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# Regional Tectonics and Seismicity of Eastern Nebraska

Annual Report
June 1978 - May 1979

Prepared by R. R. Burchett

Nebraska Geological Survey

Prepared for
U. S. Nuclear Regulatory
Commission

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# REGIONAL TECTONICS AND SEISMICITY OF EASTERN NEBRASKA

Annual Report
June 1, 1978-May 30, 1979

R. R. Burchett, Principal Investigator

Date Published: February 1980

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## ABSTRACT

This annual report presents and interprets the information obtained by the Conservation and Survey Division (Nebraska Geological Survey) during contract year June 1, 1978, to May 30, 1979, under contract NRC-04-76-315 with the U.S. Nuclear Regulatory Commission. The information pertains to the geology, structure, tectonics, and seismicity of eastern Nebraska with emphasis on the vicinity of the intersection of the Union and Humboldt Fault zones. Some of the information presented here results from a combination of studies begun in earlier years but the greater part results from studies begun during the contract year.

The scope of the studies is summarized as follows:

1. Rock outcrops in southeastern Cass and northeastern Otoe counties were reexamined and reevaluated, and 39 test holes were drilled to determine the altitude of the upper surface of the Kereford Limestone of Pennsylvanian age;
2. Three new seismographs were installed in eastern Nebraska;
3. Gravity surveys in eastern Nebraska were extended;
4. Ground magnetic surveys in southeastern Cass and northeastern Otoe counties were made and evaluated.

Discussion of the results of these studies constitute the remainder of this report.

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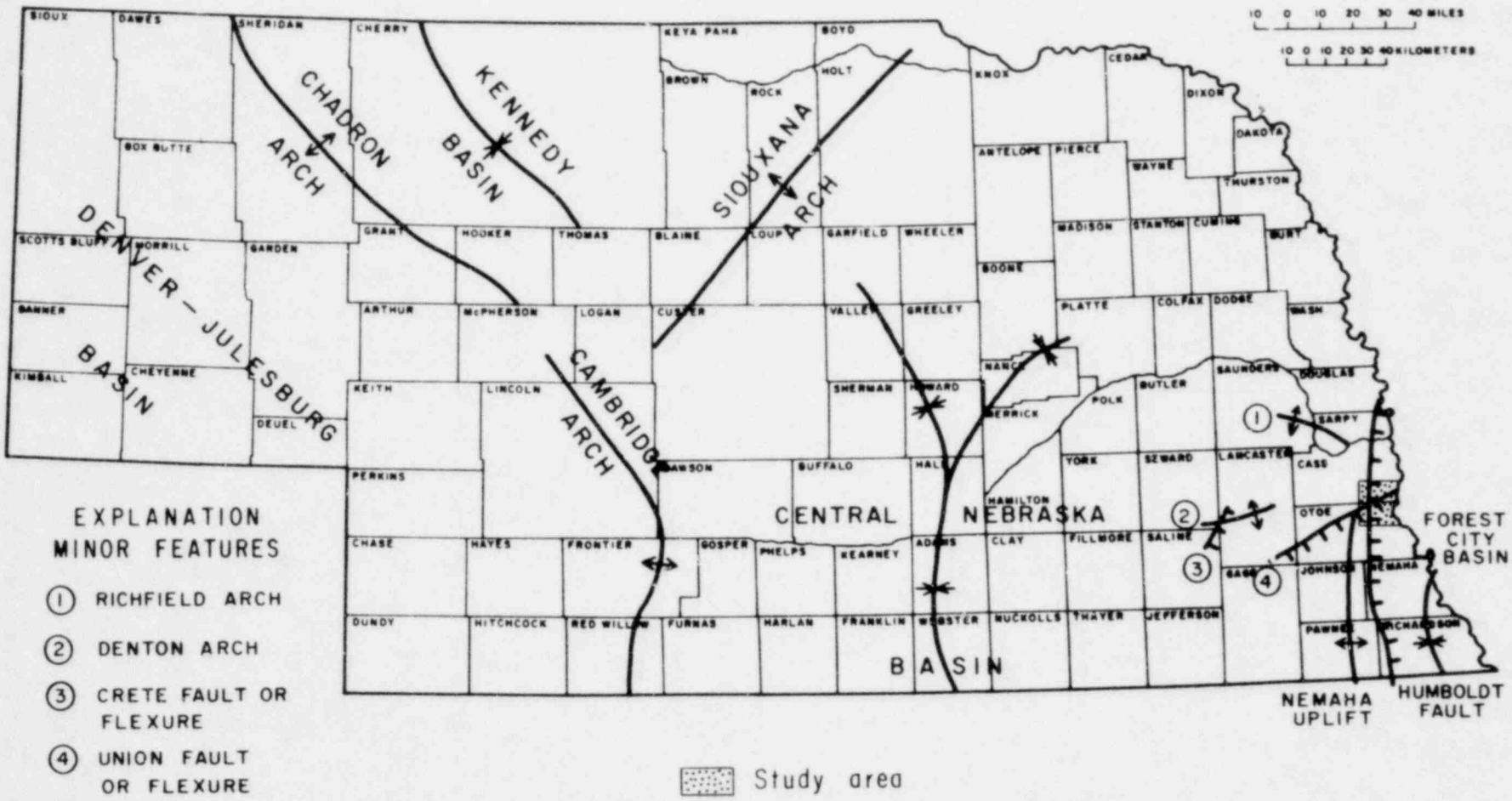
# STRUCTURE OF THE KEREFORD LIMESTONE NEAR THE INTERSECTION OF THE UNION AND HUMBOLDT FAULTS IN EASTERN NEBRASKA

R. R. Burchett, J. L. Arrigo, and D. A. Uhl

## Introduction

The Humboldt and Union Faults intersect near southeastern Cass and northeastern Otoe counties in eastern Nebraska (fig. 1). This area was chosen as a specific study site for the 1978-79 contract to determine the relation of these faults to each other. The Humboldt Fault Zone defines the eastern margin of the north-south trending Nemaha Uplift. Eastward from the fault zone the rock strata are downthrown or dip steeply into the Forest City Basin. The Union Fault defines the southern margin of the northeast-southwest trending midcontinent gravity anomaly. Southward from it the rock strata either are downthrown or dip steeply into the Forest City Basin.

The primary purposes of this investigation were to acquire, by drilling test holes, subsurface data needed to correlate buried strata with strata that crop out and to gain a better understanding of buried structural features in eastern Nebraska. The top of the Kereford Limestone, a formation in the Shawnee Group of the Virgil Series of the Pennsylvanian System, was chosen as a datum plane for a structure map because the Kereford underlies most of the study area at a shallow depth and is




PRINCIPAL STRUCTURAL FEATURES OF NEBRASKA (Carlson, 1970)

Figure 1

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easily identified in rock cuttings and cores obtained by drilling. All available data on the altitude of this surface in outcrops and in test holes were used as control points for contour lines depicting the configuration of the Kereford's upper surface (fig. 2).

## Scope of Investigation

Thirty-nine shallow rotary test holes were drilled in southeastern Cass and northeastern Otoe counties (fig. 3) by the Rieschick Drilling Company of Falls City, Nebraska. The holes averaged about 150 feet (45.7 m) in depth, and each was logged electrically as well as by visual examination of rock cuttings. Some of the holes penetrated the Kereford Limestone; others were drilled to an identifiable horizon whose height above or depth below the Kereford is known, thus providing a Kereford datum. The holes were drilled in May and June of 1979 under a cooperative agreement between the Conservation and Survey Division (Nebraska Geological Survey) and the U.S. Nuclear Regulatory Commission (Contract NRC-04-76-315).

A binocular microscope was used for examination of the cuttings. Logs of the test holes, based on descriptions of the cuttings, are presented in Appendix A. Figures 4 and 5 show a composite section of the Upper Pennsylvanian rocks drilled in the study area, together with a composite electric log of those rocks.

The geologic bedrock map illustrated in figure 6 shows the distribution of groups ranging in age from Late Pennsylvanian


STRUCTURAL CONTOUR ON TOP OF THE KEREFORD LIMESTONE IN SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 2

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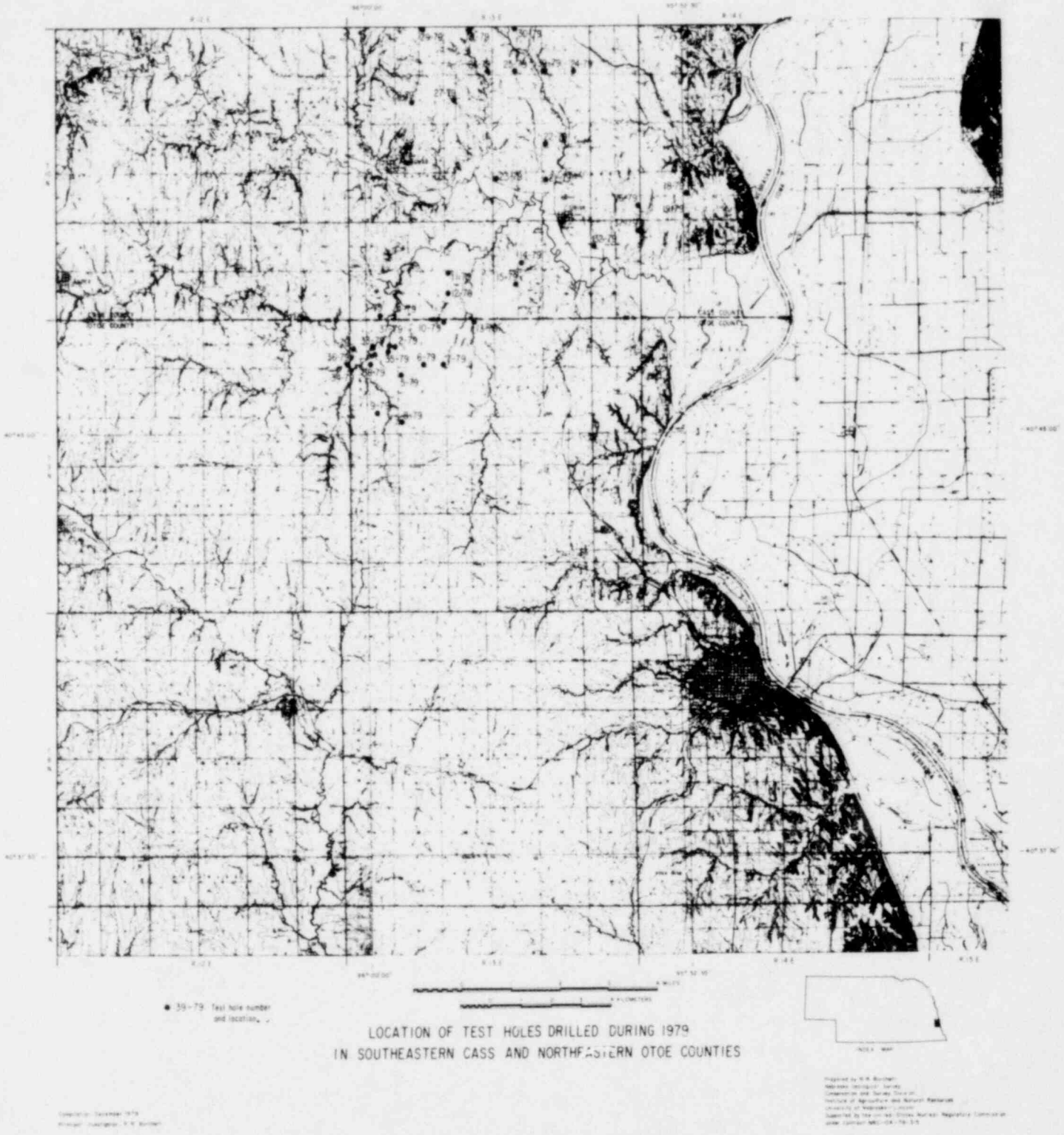


