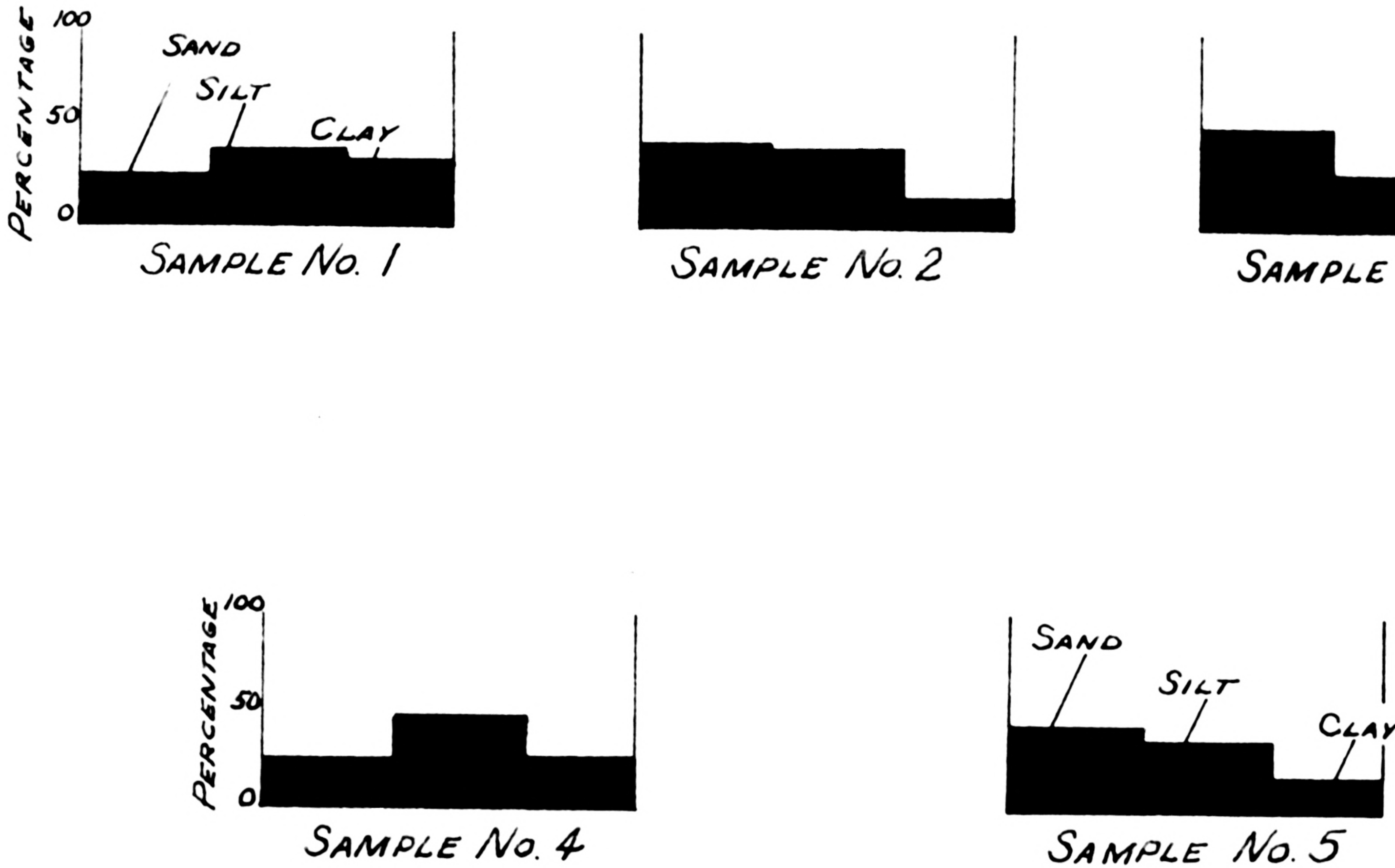


Cross Section Showing Test Hole Locations

Stag Hill Area SE ¼, NE ¼, S 23, T10S, R7E

Horizontal Scale not shown Vertical Scale 1" = 20'

Figure 2



Hydrometer Analysis of Samples Taken in SE¼, NE¼, S. 23, T 10S, R 7E

Figure 3

fractions increase, with the silt reaching a maximum in a gully one and one-half to two feet below the top of the exposure. The amount and lithologic characteristics of the sand fraction indicates a fluvial environment of deposition.

