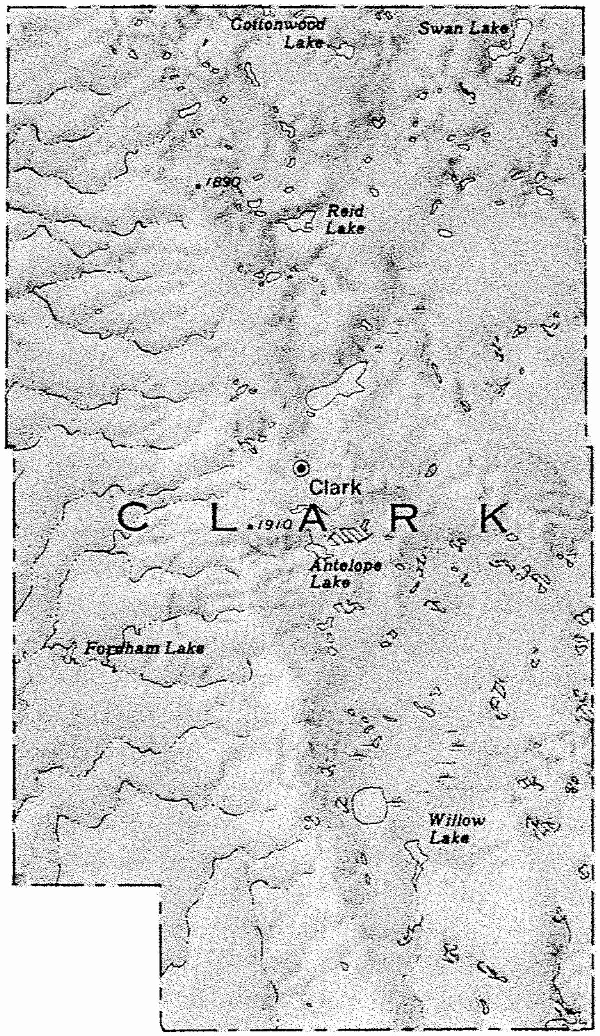
BULLETIN 29

GEOLOGY AND WATER RESOURCES OF CLARK COUNTY, SOUTH DAKOTA



PART I: GEOLOGY

by C. M. Christensen

Prepared in cooperation with the United States Geological Survey, Oahe Conservancy Sub-District, and Clark County

DEPARTMENT OF WATER AND NATURAL RESOURCES
SOUTH DAKOTA GEOLOGICAL SURVEY-1987

STATE OF SOUTH DAKOTA
George S. Mickelson, Governor

DEPARTMENT OF WATER AND NATURAL RESOURCES
John J. Smith, Secretary

DIVISION OF GEOLOGICAL SURVEY
Merlin J. Tipton, State Geologist

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Science Center
University of South Dakota
Vermillion, South Dakota

1987

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ABSTRACT

Clark County is located in east-central South Dakota near the western edge of the Coteau des Prairies and has an area of 974 square miles. The Pleistocene deposits which mantle the Cretaceous Pierre Shale bedrock surface consist primarily of till which lesser amounts of stratified drift. Late Wisconsin drift covers the entire surface of the County and various deposits of pre-Wisconsin drift are present in the subsurface, however, no early Wisconsin deposits exist in the mapped area. Because materials commonly used for absolute age dating were not found in Clark County, most age relationships are based on the use of topography, physical characteristics and stratigraphic relationships, as well as absolute dates from surrounding area. Several areas of surficial and buried outwash are present in the County. Ground water and sand and gravel are the most important mineral commodities.

INTRODUCTION

Purpose

Investigation of the geology and water resources of Clark County is one of a series of cooperative studies conducted through the combined efforts of the South Dakota Geological Survey and the United States Geological Survey. Each study is conducted with several goals in mind. Of primary concern is the location and evaluation of the mineral and water resources available in each of the counties being studied. In addition, the knowledge gained from each study will be a most important contribution to understanding the overall geology of South Dakota.

Results of the Clark County investigation are published in two parts. Part I contains the geology, with special emphasis on deposits of Pleistocene age, and Part II (Hamilton, 1986) contains the water resources. Two other reports which resulted from the investigation deal with the sand and gravel resources (Schroeder, 1978) and major aquifers (Hamilton, 1978) in the County. In addition, a compilation of all basic data resulting from the study will be available as an open-file report at the office of the South Dakota Geological Survey in Vermillion.

Location

Clark County is located in east-central South Dakota near the western edge of the Coteau des Prairies and has an area of 974 square miles (fig. 1). It is bordered on the west by Spink and Beadle Counties, on the north by Day County, on the east by Codington and Hamlin Counties and on the south by Beadle and Kingsbury Counties.

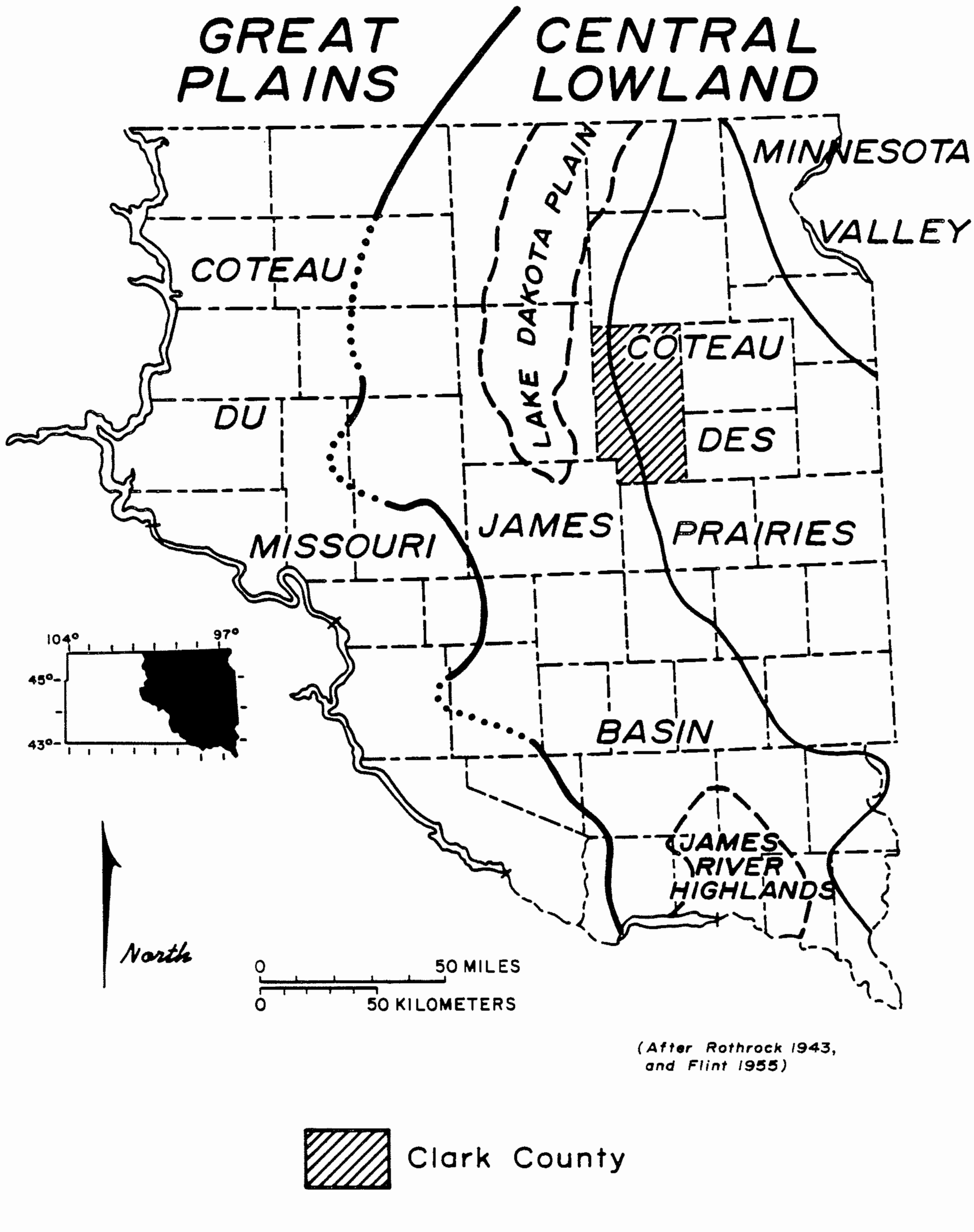


Figure 1. Map of eastern South Dakota showing physiographic divisions and location of the study area.

Previous Investigations

The County has been included in a number of reconnaissance studies dealing with the bedrock and general geology of South Dakota (Todd, 1894; Darton, 1909; and Rothrock, 1943). Flint (1955) made a reconnaissance survey of the Pleistocene geology of eastern South Dakota which included Clark County. In addition, the ground-water resources in the vicinity of the City of Clark have been studied several times in recent years (Wong, 1960, and Barari, 1980).

Several of the surrounding counties have also been extensively studied or are presently being investigated. These include Beadle County (Hedges and Howells, 1968), Day County (Leap, in preparation), Codington County (Gilbertson, in preparation), Hamlin County (Beissel and Gilbertson, 1987) and Kingsbury County (Lehr and Johnson, in preparation; and Hamilton, in preparation).

Method of Procedure

Information contained in this report results in part from geologic mapping completed during three field seasons in 1973, 1974 and 1975. The geology was mapped on aerial photographs having a scale of approximately 1:70,000 (about 1 inch = 0.9 miles) and later transferred to a base map of the same scale. The resulting map was then reduced to a scale of more manageable size for reproduction (fig. 2).

Information obtained from natural outcrops and man-made exposures of rock material was supplemented by numerous power-auger holes, rotary-drill holes and hand-auger holes. Most subsurface information was obtained from examination of well cuttings and electric logs from holes drilled by the South Dakota Geological Survey. Supplemental information was obtained from the files of local well drillers and from a well inventory conducted in the County for Part II of this report (Hamilton, 1986). Additional information was supplied from shallow-auger holes drilled by the United States Geological Survey.

Acknowledgements

The investigation and preparation of this report were performed under the supervision of Merlin J. Tipton, State Geologist. The writer wishes to thank the entire staff of the South Dakota Geological Survey for their advice and assistance throughout the project. Special thanks go to Merlin Tipton, Dennis Beissel and Louis Hamilton for their participation in numerous field conferences and discussions.

Financial assistance for the project was contributed by the South Dakota Geological Survey, United States Geological Survey, Oahe Conservancy Sub-District and Clark County.

Figure 2. Geology and landforms of Clark County.

EXPLANATION

QUATERNARY — PLEISTOCENE — Late Wisconsin

Qwlo — **Outwash, undifferentiated** - *Sand and gravel of glaciofluvial origin; includes proglacial outwash and outwash lenses; flat to gently rolling surface.*

Qwloc — **Outwash, collapsed** - *Sand and gravel of glaciofluvial origin; may contain minor amounts of till; undulating to pitted topography.*

Qwloi — **Outwash, ice walled** - *Sand and gravel with minor amounts of silt, clay, and till; elevated feature with flat surface.*

Qwlli — **Lake sediments** - *Silt and clay with minor amounts of sand and fine gravel; flat to smoothly sloping surface; low lying.*

Qwlts1 — **Till, stagnation moraine** - *Heterogeneous mixture of boulders, sand, silt, and clay; smooth, high altitude topography; contains some sloughs.*

Qwlts2 — **Till, stagnation moraine** - *Heterogeneous mixture of boulders, sand, silt, and clay; rugged hummocky topography; contains many sloughs.*

Qwltg — **Till, ground moraine** - *Heterogeneous mixture of boulders, sand, silt, and clay; smooth and level to gently rolling topography; contains some sloughs.*

Qwlte — **Till, end moraine** - *Heterogeneous mixture of boulders, sand, silt, and clay; contains high ridges or is linear in mass.*

Geologic contact; dashed where approximately located.

Meltwater channel; pattern and color denotes the major sediment presently occupying the channel.

212 20 Federal or State highway

Lake or pond

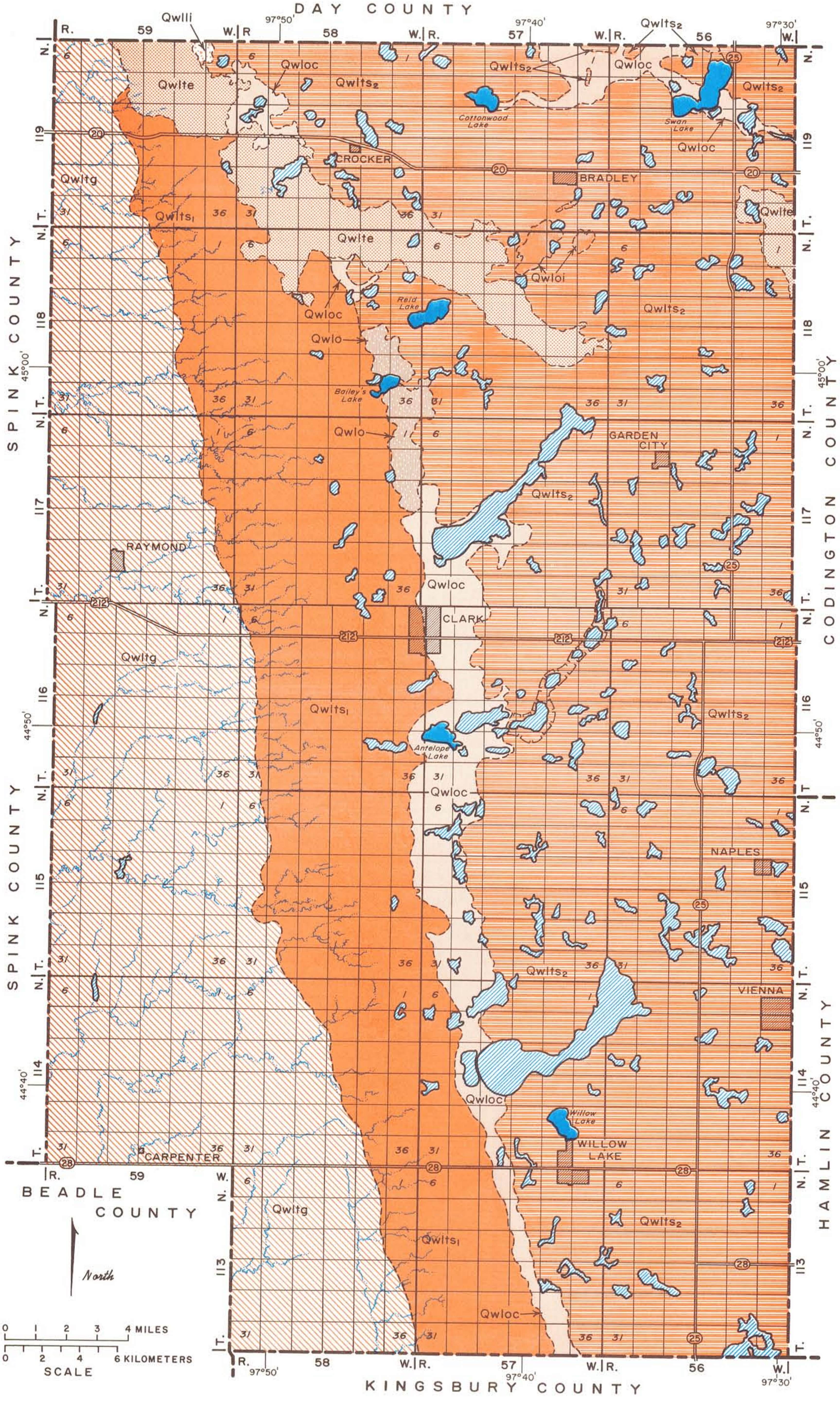
Intermittent lake or slough

Intermittent stream

Index map of South Dakota showing location of Clark County.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Sectionized township


DAY COUNTY
SPINK COUNTY
CODINGTON COUNTY
HAMLIN COUNTY
BEADLE COUNTY
KINGSBURY COUNTY
Qwlli
Qwloc
Qwlts₂
Qwlte
Qwltg
Qwlts₁
Qwlo
Qwloi
CROCKER
BRADLEY
GARDEN CITY
RAYMOND
CLARK
NAPLES
VIENNA
WILLOW LAKE
CARPENTER
Cottonwood Lake
Swan Lake
Reid Lake
Bailey's Lake
Antelope Lake
Willow Lake
97°50'
97°40'
97°30'
45°00'
44°50'
44°40'
North
0 1 2 3 4 MILES
0 2 4 6 KILOMETERS
SCALE

The study was initiated at the request of the Clark County Commissioners and the cooperation of the Commissioners, as well as the other residents of the County, is gratefully acknowledged.

