THE SURFICIAL GEOLOGY OF THE GUTHRIE NORTH QUADRANGLE, LOGAN COUNTY, OKLAHOMA

By

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Bachelor of Science

Illinois State University

Normal, Illinois

1973

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1975

THE SURFICIAL GEOLOGY OF THE GUTHRIE NORTH QUADRANGLE, LOGAN COUNTY, OKLAHOMA

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PREFACE

This thesis is a study of the geology of the Guthrie North Quadrangle, Logan County, Oklahoma--the main interest being the Quaternary alluvial, eolian, and colluvial deposits along the Cimarron River. To aid in the correlation of the alluvial deposits, cross sections and longitudinal profiles were prepared. Also, this thesis includes an environmental study of twelve square miles just to the north of Guthrie, Oklahoma.

The writer is grateful to many individuals who assisted him in this study. Dr. John E. Stone provided assistance in both the field work and writing aspects of this thesis. Thesis committee members, Dr. Gary F. Stewart, Dr. John D. Naff, and Dr. Douglas C. Kent, made helpful suggestions, comments, and criticisms of the study. The Oklahoma Geological Survey provided some field expenses during the summer of 1974. Finally, this thesis could never have been completed without the understanding, patience, sacrifices, and dedication of the writer's parents and, most importantly, his wife, Florence.

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ABSTRACT

The main objective of this thesis was the differentiation and the mapping of the surficial deposits along the Cimarron River in the Guthrie North Quadrangle, Oklahoma. The bedrock in the study area, consisting of parts of the Garber and Wellington Formations, was not differentiated because of the overriding interest in the surficial deposits and the poor exposure of bedrock. To aid in correlation of the alluvial deposits, a longitudinal profile of each terrace and the floodplain was constructed. Cross sections also were prepared to show the vertical relationships of the surficial deposits. There are five Quaternary alluvial deposits along the Cimarron River in central Oklahoma. In descending order they are: the Paradise Terrace Alluviam, the Summit View Terrace Alluvium, the Perkins Terrace Alluvium, the Lawrie Terrace Alluvium, and floodplain alluvium. The four terraces may be a result of cyclic climatic changes during the Pleistocene. The eolian deposits in the study area are comprised of dune sand of two ages and of loess. Colluvium is present on almost all of the hillsides, being thickest at the bases of slopes where it commonly interfingers with alluvium.

The usefulness of the surficial map of the Guthrie North Quadrangle, Oklahoma, is greatly enhanced by the environmental evaluation of each of the geologic units present. This will enable planners in the study area to make wiser decisions in regard to zoning and urban development. The same type of environmental evaluation also was made for the

soils in the study area. With these interpretations, several environmental maps of a twelve-square-mile area just north of the city of Guthrie, Oklahoma, were prepared.

INTRODUCTION

Most of the surficial geological studies in central Oklahoma have not stressed Quaternary deposits. In most cases these deposits have been ignored or, if mapped, have been undifferentiated. Most of these studies were concerned mainly with sedimentary bedrock because of the overriding economic importance of petroleum in Oklahoma. In recent years, however, there has been a growing concern with environmental geology and urban planning. Mapping of the surficial deposits is an important part of environmental geology, for all of Man's structures are built on, with, or through earth materials, generally surface or near-surface materials.

Objectives

The main objective of this thesis was to map and define the surficial geology of the Guthrie North Quadrangle, to arrange these surficial deposits into a stratigraphic sequence, and to relate them to the regional geological history of the Quaternary.

Another objective was to define some of the more important engineering properties of the soils and of the geology. This will be useful in intelligent environmental interpretations of the study area for use by engineers, planners, contractors, and others.

Location

The Guthrie North Quadrangle is located in the center of Logan County, Oklahoma (Figure 1) with the southern edge of the quadrangle about forty miles north of Oklahoma City, the capitol of the state. This area is accessible from the north and south by U. S. Highway 77 and Interstate Highway 35, and from east and west by way of State Highway 33. Two lines of the Atchison Topeka and Santa Fe Railroad are located in the quadrangle, with one crossing north-south at almost the center of the area, and the other branching off this line to the west at Guthrie. Guthrie, the Logan county seat, is located in the center of the southern edge of the quadrangle.

Previous Work

There have been very few surficial geologic studies in or around the Guthrie North Quadrangle, Oklahoma. F. L. Aurin, H. G. Officer, and C. N. Gould (1925, 1926) made regional studies correlating the Permian red-beds through Kansas, Oklahoma, and Texas. Joseph M. Patterson (1936) prepared a bedrock geologic map of Logan, Lincoln, and southern Payne counties. None of the above mentioned even the existence of extensive surficial deposits. The "Geologic Map of Oklahoma" (Miser and others, 1954), which emphasizes bedrock, shows some of the surficial deposits differentiated only as terrace or floodplain alluvium.

A surficial geologic map of the 1:250,000 Oklahoma City Quadrangle is being prepared by the Oklahoma Geological Survey and the U. S. Geological Survey. Again, bedrock is emphasized and those surficial

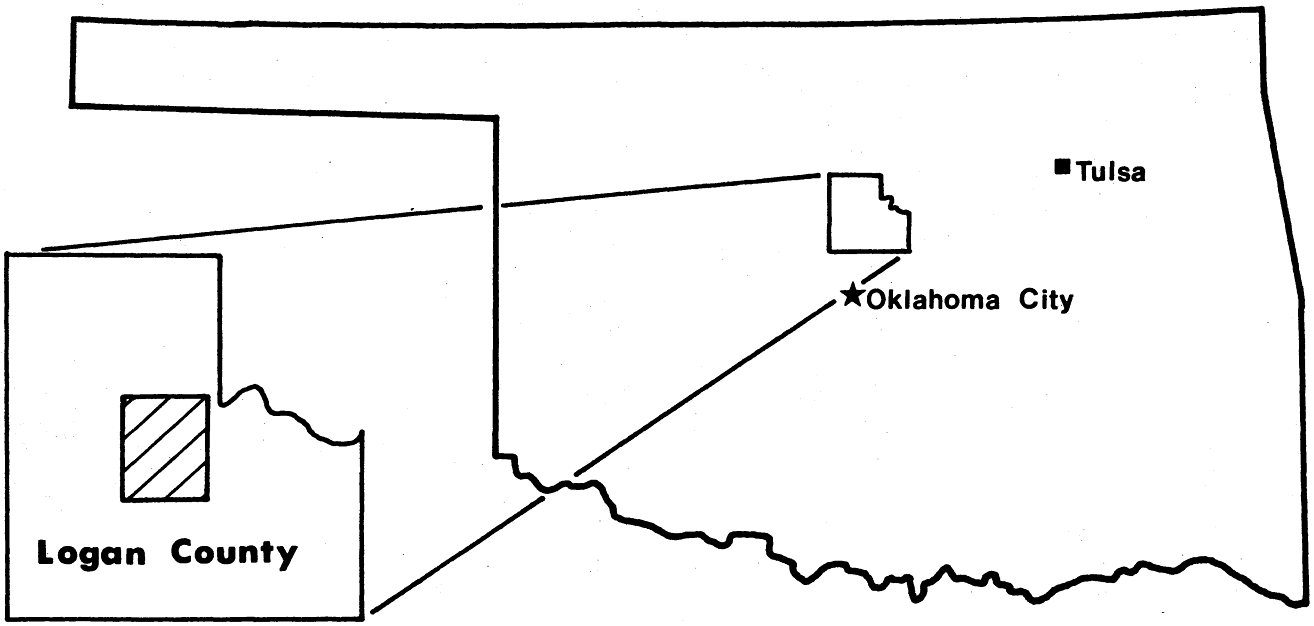


Figure 1. Map showing position of Logan County and the Guthrie North Quadrangle in Oklahoma

deposits that are mapped are shown either as terrace or as floodplain alluvium.

No previous studies have stressed Quaternary geology along the Cimarron River in central Oklahoma. In northwestern Oklahoma, however, geologic studies of Blaine and of Woods counties by Robert O. Fay do differentiate Quaternary deposits and discuss development of the Cimarron River there in some detail (Fay, 1962, 1965). There also have been Quaternary studies along the Cimarron River in Kansas in which the surficial deposits were described but not mapped (McLaughlin, 1949). John C. Frye and A. Bryon Leonard (Frye, 1948, 1954) have made several reconnaissance studies of the Quaternary geology of western Texas, Kansas, Oklahoma, and Nebraska.

The soils of the study area have been mapped at a scale of 1:20,000 by the Soil Conservation Service in the Logan County Soil Survey (Galloway, 1960).

REGIONAL GEOLOGY

The geology of central Oklahoma is dominated by gently westward dipping Permian red-beds of sandstone and shale overlying several thousand feet of older Paleozoic sediment. Several rivers cross the central Oklahoma area, leaving many surficial deposits in and along their valleys. Along the Cimarron River, these deposits are four terrace deposits, dune sand, loess, and floodplain alluvium.

The Arbuckle Mountains are about eighty miles south of the Guthrie North Quadrangle; to the east about ninety miles is the western flank of the Ozark dome; and to the southeast about one hundred and thirty miles are the Ouachita Mountains.

METHODS OF STUDY

The geology was mapped mainly through field work and airphoto interpretation. Only methods and techniques which are relatively uncommon and/or that are not readily referenced in the literature are described below.

The soil maps of the Logan County Soil Survey were helpful in the initial differentiation of the geologic units. Table 1 shows the parent material from which each soil is derived at most places. A common problem is that at many localities the parent material is colluvium and has not been recognized as such. This can be very misleading in determining the type of bedrock present.

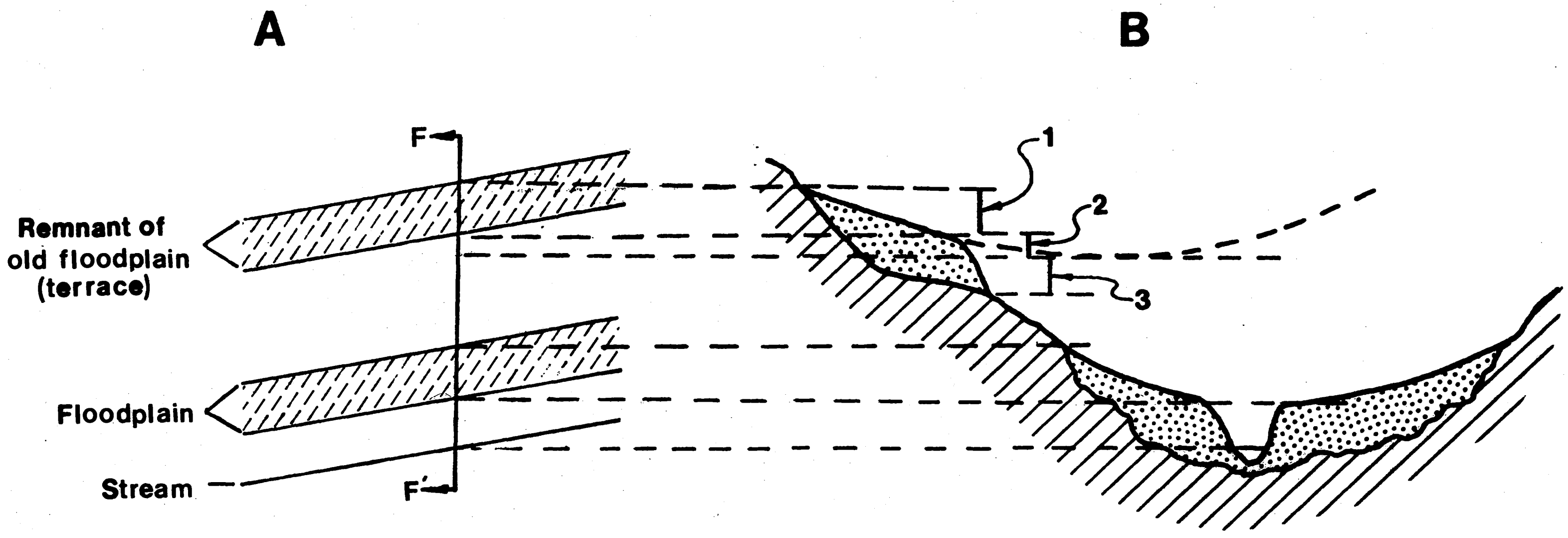
Terrace deposits were tentatively correlated on the basis of similarities in lithology and elevation above the Cimarron River. These correlations were refined with the aid of longitudinal profiles (Plate 3). A longitudinal profile is a projection of alluvial surfaces to a base line. An alluvial surface is a relatively planar surface which is assumed to represent the floodplain at the time of deposition of that terrace alluvium (Figure 2). Floodplains are not flat, however, but are concave in cross profile. The difference in elevation between the center and the sides (which commonly is 15-20 ft.) is plotted and correlated on the longitudinal profiles.

A rose diagram of the distribution of the bedrock joints was prepared by rounding off joint readings to the nearest compass direction

Table 1.--Soil-bedrock correlations in central Oklahoma

Soil Series	Probable Parent Material
Port	alluvium
Pulaski	alluvium
Mixed Alluvial	alluvium
Yahola	alluvium
Lincoln	dune sand
Bethany	terrace alluvium
Derby	dune sand
Teller	terrace alluvium
Vanoss	loess, terrace alluvium
Dougherty	dune sand
Minco	loess
Noble	colluvium
Norge	terrace alluvium
Reinach	terrace alluvium
Chickasha	sandstone
Darnell	sandstone
Lucien	sandstone
Stephenville	sandstone
Zaneis	sandstone interbedded with shale
Vernon	shale
Renfrow	shale
Kirkland	shale

Data extracted from Gray and Galloway (1960)



A - HYPOTHETICAL LONGITUDINAL PROFILE.

B - CROSS SECTION OF VALLEY AT F-F′ ON PROFILE.

1 Remnant of old floodplain.
2 Part of old floodplain that has been eroded away. } not plotted on profile.
3 Deposit below old floodplain. }

Figure 2. Diagram showing the relationship of a hypothetical longitudinal profile to a related cross-section

in multiples of ten (i.e., 10^o, 20^o, 30^o, etc.). Then the frequency at each ten degree bearing was scaled and plotted on the proper ray (Figure 6).

GEOMORPHOLOGY

Physiographically, central Logan County is located in the Osage Plains Section of the Central Lowlands Province (Hunt, 1967). This area is typified by rolling hills that have nonresistant shales in the valleys with more resistant lenticular sandstones on the hilltops.

Many unconsolidated deposits underlie the landscape of the study area. Four terraces border the Cimarron River with the higher and older ones being the more dissected. These terraces are described below in the order of formation. Sand dunes are common on the terraces and much of the uplands to the north and east of the river.