GEOMORPHIC HISTORY OF THE AREA

Tertiary

Climatic conditions in the Late Tertiary period were essentially the same as today, except that the relief was not quite as prominent. The Kansas River flowed eastward essentially in its same course, and it flowed over a fairly flat eastward sloping plain. Evidence for this is the lack of chert gravels on the divide areas in the Manhattan vicinity, but chert gravels on the high divides from Wamego to Kansas City indicate a pre-Pleistocene drainage much the same as it is today (Beck, 1959; Carlson & Davis, 1952). No material in the Manhattan area has been recognized as being pre-Pleistocene; however, some chert gravels on Stagg Hill could be considered as such.

Pleistocene Epoch

Introduction. With an increase in precipitation the world over and a general decrease in temperature, ice accumulated in an area south of Hudson's Bay in Canada, and formed the Labrador Ice Center. Ice accumulation also occurred north of present Lake Superior (Keewatin Ice Center), and on the east of the Canadian Rockies (Cordilleran Ice Center). The ice flowed in all directions from the center when the necessary thickness of ice was reached. Four major ice front advances occurred during the Pleistocene epoch in North America. The ice fronts would recede with temperature increases, and melt water from the glaciers deposited the material which the glaciers carried. Soil profiles developed on this material and these periods of increased temperature and soil development are termed interglacial stages. The Pleistocene stratigraphy of Kansas was described by Frye (1952), and was modified in 1961 by the State Geological Survey as follows:

- Pleistocene Epoch
  - Upper Pleistocene Subepoch
    - Recent
      - Dune sand
      - Alluvium
    - Wisconsinan Stage
      - Late Wisconsinan substage
        - Bignell soil
        - Bignell formation
        - Unnamed sand and gravel
      - Early Wisconsinan substage
        - Brady soil
        - Peoria formation
        - Unnamed sand and gravel
    - Sangamonian stage
      - Sangamon soil
    - Illinoisan stage
      - Loveland formation
      - Crete formation
    - Yarmouthian stage
      - Yarmouth soil
  - Lower Pleistocene subseries
    - Kansan stage
      - Sappa formation
      - Grand Island formation
      - Kansas till
      - Atchison formation
    - Nebraskan stage
      - Fullerton formation
      - Holdredge formation
      - Nebraska till
      - David City formation

Evidence of Nebraskan deposits in the Manhattan-Junction City area is for the most part absent, but material was undoubtedly deposited when the ice melted; however, because of the degrading action of the streams through the rest of the Pleistocene, the material has been almost entirely removed, with some high level gravels of possible Nebraskan or Tertiary age remaining.

Aftonian Interglacial. Extensive deposits of material carried by the advance of the glacier during Nebraskan time were deposited in North America. These deposits were laid down directly by the glacier or deposited by streams flowing from the glacier. With an increase in temperature, the ice front receded and more temperate conditions permitted the development of a soil profile called the Afton soil. Evidence for the Afton soil has not been found in this area.

Kansan Glacial Stage. With a decrease in temperature and an increase in precipitation, ice again accumulated in the Labrador region and began to flow. The advancement of the ice front was into the area of northeast Kansas during this stage, hence, the name Kansan. The ice front reached a limit extending from the Big Blue River on the west and the Kansas River on the south. Because of the damming effects of the ice, many marginal lakes were formed, Kaw Lake being the most extensive in this area (Smyth, 1898). The glacier deposited till in most of the northeastern sections of Kansas, but since the glacier did not extend as far southwestward as Manhattan, glacio-fluvial and fluvial deposits are the only evidence of the Kansan stage of glaciation that is represented in the Manhattan-Junction City vicinity. During Kansan time, the Kansas River was a degrading stream, eroding the material deposited during late Tertiary and Nebraskan time. This degrading was produced mainly by two processes: a great influx of water melting from the glacier, and a forebulge produced by the weight of the glacier, which increased the gradient of the Kansas River in the area. Deposits of drift of Kansan age are not found in the Kansas River Valley in this vicinity, since the ice front did not reach this far southwest; however, thick deposits of sand and gravel, nearly 150 feet above the present flood plain as in SE¼, NE¼ sec. 23, T. 10 S., R. 7 E., were deposited by glacio-fluvial action. As the ice front, during an increase in temperature, retreated, silt and clay was deposited upon the sands and gravels. The valley which has been cut by the Kansas River during this period was filled completely in this area because of the agrading action of the river.

Yarmouthian Interglacial. An increase in temperature caused the ice front to retreat and permitted sufficient time for a soil profile to develop in parts of Kansas. A record of the Yarmouth soil has not been preserved in this area, probably bedause of the erosion which took place during the following periods of degradation.