LOCATION OF TEST HOLES DRILLED DURING 1979
IN SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 3



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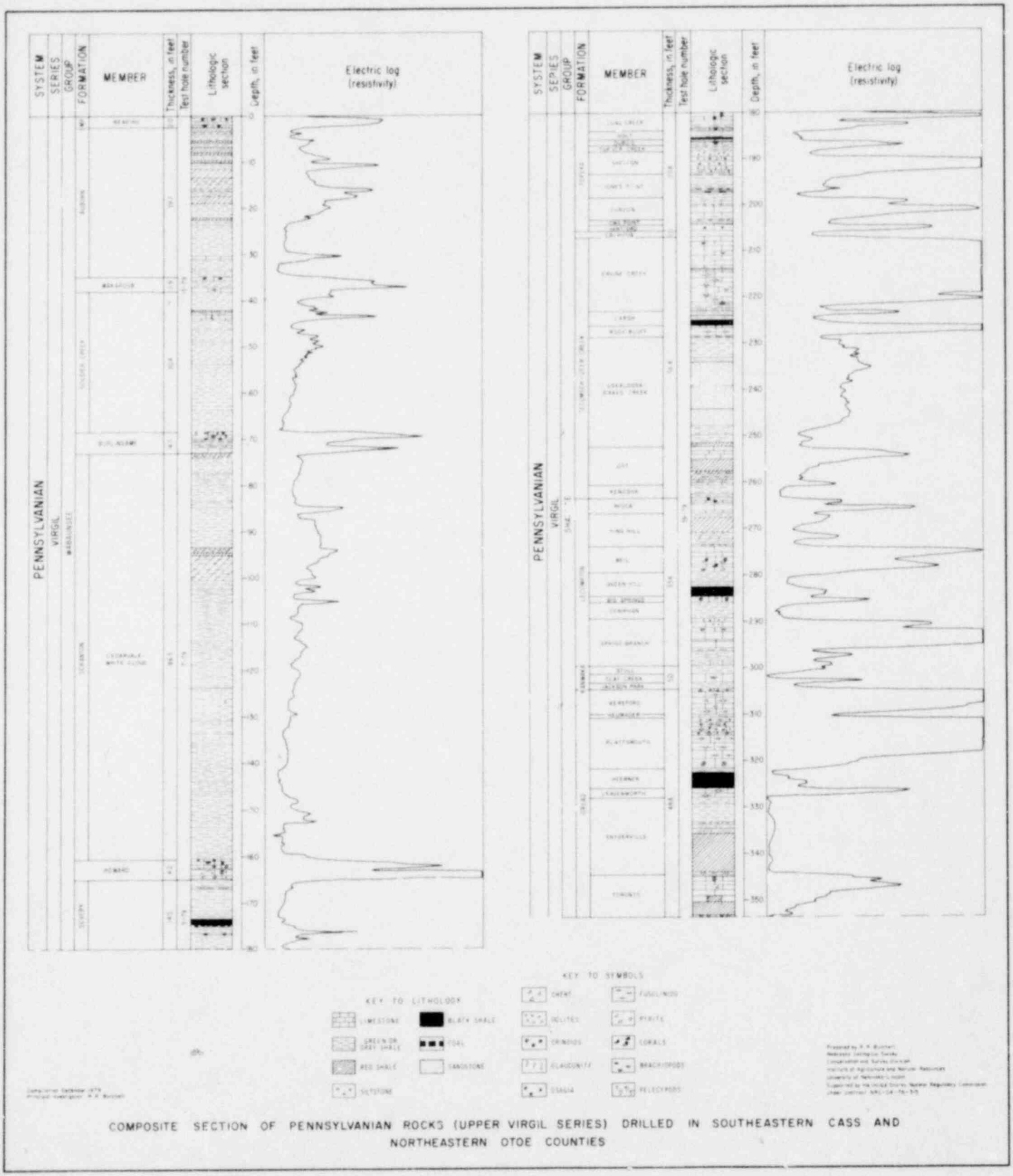


COMPOSITE SECTION OF PENNSYLVANIAN ROCKS (UPPER VIRGIL SERIES) DRILLED IN SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 4

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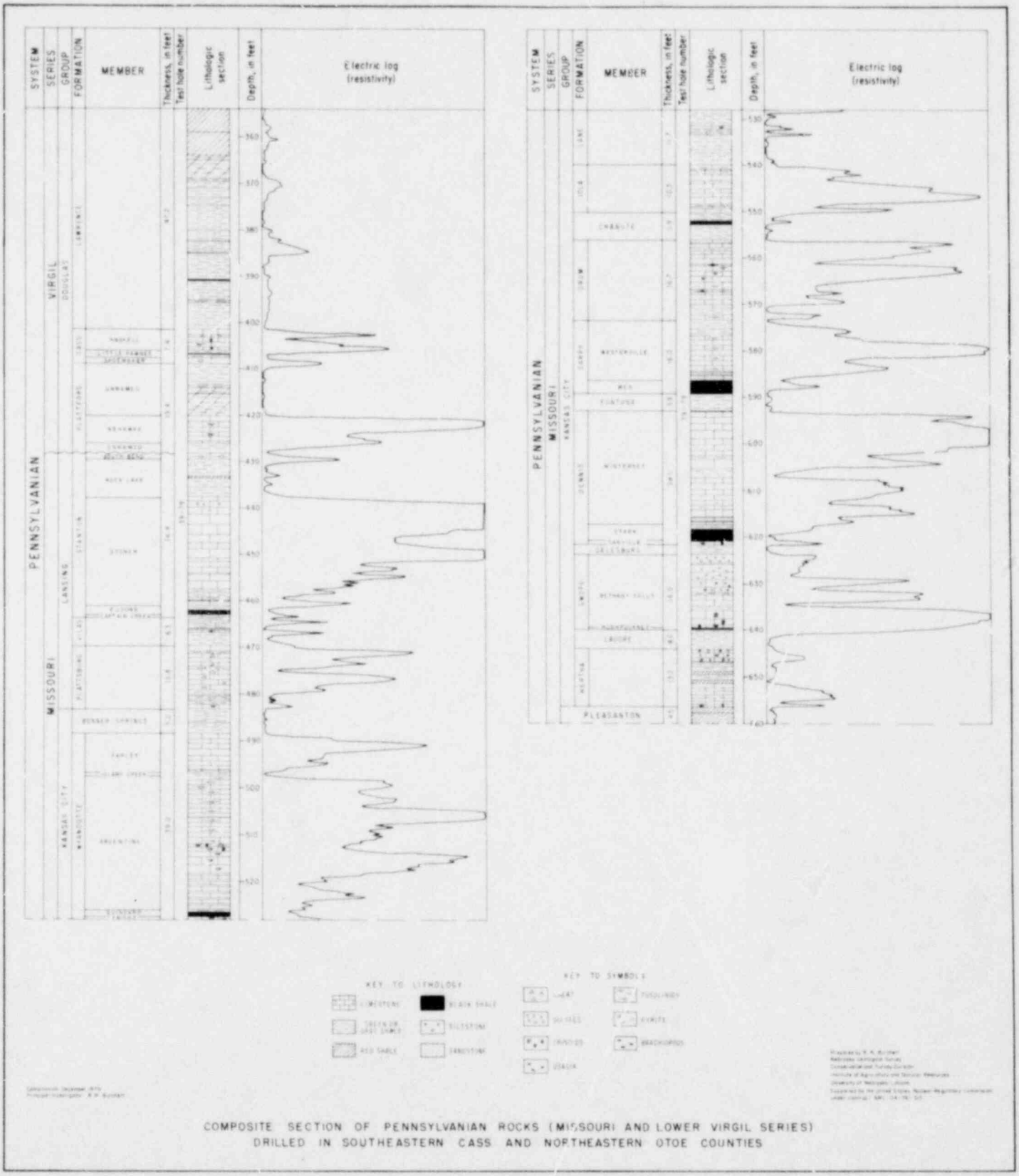


COMPOSITE SECTION OF PENNSYLVANIAN ROCKS (MISSOURI AND LOWER VIRGIL SERIES) DRILLED IN SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 5



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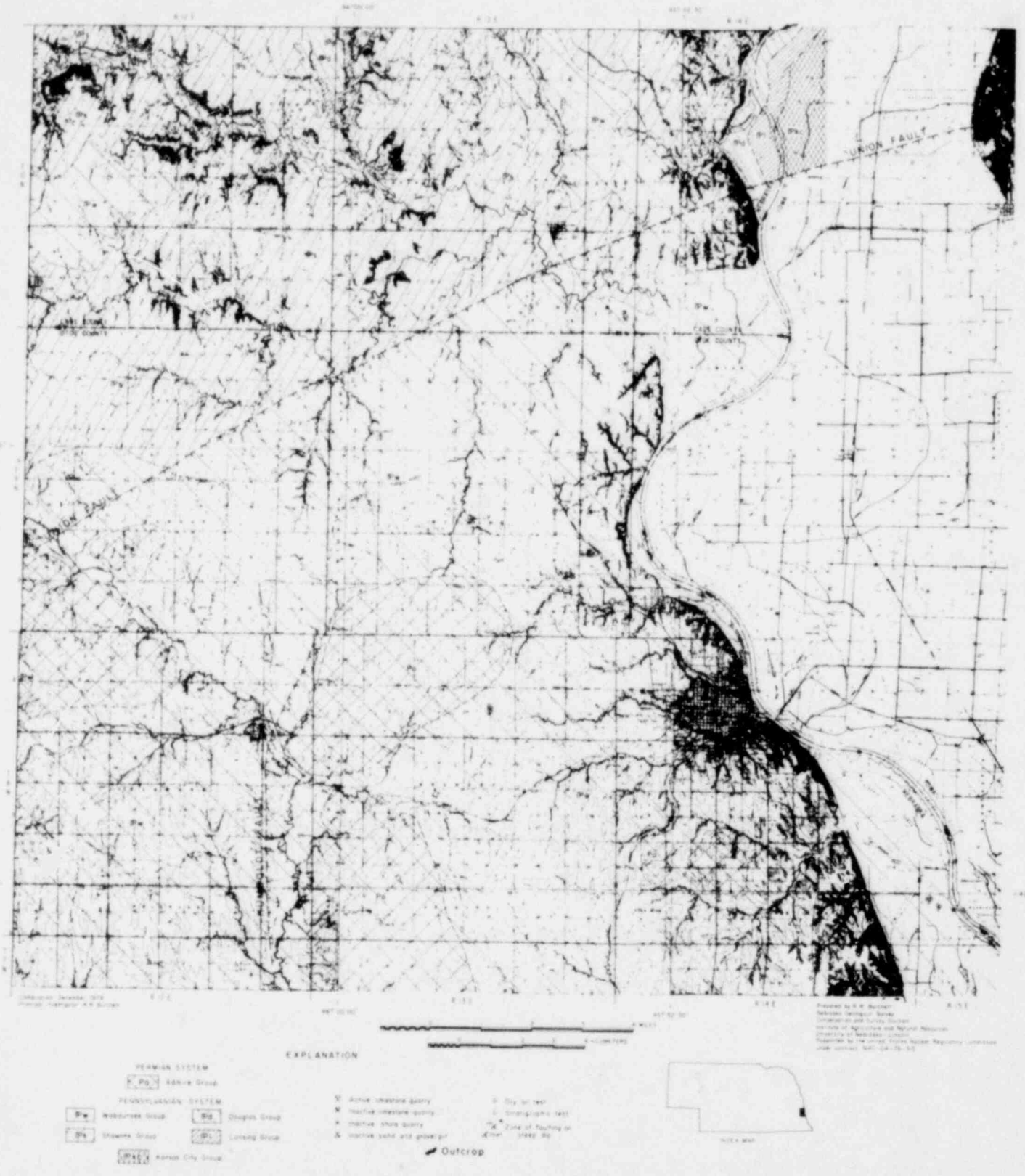


GEOLOGIC BEDROCK OF SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 6



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to Early Permian. Location of bedrock outcrops, mostly along valley sides, are shown in solid black. A careful reexamination of outcrops along the Union Fault provided additional data for mapping purposes. By determining the altitude of many outcrops, the investigators obtained additional vertical control points for the structure map.