The entire quadrangle is within the drainage basin of the Cimarron River. Tributaries of the Cimarron River in the study area form a dendritic drainage pattern modified by some structural control by joints in the bedrock. This can be inferred by comparing the bearings of some of the stream segments in the northwest section of the map to the rose diagram of bedrock joints (Figure 6).

Paradise Terrace

The Paradise Terrace is the highest and the oldest terrace in the study area. It is located in the central portion of the quadrangle along the high divide between Skeleton Creek and the Cimarron River. Much of the surface of the Paradise Terrace either has been covered by dune sand or has been destroyed by erosion. From the longitudinal profile of the Paradise Terrace (Plate 3), the relief on the original floodplain can be estimated to have been about fifteen feet, and the gradient of the floodplain to be about three feet per mile. This terrace is located about forty feet above the next lower terrace, the Summit View Terrace. The location of the floodplain of the Cimarron River at the time of formation of the Paradise Terrace is shown in part on the paleo-floodplain map (Figure 3).

The formal name "Paradise Terrace" is taken from the Paradise Terrace Alluvium on which it was formed (Blair, 1975).

Summit View Terrace

The Summit View Terrace is the third terrace above the Cimarron River's floodplain. The colluvium from the Summit View Terrace Alluvium is quite distinctive, as it contains considerable gravel as much as four inches in diameter, which made the locating of this terrace easier. The profiling and correlation of the Summit View Terrace was much easier than that of the Paradise Terrace because of the presence of more deposits but was not without problems. The major problem was the presence of the large meander that kept the terraces on either side of it from correlating. This was solved by the addition of another part of the base line going around with the meander (see location map, Plate 3). This terrace is mostly covered with dune sand, which adds to the difficulty of the profiling. From the longitudinal profile (Plate 3) the relief on this floodplain can be estimated to have been about fifteen feet and the gradient to have been about three or four feet per mile. The Summit View Terrace is located about fifty feet above the Perkins Terrace.

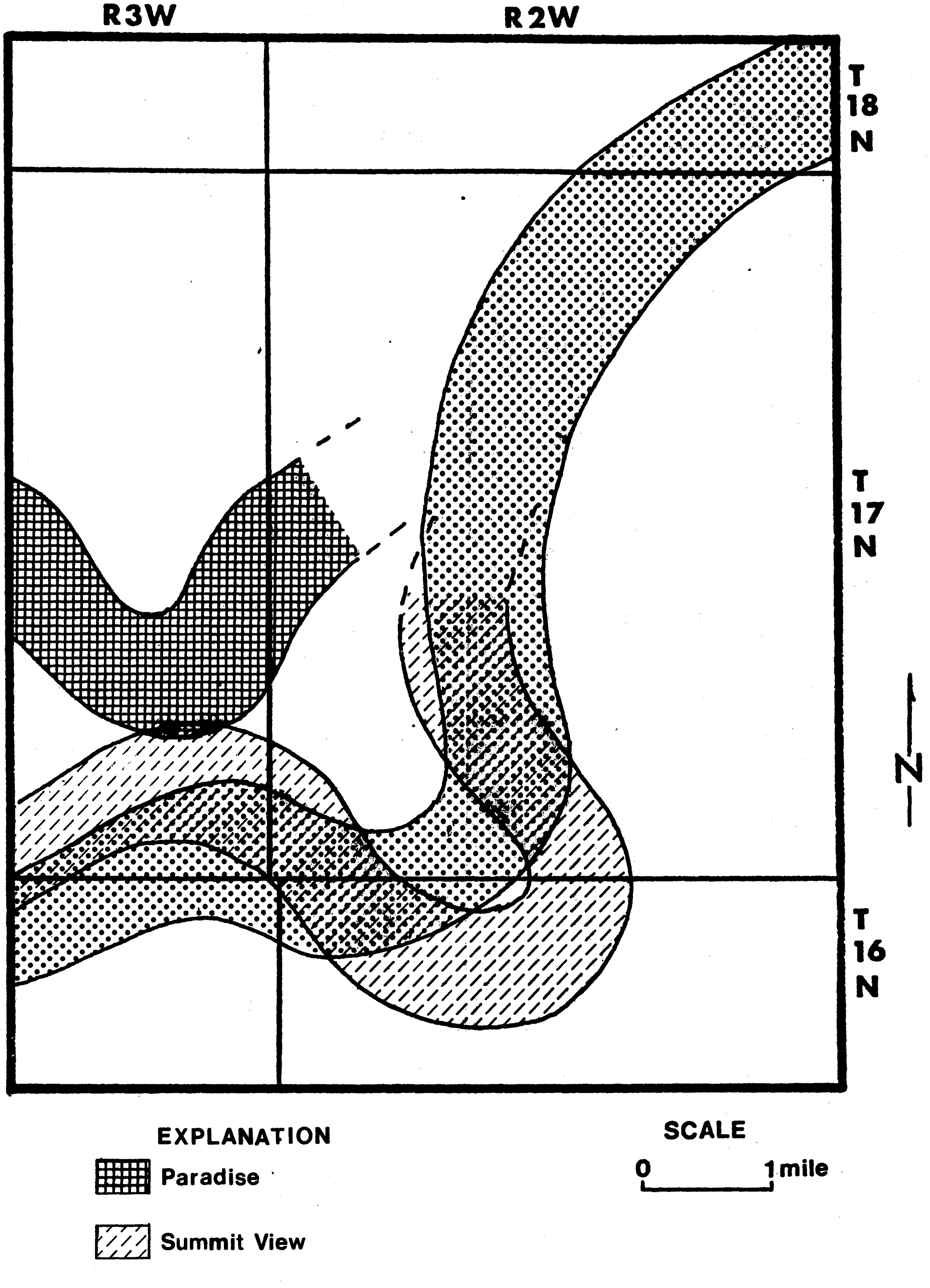


Figure 3. Paleo-floodplain map of the three uppermost terraces in the Guthrie North Quadrangle, Oklahoma

The formal name "Summit View Terrace" is taken from the Summit View Terrace Alluvium on which it was formed. The Summit View Terrace Alluvium is formally named in this paper (see Quaternary Stratigraphy).

Perkins Terrace

The Perkins Terrace is the most widespread of all of the terraces along the Cimarron River in the study area. It is located in many places along both sides of the Cimarron River (Plate 1). Although there is a large amount of dune sand covering this terrace, there were enough good surfaces so that the plotting of the longitudinal profile was easy. From the profile (Plate 3) it can be seen that the relief on the old floodplain was about fifteen feet and the gradient was about three feet per mile. The Perkins Terrace is about twenty-five feet above the present Cimarron River floodplain. There commonly is a well-formed riser between this terrace and the lower Lawrie Terrace or the present Cimarron floodplain.

The formal name "Perkins Terrace" is taken from the Perkins Terrace Alluvium on which it was formed (Blair, 1975).

Lawrie Terrace

The Lawrie Terrace is the lowest of the terraces present. It is located along both sides of the Cimarron River and up many of its tributaries. There are sand dunes present at many locations on this terrace along the Cimarron (Plate 1). From the profile it can be seen that the Lawrie Terrace has approximately the same relief, ten feet, and the same gradients, three feet per mile, as the present Cimarron floodplain. In most places a riser of about eight feet from the floodplain to the Lawrie Terrace is very well developed.

Along the Cottonwood and Pin Creeks, the Lawrie Terrace is rock defended near their confluences with the Cimarron River, so there is little or no floodplain at these locations (see Plate 1). The fact that the Lawrie Terrace is rock defended near the mounts of these creeks is supported by the exposure of bedrock (sandstone) in their channels near water level. This is also supported by the longitudinal profiles (see Plate 3) which show that the flats paralleling the creeks are the Lawrie Terrace, not floodplain.

The formal name "Lawrie Terrace" is taken from the Lawrie Terrace Alluvium on which it was formed. The Lawrie Terrace Alluvium is formally named in this paper (see Quaternary Stratigraphy).

Floodplain

The present Cimarron River floodplain has about ten feet of relief. The gradient of the floodplain is about three feet per mile, the same as the gradient of the river. Both Cottonwood and Pin Creeks have much steeper gradients than the Cimarron River, which would be expected because of the youthful nature. But as shown on the longitudinal profile (Plate 3), Skeleton Creek has a much lower gradient than the Cimarron River. This is probably due to the fact that the stream is cutting through shale as it flows parallel to strike of the bedrock.

Sand Dunes

Sand dunes are common in the study area of the floodplain, on the terraces, and in some of the upland areas. The largest dunes are developed on the surface of the old dune sand (see Quaternary

Stratigraphy), which is located mostly on the upland and the upper three terraces and is mostly on the north and east side of the river. There are several well-formed barchan sand dunes in the center of Section 17 and in the northwest corner of Section 20, T. 17N., R. 2W. An almost perfect parabolic sand dune can be seen in the SE¼ Section 8, T. 17N., R. 2E. These dunes and others on the study area show that the primary wind direction here at the time of their formation was from the south 15^{o} to 40^{o} west. This is essentially the prevailing wind direction today.

Smaller sand dunes are found on the lowest terrace and the present floodplain (see Plate 1). These dunes have developed in the young dune sand (see Quaternary Stratigraphy). They seldom have smooth gently sloping shapes as do the sand dunes developed on the old dune sand, but have somewhat erratic shapes which may be due to floodwaters deforming them.

BEDROCK STRATIGRAPHY

The bedrock in the Guthrie North Quadrangle is in the middle upper Permain System in the Leonardian Series (Patterson, 1936). There are about three hundred feet of exposed bedrock section on the study area.

Some geologists have divided the bedrock in the study area into two formations, the Wellington Formation overlain by the Garber Sandstone (Patterson, 1936; Gould and Officer, 1920). The author's initial plan was to map the two formations, but he was unable to agree with what was previously thought. This was due to the similar lenticular nature of these two formations. Because the emphasis of this thesis is with the Quaternary, and this is a bedrock correlation problem, the two formations were considered to be one mapping unit.

Wellington and Garber Formations

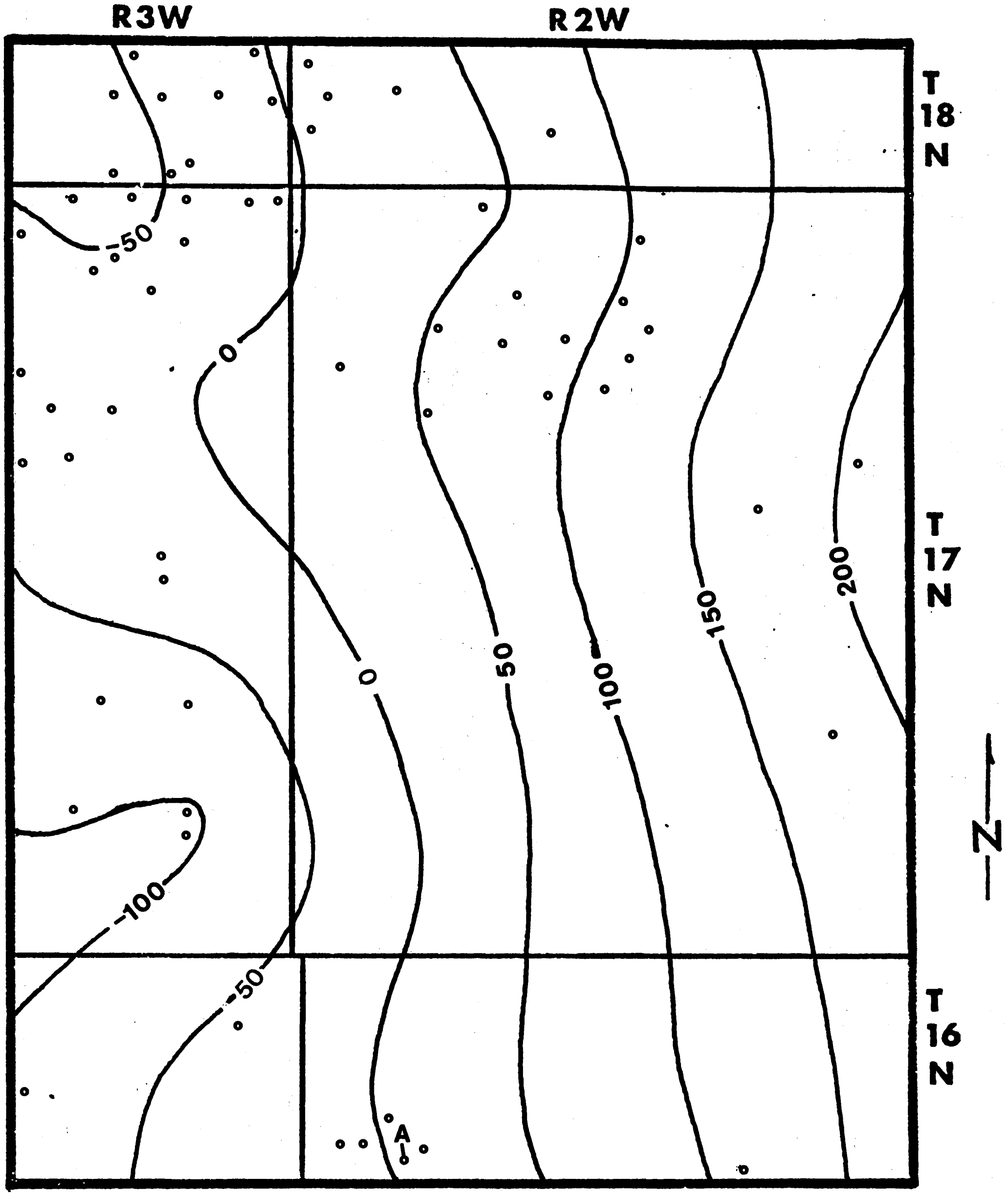
There are three main lithologies in the Wellington and Garber Formations, sandstones, shales, and clay-pebble conglomerates. The dominant lithology is sandstone. These sandstones are lenticular, and the lenses become more numerous upward in the section and to the south. These sandstones lenses range in thickness from two or three feet to as much as fifty feet and are as much as one mile wide. They are generally cross-bedded and are commonly calcareous. They are usually a very well sorted reddish-brown fine sand, but occasionally are white or light gray. The shales that are interbedded with the sandstone are usually red with an occasional light gray layer. They grade from soft blocky claystone to stratified silty shale. Within the shales there commonly are layers of small calcareous septarian concretions and/or iron concretions up to one inch in diameter. Commonly, there are lenses of clay pebble conglomerate just below a sandstone lense and above a shale. These clay-pebble conglomerates are seldom more than three feet thick. They are high in calcium carbonate, and contain rounded clay pebbles and fragments of the sandstone described above.

STRUCTURAL GEOLOGY

The bedrock in the study area dips to the west-southwest approximately forty-five feet per mile.