Illinoisan Stage. The advance of the ice front from the Labrador Center once more produced a period of glaciation in North America. Although the Illinoisan ice sheet was expansive, deposits direct from the ice such as drift are not present in Kansas. The climatic conditions, however, caused the streams away from the ice to be degrading streams, incising into the earlier deposited Kansas till and outwash. Local parent material was eroded and carried further down stream. As the temperature increased once more and precipitation began to diminish, streams began to aggrade instead of degrade. Coarse sands and gravels were deposited initially, and as runoff diminished further, finer material such as silt and clay was deposited on top of the sands and gravels. In the Kansas River Valley in this area, the surface of these deposits lies from 25 to 80 feet above the present flood plain, and have been named the Buck Creek terrace deposits.

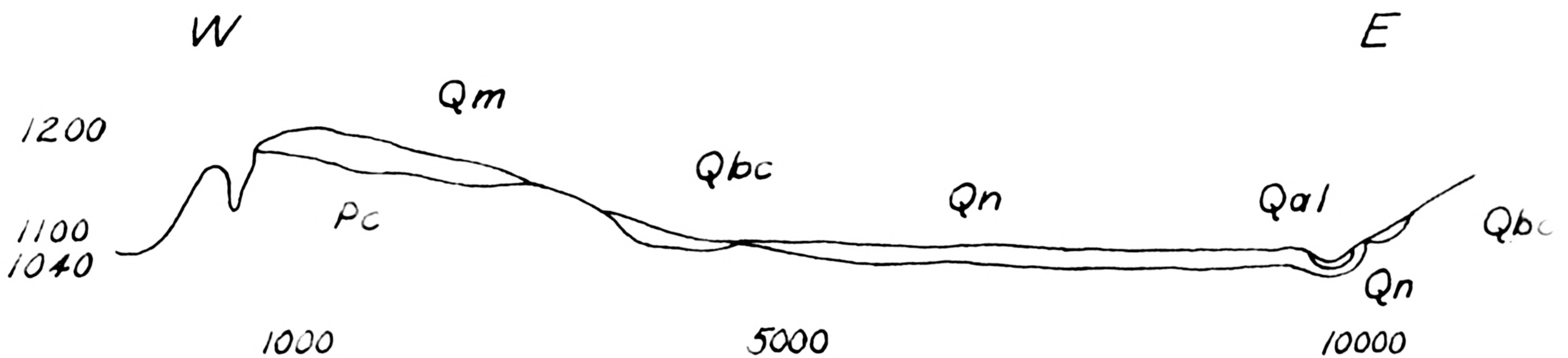
Sangamonian Interglacial Stage. Deposition eventually ceased and weathering processes began to form a weathered profile. The material in the river valleys was subject to much eolian action and, consequently, the silt and clay-sized particles were deposited on the higher divide areas in Kansas as loess. The Sangamon soil profile developed on the Loveland loess and is extensive in Kansas, but exposures of it were not found in this area. Deflation in the river valleys tends to carry the material to places of high relief and subsequent erosion has removed it from the area.

Wisconsinan Glacial Stage. The Wisconsinan stage, unlike the other three periods of glaciation, is characterized by two or more fluctuations in the advancement of the ice. Again a change from warm to cold and an increase in precipitation caused the ice sheet to advance. The ice did not reach Kansas, and consequently, material was not deposited as a direct result of the ice, but rather by fluvial action. The streams were degrading again with the change of temperature and precipitation and cut farther into their channels which had been filled with Illinoisan deposits. With warmer weather at the beginning of the Bradyan sub-age, however, streams began to aggrade, and sand and gravel were deposited followed by silt and clay deposition. A warmer climate induced vegetation, and a soil profile called Brady was developed upon the early Wisconsinan material. A change from warm to cold temperatures occurred again, and the streams began to degrade once more. Streams began to cut deeper into their established channels, and the material eroded was carried downstream. With warmer temperatures, the streams began to aggrade, and deposited this material. This was the last advance of the ice in North America and ended the Pleistocene epoch. The silt and clay-sized material deposited by fluvial action was deflated to the divide areas in Kansas forming the Peoria loess, but little evidence is present in this area for the establishment of this deposit. Hence, during Wisconsinan stage, because of two advances of the ice, two terrace levels have been formed, an early and late Wisconsinan. The former has been named the Newman, and as yet the latter has not been named. The Newman terrace level is readily distinguished in this area, but the late Wisconsinan is not as prominent, and has been included as part of the flood plain or alluvium. The gravel found in the Wisconsinan terrace deposits is composed for the most part of granitic and metamorphic rock fragments, indicating a more regional source area than for the Buck Creek and Menoken terrace deposits, which contain abundant chert gravels and some limestone fragments, indicating a more local genesis.