Physiography

Over half of Clark County is located within the confines of the Coteau des Prairies. This impressive highland, which was probably named by French fur traders, occupies an area nearly 200 miles long extending from the North Dakota border to eastern Union County in the southeastern corner of South Dakota (U.S. Geological Survey, 1964). The Coteau des Prairies has a characteristic flatiron shape when viewed on a topographic map. From the nose of the "flatiron" at the northern border of the State, it widens to over 60 miles in the east-central part of the State. The western edge of the Coteau des Prairies trends nearly north-south through central Clark County.

The topography of the Coteau des Prairies can best be described as of the knob and kettle type. Closed depressions abound and external drainage from this part of the County is essentially absent. The western edge of the Coteau des Prairies in central Clark County contains the headwaters of numerous small, intermittent streams that eventually coalesce in eastern Spink County and become part of the James River tributary system. Topographically that part of the County that is not within the Coteau des Prairies consists of a gently sloping surface that eventually merges with the flatlands of the Lake Dakota plain in Spink County.

GEOLOGY

Stratigraphic Relations

Stratigraphic nomenclature used herein conforms to that accepted by the South Dakota Geological Survey (Agnew and Tychsen, 1965) and to the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961). Because a complete discussion of the pre-Pleistocene stratigraphy is well beyond the scope of this report, only those older deposits that have directly influenced events of the Pleistocene Epoch will be mentioned. Total emphasis will thus be placed on deposits of Pleistocene age. For information regarding older stratigraphic units, the reader is referred to Schoon (1967).

Pierre Shale

Although not exposed at the surface in Clark County, the Cretaceous age Pierre Shale is the first bedrock encountered beneath the Pleistocene deposits of the study area (fig. 3). The Pierre consists of blue-gray, calcareous shale which locally contains bentonite layers and marly zones. Within the confines of the study area, the Pierre Formation attains a maximum thickness

Figure 3. Bedrock map of Clark County showing contours on the bedrock surface.

●1455 — *Control point - number is elevation above sea level.*

●1385- — *Control point where bedrock elevation is less than the number shown.*

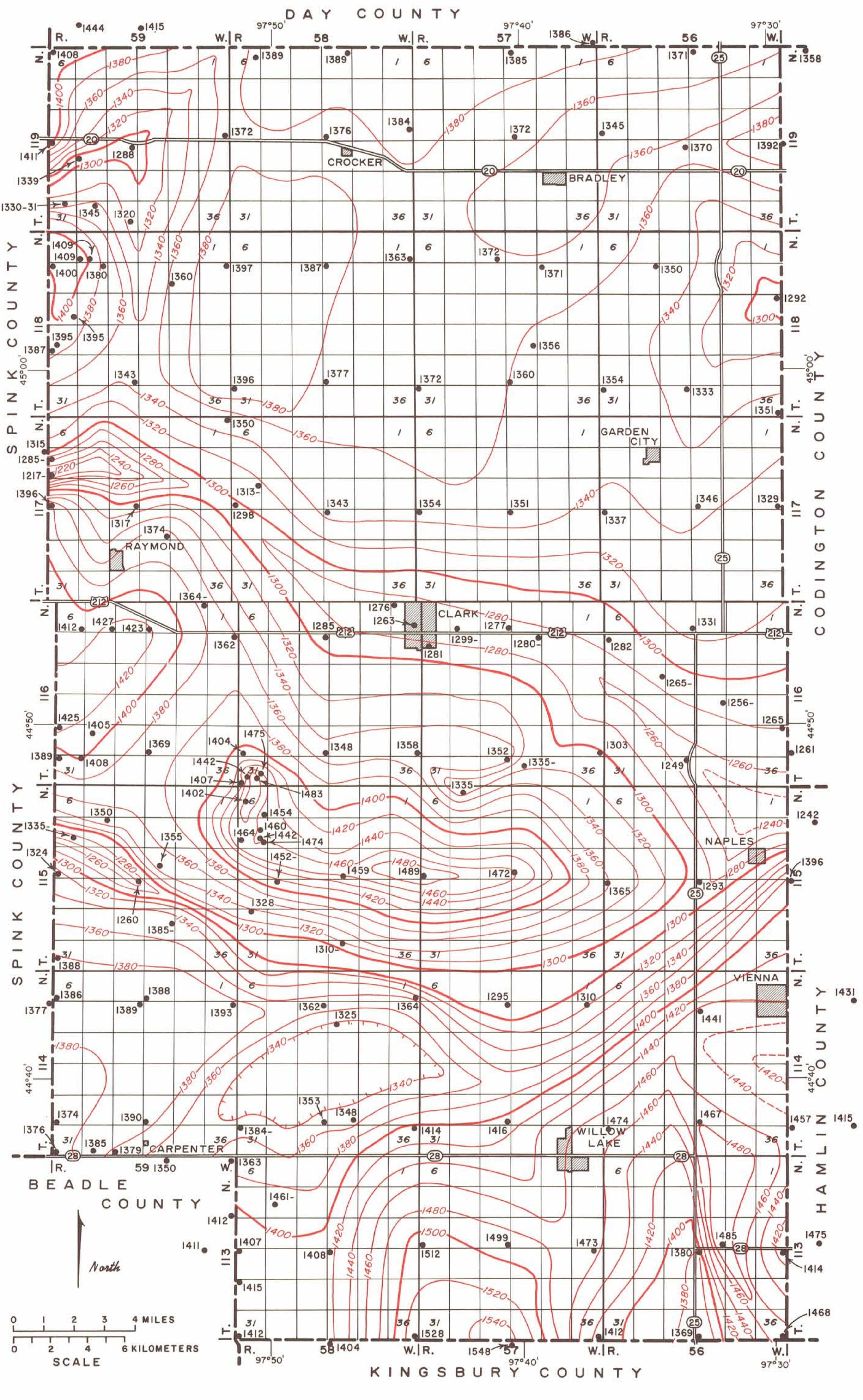
1340 — *Contour on bedrock surface. Number is elevation above sea level. (Dashed where approximated)*

Contour interval = 20 feet

Index map of South Dakota showing location of Clark County.

Sectionized Township

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36



DAY COUNTY
SPINK COUNTY
CODINGTON COUNTY
HAMLIN COUNTY
KINGSBURY COUNTY
BEADLE COUNTY
CROCKER
BRADLEY
GARDEN CITY
RAYMOND
CLARK
NAPLES
VIENNA
WILLOW LAKE
CARPENTER
R. 59 W.
R. 58 W.
R. 57 W.
R. 56 W.
T. 119 N.
T. 118 N.
T. 117 N.
T. 116 N.
T. 115 N.
T. 114 N.
T. 113 N.
97°50'
97°40'
97°30'
45°00'
44°50'
44°40'
North
SCALE
0 1 2 3 4 MILES
0 2 4 6 KILOMETERS

of nearly 400 feet and rests unconformably on the underlying Niobrara Formation. Present-day relief on the surface of the Pierre Shale is nearly 300 feet (fig. 3) and has resulted mostly from pre-Pleistocene and early Pleistocene drainage development. Only to a very minor extent did this undulating bedrock surface influence the location of the overlying Pleistocene deposits. In most cases the thick Pleistocene deposits completely mask the topography of the bedrock surface.

Pleistocene Deposits

Those Pleistocene deposits which mantle the bedrock throughout the entire County consists primarily of till with lesser amounts of stratified drift such as outwash and lacustrine sediment. Late Wisconsin Pleistocene age material covers the entire surface of the study area. Correlation of test-hole data from Clark County with surface and subsurface information from areas to the east, where both early Wisconsin and pre-Wisconsin deposits exist, have shown that various deposits of pre-Wisconsin age are present in the subsurface of Clark County (Beissel and Gilbertson, 1987). No early Wisconsin age sediments are, however, present in the County.

Because materials commonly used for absolute dating are rare in the County, most age relationships are based on the use of topography, physical characteristics and stratigraphic relationships as well as absolute dates from surrounding areas. For these reasons the exact age cannot be assigned to those deposits of Pleistocene age that are older than late Wisconsin. These sediments are, therefore, discussed collectively under the assigned stratigraphic position of pre-late Wisconsin.

Pre-Late Wisconsin Deposits

TILL

Throughout Clark County till of pre-late Wisconsin age comprises the bulk of material between the Cretaceous Pierre Shale and the late Wisconsin sediments. This massive accumulation which existed prior to the beginning of the Wisconsin makes up the majority of core material on the Coteau des Prairies in the study area, and exercised a great deal of control over the location and accumulation of late Wisconsin sediments.

The pre-late Wisconsin till consists of a clay-rich matrix containing pebble- to boulder-size material representing a wide variety of igneous and sedimentary rocks. Scattered rocks of metamorphic origin are also present. The till is rich in shale and shale pebbles, however, no actual percentages are available because the till is not exposed at the surface and thus cannot be properly sampled within the County. Relationship of the pre-late Wisconsin till and other sediments of similar age to the overlying and underlying rocks is shown on a series of east-west cross section (fig. 4) constructed from test holes drilled for this project. It can be seen from an inspection of figures 5 through 16 that pre-late Wisconsin till attains a thickness of nearly 400 feet in the mapped area (fig. 10, MLN-52).

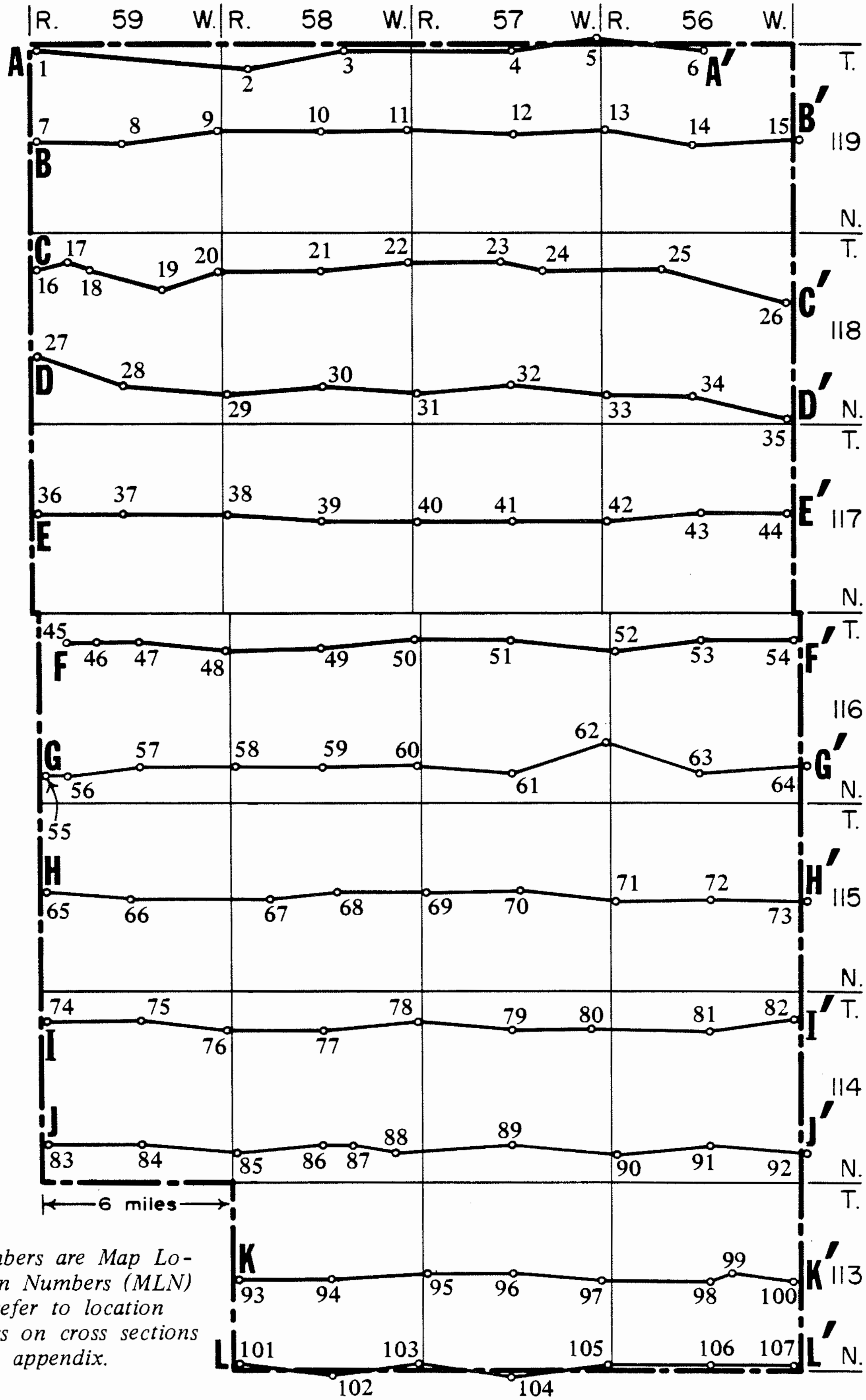
Near the surface of the pre-late Wisconsin till sheet, oxidation has been intense resulting in the normal yellow-brown color associated with oxidized till sheets in the area. This distinct color aids in the quick recognition of the till in drill holes and enabled the writer to locate and map the surface of the buried till sheet without difficulty. Oxidation is much more pronounced on the surface of the older pre-late Wisconsin till than on the late Wisconsin (figs. 7 through 12) indicating a much longer period of exposure to the atmosphere.

Even though the pre-late Wisconsin till is not exposed at the surface, it can be safely stated that the till is highly fractured and contains many oxidation joints. This fact is readily apparent from a close examination of drill cuttings from the older till. Well below the oxidized part of the till, oxidized cuttings still occur in the samples. These cuttings are not recirculated material from the upper part of the till sheet but are indeed, fresh cuttings being recovered at the same interval as the unoxidized cuttings. This fact along indicates the presence of oxidation joints in the till sheet below the normal depth of total oxidation. Associated with these samples are various amounts of selenite and calcite that existed as joint fillings in the center of the oxidation joints.