A structure contour map of the study area was prepared using electric logs (see Figure 4). The unit that was contoured is shown in Figure 5. It is the base of a limestone thought to be the Upper Permian Herington Limestone. From the structure map it can be seen that there is a fairly well developed nose trending to the west across the north central part of the area. To add to the accuracy of this map, approximately fifty control points around the outside of the study area were used during contouring.

Several hundred joint readings, made with a hand-held Bruton compass, shows two major sets of joints (N. 80^{o}W., N. 0^{o}W.) and the two minor sets of joints (N. 40^{o}W, N. 60^{o}E.) (see Figure 6). These coincide well with the directions determined by Melton (1929) during his study of joint patterns in central Oklahoma. He shows almost the same major and minor joint directions, and concludes that the fractures were formed in response to the stress fields developed during the folding of the Ouachita Mountains (Melton, 1929).



Datum: Mean Sea Level; Contour Interval: 50ft.

SCALE

0 1 mile

EXPANATION

∘ - Control Points from Electric Logs

A - Sample Log Location

Figure 4. Structure contour map of the base of a distinctive limestone, probably the Lower Permian Herington Limestone, in the Guthrie North Quadrangle

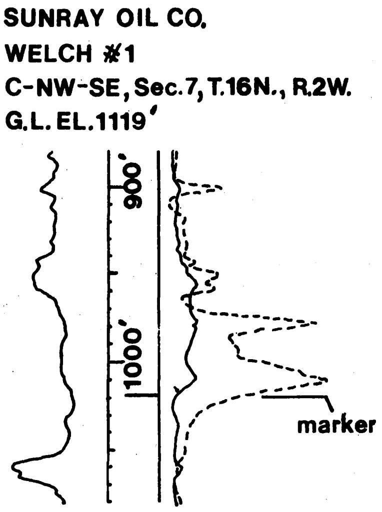


Figure 5. Portion of electric log showing the base of the Herington Limestone which was used in the development of the structure map of the Guthrie North Quadrangle, Oklahoma

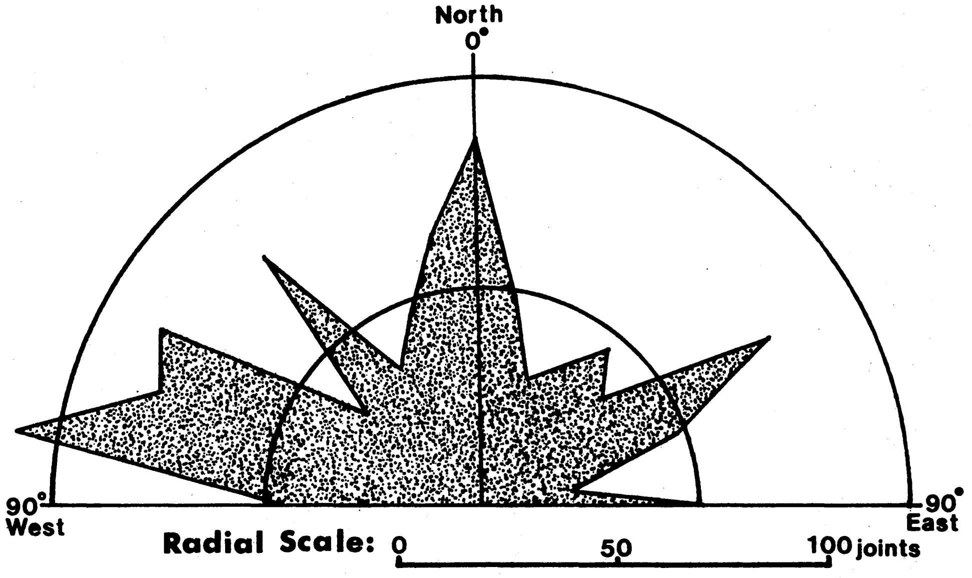


Figure 6. Rose diagram of a sample of joints in bedrock, Guthrie North Quadrangle, Oklahoma

QUATERNARY STRATIGRAPHY

The names used in the following discussions are based upon principles of stratigraphic nomenclature set forth by the Minnesota Geological Survey (Stone and others, 1966). The stratigraphic names of the terrace alluviums coincide with the formal geomorphic names used earlier in this paper.

The reader should refer periodically to the surficial geologic map (Plate 1) and to the cross sections (Plate 2) so that the distribution and the relationships of the deposits described in this section will be better understood.

Lag Gravel

Lag gravel are common on many of the higher stream divides in the study area. These generally are fairly large, ranging up to as much as six inches in diameter. All of the pebbles found by the author were iron-stained quartzite which appeared to be highly weathered. The staining and the fact that only quartzite samples were found is evidence that the gravel have been exposed for quite a long period of time. The origin of this gravel is controversial, but the author believes that they perhaps were once part of the conglomeratic Ogallala Formation that probably once extended across this area from the Rocky Mountains.

Paradise Terrace Alluvium

The Paradise Terrace Alluvium is a clayey fine-to-coarse grained sand with some quartzite gravel. The largest pebbles found are two to three inches in diameter. This terrace alluvium is the highest and oldest found in the study area. It typically is highly weathered and all but a few remnants have been eroded away.

This terrace deposit is approximately thirty feet thick at its maximum with as much as the upper two feet reworked by the wind. The base of the Paradise Terrace Alluvium is approximately two hundred and twenty feet above the Cimarron River floodplain. The Paradise Terrace Alluvium is commonly light tan-to-buff, but along the road that separates Section 14 and Section 15, T. 17N., R. 3W. there is an exposure in which a 2-foot light gray layer was found. This layer was sampled and X-rayed to determine the clay mineralogy (see Table 2). The predominant clay mineral present is sodium montmorillonite, which may be a weathering product of volcanic ash. If the clay is a weathering product of an ash, then this information will be very helpful in correlation (see Discussion). It commonly is thought that ash flows in terrace alluvium were deposited in backwaters or oxbow lakes (Frye, 1949). The author feels that this probably is the case here.

The name "Paradise Terrace Alluvium" is taken from the Paradise Cemetery which is located on this terrace alluvium approximately fifteen miles east of the study area (Blair, 1975).

Summit View Terrace Alluvium

The Summit View Terrace Alluvium is much more extensive than the

Table 2.--Percentages of clay minerals in alluvial deposits in the Guthrie North Quadrangle, Oklahoma (Ngah, 1974)

Alluvial Deposit	No. of Samples	Percentage of Each Clay Illite:Kaolinite: Montmorillonite
Paradise Terrace Alluvium	8	44:7:49
white layer	3	7:3:90
Summit View Terrace Alluvium	9	71:3:26
Perkins Terrace Alluvium	10	49:5:46
Lawrie Terrace Alluvium	6	54:9:37
Floodplain alluvium	7	37:7:56

Paradise Terrace Alluvium, but much of it is covered with dune sand (see Plate 1). The upper eight to ten feet of the Summit View Terrace Alluvium in most places is a moderately well sorted, medium sand that varies in color from buff to a dark red-brown, with the upper four inches to two feet generally having been reworked by the wind. In the SE¼ of Section 4, T. 16N., R 2W., there is a dark organic clay in the upper part of this terrace deposit which was probably deposited in an oxbow lake. It is probable that similar deposits occur erratically throughout this and the other alluvial deposits. The lower two to three feet of the Summit View Terrace Alluvium is a poorly sorted sandy gravel that is commonly iron-stained reddish-brown. The pebbles and cobbles present are quartzite with a few granitic types. They range from one to five inches in diameter, and the surface of each usually is stained brown to reddish-brown. At its maximum, this deposit is approximately thirty feet thick. The author hereby names the third terrace deposit up from the floodplain of the Cimarron River in central Oklahoma the Summit View Terrace Alluvium, after the Summit View Cemetery, two miles north of the city of Guthrie, Oklahoma, which lies on this deposit. This terrace alluvium is covered with dune sand in most localities; the best exposure is in the road ditch in front of the Summit View Cemetery.

Perkins Terrace Alluvium

The lower ten feet or so of the Perkins Terrace Alluvium is a moderately well-sorted coarse sand. This sand is cross-bedded and contains a few lenses of silt, gravel, and clay. It is commonly iron-stained reddish-brown, but in a few areas this alluvium was found to be unstained--being light brown. The upper ten to fifteen feet of this terrace alluvium is a moderately well sorted, reddish-brown silty fine sand, which probably is the source of the numerous loess deposits in the study area.

The Perkins Terrace Alluvium is well preserved along the Cimarron River in central Oklahoma. Much of this deposit is covered with dune sand but it is well exposed in many road cuts and stream valleys (see Plate 1).

About six miles west of the study are there was a specimen of a saber-tooth cat found in a sandpit in the Perkins Terrace Alluvium. The significance of this as it relates to dating of this terrace alluvium will be discussed later in this paper.

The name "Perkins Terrace Alluvium" has been used informally for several years by geologists in central Oklahoma. The name is derived from the town of Perkins, Oklahoma, which is located on this deposit approximately twenty miles east of the study area (Blair, 1975).

Lawrie Terrace Alluvium

The Lawrie Terrace Alluvium is a moderately well sorted buff to reddish-brown medium sand. In some localities it is variable with occasional lenses of clay, silt, or gravel, and in many areas the upper four inches to two feet have been reworked by the wind.

The Lawrie Terrace Alluvium is the most extensive of all those present in the study area (see Plate 1). The maximum thickness of the deposit is about thirty-five feet. This terrace deposit also is present along several of the tributary streams near the Cimarron River. Here, however, it is a very well sorted fine sand or silty clay. This significant difference in lithology is due to the fact that the terrace alluvium found along the tributary streams was derived from the local bedrock, while the terrace alluvium along the Cimarron River has been derived from all of the geologic units between the study area and from the Rocky Mountains.

The author hereby names the first terrace deposit up from the floodplain of the Cimarron River in central Oklahoma the "Lawrie Terrace Alluvium" after Lawrie Creek, which crosses this terrace in the Guthrie Quadrangle. Exposures of this terrace alluvium are almost nonexistent but may be observed in excavations such as a sandpit, or in borings.

Floodplain Alluvium

Floodplain alluvium is found beneath the floodplains of the Cimarron River and its tributaries in the study area. Along the Cimarron the floodplain alluvium is a light to dark reddish-brown fine to coarse sand, with some beds and lenses of silt, clay, and gravel. In some places the upper four inches to two feet of the deposit have been reworked by the wind. It is typically cross-bedded or horizontally bedded.

Along the floodplains of the smaller tributary streams, alluvium usually is a reddish-brown silty or clayey fine sand. The depth of the floodplain alluvium along the tributary streams is highly variable, with a maximum of fifteen feet. It is generally deepest beneath the middle of the tributary floodplains and deepens as one approaches the Cimarron River.

The floodplain alluvium has probably cut into but no deeper than the Lawrie Terrace Alluvium, as shown in cross-section Y-Y''' (Plate 2).

Borings in the Lawrie Terrace Alluvium show a maximum thickness of 34 to 36 feet, and borings in the floodplain alluvium, outside of what probably was the floodplain of the Lawrie Terrace Alluvium, show a maximum thickness of 20 feet. Taking into account the riser of about eight feet, the base of the Lawrie Terrace Alluvium probably extends about six to eight feet below that of the floodplain alluvium. The floodplain alluvium of the Cimarron River is much like that of the Lawrie Terrace Alluvium lithologically, adding to the difficulty of determining the true maximum thickness of this deposit.

Old Dune Sand

Old dune sand is found on some of the uplands near the Cimarron River, but mostly overlying the upper three terrace deposits (see Plate 1). It typically is a rather well sorted yellow-brown medium sand. The maximum thickness is approximately thirty feet. The most diagnostic feature of the old dune sand is a well developed soil that commonly has a multible "B" horizon called lamellae. These lamellae usually are two-inch layers of red clayey sand that are separated by about six to eight inches of clean sand. They are roughly horizontal and in some places are discontinuous. Several explanations for these lamellae, from a varying water table to differences in initial deposition (Gray, 1969), have been suggested, but none really is are satisfactory.

Most of the sand in the bedrock and in the alluvial deposits in the study area is stained reddish-brown by iron oxide coatings. As the wind blows the sand around, it tends to knock off most of the iron oxide, so dune sand is much cleaner than the alluvial deposits. The lack of iron oxide coatings and good sorting were used in differentiating the eolian sand from alluvium.

Young Dune Sand

Young dune sand is located mostly on the Lawrie Terrace and the floodplain of the Cimarron River. Young dune sand has less soil development and is heaped into sand dunes that are smaller, steeper, and more irregular than those composed of old dune sand. This dune sand typically is a rather well sorted medium sand.

In a floodplain environment such as that of the Cimarron River, sand is winnowed from the river alluvium forming dunes in the bed or on the bordering areas (Fairbridge, 1968).

Loess

By classical definition, loess is a largely homogenous, unstratified silt. But this definition is no longer completely accepted for "true" loess (Fairbridge, 1968). As in some places in the study area, loess can be finely stratified with a small amount of fine sand and clay. Calcium carbonate concretions which are indications of leaching are common approximately ten feet below the surface of the loess.

A thin veneer of loess is draped over much of the study area, but only those deposits in excess of two feet were mapped. Some of the deposits of loess (see Plate 1) are in excess of fifteen feet thick. Loess would be expected on the north or east sides of the river, due to the prevailing southwest winds in the area, but in the southwestern portion of the map, loess was found south of the river (see Plate 1). This occurrence probably is explained by the fact that the wind in the area in the Pleistocene, as today, blows a substantial amount from the north.

The major source for the loess probably was the Cimarron River during the time the Perkins Terrace Alluvium was being deposited. This is hypothesized because it has a substantial amount of silt in its upper ten feet or so. This subject will be pursued later in this paper.

Colluvium

Colluvium probably is the most extensive surface deposit in the study area. Along the margins of the stream valleys, colluvium is likely to interfinger with alluvium (Lattman, 1960). The stream-transported detritus and colluvium are not always easy to distinguish unless angular debris is present, but it typically is highly weathered, has a "cruddy" appearance with iron oxide and manganese oxide staining and concretions, and has a slaty structure. The presence of angular fragments, especially on slopes, nearly always indicates colluvium. Colluvium is present on almost every slope in the area. It ranges from just a few inches to as much as seven feet, but it was not mapped where it was less than two feet thick.

The author divided colluvium into three categories: fine colluvium, coarse colluvium, and terrace colluvium. Fine colluvium and coarse colluvium are both derived entirely from the bedrock material upslope, and terrace colluvium is derived either wholly or in part from terrace alluvium. The texture and composition of the colluvium vary with the texture and composition of the upslope material.