The Kansas River valley and its major tributary valleys are asymmetrical (Fig. 4) like a majority of the stream valleys in the northern hemisphere. The streams are on the right hand side of the valley throughout much of the area of this investigation.

GROUND WATER

Ground water can be explained as water occurring in the subsurface which is readily available for springs and wells. The water table is the geometric expression of the surface of the ground water level. The water table is a static surface and will fluctuate with an increase or decrease in the amount of discharge or recharge in any particular locale. The principles of ground water occurrence are not described here but are included in any bulletin published by the State Geological Survey on ground water. The depth to the water table in the alluvium in this area is approximately 17 feet with some minor



CROSS SECTION OF CLARKE CREEK VALLEY

SECTIONS 24, 25, 26, T11S, R6E

FIGURE 4

variations. The configuration of the water table from Manhattan west to Fort Riley, Kansas, is shown on Plate II. Lack of well data in Fort Riley prohibited drawing contours in that section of the valley.

Recharge in this area is accounted for by water in the form of precipitation percolating down through the soil profile to the water table. Recharge may occur other ways such as an influent stream but precipitation is the main source of recharging the ground water table.

Ground water occurs in plentiful amounts throughout the Kansas River Valley in all the Quaternary and Recent alluvium deposits. Its principal uses are domestic, stock and irrigation. Irrigation has flourished in the past ten years in this area and consequently many new irrigation wells are present. The majority of these wells are on the flood plain; however, there are a few located on the Newman and Buck Creek terrace levels. Those situated on the flood plain have an average depth of 47 feet but there are some as deep as 57 feet. Wells on the Newman and Buck Creek terraces are deeper, and are approximately 65 feet deep. All the irrigation wells are seated on bedrock and yield at least 750 gallons per minute, depending on the type of pump and the size of well.

Irrigation wells are in use on larger farms whereas most small plots and homes derive their domestic and stock supply from driven wells. This consists of a sand point being driven to the water table, and these are usually placed in the basement of the house when they are for domestic use. Small electric pumps or hand pumps are used to produce the water. There are very few dug wells in this area and those that are present are not used to any great extent.

The driven well is less expensive than the drilled well, however, the water at shallower depths is extremely hard and unpalatable to many. Water which is obtained at the bedrock contact is less hard and more suitable for domestic use, but for an ordinary household, a driven well would supply more than enough water for average consumption.

Practically all the Menoken terrace deposit mapped in this area lies either on the Ft. Riley Reservation or in the upland areas and consequently wells were not found to exist in this deposit. A minor source of water could be expected at a bedrock contact at the base of the Menoken gravels but this also would be dependent upon the topography of the particular locale.

Water is available in abundant quantities in the Kansas River Valley in this area and with controlled use in times of drought it could be expected to supply the area indefinitely for domestic, stock and irrigation uses.

SUMMARY

In the Manhattan-Junction City area of the Kansas River Valley, material deposited during the Quaternary period is represented by three distinct terrace levels: the Menoken (Kansan), Buck Creek (Illinoisan), and Newman (Wisconsinan). Glacial till is not present in this area, indicating that the ice had not

advanced to this region, or that erosion has completely removed any trace of the material. The former is thought to be the case.

The terrace levels have been identified mainly on the basis of their relative physiographic positions, and in part, on their lithology. The Illinoisan and Wisconsinan deposits are extensive throughout the area, and the Kansan terrace deposit is present on the divides in the area, usually from 150 to 200 feet above the present river channel. The Newman terrace deposits contain gravels of fragments of granitic and metamorphic rock, distinguishing it from the Kansan and Illinoisan deposits which contain abundant chert gravels.

Extensive dissection has eroded any evidence of a scarp on the Kansan deposits and in most cases, on the Illinoisan deposits. Alluvial fans have developed upon Buck Creek deposits. The Newman terrace has a well-defined escarpment the length of the valley on the north and south sides of the river, and is almost completely void of any dissection.

Oxidation of the Menoken and Buck Creek terrace deposits is well-defined, with the distinctive reddish-brown color, whereas the Wisconsinan material is predominantly medium to dark gray indicating a lack of oxidation.