OUTWASH

An inspection of figures 5 through 16 will show the presence of outwash within the pre-late Wisconsin drift sheet. In some areas of the County a large outwash body exists at the base of the drift (figs. 5, 6, 7, 8, 9 and 13). This outwash represents a sizeable aquifer (Hamilton, 1986) and is the source of much of the local ground water produced from domestic wells in the area. It is thought that the outwash was deposited in front of the advancing pre-late Wisconsin ice and was later overridden by the moving ice sheet. The outwash consists mainly of sand and fine gravel but locally may be very coarse gravel or very fine sand. It is composed of a wide variety of igneous and sedimentary rock fragments, numerous shale pebbles and at some locations contains abundant lignite particles. Large cobbles and boulders are also present in the outwash and in many areas interbedded, thin layers of till are common.

Additional outwash bodies, some of which are quite extensive, (fig. 11) are also present at various localities within the pre-late Wisconsin till. Those outwashes that are continuous over large areas of the County are discussed in detail by Hamilton



Numbers are Map Location Numbers (MLN) and refer to location of logs on cross sections and in appendix.

Figure 4. Index map of Clark County showing locations of geologic cross sections.

Figure 5. Geologic cross section A-A′ (for location see figure 4 and appendix).

Qal...Alluvium
Qwlt(ox)...Oxidized late Wisconsin till
Qwlt(unox)...Unoxidized late Wisconsin till
Qwlo...late Wisconsin outwash
Qoa...Undifferentiated outwash-alluvium
Qpwt(ox)...Oxidized pre-Wisconsin till
Qpwt(unox)...Unoxidized pre-Wisconsin till
Qpwo...pre-Wisconsin outwash
Kp...Pierre Shale

Vertical exaggeration = 105.6X

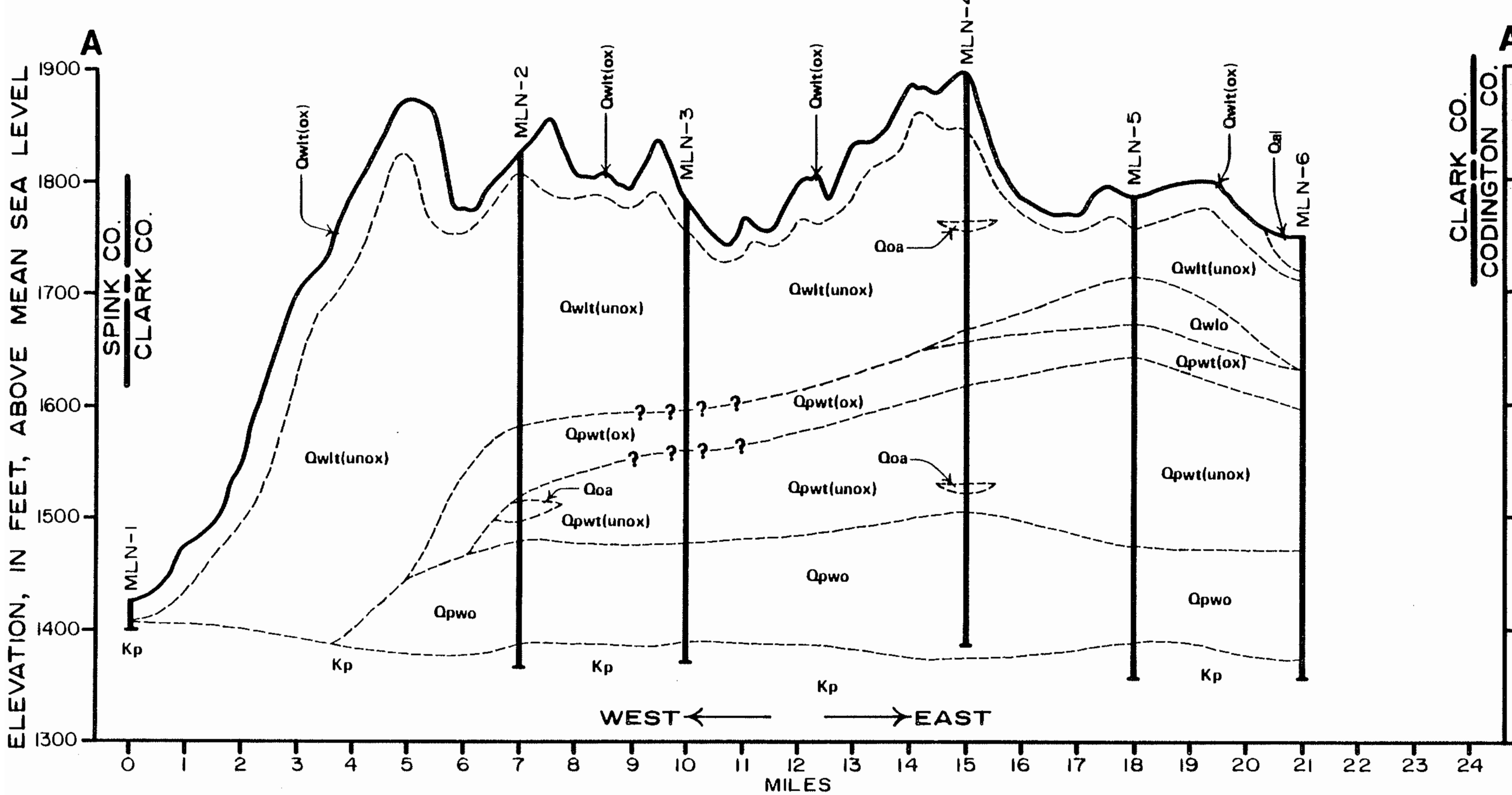


Figure 6. Geologic cross section B-B′ (for location see figure 4 and appendix).

Qwlt(ox)...Oxidized late Wisconsin till
Qwlt(unox)...Unoxidized late Wisconsin till
Qwlo...late Wisconsin outwash
Qls...Undifferentiated lake sediments
Qoa...Undifferentiated outwash-alluvium
Qpwt(ox)...Oxidized pre-Wisconsin till
Qpwt(unox)...Unoxidized pre-Wisconsin till
Qpwo...pre-Wisconsin outwash
Kp...Pierre Shale

Vertical exaggeration = 105.6X

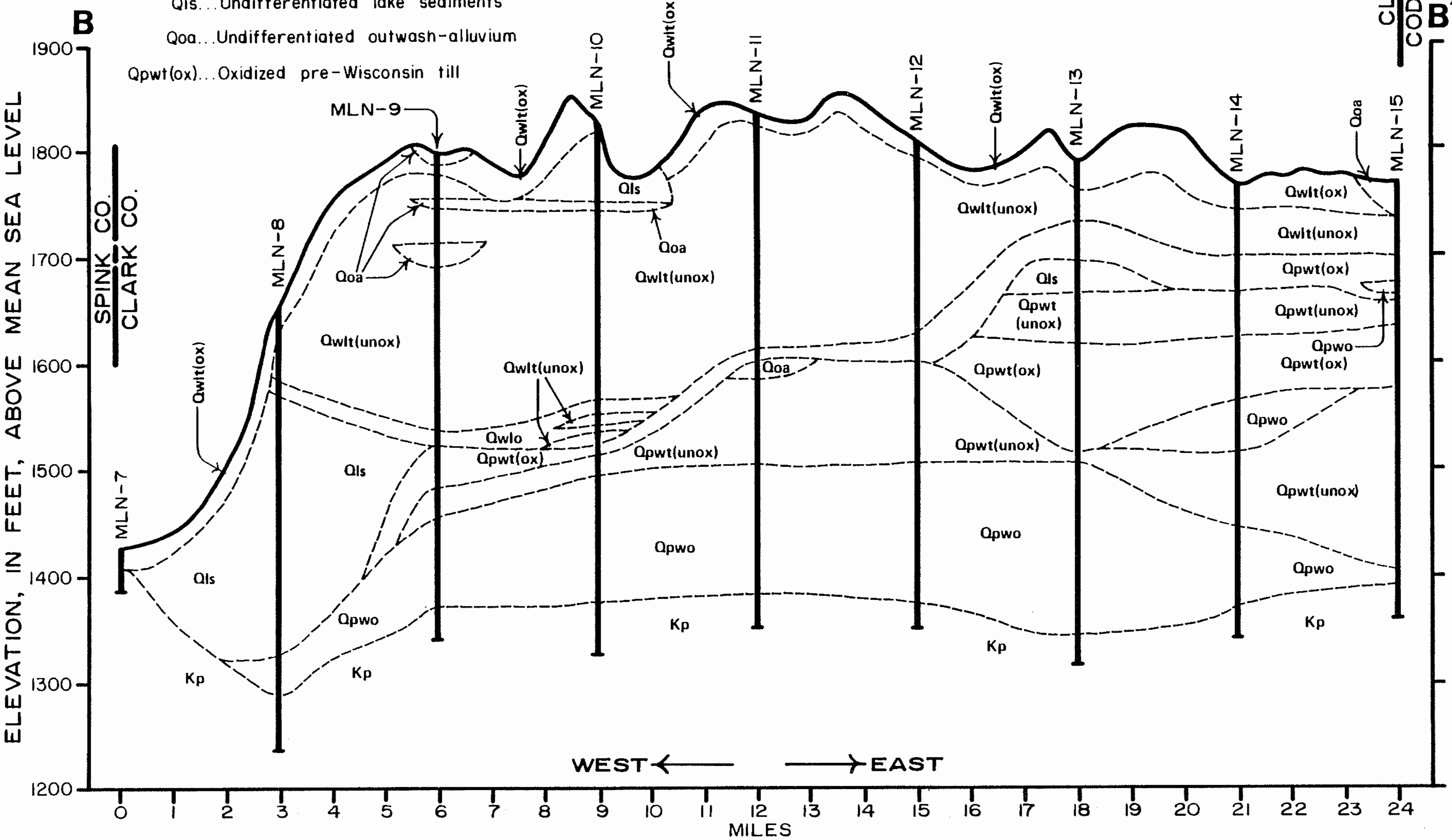


Figure 7. Geologic cross section C-C′ (for location see figure 4 and appendix).

Ql...Loess

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qwlo...late Wisconsin outwash

Qls...Undifferentiated lake sediments

Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Qpwo...pre-Wisconsin outwash

Kp...Pierre Shale

Vertical exaggeration = 105.6X

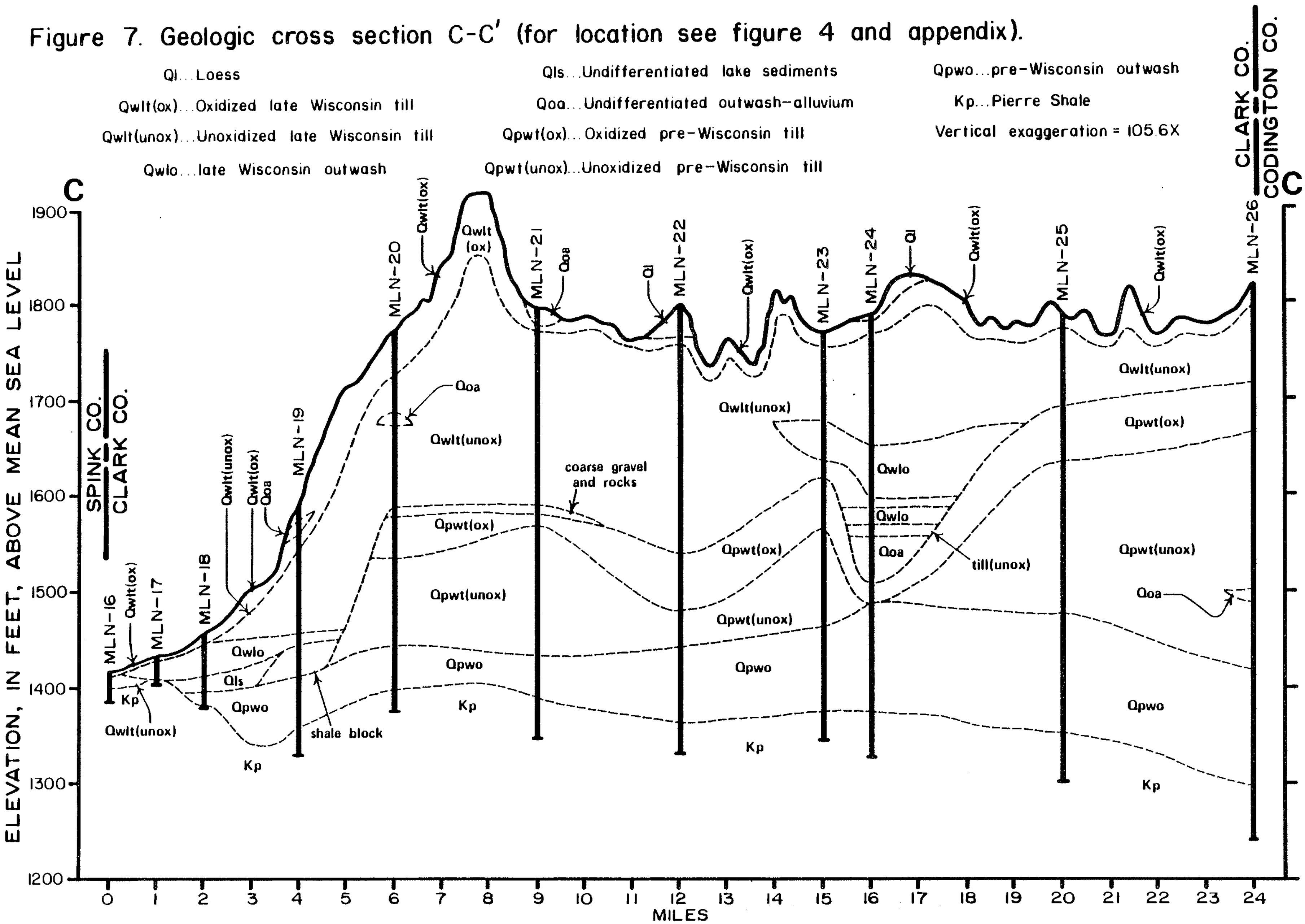


Figure 8. Geologic cross section D-D′ (for location see figure 4 and appendix).