Fine colluvium is a reddish-brown clayey to silty sand with small fragments of shale (<.5 in.) and/or some sandstone fragments up to one foot in diameter. Coarse colluvium is a reddish-brown clayey to silty sand with small fragments of shale (<.5 in.) and sandstone fragments including many blocks more than one foot in diameter. Terrace colluvium is a reddish-brown medium to coarse sand that in some areas may be mixed with either fine colluvium or coarse colluvium.

Artificial Fill

These are the most recent of all deposits on the study area. These are man-made and usually are a product of some engineering works such as railroads, highways, or earthen dams. The earthen dams are so numerous that it was decided not to map some of the smaller ones, especially since such structures are so obvious. The Guthrie Sanitary Landfill is a special artificial deposit which consists of garbage and trash that has been covered utilizing nearby surficial deposits.

DISCUSSION

Differentiation of Dune Sand

Dune sands of two ages were differentiated on the basis of morphology, soil development, and elevation above the Cimarron River. Young dune sand, which occurs mostly on the Lawrie Terrace and on the floodplain of the Cimarron, probably was deposited during the development of both of these. Old dune sand is thought to have been deposited largely during the time the Perkins Terrace was the floodplain of the Cimarron, since most of the old dune sand lies on this terrace and since there is no highly weathered dune sand of old dune sand type found on the lower (younger) alluvial deposits. During the times the Paradise and Summit View Terraces were floodplains of the Cimarron, there probably were episodes of dune sand deposition, but if so, they probably were covered in most places by younger eolian sand of Perkins age. Thus, the differentiation of the dune sands into more than two units was considered to be beyond the scope of this thesis if, indeed, it is possible.

Loess Deposition

The author was unable to recognize more than one unit of loess in the Guthrie Quadrangle. Although there may be more than one, no paleosols or leached zones were observed within the loess. This would seem to indicate that the loess may have been deposited fairly continuously during one episode.

The source of this loess undoubtedly was the Cimarron River, but the question of when it was deposited is less easily answered. Only one terrace alluvium has an extensive amount of silt in the upper part, and that is the Perkins Terrace Alluvium. The loess, therefore, is thought to have been deposited during or after the time of deposition of the upper part of this terrace deposit. Also, the ten feet of leaching that has occurred in the loess would indicate a fairly long time of weathering.

Age of Terrace Deposits

Four terrace deposits were mapped in the study area. Farther upriver in Blaine and Woods Counties, Robert O. Fay mapped three terraces along the Cimarron (Fay, 1962, 1965). It is difficult to say how these terraces correlate with those found by the author without constructing a longitudinal profile between the two areas. The four terraces may be due primarily to the cyclic changes in the climate that accompanied the glacial periods (Thornbury, 1967). Using the rationale of the Huntington Principle which states that valley degradation takes place in wet climates and aggradation takes place in dry climates (Fairbridge, 1968), it would seem logical that the cyclic climatic changes could cause this terrace succession.

Two items were used in the relative dating of the Quaternary deposits. The montmorillonitic clay layer found in the Paradise Terrace Alluvium may be altered ash. So far, the youngest ash that has been found in Oklahoma is thought to be the Pearlette ash, which is Kansan in age (Frye, and others, 1948). If this light layer of montmorillonitic clay is altered from ash, then the Paradise Terrace may be older than Kansan, since the Pearlette ash commonly is unaltered. On the other hand, this particular deposit may be the Pearlette or even a younger ash that has been better exposed to weathering than most deposits of the Pearlette.

The skull of a saber-toothed cat has been found in a sandpit in the Perkins Terrace Alluvium. This particular species, Smilodon californicus, is thought to be no older than Illinoian (Kitts, 1958). If this is true, then the Perkins Terrace Alluvium was deposited during or after the Illinoian.

The evidence that exists, though certainly not conclusive, suggests that the four terraces (and the related deposits) correspond to the four cycles of the Pleistocene since the oldest of the terraces may be older than Kansan and the ~~third~~ second oldest terrace (the Perkins Terrace) could be Illinoian.

The uncertainty of such tentative correlations as the above is dramatized by the fact that about six miles east of the study area there are two well developed paleosols within the Perkins Terrace Alluvium. These indicate, of course, long periods of non-deposition followed by deposition. It is possible that similar episodes are recorded somewhere within each terrace alluviums.

GEOLOGICAL HISTORY

The history of the geological units exposed in the Guthrie North Quadrangle begins with the deposition of the Garber and Wellington Formations in a deltaic environment during the Late Permian time. Younger Paleozoic and possibly Mesozoic rocks were deposited above the Garber and Wellington Formations, but any that were deposited have been eroded away.

During the Pliocene Epoch, the conglomeratic Ogallala Formation was deposited as an enormous alluvial apron spreading eastward from the Rocky Mountains. This is thought to have extended over the study area, accounting for the lag gravels found on the uplands at many localities.

During the Pleistocene, the ancestral Cimarron River, which probably had contributed to the deposition of the Ogallala, undoubtedly participated in the major episode of erosion which removed the Ogallala (and probably considerable bedrock as well) from the area east of the present-day High Plains. Later in the Pleistocene, the Cimarron River alternately eroded and aggraded, producing the Quaternary deposits (and related geomorphic features) described herein. The four alluvial terraces probably are a result of cyclic climatic changes which were associated with the glacial and interglacial ages of the Pleistocene. During the times of humid, temperate climates, the river probably was downcutting. During drier and probably cooler climate, the river probably was depositing alluvium in a broadening floodplain.

Dune sand and loess deposition probably also were related to the cyclic climate changes. Dune sand probably was deposited during each of the drier climatic episodes. The oldest dune sand that can be differentiated probably was deposited, for the most part, during the dry latter part of the deposition of the Perkins Terrace Alluvium, as described in the section entitled "Discussion." As the southwest winds blew the sand from the alluvium into dunes, the lighter silt was deposited on the uplands around the river as loess.

During the Holocene, the Cimarron River has been depositing alluvium in its present floodplain. The smaller and younger sand dunes on the Lawrie Terrace and the floodplain were formed by southwest winds during a relatively recent arid episode, perhaps during the Hypsithermal.

Within the last hundred years, Man probably has been the most active agent of both erosion and deposition in the Guthrie Quadrangle. Erosion has been in the form of road cuts and other excavations and deposition has been in the form of artificial fills, such as dams and road fills.

ENVIRONMENTAL GEOLOGY

Environmental geology is the application of the knowledge of geological conditions to the most adequate land use. This section deals with three of the more important aspects of environmental geology, engineering geology, soils, and hydrogeology.

Engineering Geology

Several geological factors affect engineering projects in the study area. Contact seeps and springs are common (see Figure 8). When the foundation of a house or other building is in a shale below a seep or a spring, heaving is intensified due to the periodic wetting of the shale. There also are problems when a paved road crosses a spring or a seep. Cracking and weakening of the road surface is a result of the swelling of the clays. The strength of the shale will decrease greatly with the addition of water, and increase the possibility of slope failures. In many areas in central Oklahoma, such simple-sounding problems as these have cost taxpayers hundreds of thousands of dollars. The best way to handle seeps and springs is by means of a drain to intercept the water before it gets to a place where it can cause problems.

Another potential problem in the study area is the stability of slopes underlain by fairly thick accumulations of colluvium. The contact between colluvium and underlying bedrock is a common location of slope failures. Failures are especially likely after a rain when water

Table 3.--An environmental evaluation of the surficial geologic units in the Guthrie North Quadrangle, Oklahoma

	Floodplain Alluvium along Cimarron	Floodplain Alluvium along tributaries	Lawrie Terrace Alluvium	Perkins Terrace Alluvium	Summit View Terrace Alluvium	Paradise Terrace Alluvium	Young Dune Sand	Old Dune Sand	Loess	Colluvium	Garber and Wellington Formations	
											Shale	Sandstone
PROPERTIES												
1. Shrink-Swell	L	M	L	L	L	L	L	L	L	L-H	H	L
2. Permeability	H	M-H	M	H	M	M	H	M	M	L	L	H
3. PH	M-H	M-H	M	M	M	M	M	M	M-H	M	M-H	L
4. Rippability											H	M
5. Flooding	H	H	M	L	L	L	M	L	L	L-M	L	L
6. Corrosivity uncoated steel	L	M	L	M	M	M	L	L	L	L	M	L
concrete	L	M	L	M	M	M	L	M	L	L	L	L
APPLICATIONS												
1. Septic tank absorption field	-	-	+	+	+	+	-	+	+	+	-	o
2. Landfill	-	-	-	o	+	+	-	o	+	-	-	o
3. Landfill cover material source	+	+	+	+	+	+	+	o	+	o	-	o
4. Sewage lagoon	-	-	-	-	-	o	-	-	-	o	+	-
5. Shallow excavations	-	-	+	+	+	+	o	o	+	+	-	-
6. Dwellings with a basement	-	-	-	+	+	+	-	+	o	-	-	o
7. Dwellings without a basement	-	-	-	+	+	+	-	+	o	-	-	o
8. Buried utilities	+	o	+	o	o	o	+	+	+	o	o	o

H = high
M = medium
L = low

+ = good
o = fair
- = poor

has increased the unit weight of the colluvium and has reduced its shear strength. This problem is greatest where cuts are made on hillsides, as is common in road construction. The possibility of slope failures is reduced when either the slopes are cut back to a more gentle angle or retaining walls are used in conjunction with drains.

Table 3 shows engineering evaluations of the surficial geologic units in the study area, the distribution of which is shown in Plate 1. The values were obtained by evaluating the factors that pertain to each property or activity in Table 3 (see Appendix for discussion of factors that were considered). The data shown in Table 3 are based in part upon interpretation and judgement. Furthermore, because of the scale of mapping used, small variations in the distribution of some deposits could not be shown even if they were identified. It should be emphasized, therefore, that site investigations should be carried out prior to any construction.

Soils

An environmental study based on pedologic soils was made of twelve square miles immediately north of Guthrie, Oklahoma (see Figure 7). This area was chosen because of the likelihood of urban development in the near future. The purposes of the study were to:

1) give the author experience in using soils information for environmental purposes

2) to compare the utility of soils mapping and of geologic mapping, and

3) to evaluate the accuracy of the soil mapping in the light of geologic mapping.

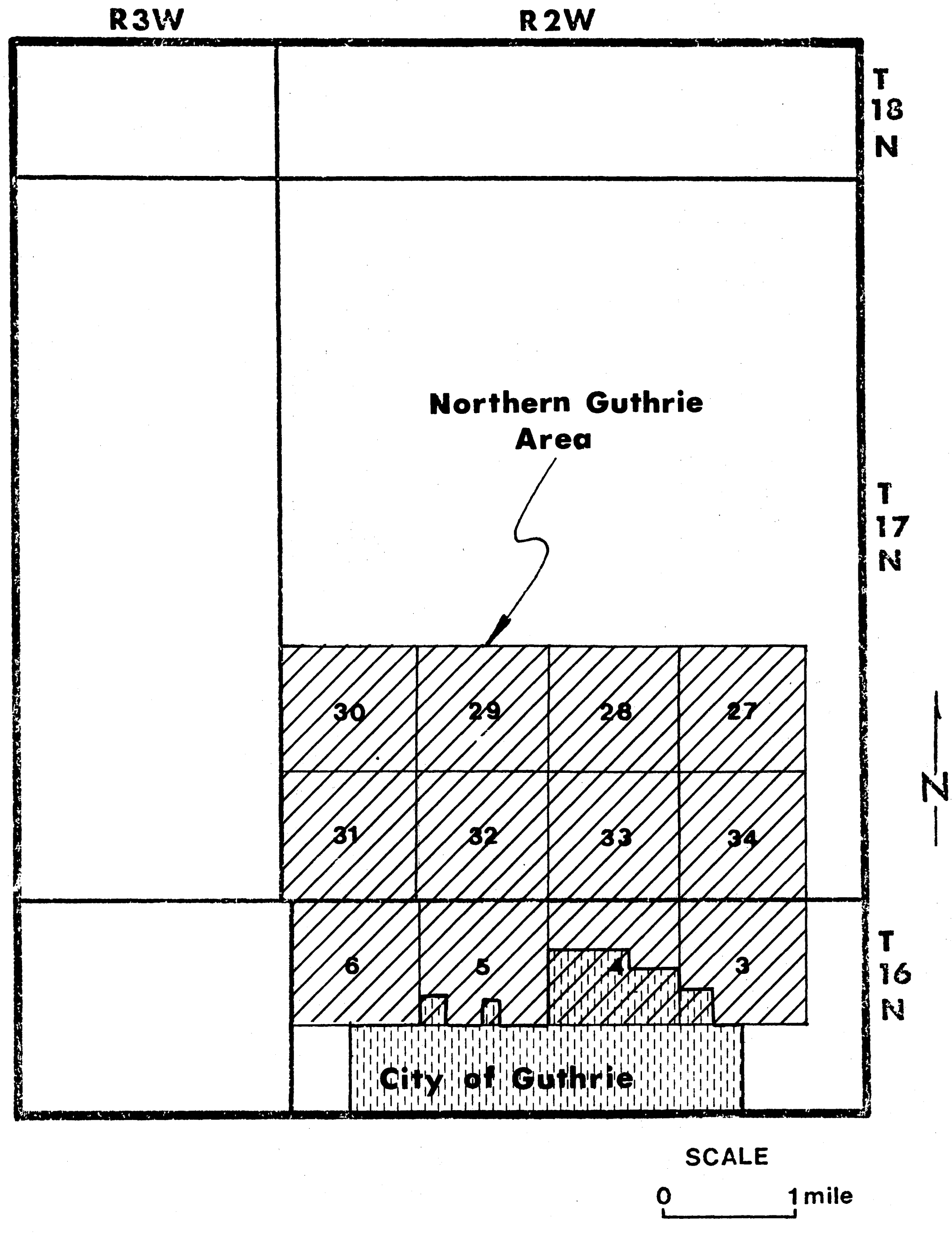


Figure 7. Map showing positions of the city of Guthrie and of the northern Guthrie area in the Guthrie North Quadrangle, Oklahoma

Table 4.--An environmental evaluation of the soils present in the Guthrie North Quadrangle, Oklahoma