Most upland and lowland areas are mantled by unconsolidated Quaternary deposits such as loess, till, and alluvium. The maximum aggregate thickness of these deposits is about 300 feet.

## Results of Investigation

Interpretations based on drilling results and field observations during this investigation are summarized as follows:

(1) The Union and Humboldt Faults probably are not single structures, as previously interpreted. Instead, they are complex zones of faults and steep dips.

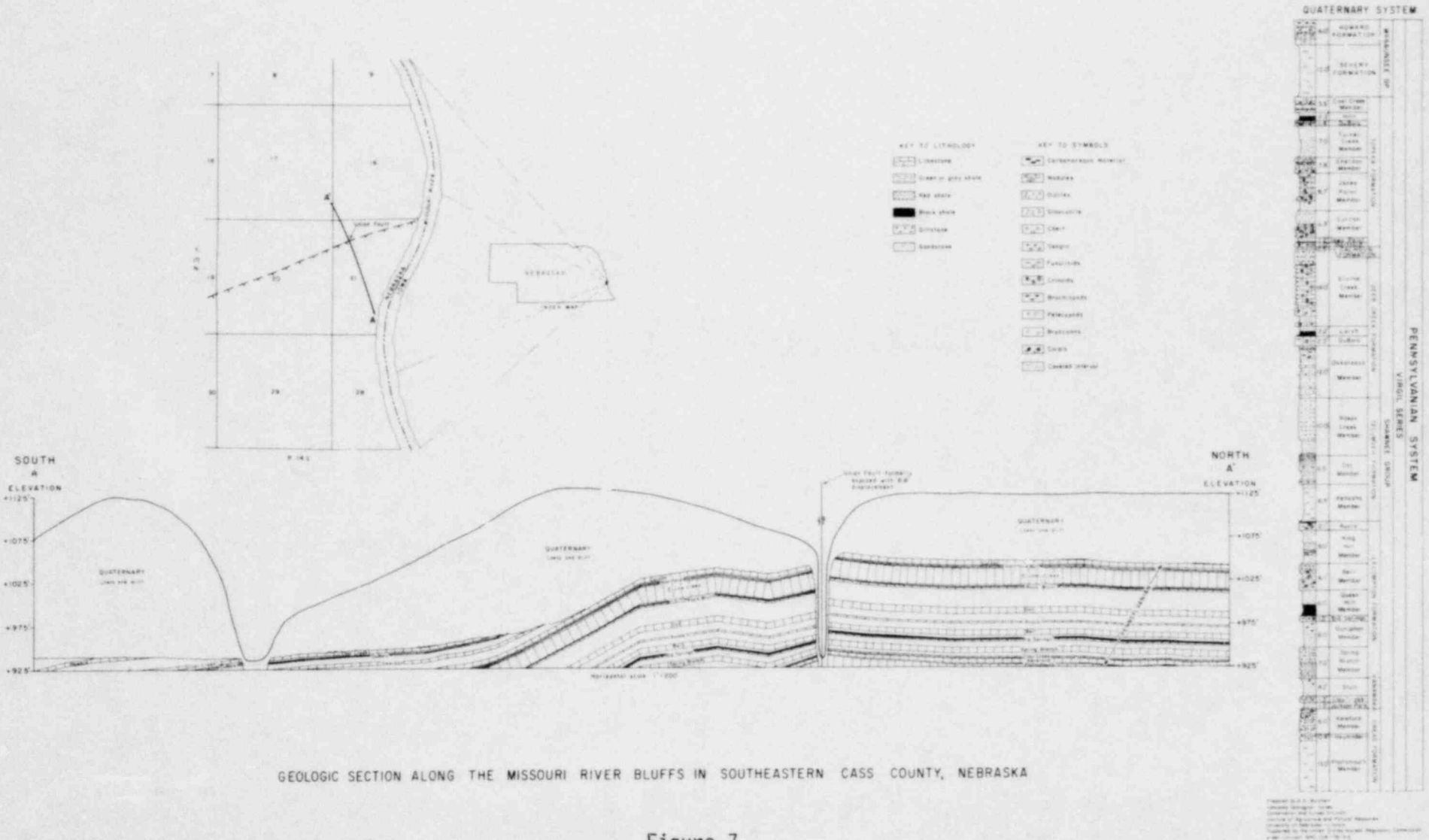
(2) The Pennsylvanian age rocks are faulted along the Union Fault. The direction and angle of dip exhibited by the Pennsylvanian strata on both sides of the Union Fault differ markedly within very short distances, thus indicating that the structural pattern is highly complex. The greatest dip measured, about 15°SE, was in the SW sec. 6, T. 9 N., R. 13 E., in Otoe County.

(3) Pennsylvanian age rocks overlying the Humboldt Fault in the southern third of the study area appear to be faulted and in the northern two-thirds of the study area, nearer

to the intersection of the Union and Humboldt Fault traces, appears to have steep dips without evident faulting.

(4) Only two faults have actually been observed in outcrops within the study area, and both are located along the Union Fault. One is in the NW NW sec. 21, T. 10 N., R. 14 E., Cass County, and was observed by Condra and Reed (1938) many years ago before quarrying destroyed the outcrop. Throw along this fault was reported to be 3.8 feet (2.7 m) in the Deer Creek Formation of Pennsylvanian age, but no mention was made whether that or any other faults involved Quaternary deposits. A southeast-northwest geologic section along the Missouri River Bluffs, in the vicinity of the fault, is shown in figure 7. The other fault is in the NE SW sec. 6, T. 9 N., R. 13 E., Otoe County. Here the Lecompton Formation of Pennsylvanian age is displaced about 3 feet (0.9 m). Overlying Quaternary deposits do not appear to be faulted.

(5) Displacements along the faults not observable in outcrops but indicated on figure 2 are interpretive for the following reasons: Thick glacial deposits mantle the bedrock throughout most of the study area; outcrops are of small areal extent and consist of strata so similar that their correlation is difficult; and the distance between outcrops and test holes available for interpretation ranges from 0.1 (0.161 km) to 1 mile (1.61 km). The greatest interpreted throw of the Kereford Limestone on the Union Fault, about 150 feet (45.7 m), is in sec. 6, T. 9 N., R. 13 E. The greatest




GEOLOGIC SECTION ALONG THE MISSOURI RIVER BLUFFS IN SOUTHEASTERN CASS COUNTY, NEBRASKA

Figure 7

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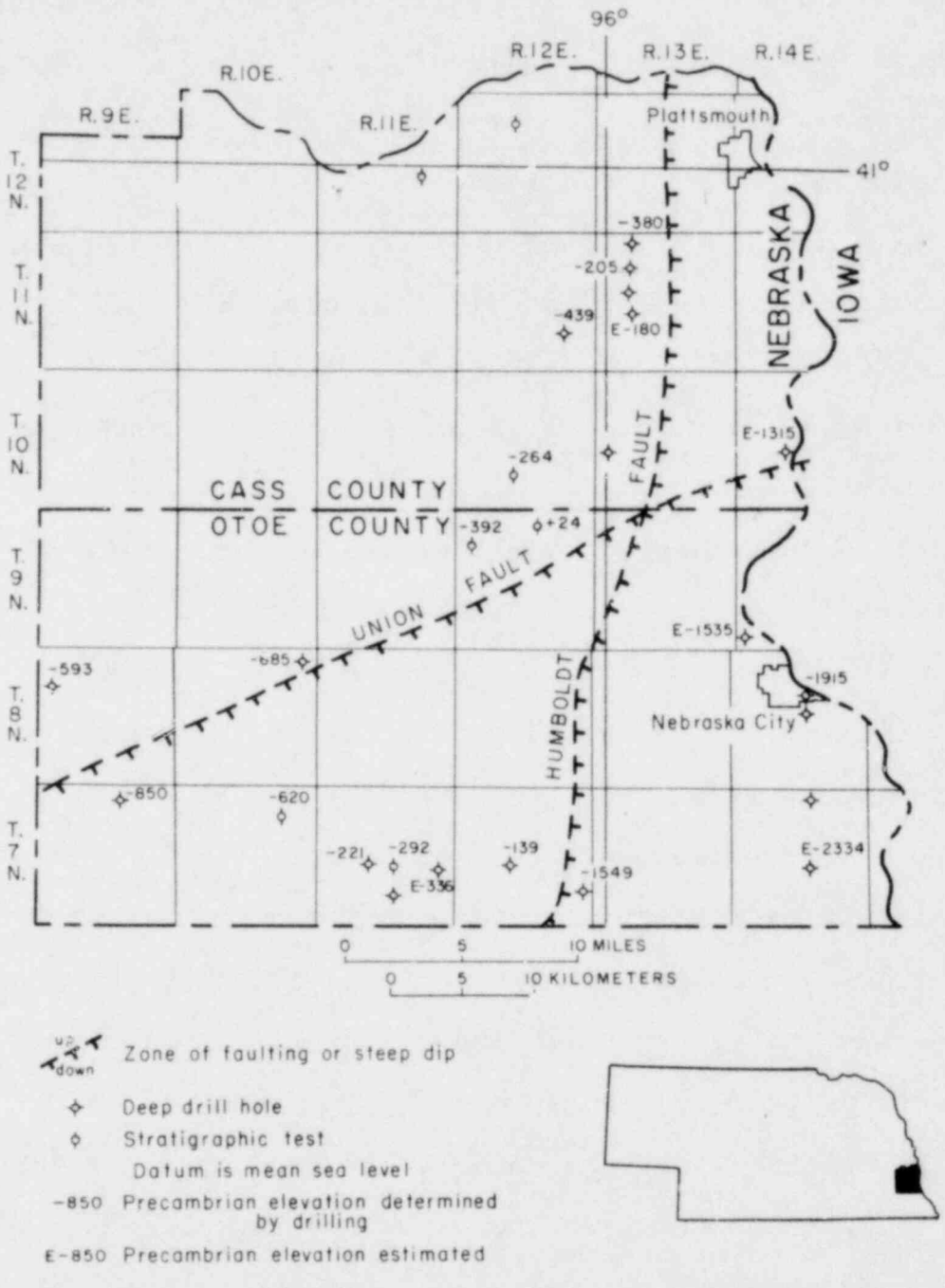
throw along the Humboldt Fault in the study area--about 100 feet (30.5 m)--is in T. 8 N., R. 12 E. Single faults are postulated but cannot be demonstrated because alluvium and glacial deposits mantle the faulted rocks.

(6) The altitude of the top of the Kereford Limestone (fig. 2) ranges from about 550 feet (168 m) above mean sea level in the south-central part of the study area to over 1,175 feet (358 m) near the center of the northern border of the study area.

(7) Faults and/or steep dips in the area probably reflect faulting and steep dips at depth. Deeper structures are indicated by contours drawn on the base of the Hertha Limestone, a formation in the Kansas City Group of the Missouri Series of the Pennsylvanian System (Burchett, 1978) and on the surface of Precambrian rocks (Carlson, 1967).