Ql...Loess

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qwlo...late Wisconsin outwash

Qls...Undifferentiated lake sediments

Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Qpwo...pre-Wisconsin outwash

Kp...Pierre Shale

Vertical exaggeration = 105.6X

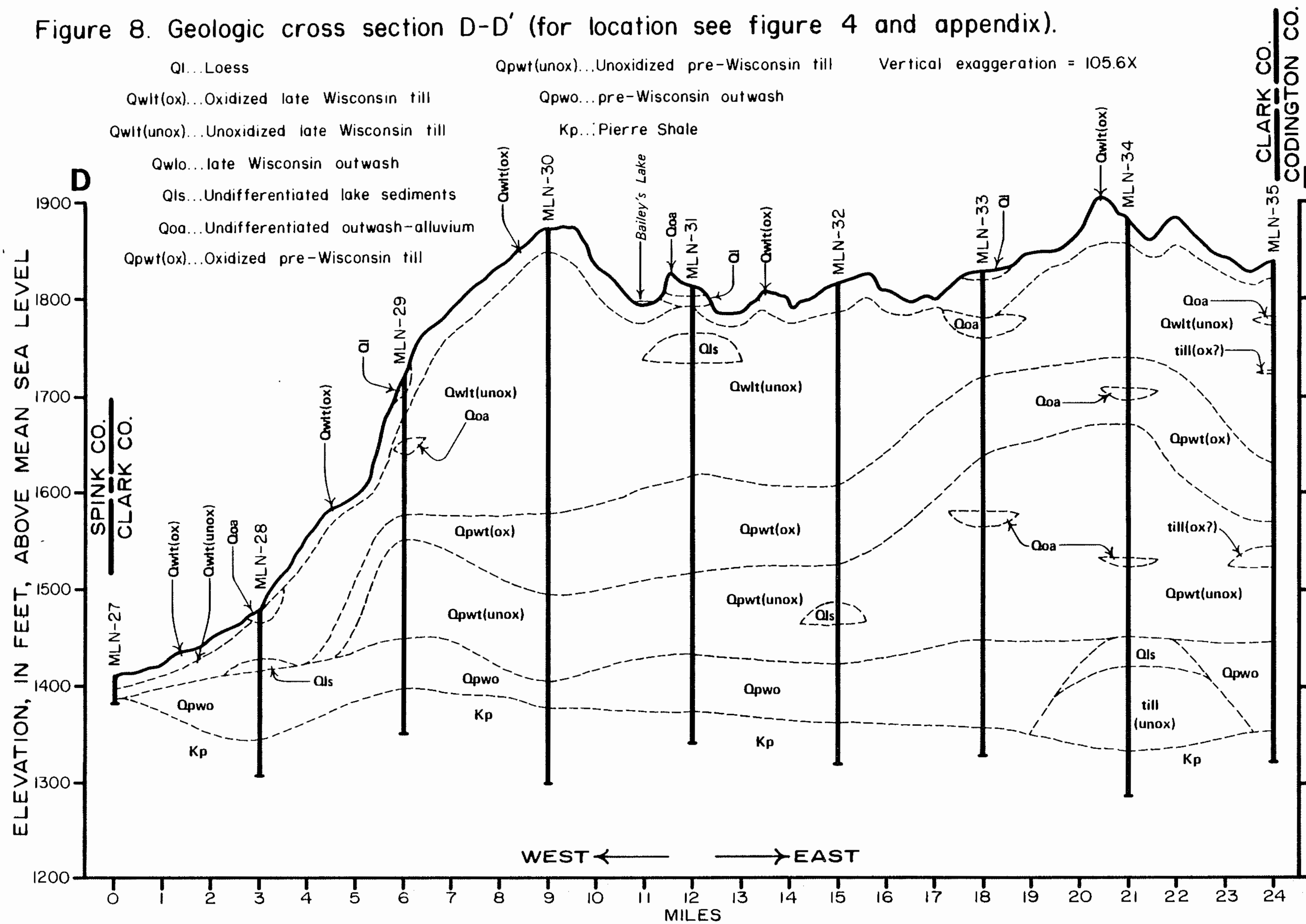


Figure 9. Geologic cross section E-E' (for location see figure 4 and appendix).

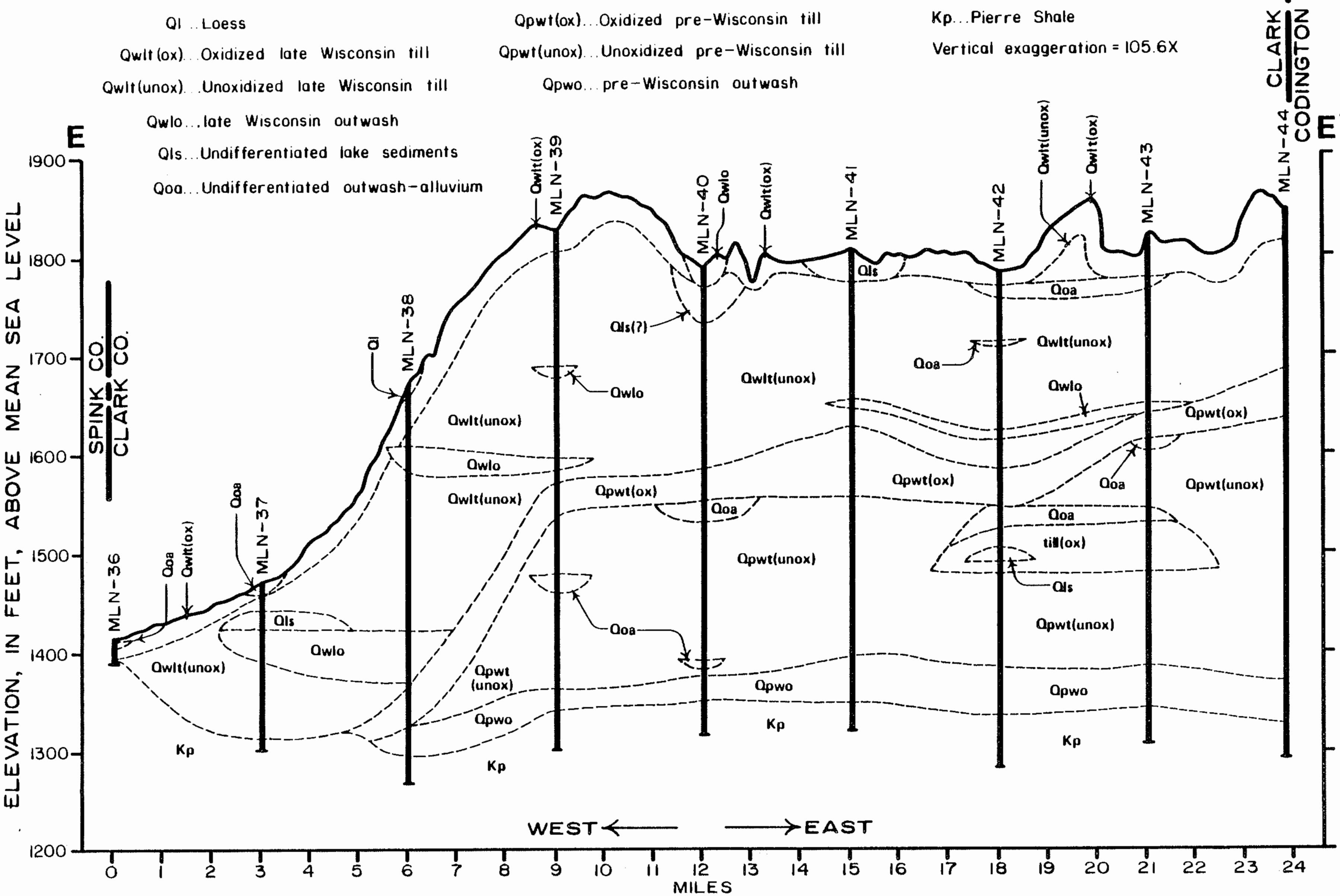


Figure 10. Geologic cross section F-F' (for location see figure 4 and appendix).

Ql...Loess

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qwlo...late Wisconsin outwash

Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Qpwo...pre-Wisconsin outwash

Kp...Pierre Shale

Vertical exaggeration = 105.6X

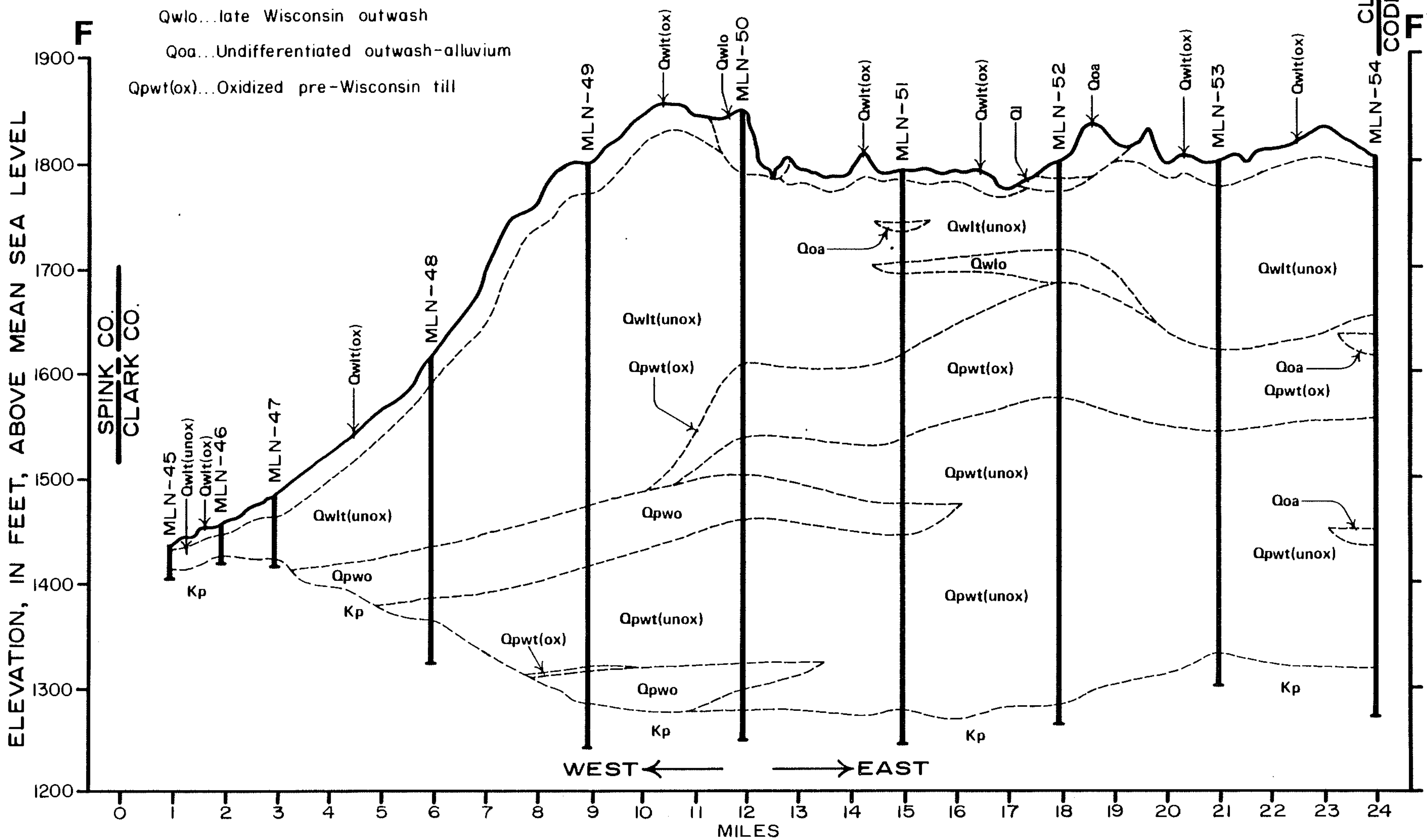


Figure 11. Geologic cross section G-G′ (for location see figure 4 and appendix).

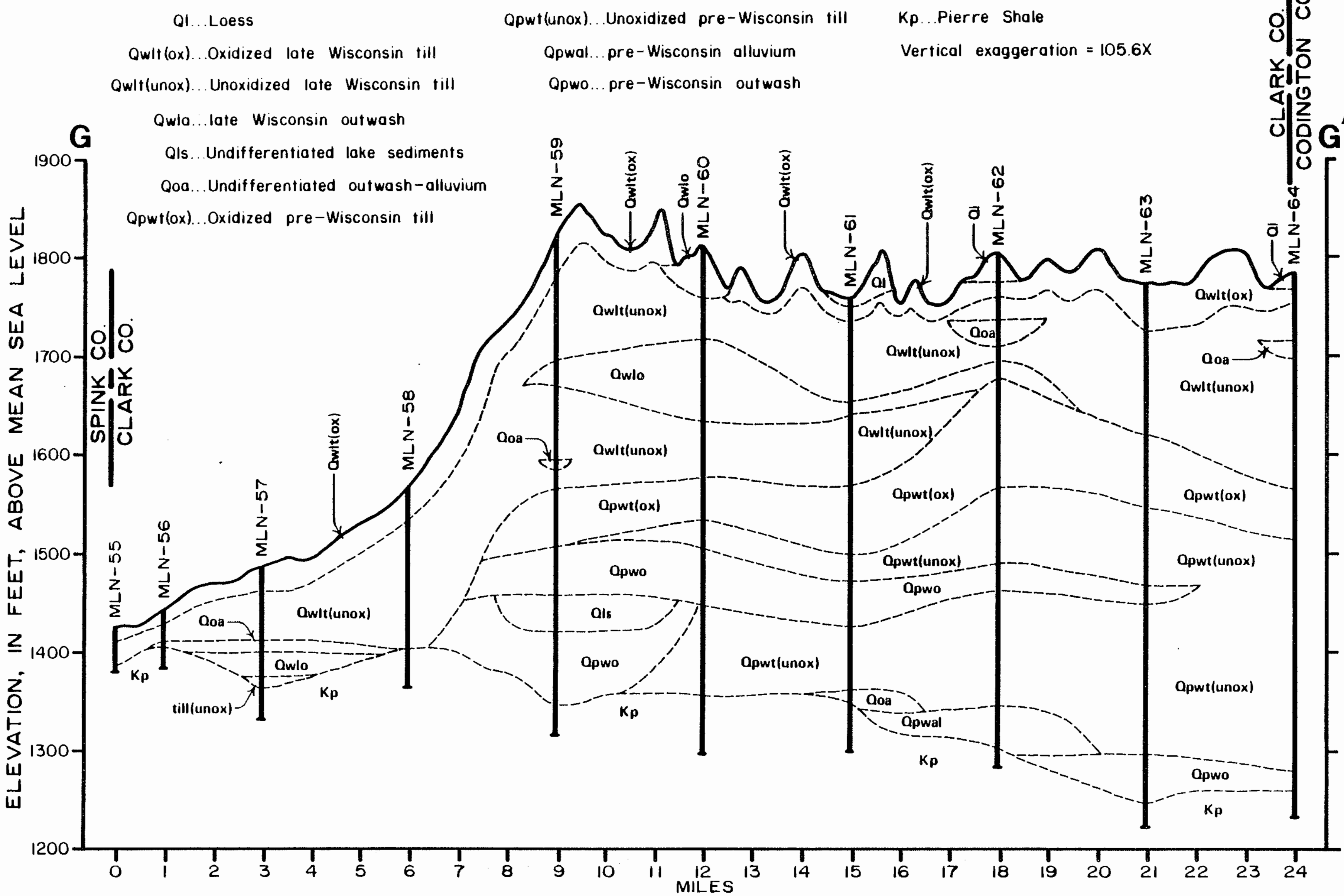


Figure 12. Geologic cross section H-H′ (for location see figure 4 and appendix).