	Recent Deposits					Other Unconsolidated Deposits									Sandstone and Shale					Shale		
	Port	Pulaski	Mixed Alluvial	Yahola	Lincoln	Bethany	Derby	Teller	Vanoss	Dougherty	Minco	Noble	Norge	Reinarch	Chickasha	Darnell	Lecien	Stephenville	Zaneis	Vernon	Renfrow	Kirkland
PROPERTIES																						
1 Shrink-Swell	M	L	L	L	L	M	L	L	M	L	L	L	M	L	L	L	L	L	M	M	H	H
2 Permeability	H	H	H	H	H	M	H	M	M	M	M	L	M	M	M	H	H	M	M	L	L	L
3 PH	M-H	M	M-H	M-H	M-H	M	M	M	L	L	M-H	M	M	M	M	L	M-H	L	M	M-H	M-H	M-H
4 Depth to Rock	H	H	H	H	H	H	H	H	H	H	H	H	H	H	M	L	L	M	M	L	M	M
5 Flooding	H	H	H	H	M	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L
6 Corrosivity uncoated steel	M	L	L	L	L	H	L	L	M	L	L	L	M	L	M	L	L	M	M	H	M	H
concrete	L	M	L	L	L	L	M	M	M	M	L	L	L	L	L	L	L	L	M	L	L	L
APPLICATIONS																						
1 Septic tank absorption field	-	-	-	-	-	-	-	+	+	+	+	+	-	+	o	-	-	-	-	-	-	-
2 Landfill	-	-	-	-	-	o	-	+	+	o	+	-	o	-	o	-	-	-	o	-	-	-
3 Landfill cover material source	+	+	+	+	+	-	-	+	o	o	+	+	o	+	+	-	-	-	o	-	-	-
4 Sewage lagoon	-	-	-	-	-	+	-	-	o	-	o	-	+	-	o	-	-	-	o	+	+	+
5 Shallow excavations	-	-	-	-	-	+	o	+	+	o	+	+	+	+	+	-	-	-	+	-	-	-
6 Dwellings with a basement	-	-	-	-	-	-	+	+	o	+	o	+	o	-	+	o	o	o	o	-	-	-
7 Dwellings without a basement	-	-	-	-	-	-	+	+	o	+	o	+	o	-	+	-	-	-	o	-	-	-
8 Buried utilities	o	o	+	+	+	-	+	o	o	+	+	+	o	+	o	-	o	+	o	-	o	-

H = high
M = medium
L = low

+ = good
o = fair
- = poor

Much of the United States has been mapped pedologically by the Soil Conservation Service. Although this originally was intended for agricultural purposes, these maps can be very useful for non-agricultural planning and development; however, caution should be used in relying on the soil maps blindly. Many times, geological maps can show the small inaccuracy in some soil maps which will aid in the environmental evaluation of an area. For example, a common mistake on soil maps is the mapping of a residual soil when a colluvial soil is present.

The soils present in the northern Guthrie area were evaluated environmentally (Table 4), and the evaluation is similar to the one developed for the geologic units in the previous section. The limits used in the determination of the values found in Table 4 are presented in the Appendix.

Interpretative Maps

Using the soil map of the northern Guthrie area (Plate 4) along with the environmental evaluation of each soil (Table 4), many useful interpretations of this area can be made. But this procedure does not give the lay person a quick idea of the extent of a certain variable. To see the problem areas in a glance, it often is necessary to prepare a map of one variable such as depth to bedrock, flooding-prone areas, permeability, and the like. See Table 4 for other factors that could be mapped.

Plate 5 is an example of an environmental map, based on soils, that shows only one property--shrink-swell potential over the northern Guthrie area. If only one property is of concern for a certain project, this type of map can be used quite effectively to pinpoint areas of high or low values. This map would be used if an individual were looking for a building site where the soil would not cause extensive cracking of the foundation. One must remember, however, that this is only one property, and that many others should be considered in the choosing of a building site. Such a map, furthermore, does not preclude the building of a structure in areas rated as high or moderate, but problems certainly will occur in such areas unless special precautions (often expensive) are taken.

Plate 6 shows relative suitabilities for single-story structures in the northern Guthrie area. This type of environmental map is useful in locating areas suitable for urban development without looking at each individual property. It should be stressed that site investigations should be carried out prior to any construction.

Hydrogeology

Even though this part of Oklahoma receives an average of thirty-two inches of rain per year, droughts during the recent past have caused water to be scarce. In the study area, most of the water for domestic and municipal purposes is obtained from the Garber Sandstone, Cimarron alluvial deposits, Cimarron River, and Liberty Lake. Table 5 shows a comparison of these different sources.

Ground Water

The main bedrock aquifer in the study area is the lenticular Garber Sandstone. It is not a very good aquifer especially to the north, because of increased shalyness. The Garber Sandstone yields approximately

100 to 250 gpm near Oklahoma City, but around Guthrie, the best that can be expected is about 10 gpm. In most places the Garber is an adequate source for water for homesteads, but in some localities the water tends to be quite hard with a range of dissolved solids up to 1,100 ppm (Anonymous, 1972).

Table 5.--A comparison of water sources in the Guthrie North Quadrangle, Oklahoma (after Anonymous, 1972)

Water Source	Expected Yield	Amount Used	Dissolved Solids (ppm)
Ground Water:			
Garber Sandstone	10 gpm	NA	100-1100
Cimarron alluvial deposits	100-300 gpm	NA	350
Surface Water:			
Cimarron River	NA	458 A ft/yr*	600-2200
Liberty Lake (off the study area, Guthrie's municipal supply)	2.3 mgd	.92 mgd	280

NA - no available data

* - for all of Logan County (irrigation)

Contact seeps and contact springs are common in the bedrock of the study area. A seep is an area where water oozes to the surface, saturating the soil, while a contact spring is an actual trickle (or more) of water to the surface of a contact. These occur when a more permeable unit, such as sandstone, overlies a less permeable unit, such as shale (Figure 8B).

Some alluvial deposits in this area contain a large amount of ground water. The lower two terrace deposits and the present alluvium have a very high potential as a source for water. The floodplain alluvium and the Lawrie Terrace Alluvium are very closely related hydrologically because of the similarities of lithologies and because of their close physical relationship (see Plate 2). They have a common water table that generally is located about ten to fifteen feet below the surface of the floodplain alluvium. In these deposits, well yields range from 100 to 300 gpm. Dissolved solids average about 350 ppm.

The lower part of the Perkins Terrace Alluvium is a coarse sand, and in some areas it is saturated with water. Contact springs are common at the basal contact of the terrace alluvium when exposed (see Figure 8A).

In 1951, the Atchison, Topeka & Santa Fe Railroad wanted to smooth the turn on the north side of the Cimarron River about two and one-half miles north of Guthrie (Holman, 1974). The excavation cut the bedrock that was supporting a perched water table in coarse sand (see Figure 9). Water flowed out of the alluvium at a rate of about 50,000 gallons per hour, and caused some of the sand on the sides to liquefy and bury a crawler-tractor. After a week, water still was flowing at a rate of about 27,000 gallons per hour, making it evident that a drain was needed. Water still is being drained along a one-half mile length of track and is being pumped about two miles to the south to a commercial florist in Guthrie. This water is valuable to the florist because of its high

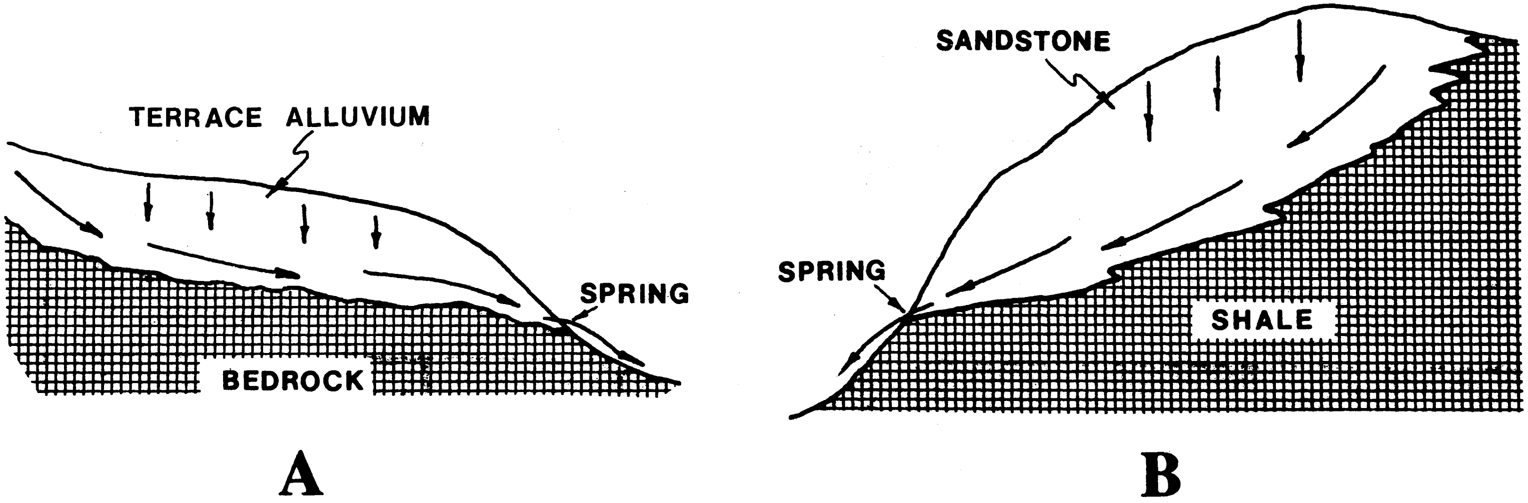


Figure 8. Diagrams showing (a) contact spring between bedrock and terrace alluvium, and (b) contact spring between sandstone and shale

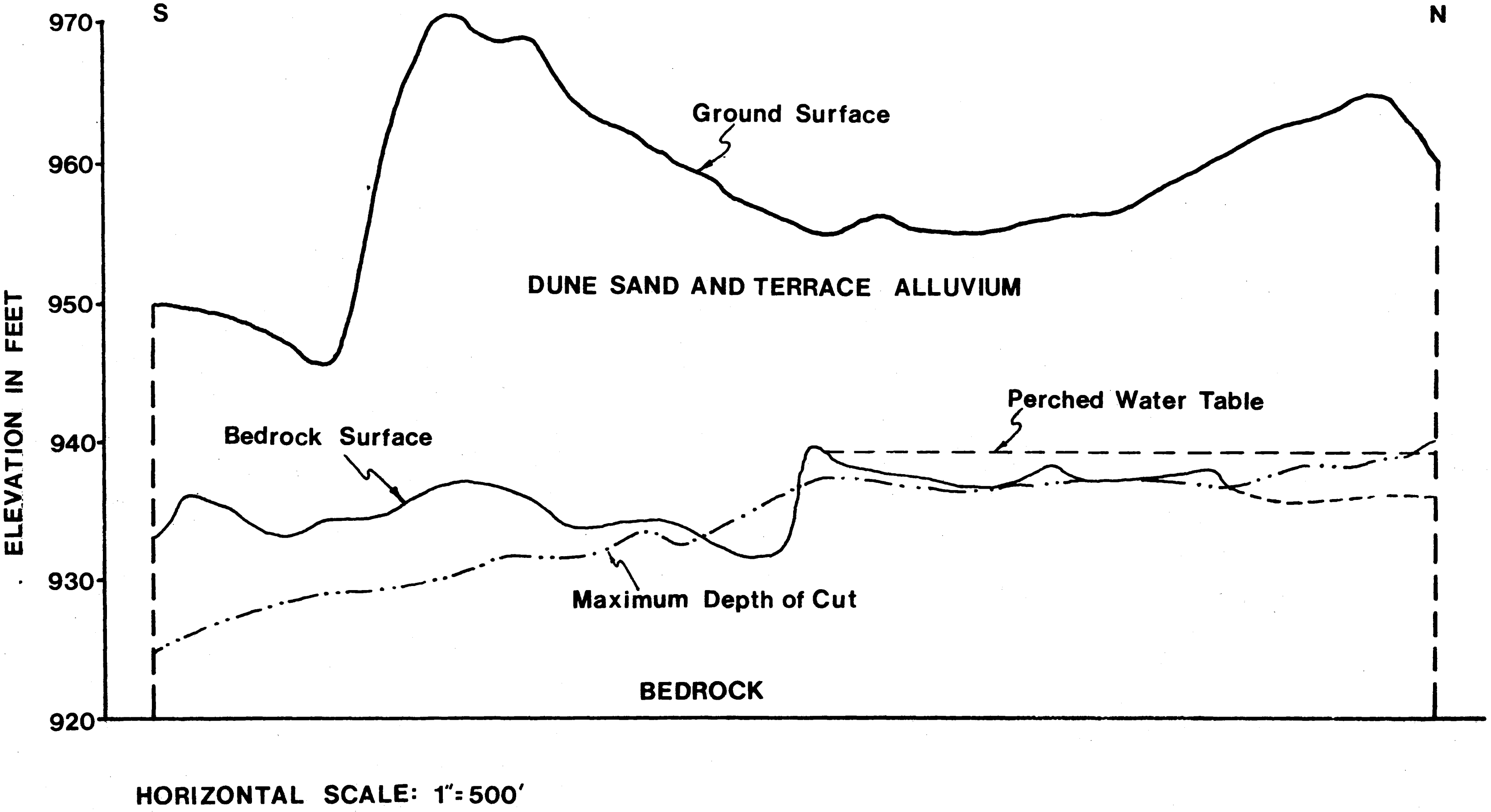


Figure 9. Cross-section of railroad cut on the north side of the Cimarron River, 2½ miles north of Guthrie, Oklahoma (Holman, 1974)

quality and the lack of chemical additives. The Perkins Terrace Alluvium is prominent in the study area and may be an important source of water in the future. The higher terrace deposits also may have potential for water production.

Surface Water

The Cimarron River has a fairly large drainage basin located mostly in an arid to semi-arid region. It has a wide variation of flow which has been recorded at a gaging station just north of Guthrie. This station shows a 33-year average annual flow of 624,500 acre-feet with a maximum of 158,000 cfs and a minimum of .1 cfs. The quality also is variable, the dissolved solids ranging from 600 to over 2000 ppm. (Anonymous, 1972). The variable quality and flow make the Cimarron River an undesirable source of water for most uses.

The lakes in this area all are man-made. These lakes commonly are clouded with colloidal clays. However, there are a few lakes in the quadrangle that generally are clear. These occur where the tributaries that have been dammed up have little or no shale exposed in the areas they drain. It also helps if the area drained by the tributary is small. The city of Guthrie, Oklahoma, uses Liberty Lake as a municipal water supply. It is located about three miles south of Guthrie and is clear due to the circumstances described above. From this lake, the city of Guthrie uses an average of .92 mgd. Its quality is fairly good with an average total dissolved solids of 280 ppm (Anonymous, 1972).

ECONOMIC GEOLOGY

For the last sixty years, central Oklahoma has benefitted economically from the presence of oil. There are three fair-sized oil fields on or near the Guthrie North Quadrangle. They are the West Lawrie, East Guthrie Lake, and Guthrie Oil Fields.

The second most important economic product in this area is sand and gravel. At present, there are two dredges mining in the area. One is working the floodplain alluvium of the Cimarron River, while the other is operating in the Lawrie Terrace Alluvium. For the most part, they are mining medium to coarse sand.