(8) Several deep drill holes have penetrated the Precambrian age rocks in Cass and Otoe counties. Locations of these holes and the elevation of the Precambrian surface are shown in figure 8. Interpretation of these elevations indicates that faulting probably occurred in the Precambrian rocks along the Union Fault, also that Precambrian faulting has occurred along the Humboldt Fault even though the Pennsylvanian rocks do not appear to be faulted adjacent to and north of the intersection of the Union and Humboldt Faults.

(9) Microearthquakes recently recorded in Kansas and Nebraska (see next chapter) indicate that the Humboldt Fault Zone is




# ELEVATION OF PRECAMBRIAN SURFACE

Figure 8

still slightly active. Past earthquakes of greater magnitude also may have been associated with movements in the same fault zone.

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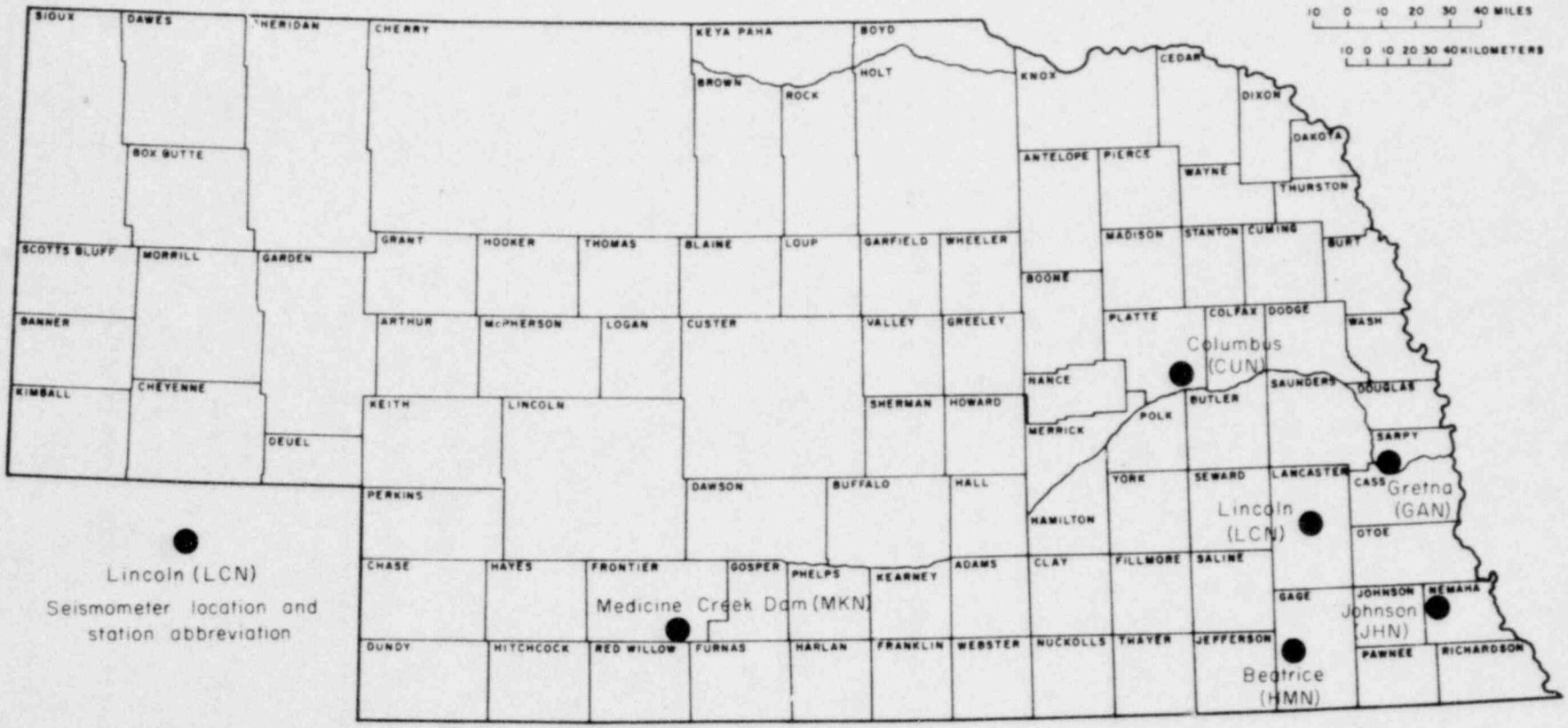
# EARTHQUAKE MONITORING NETWORK IN NEBRASKA

R. R. Burchett

The Conservation and Survey Division (Nebraska Geological Survey) and Dr. John Clough and Dr. Russell Smith of the Geology Department of the University of Nebraska-Lincoln collaborated in the installation of three portable microearthquake stations in Nebraska during contract year 1978-79. Two of the stations, near Beatrice and near Johnson, are replacements for the stations near Crete and Auburn which developed high background noise. The third was installed at a new site near Columbus. An additional station was installed during the year in southwestern Nebraska by the Kansas Geological Survey in cooperation with the University of Kansas Department of Geology.

As of July 1, 1979, a total of six earthquake monitoring stations were operating in Nebraska. Locations of the these stations are shown in figure 9. Precise location and other pertinent information about these stations are given below:

Site designation LCN. Location: E/2 NE NE SE sec. 23, T. 10 N., R. 6 E.; lat. 40° 48' 42" N., long. 96° 42' 07" W.; on University of Nebraska-Lincoln campus at Lincoln in Lancaster County, Nebraska. Instrument altitude: 1,165 ft. (355 m) msl datum. Operation begun September 1, 1977.




LOCATION OF EARTHQUAKE MONITORING STATIONS IN NEBRASKA AS OF JULY 1, 1979

Figure 9

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Site designation GAN. Location: SW NE NE SW sec. 12, T. 12 N., R. 10 E.; lat 41° 01' 17" N., long 96° 14' 47" W.; in Schramm State Park near Gretna in Sarpy County, Nebraska. Instrument altitude: 1,098.5 ft. (335 m) msl datum. Operation begun December 16, 1977.

Site designation CUN. Location: Center SL NE NW sec. 1, T. 17 N., R. 1 W.; lat 41° 28' 44" N., long. 97° 22' 48" W.; on Platte Technical Community College campus near Columbus in Platte County, Nebraska. Instrument altitude: 1,530 ft. (466 m) msl datum. Operation begun July 12, 1978.

Site designation JHN. Location: NW corner SW NE sec. 36, T. 6 N., R. 12 E.; lat. 40° 26' 49" N., long. 96° 01' 03" W.; on Douglas Boellstorff farm near Johnson in Nemaha County, Nebraska. Instrument altitude: 1,080 ft. (329 m) msl datum. Operation begun December 5, 1978.

Site designation HMN. Location: NW SW SE NW sec. 26, T. 4 N., R. 5 E.; lat. 40° 17' 11" N., long. 96° 50' 08" W.; on Homestead National Monument of America Site near Beatrice in Gage County, Nebraska. Instrument altitude: 1,207 ft. (368 m) msl datum. Operation begun June 20, 1979.

Site designation MKN. Location: lat. 40° 22.44' N., 100° 13.50' W.; near Medicine Creek Dam in Frontier County, Nebraska. Instrument altitude 2,395 ft. (730 m) msl datum. Operation begun March 11, 1979.

Equipment at stations LCN, GAN, CUN, and JHN consists of Geotech Portacorders model RV-320 and Geotech model S-13 seismometers and at the HMN and MKN stations consists of Geotech model S-500 seismometers.

Each station is operated by a volunteer who agreed to (1) permit installation of a seismometer vault on his property, (2) provide housing for the amplifier-filter-recorder-clock system and the WWV time-signal radio receiver, and (3) change the seismograph recorder charts, replenish the ink supply, and reset the clock whenever necessary on a 365-day-per-year basis. All seismographic records with the exception of Medicine Creek are sent to the University of Nebraska-Lincoln for preliminary analysis and then are forwarded to the Kansas and Oklahoma Geological Surveys for more detailed analysis. The seismographic records from Medicine Creek are sent directly to the Kansas Geological Survey.

The Nebraska seismometers, together with seismometers in the adjacent part of Kansas, provide continuous coverage of seismic activity along the buried Nemaha Ridge.

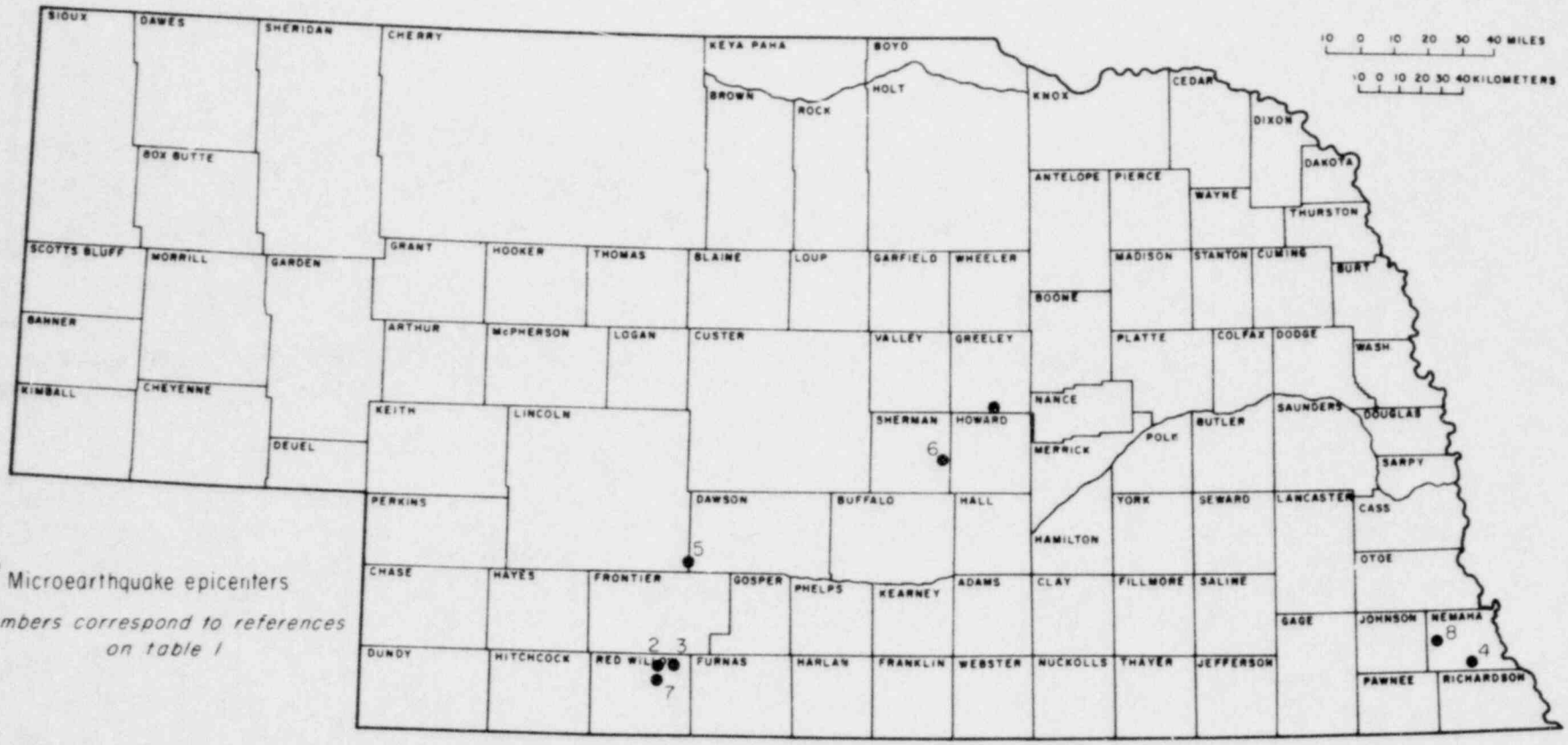
Eight microearthquakes centering in Nebraska were recorded between August 1977 and July 1979. Table 1 and figure 10 show the location of two microearthquakes in southeastern Nebraska, two in central Nebraska and four in southwestern Nebraska.