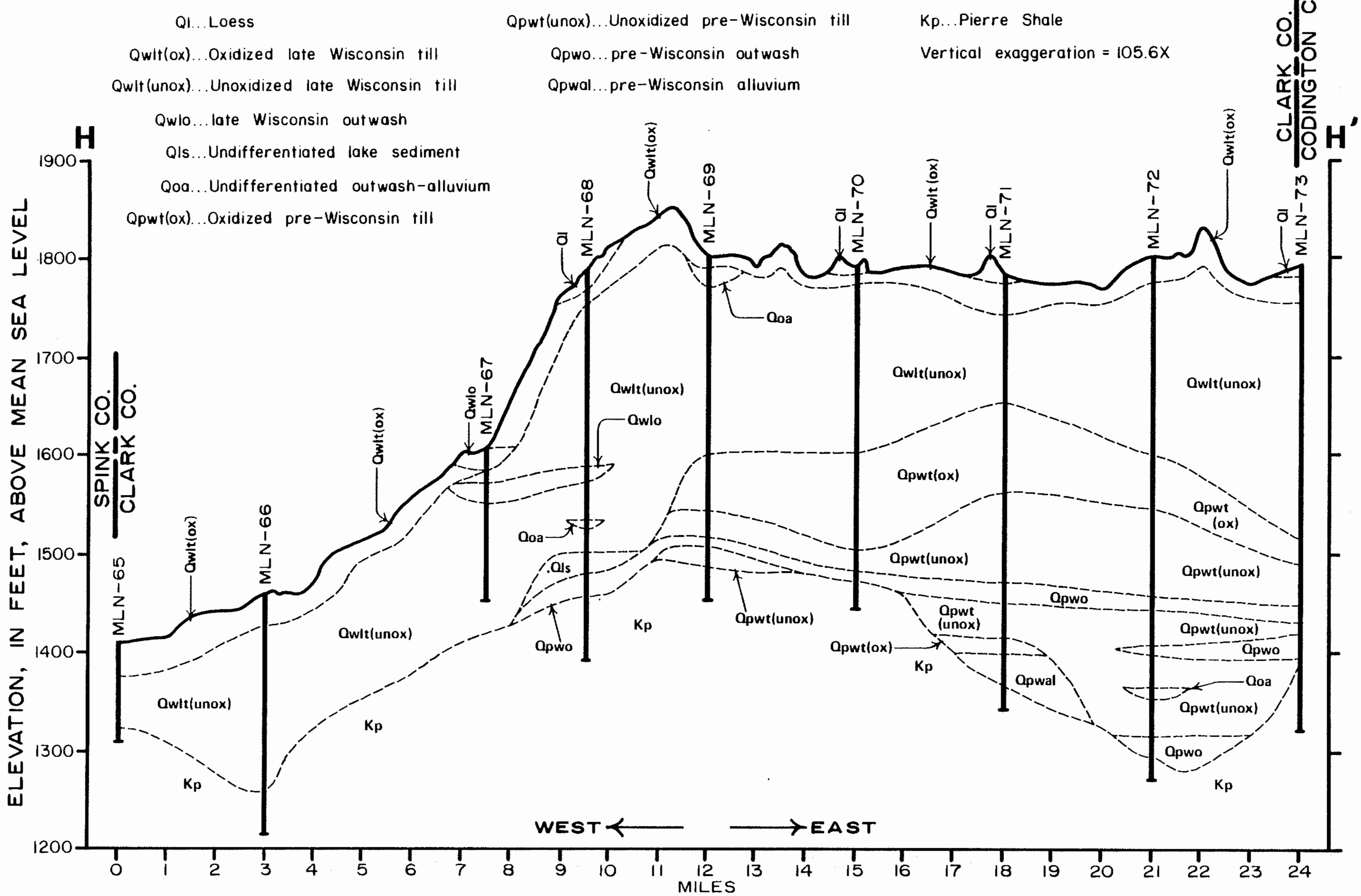


Figure 13. Geologic cross section I-I' (for location see figure 4 and appendix).

Ql...Loess

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qwlo...late Wisconsin outwash

Qls...Undifferentiated lake sediments

Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Qpwo...pre-Wisconsin outwash

Kp...Pierre Shale

Vertical exaggeration = 105.6X

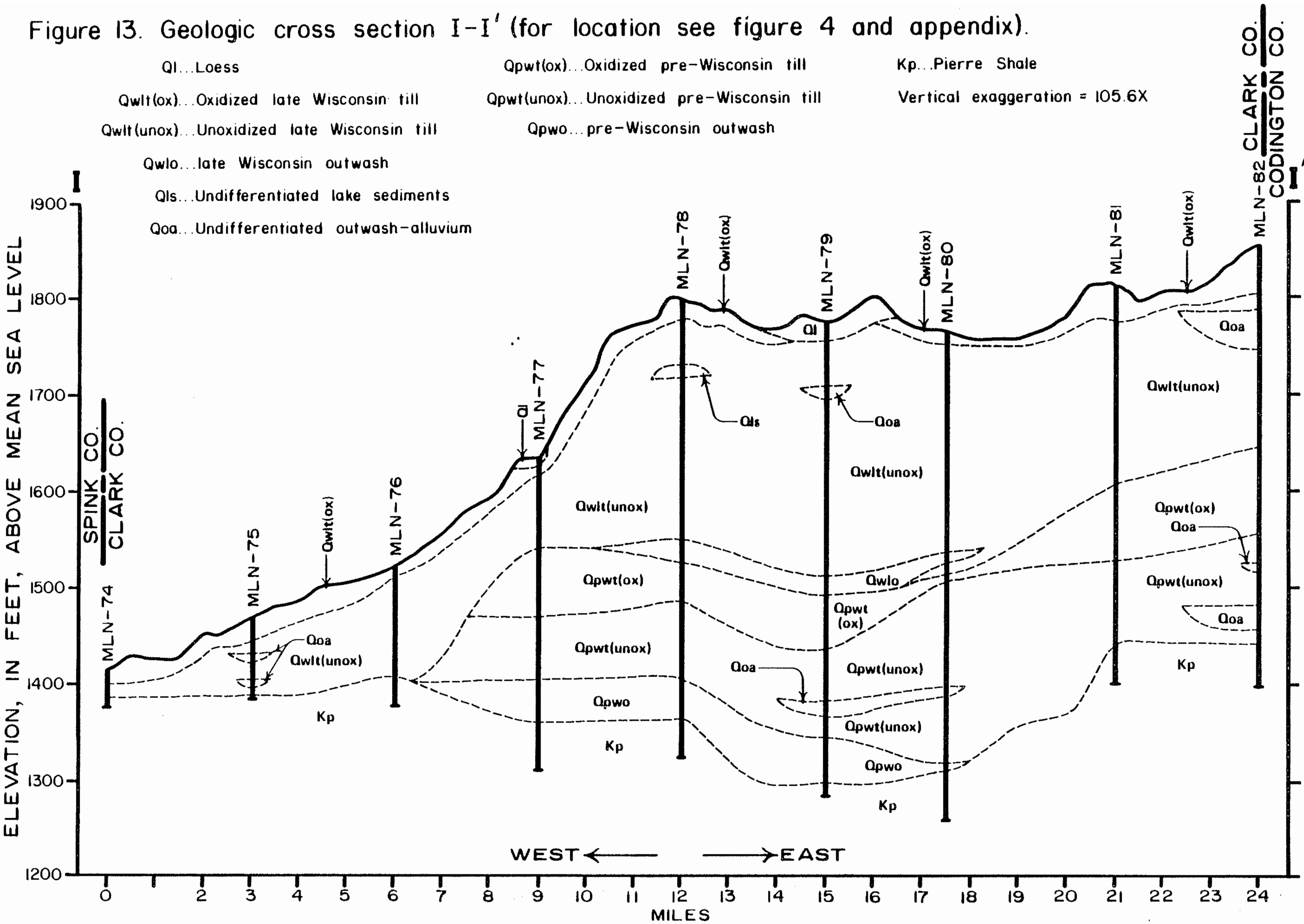


Figure 14. Geologic cross section J-J′ (for location see figure 4 and appendix).

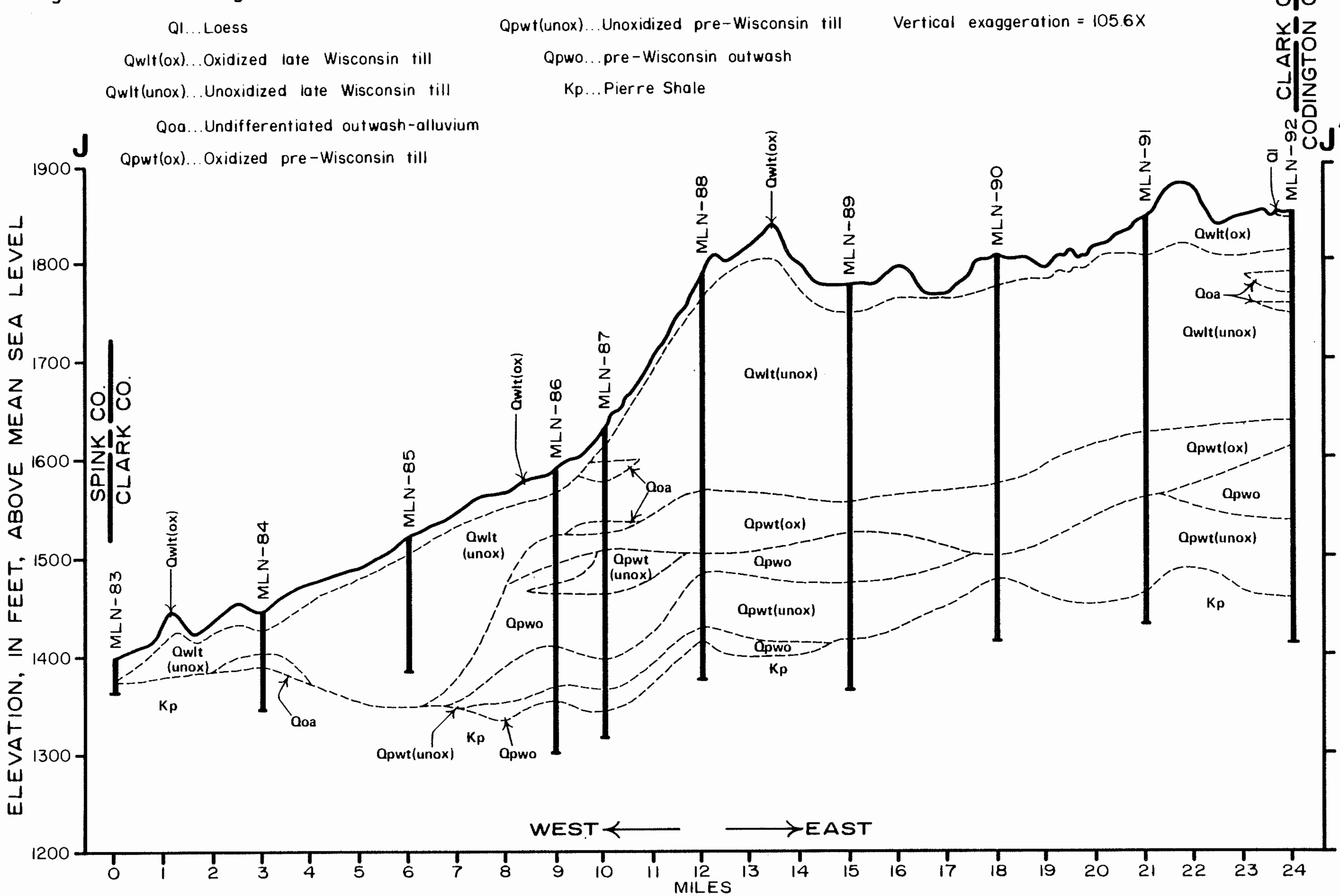


Figure 15. Geologic cross section K-K′ (for location see figure 4 and appendix).

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qls...Undifferentiated lake sediments

Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Kp...Pierre Shale

Vertical exaggeration = 105.6X

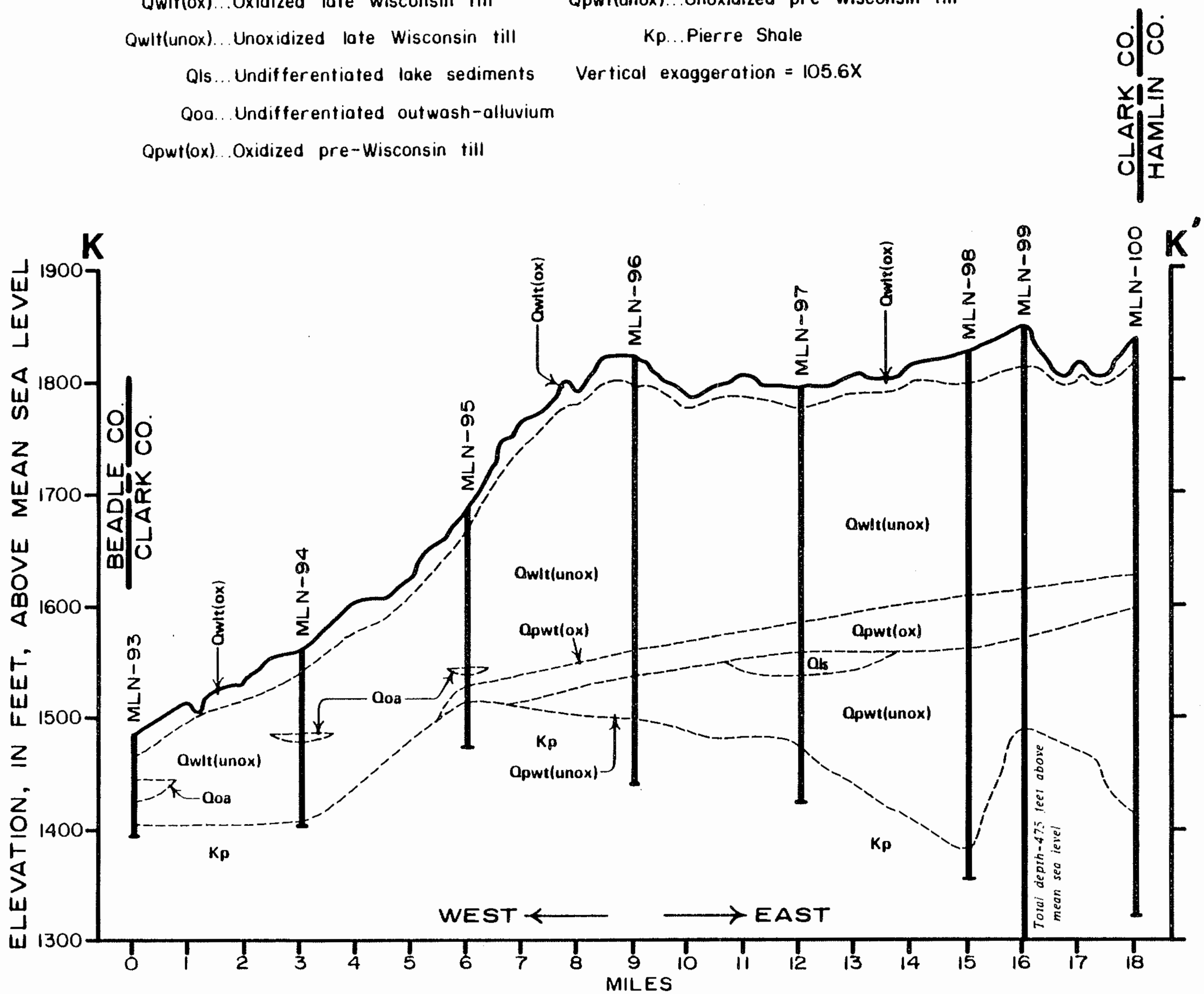


Figure 16. Geologic cross section L-L′ (for location see figure 4 and appendix).