CONCLUSIONS

The absence of pre-Pleistocene gravels on the high divide areas and the lack of buried soil profiles or other evidence of interglacial stages indicates that the gradient of the Kansas River was greater in this area than farther downstream. The Menoken terrace remnant lies approximately 150 feet higher in this area (SE¼, NE¼ sec. 23, T. 10 S., R. 7 E.), than the Menoken deposits described downstream, which also indicates a steeper gradient in this area. The Kansas River, in late Tertiary time, probably headed in the vicinity of Camps Whiteside or Funston on the Fort Riley reservation or even farther west. This is concluded because of the narrowness of the valley in this region which is barely over one mile. The narrowness may also be related to the lithologic change from the Council Grove to the Chase group. The topographic position of the material found on the high divide, and its lithologic character, indicates that it is a stream-laid deposit older than Illinoisan, and has been dated as Kansan. Topographic position has been the main criterion in establishing the age. The Kansas River Valley has degraded more extensively in this area than in the area it transverses to its junction with the Missouri at Kansas City. Lack of substantial evidence prohibits the identification of material connected with interglacial stages, and lack of fossil evidence prohibits the identification of a warm to cold to warm to cold to warm climatic condition, which existed during the Pleistocene and has been identified in other areas of the valley.

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PLEISTOCENE GEOLOGY AND GROUND WATER OF KANSAS RIVER VALLEY BETWEEN MANHATTAN AND JUNCTION CITY, KANSAS

by

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B. A., St. Joseph's College, 1960

AN ABSTRACT OF THE THESIS

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ABSTRACT

The purpose of this investigation was to reconstruct the geomorphic history of this segment of the Kansas River Valley and to determine the availability of ground water for domestic, stock and irrigation uses. This was accomplished by mapping the deposits of the Quaternary and Permian systems which comprise the river valley and the bluffs.

The area comprises approximately 100 square miles of fertile farmland with the main crops of alfalfa, corn and wheat. Irrigation is carried on extensively in the eastern sector but because of Fort Riley Military Reservation is not too extensive in the western half. Field mapping was accomplished by mapping the various contacts of the deposits on seven and one-half minute quadrangle sheets produced by the United States Geological Survey. Aerial photographs were used for reference but not as a direct means of mapping. Samples of various types were taken including the use of a power auger and these were analyzed by the hydrometer method to determine grain size relationships. Clay fractions of these samples were subjected to X-ray determination techniques in order to determine, if possible, distinguishing characteristics from various horizons. Cross-sections were drawn to point out stratigraphic relationships and the water table of the area was contoured in order to determine its oonfiguration.

The topography in this area of Kansas River Valley consists of an asymmetrical valley with a gentle rolling plain blanketed

with Quaternary sediments to the north and a sharp bedrock bluff to the south. The maximum elevation from the river to the bluffs approaches 200 feet. Bedrock consists of interbedded limestones and shales of the Council Grove and Chase groups of the Wolfcamp series, Permian system. These deposits dip gently to the west northwest at about 15 feet per mile. Other deposits include terrace deposits of Kansan, Illinoisan, and Wisconsinan age and Recent alluvium and dune sand. The Kansan deposits rest about 150-170 feet above the valley floor as in the Stag Hill area (SE¼, NE¼, Sec. 23, T. 10 S., R. 7 E.), and rest on bedrock, whereas the younger deposits lie in the river valley proper.

The Illinoisan and Wisconsinan terrace deposits and the alluvium provide adequate quantities of water suitable for irrigation, stock and domestic use throughout the valley. The deposits extend up tributary valleys which may be noted in Clarke Creek Valley (Sec. 24, 25, 26, T. 11 S., R. 6 E.) to the north and south to some extent. The water table at the time of this investigation was approximately 17 to 19 feet below ground level and the water is considerably hard. This water is used mainly for domestic and stock use and is reached by the use of a sand point. Irrigation wells have been drilled to bedrock at depths of 57 to 65 feet, and provide a plentiful source of water, permitting yields in excess of 750 gallons per minute, as reported by operators.

The significant lack of high level chert gravels in the divide areas, the narrowness of the river valley in the Camp Whiteside area and the elevation of the Kansan terrace deposits make this segment unique from the rest of the Kansas River Valley.

In summary, the area displays a subdued topography to the north and steep bluffs to the south. The Illinoisan and Wisconsinan deposits of Quaternary age are confined to the valley proper, and the Kansan terrace deposits are found on the divide areas. Bedrock consists of the Council Grove and Chase groups of the Permian system which dip gently west northwest. The principal water bearing sediments are the Illinoisan and Wisconsinan terrace deposits and Recent alluvium. This water is present in abundant quantities suitable for domestic, stock and irrigational uses.

PLATE I

AREAL GEOLOGIC MAP OF KANSAS RIVER VALLEY
BETWEEN MANHATTAN AND JUNCTION CITY, KANSAS

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PLATE II

Map Showing Water Table Contours, Test Hole and Well Locations

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