TABLE 1

MICROEARTHQUAKES IN NEBRASKA

| Map Ref. | Date | Origin Time (UTC)[1] | Latitude Degrees North | Longitude Degrees West | Approx. Magnitude[2] | Remarks |
|---|---|---|---|---|---|---|
| 1 | 1977 Aug 18 | 10:34:27+5 | 41.416 | 98.468 | 2.8 | Near Wolbach, Nebraska |
| 2 | 1977 Dec 1 | 13:04:34.19 | 40.313 | 100.366 | 2.6 | NW Norton, Kansas |
| 3 | 1977 Dec 1 | 13:22:45.38 | 40.316 | 100.297 | 2.7 | NW Norton, Kansas |
| 4 | 1978 Jan 13 | 20:15:28.0 | 40.300 | 95.800 | 1.4 | Near Howe, Nebraska |
| 5 | 1978 Sept 14 | 08:06:19.92 | 40.722 | 100.223 | 2.6 | NW Norton, Kansas |
| 6 | 1979 Apr 8 | 22:46:06.07 | 41.200 | 98.742 | 3.0 | Near Ashton, Nebraska |
| 7 | 1979 June 6 | 16:16:21.61 | 40.231 | 100.388 | 2.8 | Near Bartley, Nebraska |
| 8 | 1979 June 12 | 11:13:11.95 | 40.404 | 96.037 | 1.6 | Near Johnson, Nebraska |

[1](UTC) Coordinated Universal Time.--Subtract 6 hours for Central Standard Time
[2]Magnitudes are estimated pending final calibration of duration magnitude




MICROEARTHQUAKES IN NEBRASKA

Figure 10

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# GRAVITY AND GROUND MAGNETIC INVESTIGATIONS IN EASTERN NEBRASKA

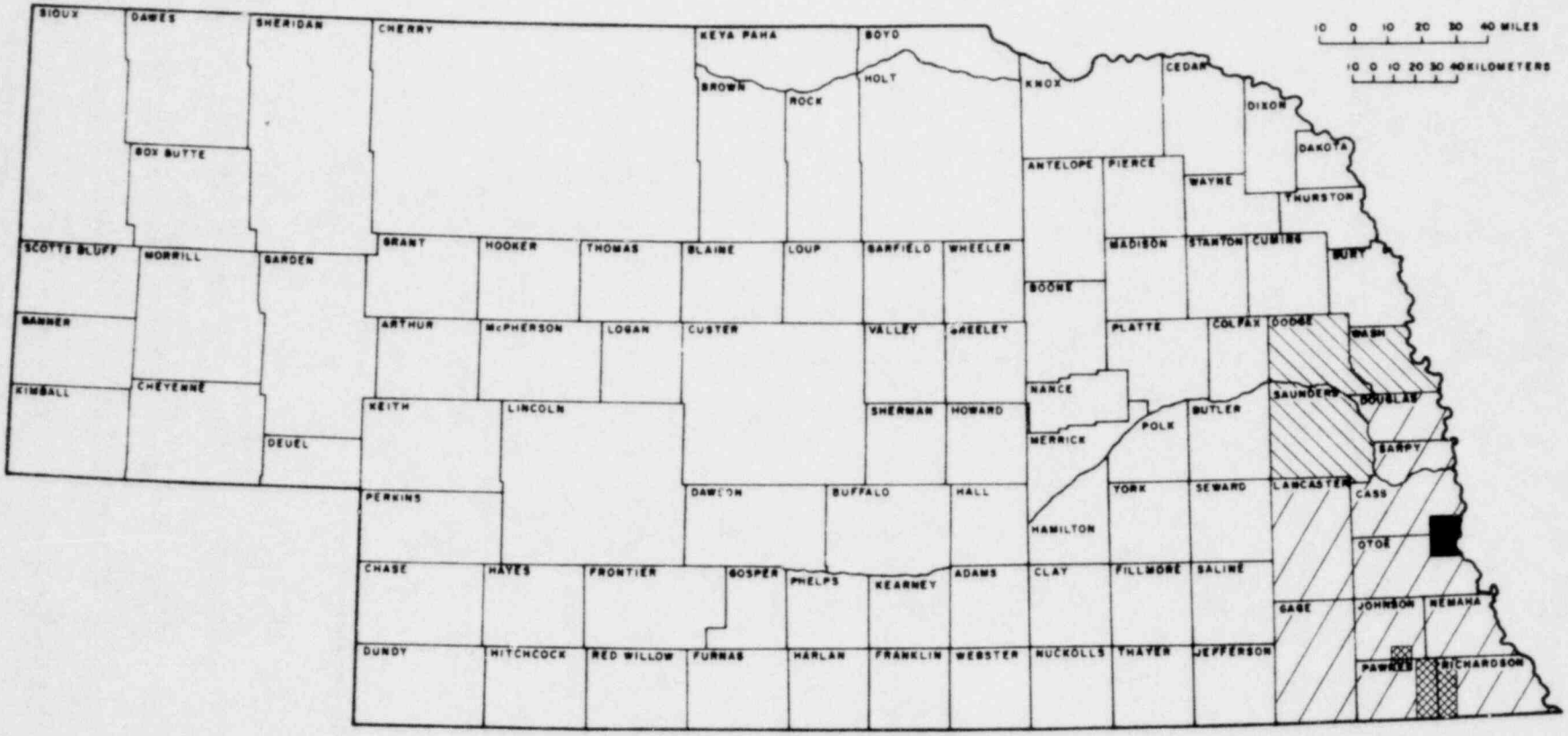
R. R. Burchett and D. G. Maroney

## Introduction

The purpose of this investigation was to extend the area covered by gravity and ground magnetic data related to the Nemaha Uplift and associated structures in eastern Nebraska (fig. 11). Gravity data were collected from Dodge, Saunders, and Washington counties. Ground magnetic data and gravity data were collected for southeastern Cass and northeastern Otoe counties.

## Gravity Study

Gravimetric surveying is a geophysical technique that aids interpretation of subsurface geologic structure. Used in this type of surveying is a very sensitive weighing device, a Worden Master, which measures differences in gravity intensity (acceleration) at specific points on the earth's surface. The principal causes of gravity anomalies generally are either the dissimilar compositions of crystalline basement rocks and overlying sedimentary rocks or density contrasts produced by vertical or horizontal displacements of rocks. However, other phenomena also can contribute to differences in gravity intensity and in combination with the principal causes can make gravity data somewhat ambiguous.




LOCATIONS OF GRAVITY AND MAGNETIC STUDIES IN EASTERN NEBRASKA

Figure 11

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All gravity base stations in the Nebraska Gravity Network are tied to the National Gravity Network base station located at the Lincoln Municipal Airport. Gravity stations established during this study were located at section corners and in some cases half-mile section lines (fig. 12). Land-surface altitudes at most stations could be determined directly from 7.5-minute topographic quadrangles. For other stations, land-surface altitudes were estimated from topographic contours and are accurate within ±2 feet.

Field gravity data were corrected for latitude, meter drift and elevation; earth tides were not considered. The maximum error in station altitudes was enough to produce variations of ±0.2 milligal. Slight inaccuracies in station locations--none greater than 0.1 minute of latitude--could have produced errors of no more than ±0.08 milligal. A ±0.02 milligal error was possible from either tidal or instrumental sources. Therefore, the maximum possible was ±0.3 milligal but generally was much less because some errors were compensatory.

Bouguer values were calculated from assumed computational density values of 2.5, 2.6, and 2.67 gm/cm$^3$. The average density value of 2.69 gm/cm$^3$ obtained by Muehlberger and others (1964) for two samples of Precambrian crystalline rocks indicated that 2.67 gm/cm$^3$ would be the most realistic Bouguer computational density value. Tests by the Nebraska Department of Roads yielded mean densities of 2.51 and 2.34 gm/cm$^3$ for Pennsylvanian and Permian rocks, respectively, in the site specific study area.


Figure 12



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These three densities were used to compute the efforts of observed gravity versus theoretical gravity for anomaly interpretation.

In southeastern Cass and northeastern Otoe counties about 275 gravity stations were used to produce a hand-contoured Bouguer gravity map (fig. 13). In addition about 1,540 gravity stations were occupied in Dodge (fig. 14), Saunders (fig. 15), and Washington counties (fig. 16). Data collected at these stations were used to produce Bouguer gravity maps for each of the counties (figs. 17, 18, & 19). These data were also integrated with previously collected data to generate a comprehensive regional Bouguer gravity map of eastern Nebraska (fig. 20).

## Ground Magnetic Study

The instrument used in the ground magnetic survey was a Geometrics$^{R}$ 826 Proton Magnetometer. This instrument measures the total magnetic field with an accuracy of $\pm 1$ gamma. Magnetic anomalies are produced by differences in the degree of rock magnetization (polarization). Although, to a large extent, magnetic intensity is related directly to the percentage of the mineral magnetite in rocks, depth to the magnetic source rocks is another variable that affects the measurements.

During field operations about 530 magnetic stations were established at 0.5- and 1.0- mile spacings in southeastern Cass and northeastern Otoe counties. Sites selected as magnetic stations were well-removed from artificial magnetic sources such as fences, power lines, and pipelines. Corrections for diurnal magnetic drift were made by making observations at a