Ql...Loess

Qwlt(ox)...Oxidized late Wisconsin till

Qwlt(unox)...Unoxidized late Wisconsin till

Qls...Undifferentiated lake sediments

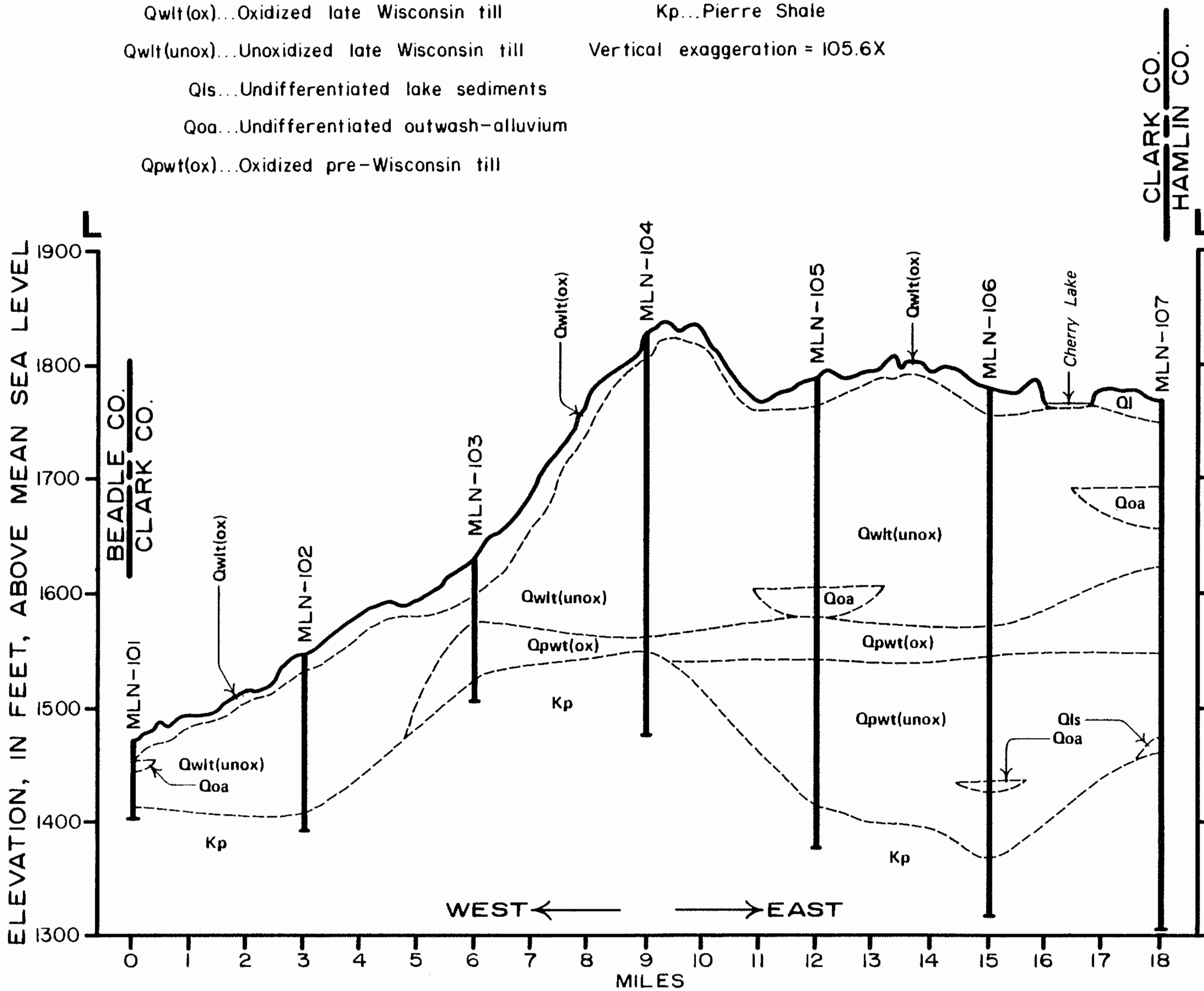
Qoa...Undifferentiated outwash-alluvium

Qpwt(ox)...Oxidized pre-Wisconsin till

Qpwt(unox)...Unoxidized pre-Wisconsin till

Kp...Pierre Shale

Vertical exaggeration = 105.6X



(1986) in Part II of this report because they represent major sources of ground water.

LACUSTRINE SEDIMENTS AND ALLUVIUM

Several isolated areas of lacustrine sediments or alluvium were penetrated by drilling in the pre-late Wisconsin materials of the mapped area. In most instances these deposits are directly associated with topographically lower areas on the surface of the Cretaceous Pierre Shale (fig. 12). Assigning an age to the deposits that exist beneath the pre-late Wisconsin drift and above the Pierre Shale surface is impossible. In reality, such deposits probably represent, and are characteristic of, normal stream and lake activity that would be expected to develop in these low areas throughout the entire period of time. Lacustrine and alluvial deposits that are not associated with the Pierre Shale surface do exist in a random fashion within the pre-late Wisconsin drift sheet. Without exception, these deposits represent an accumulation of water-laid sediments associated with very short lived streams and lakes existing near the margin of the advancing or retreating ice front.

Late Wisconsin Deposits

TILL

Over the entire surface of Clark County, till of late Wisconsin age is the predominant lithology (fig. 2). The till reaches a maximum thickness of over 400 feet along the western edge of the Coteau des Prairies (fig. 5) but thins rapidly to as little as 20 feet along the western border of the County. Average thickness of the late Wisconsin till throughout most of the area is slightly less than 200 feet.

The late Wisconsin till consists of a heterogeneous mixture of clay- to boulder-size material in a silty clay matrix.

OUTWASH

Extensive deposits of outwash exist within the mapped area (fig. 2) and are the result of a variety of glacial and fluvial actions throughout late Wisconsin time. Because the outwash was derived directly from the ice and carried only short distances before deposition occurred, the rock types comprising these deposits are similar in all cases to the rock types making up the late Wisconsin till. Of the three outwash types shown on figure 2 (Qwlo, Qwloc, and Qwloi), Qwlo is better sorted and composed primarily of sand and gravel. Those deposits labeled Qwloc, because of their mode of deposition, may contain minor amounts of till and are sometimes poorly sorted. Deposits labeled Qwloi, which represent ice-walled deposits, are primarily sand and gravel but also contain minor amounts of silt and clay, and, on occasion, some till. A full discussion of the various types of outwash is presented in the section of this report dealing with glacial landforms.

LAKE SEDIMENTS

A small deposit (less than 1 square mile) of low-lying lacustrine sediments exists along the northern border of the County approximately 7 miles northwest of the town of Crocker. The sediments are primarily silt and clay with minor amounts of sand and fine gravel. Inspection of sediment samples from hand-auger holes in this deposit revealed weak, poorly-developed varves. The lake that received the sediments existed in association with an area of collapsed outwash (Qwloc) and may have been only a short-lived area of quiet water associated with the stream that deposited the outwash.

LOESS

Although not shown as a mapped deposit on figure 2, loess exists on the surface over much of the eastern part of Clark County (fig. 17). In general, the loess is thin and discontinuous in the northeastern part of the County and becomes more continuous toward the south. Because loess thicknesses rarely exceed 5 feet and are usually of the magnitude of 1 to 3 feet, the loess was not considered a mappable unit. Loess deposits that were penetrated by test holes are shown on the cross sections (figs. 5 through 16), however, the reader is cautioned that the cross sections indicate a much greater loess thickness than actually exists because of vertical exaggeration. To show the true thickness of the deposits would be impossible on figures of this size.

Additional small, patchy areas of loess exist along the western edge of the Coteau des Prairies in western Clark County (figs. 8, 9, 12 and 13), however, these sediments were derived from a different source area than the loess in eastern Clark County. Depositional history of the various loess deposits will be discussed in a later section of this report.

Recent Deposits

Alluvium

In contrast to most glaciated areas in South Dakota, no major areas of alluvium are located within the confines of Clark County. The County contains no permanent streams. Numerous intermittent streams begin along the western edge of the County, flow westward, and exit the County within a few miles. In every instance, the stream is in a youthful stage and each exhibits active downcutting and headward erosion. Erosion far exceeds

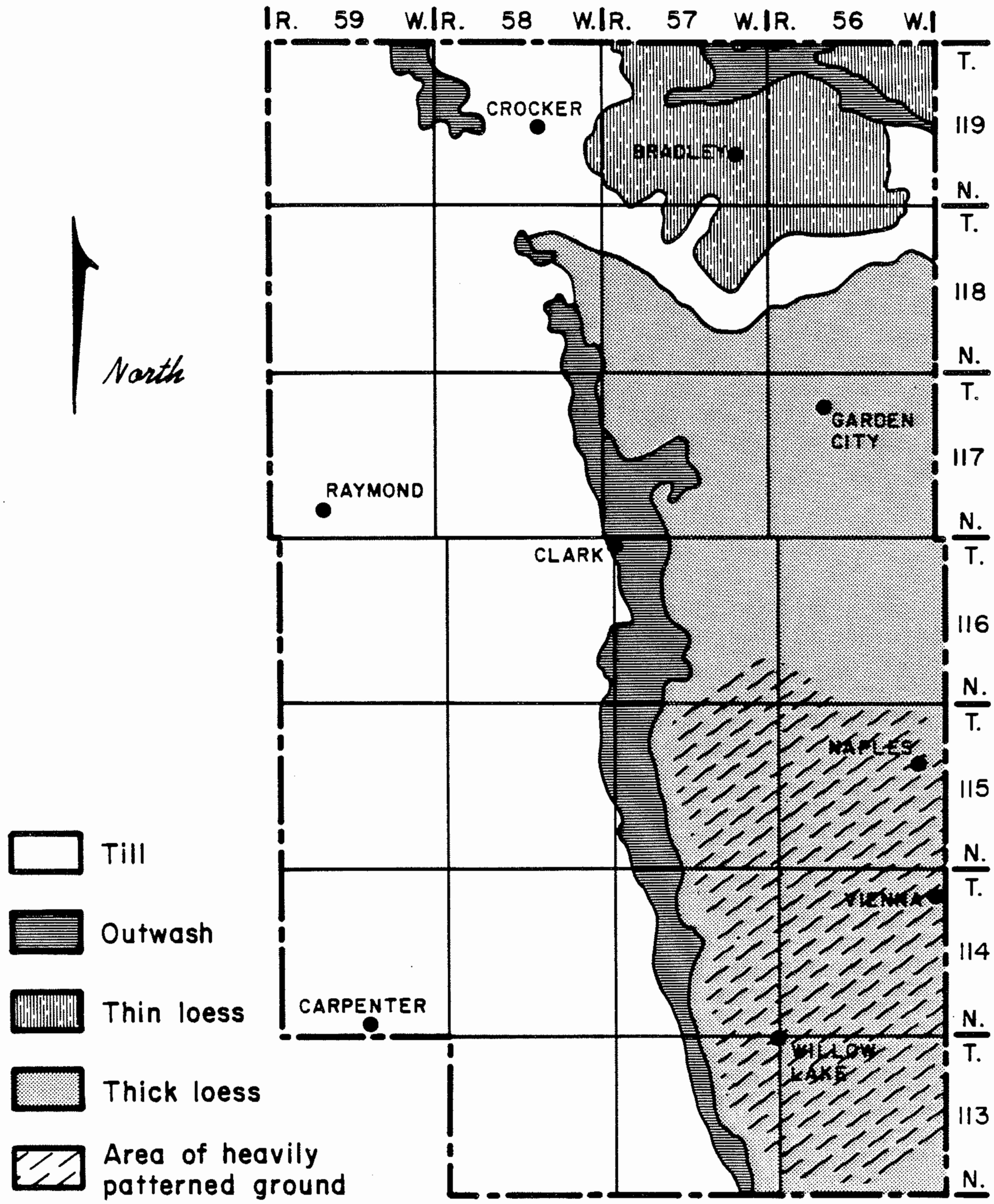


Figure 17. Generalized geologic map of Clark County showing the surficial relationship of till, loess, outwash, and patterned ground.

deposition and, as a result, only small, isolated, and very thin, patches of alluvium exist on the inside of some stream meanders. It is rare if these sediments exceed 2 feet in thickness. For this reason, no alluvium is shown on figure 2.

DEVELOPMENT OF LANDFORMS

Pre-glacial Topography

Prior to glaciation the area that is now Clark County consisted of rolling shale hills bisected by several streams. Maximum relief in the area was approximately 350 feet based on the elevation differences shown on figure 3.

The highest point on the land surface was about 1,548 feet and was located along the southern border of the County. This high was separated from another high about 15 miles farther north (elevation 1,489 feet) by a narrow valley which exits the County at an elevation of approximately 1,240 feet just north of the town of Naples along the eastern border of the County. At this point the low area joins another valley which trends nearly east-west from the town of Naples to about 3 miles north of the town of Raymond near the western border of the mapped area.

Both of the valleys mentioned above show evidence of an apparent divide (fig. 3) located about 5 miles east of the western border of Clark County.

Glacial Modification of Bedrock Topography

Pre-late Wisconsin ice entered what is now Clark County from the northeast and spread westward to an area approximately coincident with the western border of the County. The exact western edge is impossible to determine, however, a series of east-west cross sections (figs. 5 through 16) readily portray the extent of pre-late Wisconsin deposits (Qwpt and Qwpo) that presently exist in the area. It is possible that these deposits extended farther to the west than their present location, however, no evidence to support this idea was found. In fact, earlier studies by Hedges (1972), Christensen and Harksen (1975) and Christensen (1977) suggest an absence of pre-late Wisconsin age deposits over most of northern South Dakota west of Clark County.

Although some modification of the bedrock topography is likely because of erosion at or near the base of the pre-late Wisconsin ice, it is doubtful if major changes occurred. If, in fact, as the evidence suggests, Clark County is near the western edge of the pre-late Wisconsin ice advance, it is too be expected that the erosional capabilities of the ice would be much reduced. As the ice moved west and south across what is now the Coteau des Prairies, it would have been moving up slope as evidenced by the fact that pre-Pleistocene drainage in eastern South Dakota was essentially to the east and north (Christensen, 1977). It is most likely, therefore, that the western limit of pre-late Wisconsin deposits shown on figures 5 through 16 very closely approximates the western limit of ice advance during that time.

Pre-Wisconsin Topography

It is impossible to accurately reconstruct the landscape at the end of the pre-late Wisconsin glaciation, however, figures 5 through 16 show, in general, a till surface that slopes to the west across the expanse that is now Clark County. Near its western limit the till surface rises in some instances (figs. 7, 8, 13 and 16) and suggests the presence of constructional topography similar to what would be expected if these higher areas represent a north-south trending end moraine. Stream valleys were eroded into this surface (fig. 7) and contain normal sequences of alluvial sediments. Although not entirely confirmed by the cross sections (figs. 5 through 16), because such wide-spread data points tend to obscure rugged topography, the pre-late Wisconsin surface probably resembles very much the present-day land surface of the area.

GLACIAL LANDFORMS

The vast majority of landforms witnessed in Clark County at present are the direct result of glaciation during late Wisconsin time. They result both from the construction of various types of morainic deposits related to ice movement and positioning, and from the erosive powers of meltwaters issuing from the melting ice. The deposition of the sediments that comprises each unique landform was controlled by the position of the ice in relation to high and low areas of the surrounding topography.