Elsewhere in central Oklahoma along the Cimarron River, the Perkins Terrace Alluvium also is mined for sand. This sand is somewhat coarser than that in either of the two lower alluvial deposits.

Dune sand has been used by individuals in the study area, but has not been used commercially in this area to the knowledge of the author. This sand is fairly clean in some instances, but it is not as clean as the sand being produced by dredges because of the washing effect. In other areas in central Oklahoma along the Cimarron River, dune sand is being mined commercially.

There are future possibilities for other economic deposits in this area. Red-bed copper mineralization has been found in minor amounts in neighboring counties where Permian red-beds crop out also.

SUMMARY

1. The Tertiary Ogallala Formation may have overlaid this area but has been eroded away except for a few lagging pieces of quartzite gravel which have resisted weathering.

2. There are five Quaternary alluvial deposits along the Cimarron Riber in the study area. In descending order they are: Paradise Terrace Alluvium, Summit View Terrace Alluvium, Perkins Terrace Alluvium, Lawrie Terrace Alluvium, and floodplain alluvium.

3. The four alluvial terraces may reflect the cyclic changes in climate connected with Pleistocene glaciation.

4. There are extensive Quaternary eolian deposits in the study area. There were at least two episodes of dune sand deposition and one episode of loess deposition that probably overlap the two dune sands time wise.

5. Colluvium is present on almost all slopes in the study area, usually being the thickest at the base of the slope where it usually interfingers with alluvium.

6. The properties of the geologic units and the soils on the twelve-square-mile study area to the north of Guthrie shows that about one-half of this area is ideal for urbanization. There are two major engineering problems in the northern Guthrie area, flooding and high shrink-swell potential.

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APPENDIX. FACTORS CONSIDERED IN THE ENVIRONMENTAL EVALUATION OF SOIL SERIES AND OF GEOLOGIC UNITS IN THE GUTHRIE NORTH QUADRANGLE, OKLAHOMA

The environmental evaluation of the geologic units (Table 3) and of the soils (Table 4) is complex and often involves subjective judgements. Factors considered in evaluating geologic units and soils are described below.

Properties

In the Properties section of each environmental evaluation, properties are evaluated as low (L), medium (M), or high (H) in value as described below (after Anonymous, 1971).

Shrink-Swell

Shrink-swell behavior is that quality of the resolith that determines its volume change with change in moisture. Building foundations, roads, and other structures often are damaged by shrink-swell. Volume change is controlled by the amount and kind of clay minerals present. The coefficient of linear expansibility (COLE) is used by soil scientists to define the swelling potential of a soil.

$$\text{COLE} = \sqrt[3]{\frac{Dbd}{Dbm}} - 1$$

where

Dbd = dry bulk density of the less than 2mm material

Dbm = moist bulk density of the less than 2mm material.

The ranges for each value are less than 0.03 COLE for low, p.06 COLE for medium, and greater than 0.06 COLE for high.

Permeability

Permeability is the property that allows the percolation of water and/or air through a material. This property commonly is measured in inches per hour. The numerical ranges that were used are: less than .2 in./hr. for low (L), 0.2 to6.0 in./hr. for medium (M), and greater than 6.0 in./hr. for high (H).

pH

pH is a value that refers to a material as being either acid, neutral, or alkaline. In the environmental evaluation, high (H) is alkaline, medium (M) is roughly neutral, and low (L) is acid. Numerically, high (H) has a pH greater than 7.5, medium (M) has a pH between 7.5 and 5.6, and low (L) has a pH less than 5.6.

Depth to Bedrock

This is the thickness of unconsolidated material over the bedrock. The ranges used are less than 20 inches for low (L), 20 to 60 inches for medium (M), and greater than 60 inches for high (H).

Flooding Possibility

This property is not defined so easily by numerical values. The high (H) possibility for flooding exists with the recent alluvial soils which occur in floodplains. The moderate (M) possibility for flooding exists in areas where there is a soil that has developed on a low terrace. The low (L) possibility exists on all other areas. Flood prone areas delineated by the U. S. Army Corps of Engineers in the Guthrie area (Anonymous, 1970) coincides very closely with those delineated by the techniques described above.

Rippability

Rippability is the ease at which the bedrock can be broken up by a ripping device pulled by a Caterpiller D9 or its equivalent. High (H) indicates little difficulty in ripping, medium (M) indicates some difficulty may be encountered, and low (L) indicates that it may not be rippable and another means of removal may have to be employed.

Corrosivity of Uncoated Steel

Corrosivity of uncoated steel is an electrochemical process in which the metal atoms making up the surface of the object are ionized and rendered mobile. A soil with low (L) corrosivity to uncoated steel has an electrical resistivity above 5000 ohm-cm at $60^{O}F$ or an electrical conductivity of less than 0.2 mmho/cm at $25^{O}C$. Moderate (M) has an electrical resistivity between 2000 to 5000 ohm-cm at $60^{O}F$ or an electrical conductivity between 0.2 to 0.4 mmho/cm at $25^{O}C$. And a soil with a high (H) value has an electrical resistivity less than 2000 ohm-cm or an electrical conductivity greater than 0.4 mmho/cm at $25^{O}C$.

Corrosivity of Concrete

When concrete materials are placed in the ground, they will degenerate to varying degrees depending on the acidity and the amount of water-soluble sulfates present in the soil. The low (L) value on the matrix has a pH greater than 6.0 and less than 1000 ppm of SO_4. The medium (M) value has a pH between 5.0 and 6.0, and 1000 to 7000 ppm of SO_4. And the high (H) value has a pH less than 5.0 and greater than 7000 ppm of SO_4.

Applications

In this part of the environmental evaluations, several basic properties of a given soil must be evaluated in order to rate suitability of geologic units or soils for various applications as good (+), fair (o), and poor (-).

Septic Tank Absorption Field

If one is going to build a house in an area that will not be served by a public sewage disposal system, a septic system probably will be needed. The size of the area that one needs as an absorption field depends on how much effluent one is going to have and on the soil in which the field is located. For the best results, a soil should be on a gentle slope, the depth to both the bedrock and the seasonal high water table should be more than 72 inches if the bedrock is impermeable, permeability should be at least 1.0 inch per hour, and the area should not be prone to flooding. Also, the textural and the mineralogical composition is an important consideration in the evaluation of how a septic will perform.

Landfills

The landfill is the most economical method for disposal of solid wastes with present technology. The greatest problem with landfills is the potential for pollution of surface and ground water. The soils that are best as areas for landfills have a depth to bedrock and the water table greater than 72 inches, have a permeability less than 2.0 inches per hour, have a gentle slope, and are not prone to flooding.

Source of Cover Material for Landfills

A material best suited as a source for landfill cover material is more than 40 inches thick. Suitability of a soil or geologic unit for use as a cover is based on the workability, ease of digging, moving, and spreading over the daily refuse.

Sewage Lagoons

A sewage lagoon is a shallow man-made lake used to hold sewage for the time required for bacterial decomposition. A material suited for sewage lagoons has a permeability less than 0.6 inches per hour, has a depth to the water table and to bedrock greater than 60 inches, has a gentle slope, and is not prone to flooding.

Shallow Excavations

The ease of making shallow excavations is dependent on the depth to the bedrock and to the water table, and the character of the bedrock where soil is thin.

Dwellings Without Basements

A soil that is suited for residential development of houses without basements is not prone to flooding, has low shrink-swell potential, and has depths to bedrock and to seasonal high water table greater than 40 inches. The emphasis here is upon properties that affect the foundation and upon long-range problems such as flooding, which will affect the future of the dwelling.

Dwellings With Basements

Soils that are suitable for houses with basements are the same as above, but the depth to the bedrock and to the seasonal high water table should be greater than 60 inches. This figure, 60 inches, is used because it is a depth at which soils are commonly recorded as being either less than or greater than. In most cases, to have ample room for a basement there should be at least 72 inches.

Buried Utilities

A soil which is most suitable for buried utilities has a low corrosivity to both concrete and uncoated steel along with the same properties of a soil suitable for shallow excavations.

VITA

Gary Dean Meyer

Candidate for the Degree of

Master of Science

Thesis: THE SURFICIAL GEOLOGY OF THE GUTHRIE NORTH QUADRANGLE, LOGAN COUNTY, OKLAHOMA

Major Field: Geology

Biographical:

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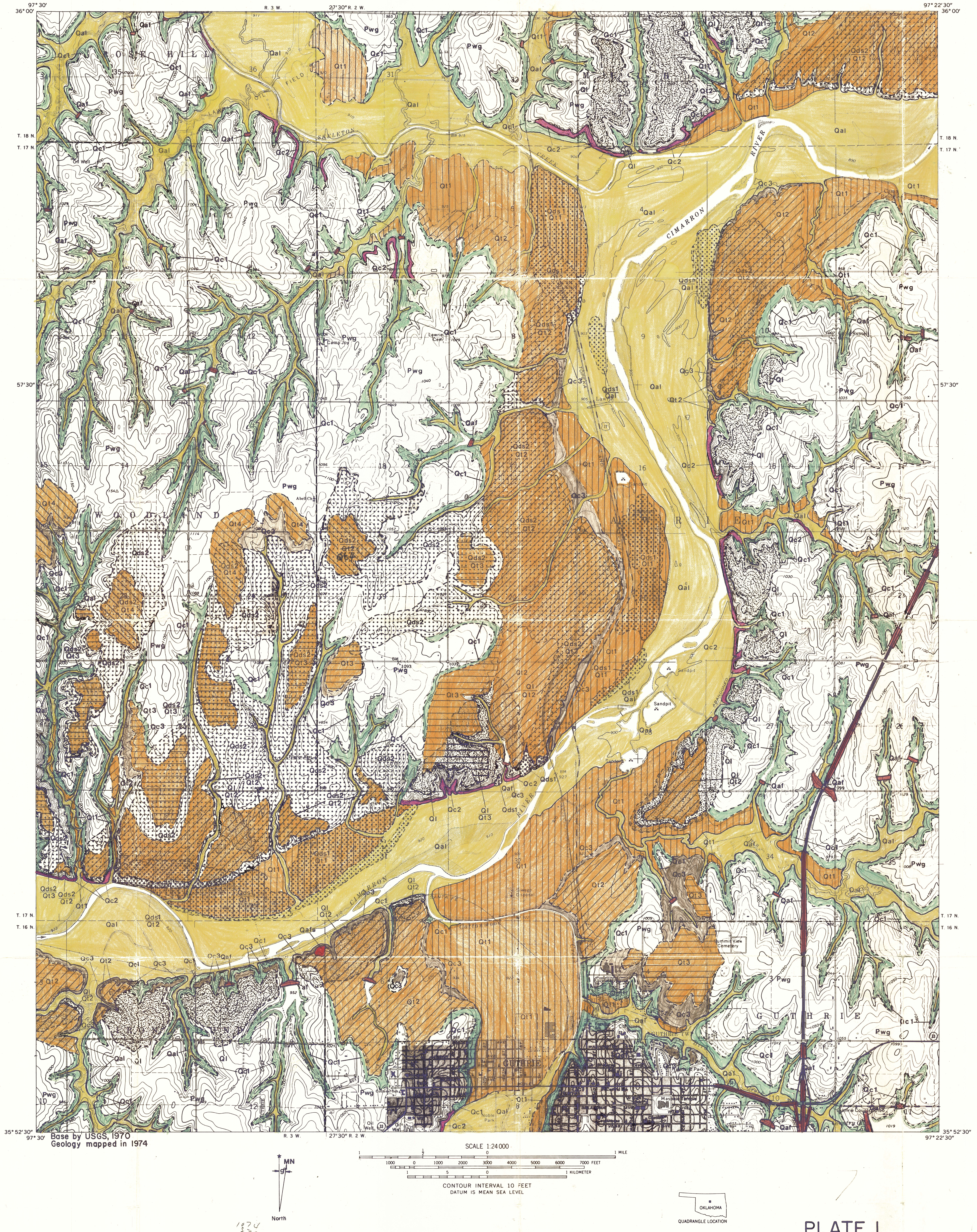
Education: Graduated from Griffin High School, Springfield, Illinois, in May, 1969; received Bachelor of Science degree in Geology from Illinois State University in August, 1973; completed requirements for the Master of Science degree at Oklahoma State University in July, 1975.

Professional Experience: Graduate teaching assistant, Department of Geology, Oklahoma State University, 1973-1975.

Meyer, Gary D

PLATE I



Base by USGS, 1970
Geology mapped in 1974

1974
820
254

EXPLANATION

SYSTEM

QUATERNARY

Qaf
Qafs

ARTIFICIAL FILL

Qaf, varies from construction rubble to natural material moved from afar or from nearby; some small fills not mapped; Qafs, Guthrie Sanitary Landfill, garabage and/or trash dumped and covered by material from site.

Qal

FLOODPLAIN ALLUVIUM*

Along Cimarron River: light to dark reddish-brown fine to coarse sand with some beds and lenses of gravel, silt, and clay; bedded or cross-bedded; up to 25ft. thick. Elsewhere: silty to clayey sand; up to 15ft. thick.

Qt1

LAWRIE TERRACE ALLUVIUM*

Along Cimarron River: dark reddish-brown fine to coarse sand with some beds and lenses of gravel, silt, and clay; bedded or cross-bedded; up to 35ft. thick. Elsewhere: silty to clayey sand; up to 15ft. thick

Qt2

PERKINS TERRACE ALLUVIUM*

Along Cimarron River: upper 10 to 15ft. reddish-brown silty sand, grading downward to reddish-brown coarse sand; bedded or cross-bedded; moderately well sorted with lenses of gravel, silt, and clay; up to 25ft. thick. Along Skeleton Creek: reddish-brown silty to clayey sand; up to 15ft. thick.

Qt3

SUMMIT VIEW TERRACE ALLUVIUM*

Light reddish-brown fine to medium sand; rather poorly sorted; locally 2 to 4ft. of quartzite gravel at base; bedded or cross-bedded; up to 30ft. thick.

Qt4

PARADISE TERRACE ALLUVIUM*

Highly weathered light-brown clayey fine to coarse sand; some quartzite gravel; rather poorly sorted; up to 30ft. thick.

Qds1

YOUNG DUNE SAND

Light-brown to yellow-brown, rather well sorted, medium sand deposited by wind on floodplains and lower terraces; dunes usually small; up to 25ft. thick.

Ql

LOESS

Tan sandy silt deposited by wind on upper terraces and uplands near Cimarron River; well sorted; 2 to 15 ft. thick; deposits < 2 ft. thick not mapped.