BOUGUER GRAVITY OF SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 13



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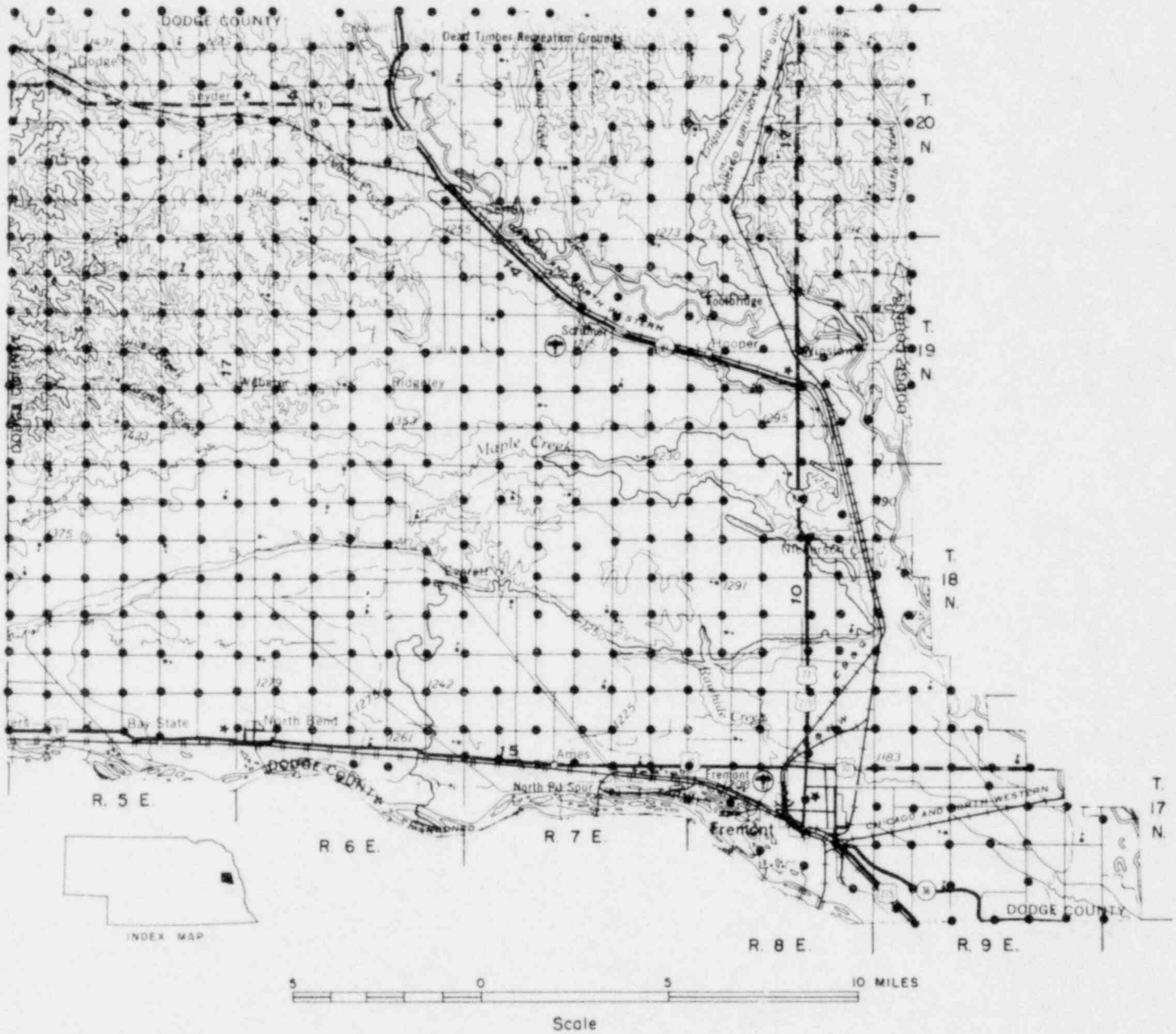


LOCATION OF BOUGUER GRAVITY STATIONS IN DODGE COUNTY

Figure 14

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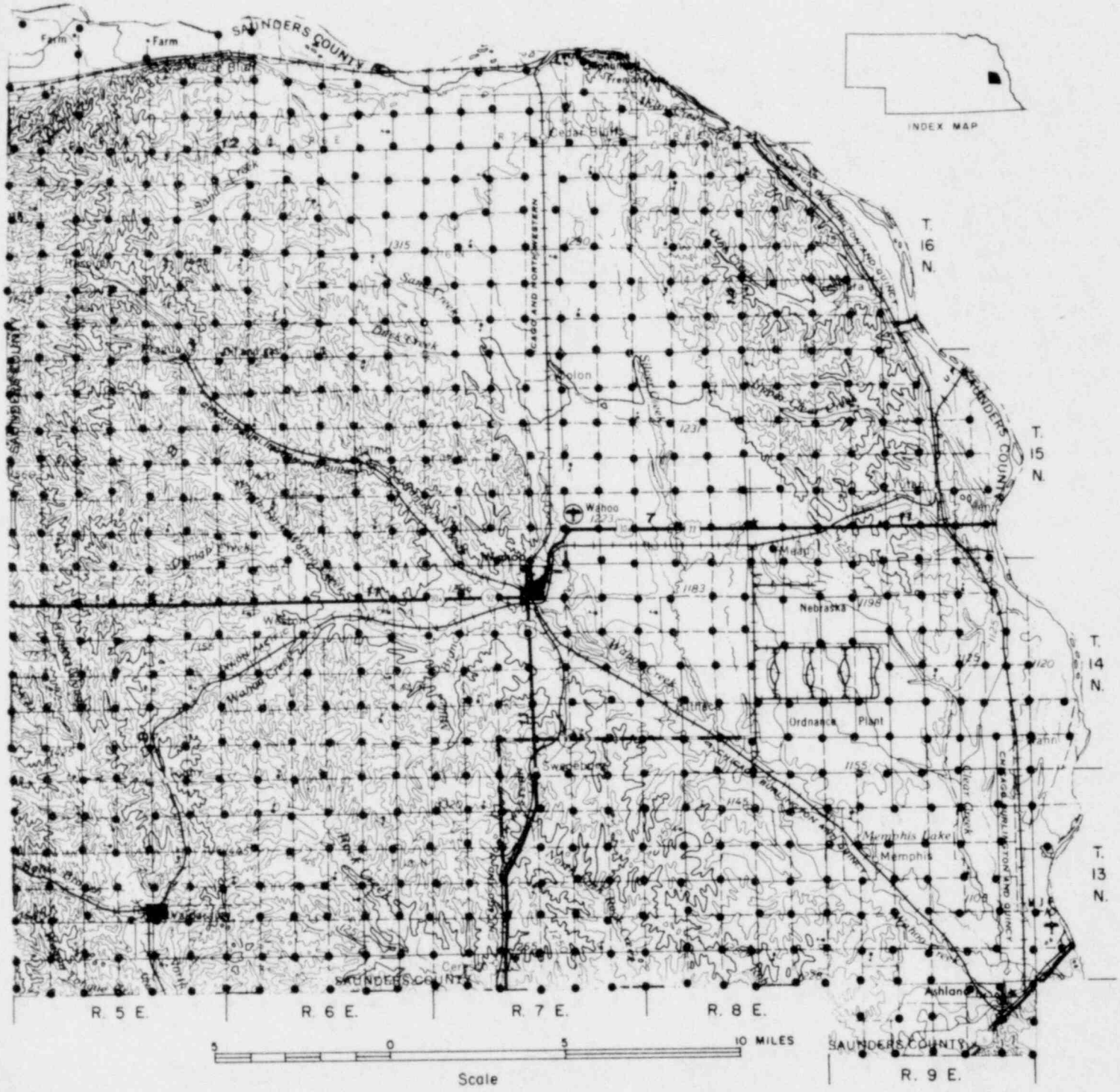


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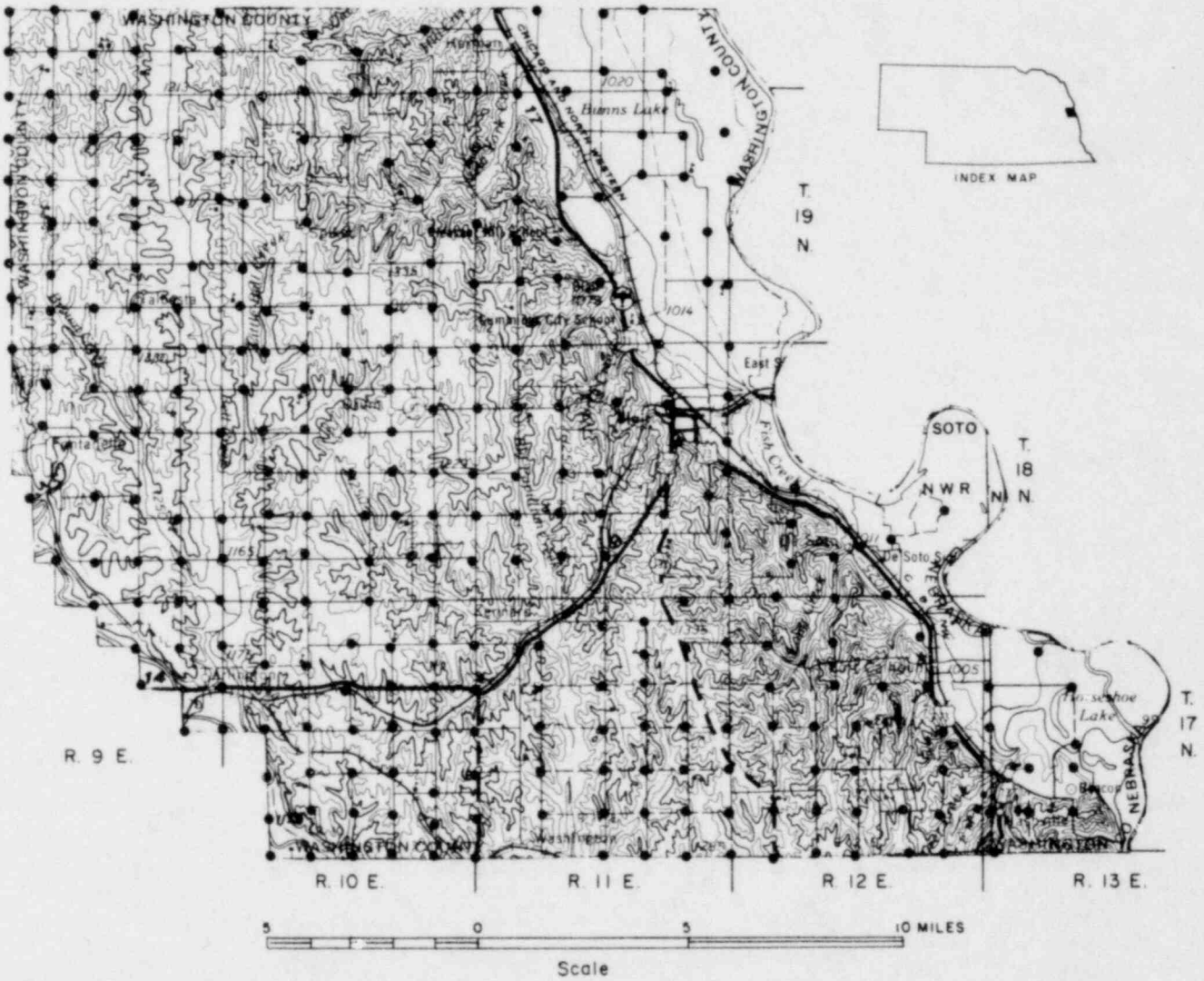
LOCATION OF BOUGUER GRAVITY STATIONS IN SAUNDERS COUNTY