Landforms Associated with Stagnant Ice

Stagnation Moraine

Moraine resulting from the stagnation of once-active ice exists in several areas of Clark County. Based on topographic distinctions the stagnation moraine has been divided into two categories. Figure 2 shows these categories as Qwlts1 and Qwlts2. Inspection of figure 2 indicates immediately that Qwlts1 contains far fewer sloughs and sloughs of much smaller size, than Qwlts2.

In reality, Qwlts1 represents a north-south trending highland that was originally mapped as end moraine by Flint (1955). The writer believes, however, that in many instances the height of the area is a reflection of underlying topography and not the result of construction by the late Wisconsin ice sheet. In addition, the area is nearly devoid of the normal constructional ridges and similar features usually associated with end moraines.

Most of the remainder of Clark County is overlain by more massive stagnation moraine (Qwlts2) containing large sloughs and kettles resulting from in situ melting of large ice blocks (fig. 2). Most noticeable is the extremely large kettle located immediately north of Willow Lake and a similar depression north of the town of Clark. These particular depressions rank among the larger of these types of features in eastern South Dakota.

Both Qwlts1 and Qwlts2 are areas of knob and kettle topography typical of that usually found in areas of stagnation. The main difference is in the degree of internal relief expressed. Relief within Qwlts1 is generally less than 50 feet; whereas, Qwlts2 contains areas of internal relief exceeding 100 feet.

Ice-Walled Outwash

Several areas of ice-walled outwash are located within the stagnation moraine a few miles south of the town of Bradley in northeastern Clark County (fig. 2). In each instance these deposits are composed primarily of sand and gravel with minor amounts of silt and clay and exist as high-level, flat-topped expressions on the landscape. As the name implies, they represent depositional areas within the stagnant ice that received sediment-laden meltwaters. The ice-walled lakes thus become repositories for the sediment removed from the ice during melting. Once the main mass of ice melted, the deposits were left high above the surrounding countryside.

It is interesting to note that the location of these deposits in Clark County is within the stagnation moraine but immediately adjacent to an area of end moraine. The writer noted this particular arrangement of similar deposits on the Coteau du Missouri (Christensen, 1977) and attributed their location to development within a stable (stagnant) ice area, while still occupying a position where meltwaters and sediment could be received from nearby active ice.

Collapsed Outwash

Figure 2 shows several areas of collapsed outwash within the mapped area. Most significant of these is a linear, north-south trending, low area extending through most of central Clark County. From about 4 miles north of the town of Clark to the southern Clark County border this low is filled with collapsed outwash (Qwloc). The sediment consists primarily of sand and gravel with minor amounts of till.

Topography of the collapsed outwash is undulating and the numerous depressions that have resulted from the melting of ice blocks lends a pitted appearance to much of the area.

Several smaller areas of collapsed outwash occur farther north in the County. One of these areas is located northwest of the town of Crocker and results from a close association with the ice margin during the formation of an end moraine. Another larger area of collapsed outwash occurs in the extreme northeastern corner of the County and trends northwest-southeast from Day County through the mapped area, and into Codington County.

In all of the areas of collapsed outwash described above, thickness of the deposits ranges from about 15 to 50 feet and averages about 25 feet. Several of the larger water bodies that formed in ice-block depressions are now water-table lakes and the lake levels thus reflect the depth to the water table. A good example is Swan Lake in northeastern Clark County.

Landforms Associated with Active Ice

End Moraine

Most of the end moraine in Clark County exists in a narrow band extending from the northwest corner of the County to an area about 5 miles south of Bradley (fig. 2). Another smaller area of end moraine is located along the eastern border of the County approximately 6 miles east of Bradley. These two areas are actually part of the same moraine.

In general, the end moraine is topographically higher than the surrounding countryside. It contains numerous rock-strewn, linear ridges and, as a unit, forms a high, lineated mass from 1 to 4 miles wide and over 15 miles long within the County. Sloughs and potholes are numerous within the end moraine, however, they are fewer in number and of a smaller size than those found in the stagnation moraine.

Outwash

A small area of outwash (Qwlo) not associated with collapsing is located in north-central Clark County in the vicinity of Bailey's Lake. The outwash consists primarily of sand and gravel and has an average thickness of about 25 feet in the mapped area. Although it is in reality a continuation of the collapsed outwash (Qwloc) previously described and exists within the confines of the same topographic low, it is mapped to Qwlo because of the contrasting surface expression when compared to Qwloc. The deposits shown on figure 2 as Qwlo have an essentially flat to gently rolling surface; whereas, those mapped as Qwloc are more undulating and pitted.

GEOMORPHIC DEVELOPMENT

Pre-Pleistocene Topography and Drainage

Although it is impossible to reconstruct with total accuracy the paleo-topography and drainage configuration of an area the size of Clark County, certain generalizations can be made and will aid in understanding the geomorphic development of the area.

Prior to the beginning of the Pleistocene Epoch, and thus before any modification by glacial ice and meltwaters, the area that is now Clark County had a maximum elevation of more than 1,500 feet above mean sea level. It was one of the highest areas within the part of South Dakota that is now known as the Coteau des Prairies. The highest point within the County was along the southern boundary at an elevation of more than 1,548 feet (fig. 3). Another highland existed approximately 15 miles to the north and was at an elevation of nearly 1,500 feet. The two high areas were separated by a low that joined an additional low in east-central Clark County. Both lows presently trend essentially east-west through the central part of the mapped area and both show evidence of a surface-water divide (fig. 3) which indicates that the area may have drained in both an easterly and westerly direction.

Information compiled to construct a present-day bedrock topographic map of eastern South Dakota by Hedges and others (1985, TASK 1, pl. 1) indicates that Clark County represents a high plateau on the Coteau des Prairies. Drainage from the area is not well defined, however, inspection of this map does substantiate the fact that Clark County is part of a divide between two major drainages to the east and west.

Pre-Wisconsin Glaciation

When the pre-Wisconsin glaciers entered South Dakota from the north-northeast, the shale landscape sloped generally from west to east across the entire State. The Missouri River did not exist and the majority of the east-west drainage from the western part of the State culminated in a major stream that flowed north through Spink and Brown Counties and into Hudson Bay. Although not as well defined, the Coteau des Prairies existed as a high plateau separating this drainageway in South Dakota from the major south-flowing streams that existed in western Minnesota and areas farther to the east. Major streams did not cross what is now Clark County. Instead, the area contained only the incised headwaters portion of several tributaries.

Although earlier workers (Flint, 1955) have mapped deposits of pre-Wisconsin age in areas west and north of Clark County in South Dakota, much additional work, including hundreds of test holes drilled for a multitude of mapping projects, have not resulted in the discovery of these deposits (Hedges, 1972;

Christensen and Harksen, 1975; Christensen, 1977; Leap, 1986; Hedges, 1987). In the study area, pre-Wisconsin ice advanced west-southwest to approximately the western boundary of what is now Clark County. Some modification of the underlying topography must have taken place during this advance, however, this modification was probably restricted to a smoothing of the topography and did not result in major changes.

The farthest advance of pre-Wisconsin ice is shown dramatically on figures 5 through 16 and in several instances these cross sections suggest the remnants of pre-Wisconsin end moraine (figs. 6, 7, and 13). Figure 7 also suggests the presence of a boulder pavement between the pre-Wisconsin till (Qpwt) and the late Wisconsin till (Qwlt) in test holes MLN-20 and MLN-21.

All indications (figs. 5 through 16) suggest that the present-day surface of the pre-Wisconsin drift sheet slopes generally from east to west across the mapped area from a maximum elevation of about 1,725 feet (figs. 6, 7, and 8) to a minimum elevation of about 1,500 feet (fig. 15). Maximum relief on this surface is approximately 200 feet.

Late Wisconsin Glaciation

Ice of late Wisconsin age entered South Dakota from the north and was diverted by the Coteau des Prairies bedrock highland, which had become a nearly insurmountable obstacle due to the additional accumulation of pre-Wisconsin drift. The result of this diversion was two distinct lobes of ice that have subsequently been called the Des Moines lobe and the James lobe after the present-day streams which occupy the two areas.

Glacial materials that exist at or near the surface in Clark County are all the result of glaciation by the James lobe ice. This ice sheet followed the low area previously created by the north-flowing drainage through Spink and Brown Counties. As the ice progressed southward, it encroached onto the Coteau des Prairies highlands to the east, totally covering Clark County, and advancing as far east as the present-day Big Sioux River in Hamlin County. In fact, the Big Sioux River began as an interlobate stream between the James lobe to the west and the Des Moines lobe to the east and owes its early existence to meltwaters issuing from the two lobes of ice.

Stagnation Moraine

Although a number of end moraines are present within the central part of the Coteau des Prairies, the vast majority of till present is classified as stagnation till and resulted from the stagnation of both lobes on the highland. The till deposits recognized in Clark County are no exception (fig. 2).

While the overall movement of the James lobe was to the south, most ice movement in what is now Clark County was to the east-southeast and resulted from encroachment of the ice onto the highlands. Once this encroachment was complete, stagnation occurred throughout Clark County and the surrounding area to the east. Active ice continued to move in the James lobe to the west and contributed superglacial material to cover much of the stagnant ice. During this period an end moraine was constructed in the northern part of Clark County (fig. 2).

Outwash Deposition

Drainage from the active ice to the west and the stagnant ice to the east was funneled southward from the end moraine and formed a narrow channel that trended north-south through most of Clark County. This channel must have carried large amounts of water as evidenced by the substantial thickness of sediments that presently exists there (discussed earlier in this report) and was rather tightly constricted between the active and stagnant ice. No stream flows in this low area today and the paleo-drainageway is now occupied by a narrow band of outwash shown as Qwlo and Qwloc on figure 2.

Further evidence that this outwash area essentially marks the boundary between active and stagnant ice is shown by the location of large depressions within the area east of the outwash. Such an abundance of large depressions is characteristic of ice blocks left undisturbed in stagnating ice. A noticeable absence of these depressions is shown on figure 2 within the area west of the outwash body.

Most notable of the depressions mentioned above are three large northeast-southwest trending sloughs attached to the east side of the outwash body north of the town of Willow Lake and both north and south of the town of Clark (fig. 2). These depressions, although probably occupied much of the time by large ice blocks, formed a partial drainage system along the western edge of the stagnant ice mass. In fact, one of the large depressions (southeast of Clark) is best described as a series of ice-block depressions within a meltwater channel (fig. 2).

Ground Moraine

West of the outwash that separated active ice from stagnant ice, a large expanse of ground moraine can be found today. This deposit is shown as Qwlg on figure 2. The major portion of the ground moraine was formed beneath the ice, however, some of the material was probably the result of ablation during the later phases of glaciation. Early workers, most specifically Flint (1955), mapped this deposit as end moraine because it forms a linear band of till between the County border and the outwash body previously discussed. It is the writer's contention, however, that the deposit is actually ground moraine. This conclusion is based on the fact that the area, although high, is in general devoid of any of the constructional characteristics commonly associated with end moraine. The height, position and linearity of the deposit can all be attributed to the position of the underlying pre-Wisconsin till topography and the location of stagnant ice to the west of the area during deposition.

Late Wisconsin Deglaciation

Withdrawal of the late Wisconsin ice from the area that is now Clark County began in the James Basin. No absolute dates are available from the County to indicate exactly when the process began, however, information from surrounding areas (Christensen, 1977) indicates that the James lobe ice would have reached its maximum between 14,000 and 15,000 years ago and that the James Basin was ice-free by 11,000 years ago. It can be further speculated that complete wasting of the stagnant ice in the eastern half of Clark County was not accomplished for an additional several thousand years because of the insulating effect of superglacial debris. Again, no absolute dates are available from Clark County, however, radiocarbon dates from superglacial drift in McPherson County range in age from 14,190 to 9,220 years before present (Christensen, 1977) and a similar range in age should be valid for Clark County. If this is indeed the case, it is probable that stagnant ice remained in eastern Clark County for at least 2,000 years after total withdrawal of active ice from the James Basin.

Loess Deposition

Beginning even before deglaciation, deposition of loess was occurring in the mapped area. As the outwash was being deposited in the low area between the active and stagnant ice, surface winds were removing the finer materials and depositing them on nearby ice. These early deposits were part of the superglacial sediments and did not remain as distinct eolian deposits. The removal of fine materials from the outwash continued, however, throughout the period of deglaciation and into Recent times. Evidence of this can be seen throughout most of the eastern half of Clark County (fig. 17). Deposits of loess ranging in thickness from less than 1 foot to over 5 feet cover this part of the County. It is easy to postulate a westerly prevailing wind based on the location of these deposits which occur almost without exception to the east of the outwash area.

Patterned Ground

Although not germane to the mode or method of loess deposition, it is necessary to discuss at this point the presence of patterned ground within the area covered by loess.

The formation of polygonal shaped patterns in areas of permanently frozen ground has been much discussed in geologic literature for some years and is not unique to Clark County. They are mentioned here only because they occur in abundance within the thicker part of the loess cover in southeastern Clark County (fig. 18). Most probably the entire area associated with the stagnant ice contained such features, and in fact, remnants of them can be seen in the County in areas of stagnation drift where the loess cover is very thin or absent. They are best preserved, however, in areas of the County where loess cover is at a maximum. In this area it is not uncommon to view patterns with diameters in excess of 1 mile. This fact is probably due to the uniform grain size (silt and fine sand) within the loess deposits which lends itself well to the formation and preservation of patterned ground.

Recent Modifications

Since the close of the Pleistocene Epoch, geomorphic development has not changed the landscape to any great extent. Essentially no external drainage exists within the eastern half of the County. Drainage is developing in the western half of the County but consists entirely of small intermittent streams and gulleys that mark the far eastern edge of the James River tributary system.

It is obvious that some lowering of the landscape has occurred and that erosion is taking place because sloughs and potholes are partially filled with sediment removed from adjacent hillsides. Deposition during the Recent Epoch has been confined to emplacement of these sediments in the sloughs and to very scattered deposition of thin alluvium in several of the drainageways.