Qds2

OLD DUNE SAND

Light reddish-brown to yellow-brown, rather well sorted medium sand deposited by wind on upper terraces and uplands; more highly weathered (multiple "B" horizon common) and has larger dunes than Young Dune Sand; up to 30ft. thick.

?

Qc1 **Qc2** **Qc3**

COLLUVIUM **

Fine Colluvium (Qc1), reddish brown clayey to silty sand with small fragments of shale (<.5in.) and some sandstone fragments up to 1ft. in diameter.

Coarse Colluvium (Qc2), reddish-brown clayey to silty sand with small fragments of shale (<.5 in.) and some sandstone fragments including many blocks >1ft. in diameter.

Terrace Colluvium (Qc3), reddish-brown medium to coarse sand derived from terrace alluvium; in some areas mixed with Fine Colluvium or Coarse Colluvium.

?

PERMIAN

Pwg

WELLINGTON AND GARBER FORMATIONS

Reddish-brown to light-grey, very well sorted, cross-bedded, lenticular, fine-gained sandstones with interbeds of reddish-brown, laminated or massive silty shales and calcareous clay-pebble conglomeates.

$$\frac{\text{Qds1}}{\text{Qt1}}$$

EOLIAN DEPOSIT OVERLYING ALLUVIAL DEPOSIT

Example shows Young Dune Sand overlying Lawrie Terrace Alluvium.

CONTACT

Dashed where approximate.

*Upper 4 in. to 2 ft. reworked in places by wind; in places 2 ft. or less of loess overlies alluvium.

**Deposited by creep and sheet wash. Texture and composition vary depending upon texture and composition of material from which it is derived. Colluvium < 2 ft. thick not mapped.

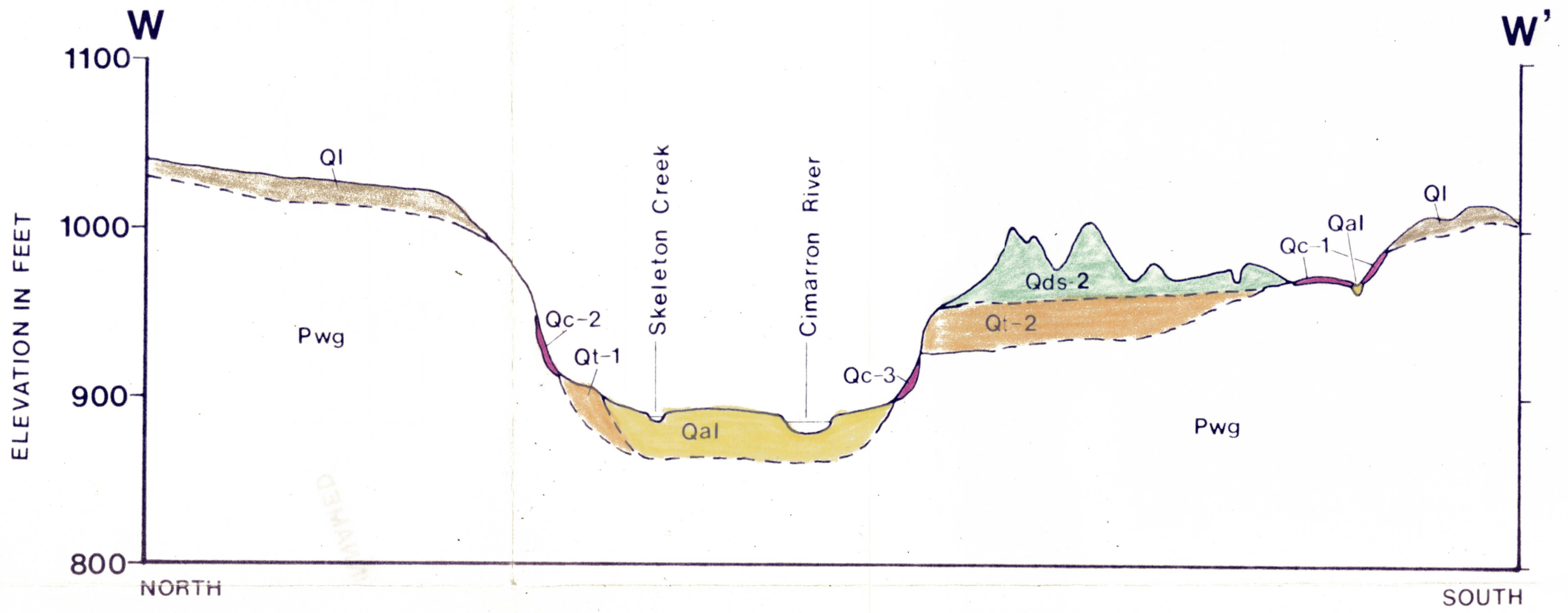
PLATE I

SURFICIAL GEOLOGICAL MAP OF THE GUTHRIE NORTH QUADRANGLE, OKLAHOMA

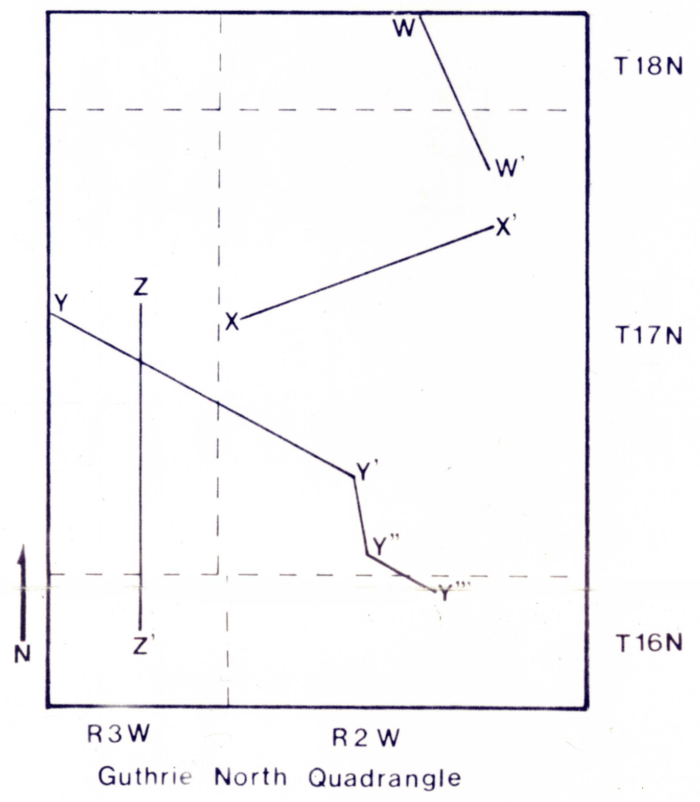
by
Gary D. Meyer
1975

PLATE 2

Plate 2
Geologic Cross Sections, Guthrie North Quadrangle, Oklahoma

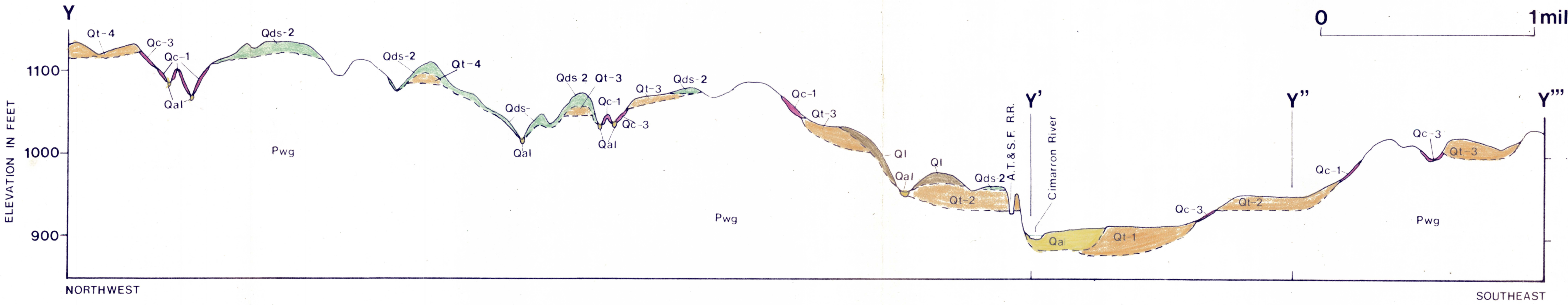


CROSS SECTION LOCATION MAP



VERTICAL EXAGGERATION
20 times

HORIZONTAL SCALE
1:24,000
0 **1mile**



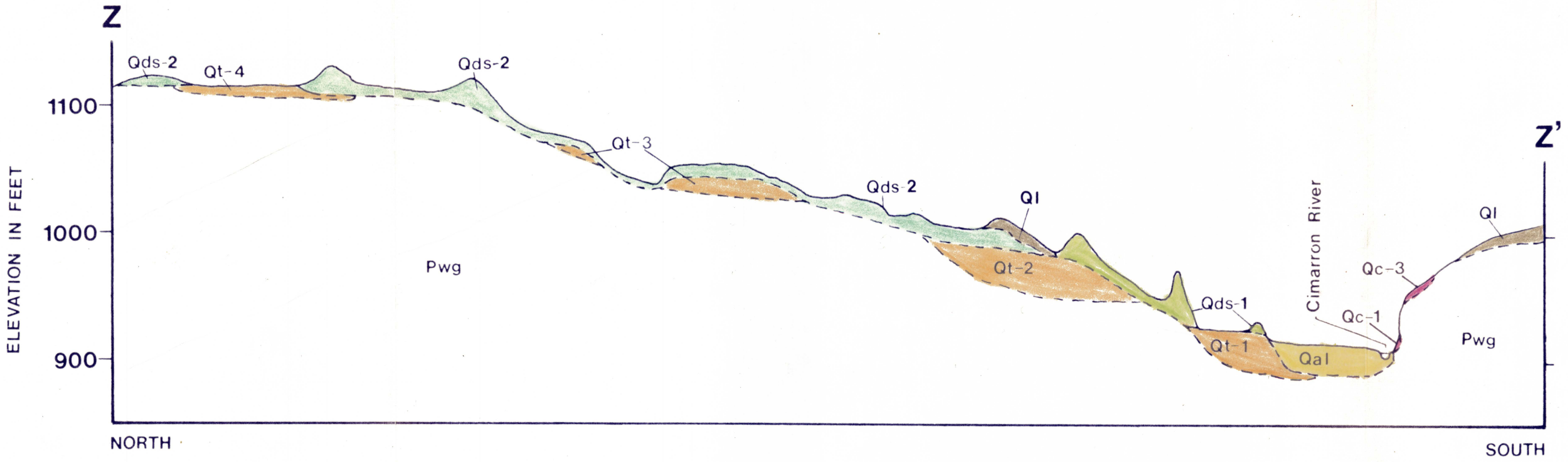
EXPLANATION

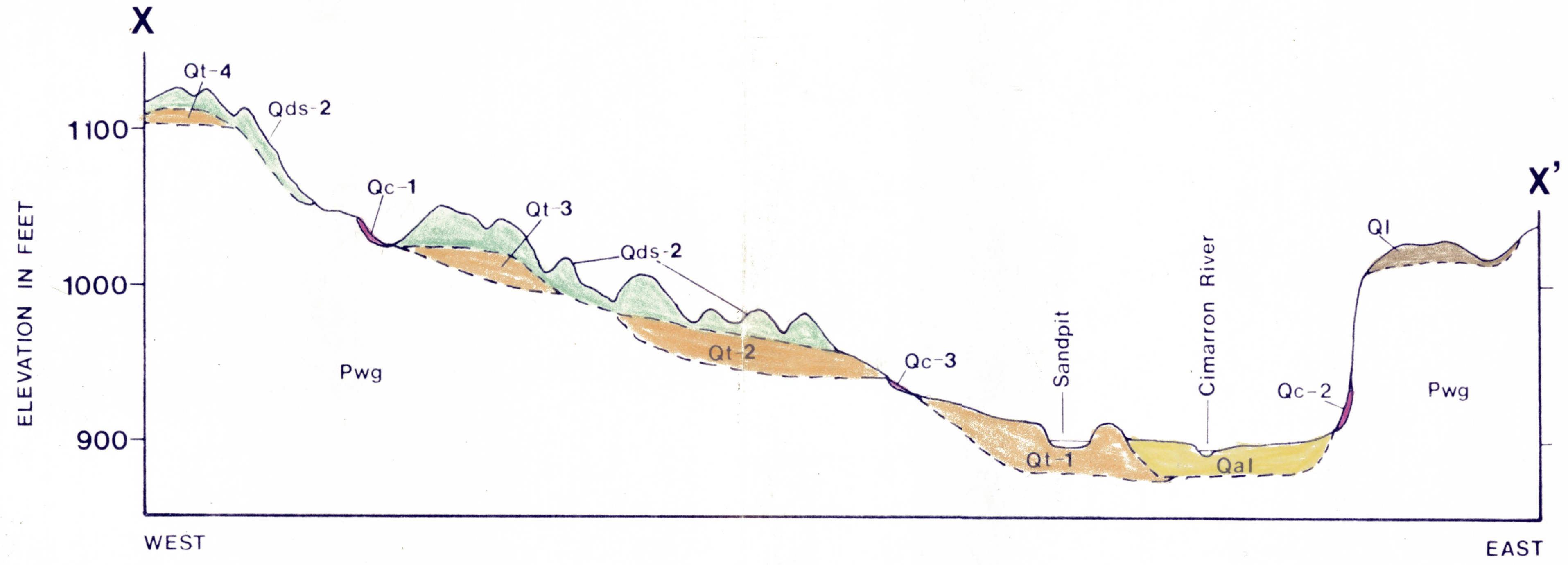
Qal	**Floodplain Alluvium**
Qt-1	**Lawrie Terrace Alluvium**
Qt-2	**Perkins Terrace Alluvium**
Qt-3	**Summit View Terrace Alluvium**
Qt-4	**Paradise Terrace Alluvium**
Qds-1	**Young Dune Sand**
Qds-2	**Old Dune Sand**
Ql	**Loess**
Qc-1	**Fine Colluvium****
Qc-2	**Coarse Colluvium****
Qc-3	**Terrace Colluvium****
Pwg	**Wellington and Garber Formations**

Sequence may not reflect age

Contact

(Dashed where approximate)





*For complete descriptions see Plate 1.