Figure 15




LOCATION OF BOUGUER GRAVITY STATIONS IN WASHINGTON COUNTY

Figure 16

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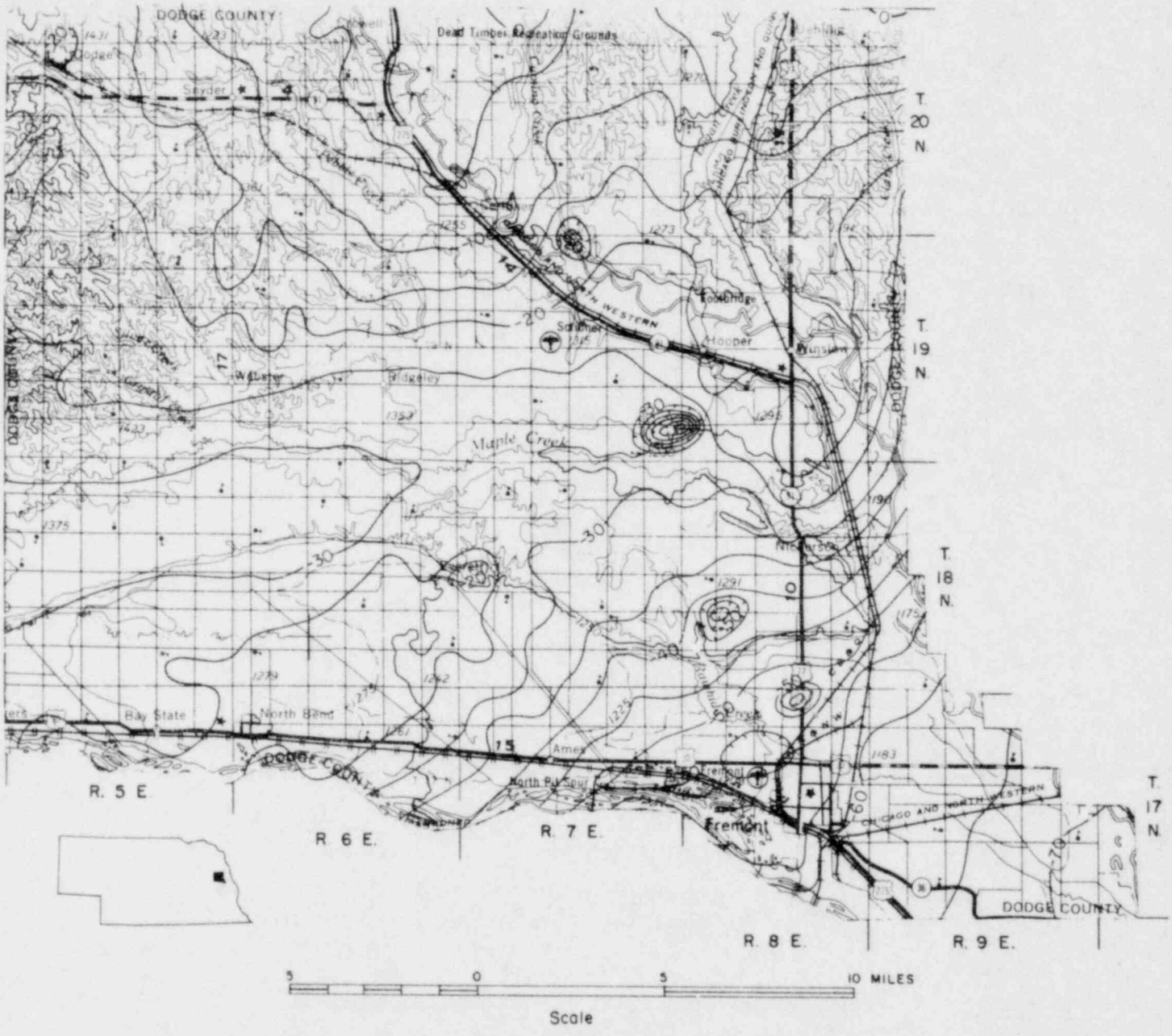


-50 Isogal–Bouguer gravity contours

*Contour interval, 5 milligals. Hachures indicate closed areas of lower gravity values. Density used in Bouguer calculations, 2.67 gm/cc. Gravity values tied to National Gravity Network*

BOUGUER GRAVITY OF DODGE COUNTY

Figure 17

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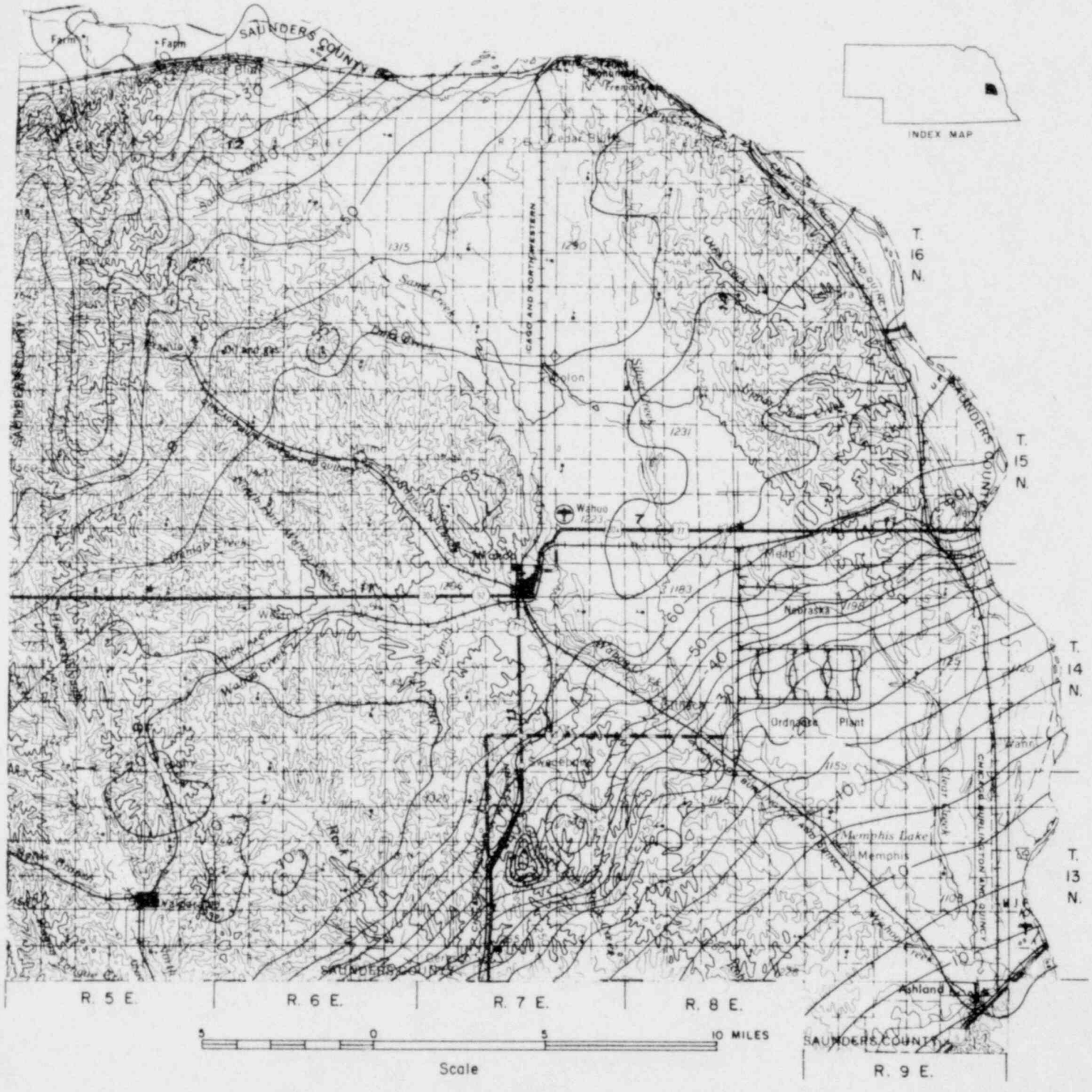


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Isogal-Bouguer gravity contours

*Contour interval, 5 milligals. Hachures indicate closed areas of lower gravity values. Density used in Bouguer calculations, 2.67 gm/cc. Gravity values tied to National Gravity Network*

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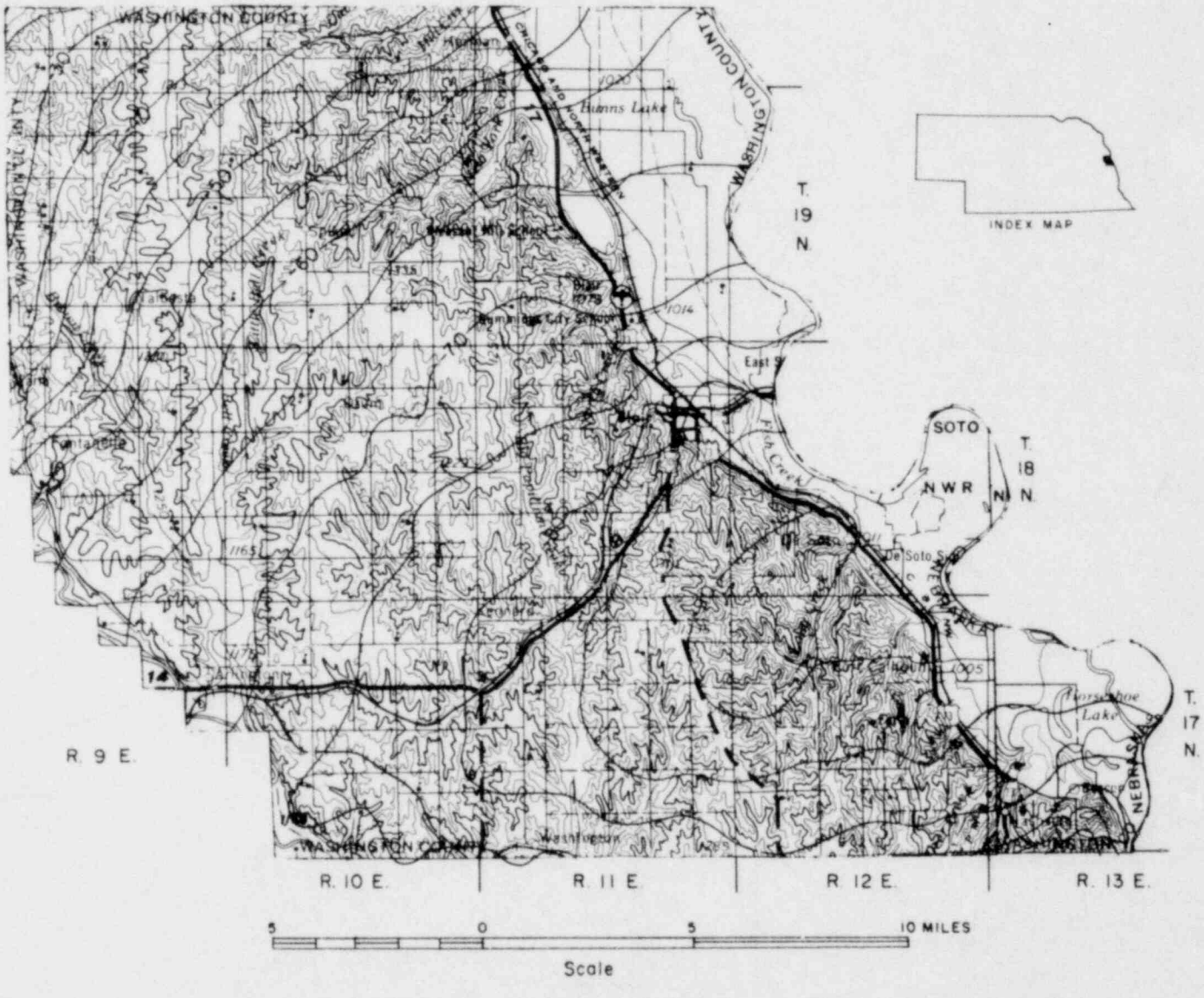
BOUGUER GRAVITY OF SAUNDERS COUNTY

Figure 18

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Isogal–Bouguer gravity contours

*Contour interval, 5 milligals. Hachures indicate closed areas of lower gravity values. Density used in Bouguer calculations, 2.67 gm/cc. Gravity values tied to National Gravity Network*