ECONOMIC GEOLOGY

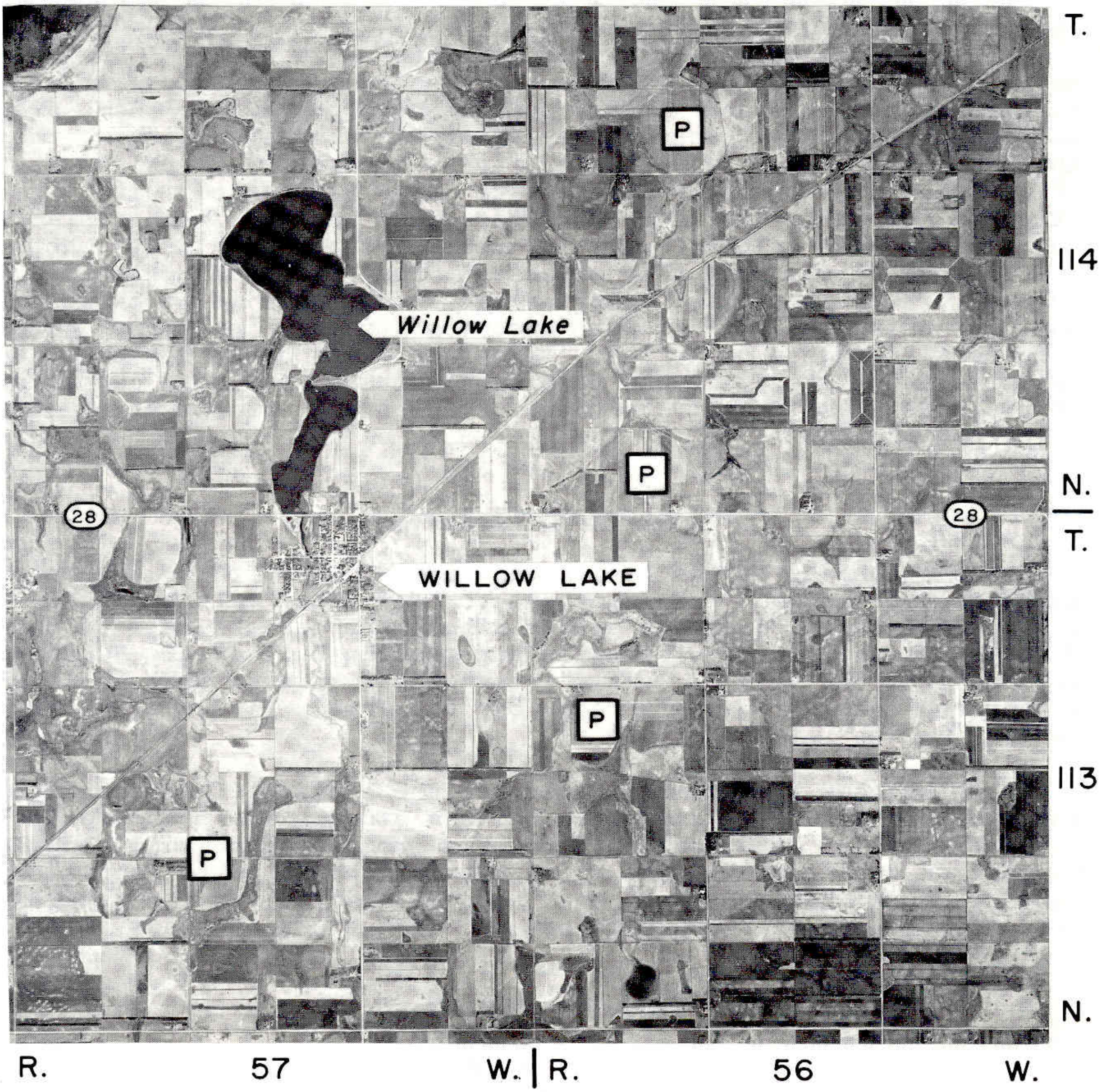
Mineral Resources

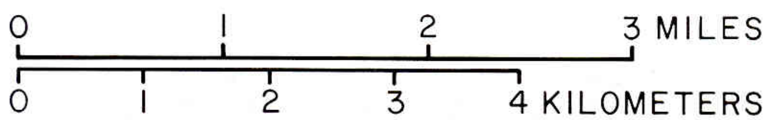
Water

The most abundant single mineral commodity available for man's benefit within the study area is water. As part of this investigation into the geology and water resources of Clark County, a complete hydrologic investigation was completed. The technical results of this investigation can be found in Hamilton (1986) and a short summation of the available water resources can be found in Hamilton (1978).

Sand and Gravel

Another important aspect of this investigation dealt with the availability of sand and gravel resources within the County. A





P Polygons marked for quick identification. Numerous others are visible.

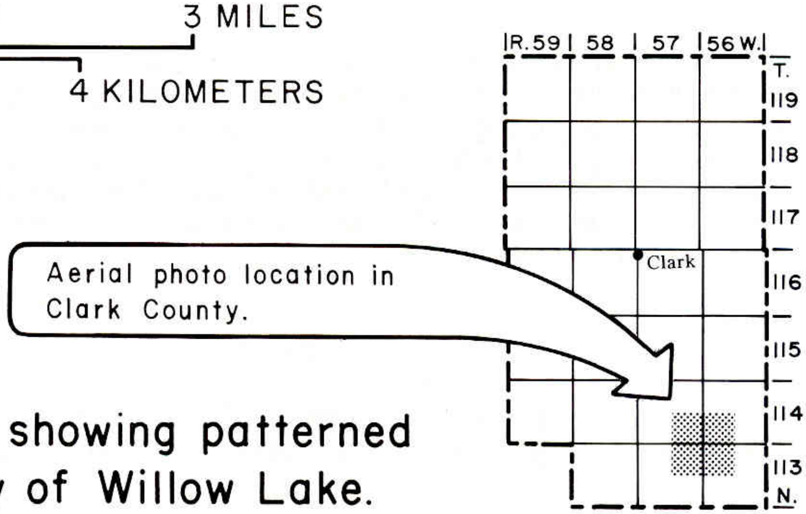


Figure 18. Air photo showing patterned ground in the vicinity of Willow Lake.

separate report outlining the results of this portion of the investigation was compiled by Schroeder (1978).

Other Mineral Commodities

To date, no other economically minable deposits such as oil, gas, ceramic clay, or metals have been located in the mapped area.

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APPENDIX

Legal descriptions of test-hole logs

The following list contains the map location numbers and legal descriptions of all test-hole logs shown on figure 4 and used to construct the cross sections (figs. 5 through 16). These logs are available from the computer files of the South Dakota Geological Survey. The map location numbers refer only to this report. Any request for logs should contain the legal description.

MAP LOCATION NUMBER		LEGAL DESCRIPTION
MLN- 1	....	NW NW NW NW sec. 6, T. 119 N., R. 59 W.
MLN- 2	....	SE SE NE NE sec. 6, T. 119 N., R. 58 W.
MLN- 3	....	NE NE NE NE sec. 3, T. 119 N., R. 58 W.
MLN- 4	....	NW NW NW NW sec. 3, T. 119 N., R. 57 W.
MLN- 5	....	SE SE SE SE sec. 36, T. 120 N., R. 57 W.
MLN- 6	....	NW NW NW NW sec. 3, T. 119 N., R. 56 W.
MLN- 7	....	NW NW NW NW sec. 19, T. 119 N., R. 59 W.
MLN- 8	....	NE SE NE NE sec. 21, T. 119 N., R. 59 W.
MLN- 9	....	SE SE SE SE sec. 13, T. 119 N., R. 59 W.
MLN- 10	....	SW SW SW SW sec. 15, T. 119 N., R. 58 W.
MLN- 11	....	NE SE NE SE sec. 13, T. 119 N., R. 58 W.
MLN- 12	....	SW SE SE SW sec. 15, T. 119 N., R. 57 W.
MLN- 13	....	NW SW SW SW sec. 18, T. 119 N., R. 56 W.
MLN- 14	....	SE SE NE NE sec. 21, T. 119 N., R. 56 W.
MLN- 15	....	NW NW NW NW sec. 19, T. 119 N., R. 55 W.
MLN- 16	....	NW NW NW NW sec. 7, T. 118 N., R. 59 W.
MLN- 17	....	SW SW SW SW sec. 5, T. 118 N., R. 59 W.
MLN- 18	....	NE NE NE NE sec. 8, T. 118 N., R. 59 W.
MLN- 19	....	SW SW NW SW sec. 11, T. 118 N., R. 59 W.
MLN- 20	....	NE NE NE NE sec. 12, T. 118 N., R. 59 W.
MLN- 21	....	NW NW NW NW sec. 10, T. 118 N., R. 58 W.
MLN- 22	....	SE SE SE SE sec. 1, T. 118 N., R. 58 W.
MLN- 23	....	SW SE SW SE sec. 4, T. 118 N., R. 57 W.
MLN- 24	....	NW NW NW NW sec. 11, T. 118 N., R. 57 W.
MLN- 25	....	NE NE NE NE sec. 8, T. 118 N., R. 56 W.
MLN- 26	....	NE NE NE NE sec. 13, T. 118 N., R. 56 W.
MLN- 27	....	SW SW SW SW sec. 19, T. 118 N., R. 59 W.
MLN- 28	....	SE SE SE SE sec. 28, T. 118 N., R. 59 W.
MLN- 29	....	NW NW NW NW sec. 31, T. 118 N., R. 58 W.
MLN- 30	....	SW SW SW SW sec. 27, T. 118 N., R. 58 W.

MAP LOCATION NUMBER		LEGAL DESCRIPTION
MLN- 31	....	NW NW NW NW sec. 31, T. 118 N., R. 57 W.
MLN- 32	....	SW SW SW SW sec. 27, T. 118 N., R. 57 W.
MLN- 33	....	NW NW NW NW sec. 31, T. 118 N., R. 56 W.
MLN- 34	....	NE NE NE NE sec. 33, T. 118 N., R. 56 W.
MLN- 35	....	SE SE SE SE sec. 36, T. 118 N., R. 56 W.
MLN- 36	....	SW SW SW SW sec. 18, T. 117 N., R. 59 W.
MLN- 37	....	SE SE SE SE sec. 16, T. 117 N., R. 59 W.
MLN- 38	....	SW SW SW SW sec. 18, T. 117 N., R. 58 W.
MLN- 39	....	NW NW NW NW sec. 22, T. 117 N., R. 58 W.
MLN- 40	....	NW NW NW NW sec. 19, T. 117 N., R. 57 W.
MLN- 41	....	NW NW NW NW sec. 22, T. 117 N., R. 57 W.
MLN- 42	....	NW NW NW NW sec. 19, T. 117 N., R. 56 W.
MLN- 43	....	SE SW SW SW sec. 15, T. 117 N., R. 56 W.
MLN- 44	....	SE SE SE SE sec. 13, T. 117 N., R. 56 W.
MLN- 45	....	SE SE SE SE sec. 6, T. 116 N., R. 59 W.
MLN- 46	....	SE SE SE SE sec. 5, T. 116 N., R. 59 W.
MLN- 47	....	SW SW SW SW sec. 3, T. 116 N., R. 59 W.
MLN- 48	....	NE NE NE NE sec. 12, T. 116 N., R. 59 W.
MLN- 49	....	NE NE NE NE sec. 9, T. 116 N., R. 58 W.
MLN- 50	....	SE NW SE SE sec. 1, T. 116 N., R. 58 W.
MLN- 51	....	SE SE SE SE sec. 4, T. 116 N., R. 57 W.
MLN- 52	....	SW NW NW NW sec. 7, T. 116 N., R. 56 W.
MLN- 53	....	SE SE SE SE sec. 4, T. 116 N., R. 56 W.
MLN- 54	....	SE SE SE SE sec. 1, T. 116 N., R. 56 W.
MLN- 55	....	NW NW NW NW sec. 31, T. 116 N., R. 59 W.
MLN- 56	....	NE NE NE NE sec. 31, T. 116 N., R. 59 W.
MLN- 57	....	SW SW SW SW sec. 27, T. 116 N., R. 59 W.
MLN- 58	....	SW SW SW SW sec. 30, T. 116 N., R. 58 W.
MLN- 59	....	SE SE SE SE sec. 28, T. 116 N., R. 58 W.
MLN- 60	....	SE SE SE SE sec. 25, T. 116 N., R. 58 W.
MLN- 61	....	NE NE NE NE sec. 33, T. 116 N., R. 57 W.
MLN- 62	....	SE SW SE SE sec. 25, T. 116 N., R. 57 W.
MLN- 63	....	NW NE NE NE sec. 33, T. 116 N., R. 56 W.
MLN- 64	....	SW SW SW SW sec. 30, T. 116 N., R. 55 W.
MLN- 65	....	SW SW SW SW sec. 18, T. 115 N., R. 59 W.
MLN- 66	....	NW NE NE NE sec. 21, T. 115 N., R. 59 W.
MLN- 67	....	NE NE NW NW sec. 20, T. 115 N., R. 58 W.
MLN- 68	....	SE SE SE SW sec. 15, T. 115 N., R. 58 W.
MLN- 69	....	SW SW SW SW sec. 18, T. 115 N., R. 57 W.
MLN- 70	....	NW SW SW SW sec. 15, T. 115 N., R. 57 W.

MAP LOCATION NUMBER		LEGAL DESCRIPTION
MLN- 71	....	NW NW NW NW sec. 19, T. 115 N., R. 56 W.
MLN- 72	....	NW NW NW NW sec. 22, T. 115 N., R. 56 W.
MLN- 73	....	NE NW NW NW sec. 19, T. 115 N., R. 55 W.
MLN- 74	....	SW SW SW SW sec. 6, T. 114 N., R. 59 W.
MLN- 75	....	SW SW SW SW sec. 3, T. 114 N., R. 59 W.
MLN- 76	....	NE NE NE NE sec. 12, T. 114 N., R. 59 W.
MLN- 77	....	NE NE NE NE sec. 9, T. 114 N., R. 58 W.
MLN- 78	....	SE SE SE SE sec. 1, T. 114 N., R. 58 W.
MLN- 79	....	NE NE NE NE sec. 9, T. 114 N., R. 57 W.
MLN- 80	....	NE NE NE NW sec. 12, T. 114 N., R. 57 W.
MLN- 81	....	NW NW SW NW sec. 10, T. 114 N., R. 56 W.
MLN- 82	....	SE SE SE SE sec. 1, T. 114 N., R. 56 W.
MLN- 83	....	SW SW SW SW sec. 30, T. 114 N., R. 59 W.
MLN- 84	....	SW SW SW SW sec. 27, T. 114 N., R. 59 W.
MLN- 85	....	NW NW NW NW sec. 31, T. 114 N., R. 58 W.
MLN- 86	....	SE SE SE SE sec. 28, T. 114 N., R. 58 W.
MLN- 87	....	NE SE SE SE sec. 27, T. 114 N., R. 58 W.
MLN- 88	....	NW NE NE NE sec. 36, T. 114 N., R. 58 W.
MLN- 89	....	SE SE SE SE sec. 28, T. 114 N., R. 57 W.
MLN- 90	....	NW NW NW NW sec. 31, T. 114 N., R. 56 W.
MLN- 91	....	SW SW SW SW sec. 27, T. 114 N., R. 56 W.
MLN- 92	....	NW NW NW NW sec. 31, T. 114 N., R. 55 W.
MLN- 93	....	NW NW NW NW sec. 19, T. 113 N., R. 58 W.
MLN- 94	....	NW NW NW NW sec. 22, T. 113 N., R. 58 W.
MLN- 95	....	SW SW SW SW sec. 18, T. 113 N., R. 57 W.
MLN- 96	....	SE SE SE SE sec. 16, T. 113 N., R. 57 W.
MLN- 97	....	NE NW NW NE sec. 24, T. 113 N., R. 57 W.
MLN- 98	....	NW NW NW NW sec. 22, T. 113 N., R. 56 W.
MLN- 99	....	SE SE SE SE sec. 15, T. 113 N., R. 56 W.
MLN-100	....	NE NE NE NE sec. 24, T. 113 N., R. 56 W.
MLN-101	....	SW SW SW SW sec. 31, T. 113 N., R. 58 W.
MLN-102	....	NW NW NW NW sec. 3, T. 112 N., R. 58 W.
MLN-103	....	SE SE SE SE sec. 36, T. 113 N., R. 58 W.
MLN-104	....	NW NE NE NE sec. 4, T. 112 N., R. 57 W.
MLN-105	....	SE SE SE SE sec. 36, T. 113 N., R. 57 W.
MLN-106	....	SW SW SW SW sec. 34, T. 113 N., R. 56 W.
MLN-107	....	SE SE SE SE sec. 36, T. 113 N., R. 56 W.