**Shown diagrammatically, not representative of true thickness.

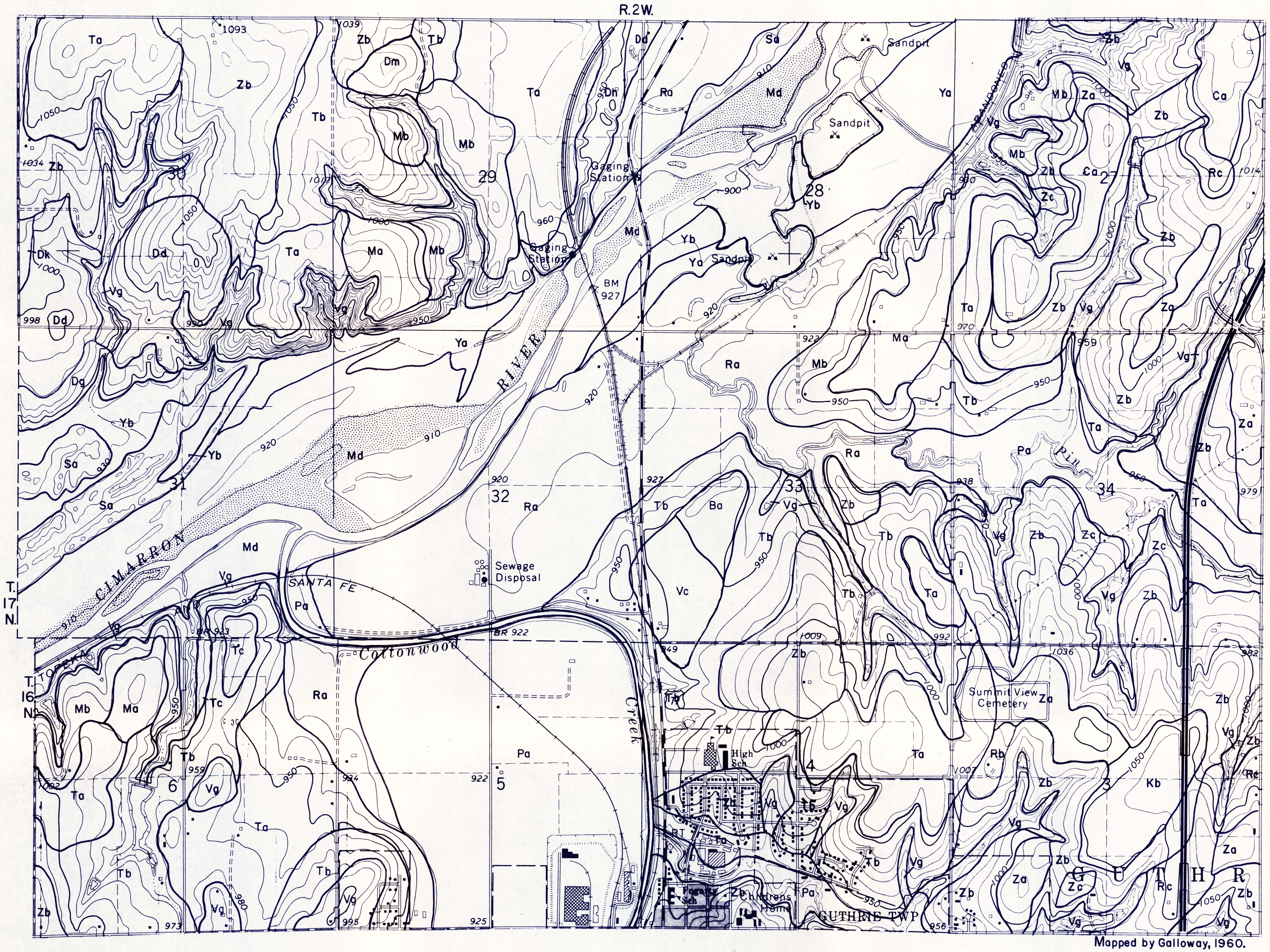
Gary D. Meyer, 1975

Plate 3

Longitudinal Profiles Along Cimarron River and Its Major Tributaries in the Guthrie North Quadrangle, Oklahoma

Gary D. Meyer, 1975

PLATE 4



Mapped by Galloway, 1960.
Modified by Gary D. Meyer, 1975.

EXPLANATION

Ba-	Bethany silt loam, 0-1% slopes.
Ca-	Chickasha loam, 0-2% slopes.
Dd-	Derby loamy fine sand, 0-3% slopes.
Dg-	" " " " , 3-8% " .
Dh-	" " " " , 8-20% " .
Dk-	Dougherty loamy fine sand, 0-3% slopes.
Dm-	" " " " , 3-8% slopes.
Ka-	Kirkland silt loam, 0-1% slopes.
Kb-	" " " , 1-3% " .
Ma-	Minco loam, 0-3% slopes.
Mb-	" " , 3-8% " .
Md-	Mixed alluvial land.
Pa-	Port soil
Ra-	Reinarch very fine sandy loam.
Rc-	Renfrow silt loam.
Sa-	Sand dunes, Lincoln material.
Ta-	Teller very fine sandy loam, 0-3% slopes.
Tb-	" " " " , 3-8% " .
Tc-	" " " " , severely eroded.
Vc-	Vanoss loam, 0-1% slopes.
Vg-	Vernon and Lucien soils, 6-20% slopes.
Ya-	Yahola clay loam.
Yb-	" very fine sandy loam.
Za-	Zaneis loam, 0-3% slopes.
Zb-	" " , 3-6% " .
Zc-	" " , 3-8% " , severely eroded.

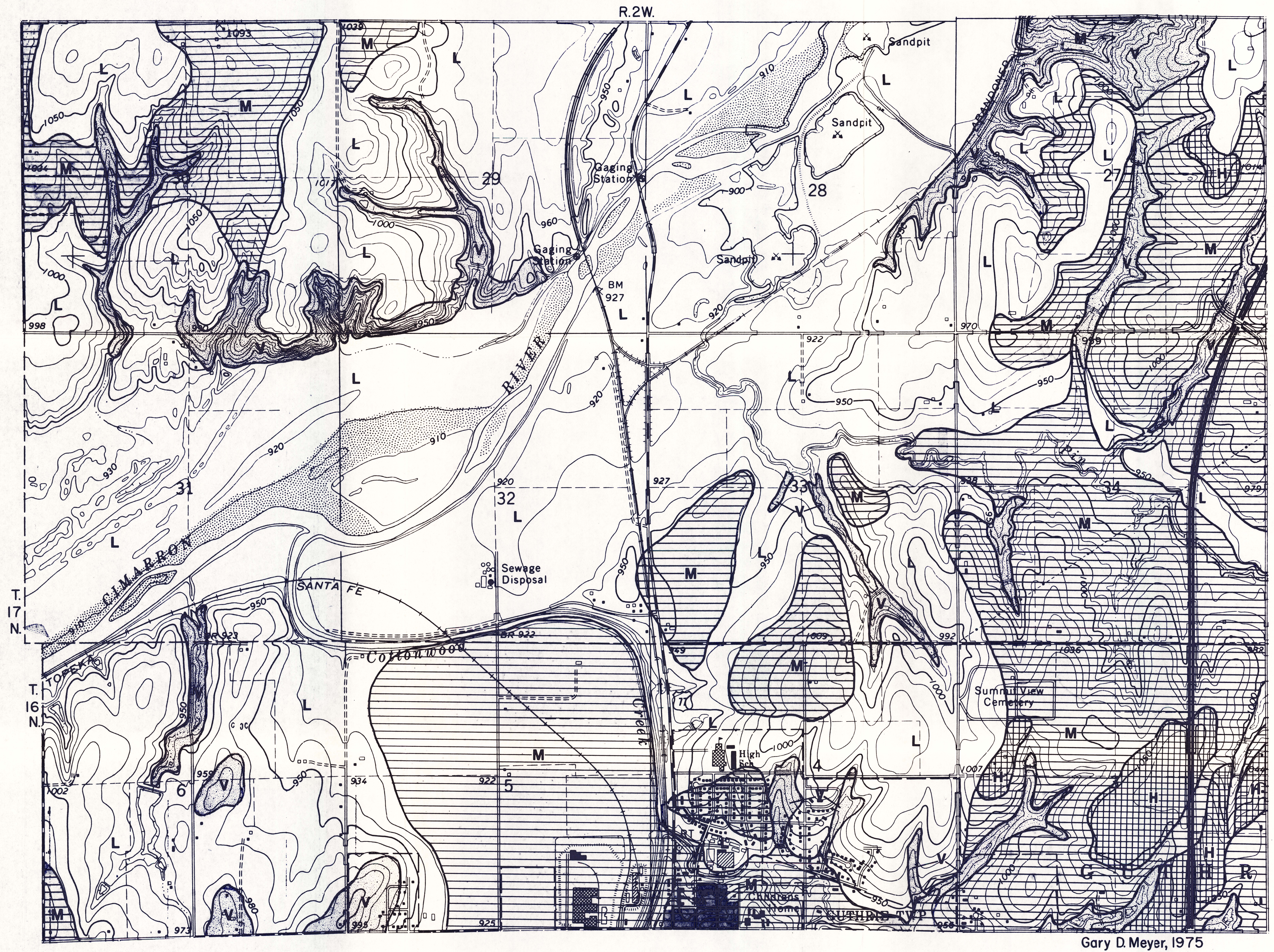
SCALE
1:12,000

0 .5 1 mile
0 5000 feet

N

PLATE 4. - SOIL MAP, NORTHERN GUTHRIE AREA, OKLAHOMA.

PLATE 5



Gary D. Meyer, 1975

EXPLANATION

L	Low Shrink-Swell Potential; values for COLE* of the soils in these areas are less than 0.03.
M	Moderate Shrink-Swell Potential; values for COLE* of soils in these areas are 0.03 to 0.06.
H	High Shrink-Swell Potential; values for COLE* of soils in these areas are greater than 0.06.
V	Variable Shrink-Swell Potential; values for COLE* of soils in these areas are too variable to be mapped at this scale.

*COLE- coefficient of linear expansibility (see Appendix)

Note: This map is generalized and is based, in part, upon interpretation and judgement. While useful for planning purposes, it should not be relied upon for evaluation of individual sites.

SCALE
1:12,000

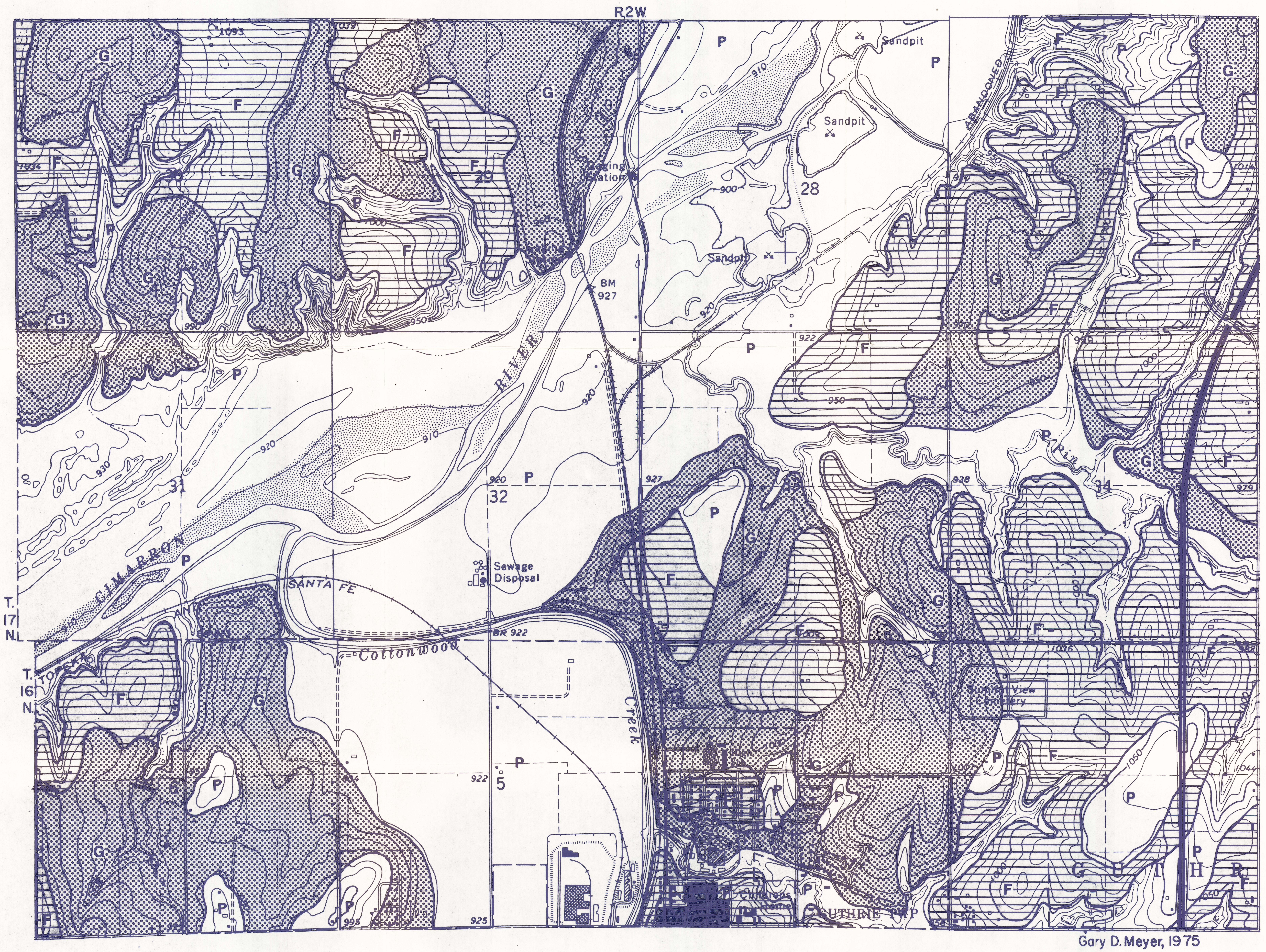
0 .5 1 mile
0 5000 feet

N

PLATE 5.-MAP OF SHRINK-SWELL POTENTIAL, NORTHERN GUTHRIE AREA, OKLAHOMA.

Meyer, Gary D.

PLATE 6



Gary D. Meyer, 1975

EXPLANATION

G Good- with slight limitations; possibility of flooding is low, shrink-swell potential of soil is low, and depth to bedrock is > 40 inches.

F Fair - with moderate limitations; possibility of flooding is low with at least one of the following being true: moderate shrink-swell potential of soil, low soil strength, or depth to bedrock between 20 and 40 inches.

P Poor- with severe limitations; at least one of the following is true: possibility of flooding is moderate or high, high shrink-swell potential of soil, or depth to bedrock < 20 inches.

Note: This map is generalized and is based, in part, upon interpretation and judgement. While useful for planning purposes, it should not be relied upon for evaluation of individual sites.

SCALE
1:12,000

0 .5 1 mile
0 5000 feet

N

PLATE 6.
MAP EVALUATING NORTHERN GUTHRIE AREA, OKLAHOMA
FOR
DWELLINGS WITHOUT BASEMENTS