BOUGUER GRAVITY OF WASHINGTON COUNTY

Figure 19

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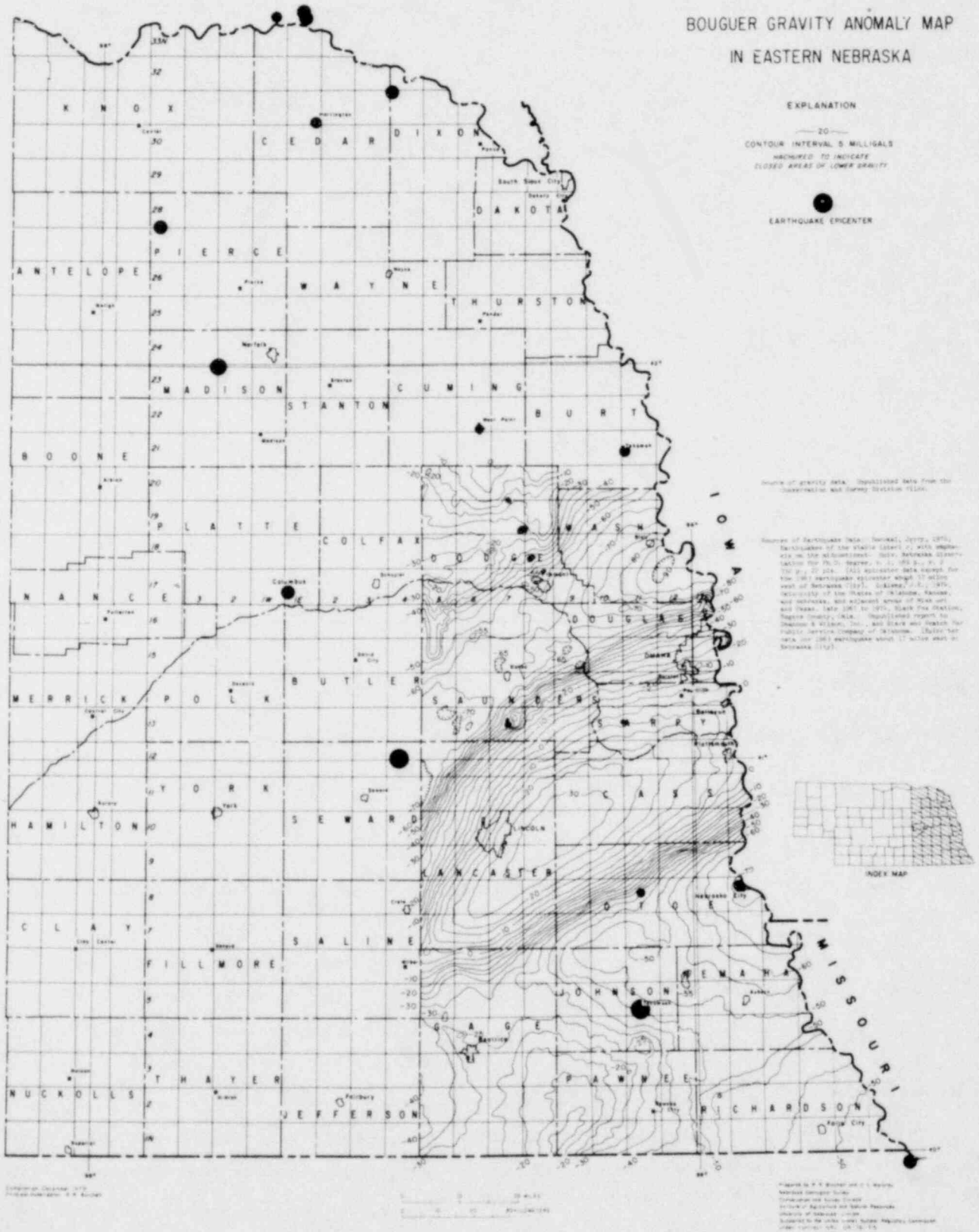


Figure 20



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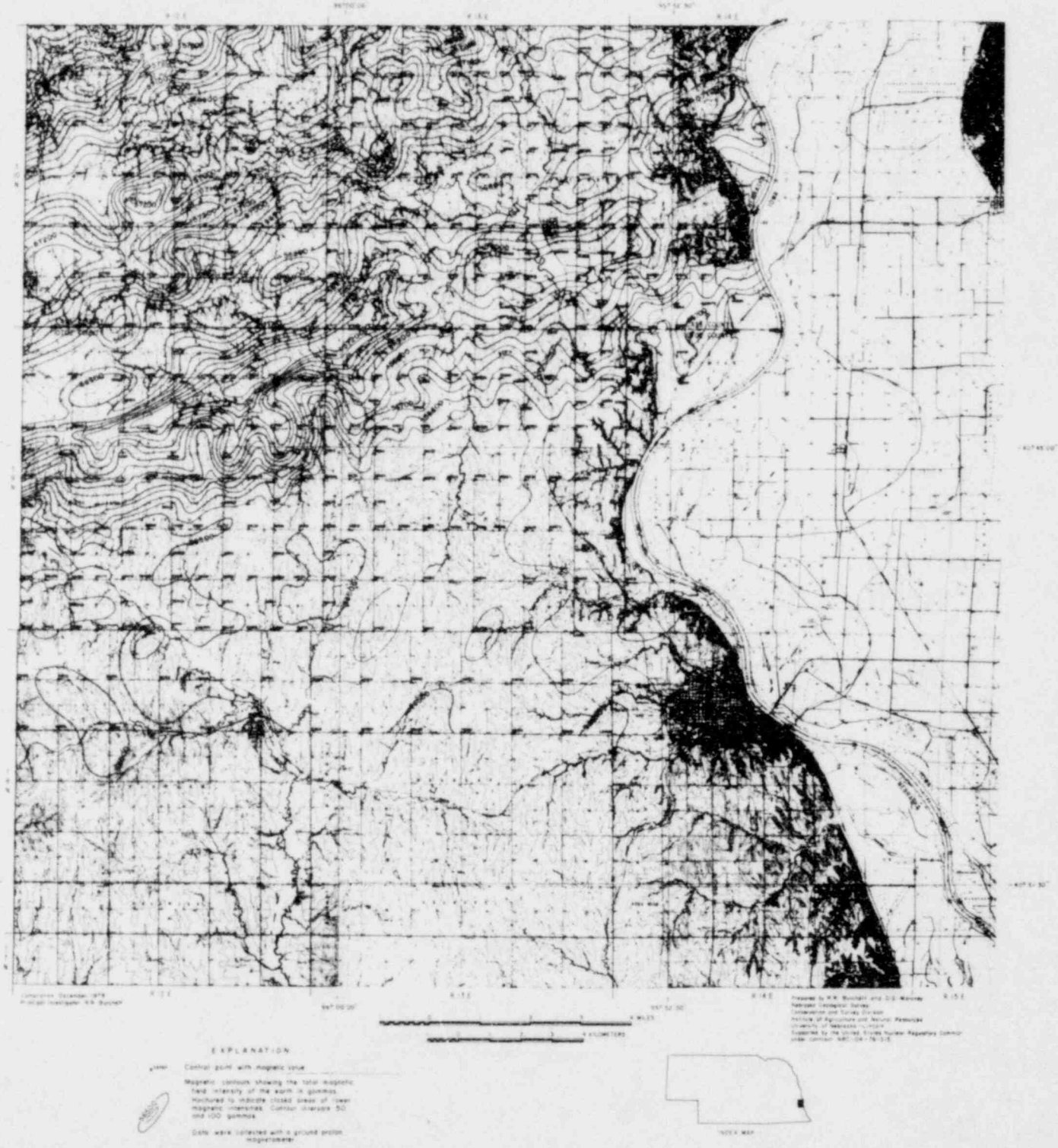
base station at 3-hour intervals and then using those observations to correct, by linear interpolation, the readings made at field stations between base stations. No corrections were made for latitude. The final magnetic intensity data were contoured by hand (fig. 21) and show very clearly the southern edge of the midcontinent anomaly.

In order to identify potential sources of observed magnetic anomalies, values of magnetic susceptibility were obtained for several rock types in the study area by using a Bison Model/3101 Magnetic Susceptibility System. According to the manufacturer, the range of the system is from 0.00001 to 0.1 CGS units with accuracy within 5 to 10 percent.

Magnetic susceptibilities of two groups of rocks were determined. The first group consisted of representative samples of glacial drift and Paleozoic rocks obtained during drilling of oil and gas test wells. Because the samples were from cuttings, corrections for density were necessary. Although some of the Paleozoic rocks were ferruginous, none of the samples had susceptibilities large enough ($> 0.0028 \times 10^{-6}$ CGS) to produce discernible magnetic anomalies. The second group was composed of samples of acidic to basic rocks from the Precambrian basement. These samples, which consisted of cuttings recovered from deep oil and gas test wells, also required density corrections. Although the selection was limited, only fresh appearing rocks were selected for measurement. The values obtained showed a wide variation between samples; they ranged from 166.0 to 4160.0 $\times 10^{-6}$ CGS.




TOTAL MAGNETIC INTENSITY OF SOUTHEASTERN CASS AND NORTHEASTERN OTOE COUNTIES

Figure 21

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## References

Muehlberger, W. R., Denison, R. E., and Lidiak, E. G. 1964. Buried basements rocks of the United States of America and Canada: Final Report, Appendix to vol. II, contract AF49(638)-1115/ARPA Order No. 180-62. Univ. Texas, Austin.

# APPENDIX A

This appendix consists of descriptions of the thirty-nine test holes drilled in southeastern Cass and northeastern Otoe counties. All locations are shown in figure 3 of the text.

All measurements in this appendix are expressed in feet. To convert to the International System of Units, multiply feet by .3048 to obtain meters.

## Test Hole 1-79

Location: Otoe County, NW NW SW sec. 6, T. 9 N., R. 13 E., approximately 394 feet south of half section line and 33 feet east of west section line.

Ground-level elevation: 1,048.5 feet above mean sea level.

Started: May 15, 1979. Completed: May 15, 1979.

Total depth: 77.0 feet.

| Description | Depth, in feet From | | To |
|---|---|---|---|
| Quaternary System: | | | |
| Soil (no sample) | 0.0 | - | 2.0 |
| Clay, brown, silty | 2.0 | - | 17.0 |
| Silt, grayish brown, clayey | 17.0 | - | 21.0 |
| Silt, reddish brown, clayey | 21.0 | - | 29.0 |
| Silt, brownish gray, sandy | 29.0 | - | 29.5 |
| Sand, fine to very coarse, and gravel, very fine to fine | 29.5 | - | 30.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Oread Formation: | | | |
| Kereford Member: | | | |
| Limestone, pale yellow, very finely crystalline; contains fusulinids and crinoids | 30.0 | - | 34.0 |
| Heumader Member: | | | |
| Shale, light gray | 34.0 | - | 34.2 |
| Plattsmouth Member: | | | |
| Limestone, pale yellow, very finely crystalline; contains fusulinids and crinoids | 34.2 | - | 36.2 |
| Shale, olive | 36.2 | - | 36.4 |
| Limestone, light tannish gray, finely crystalline; contains fusulinids | 36.4 | - | 38.0 |
| Shale, medium gray | 38.0 | - | 38.7 |
| Limestone, light gray to tannish gray, finely to very finely crystalline; contains brachiopods, crinoids, fusulinids, and coral; interbedded with shale, medium gray, thin | 38.7 | - | 47.0 |
| Heebner Member: | | | |
| Shale, medium gray | 47.0 | - | 48.0 |
| Shale, black | 48.0 | - | 51.0 |
| Leavenworth Member: | | | |
| Limestone, light bluish gray, very finely crystalline; contains brachiopods, fusulinids, and pyrite | 51.0 | - | 52.9 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Snyderville Member: | | | |
| Shale, light gray..... | 52.9 | - | 54.0 |
| Shale, light greenish gray..... | 54.0 | - | 62.0 |
| Shale, reddish brown..... | 62.0 | - | 67.5 |
| Shale, greenish gray..... | 67.5 | - | 68.7 |
| Toronto Member: | | | |
| Limestone, light tannish gray, very finely crystalline, pseudo-oolitic in part; contains brachiopods, crinoids, fusulinids, and Osagia; interbedded with shale, reddish brown and greenish gray..... | 68.7 | - | 77.0 |

## Test Hole 2-79

Location: Otoe County, NE NE NE SE sec. 6, T. 9 N., R. 13 E., approximately 130 feet south of half section line and 15 feet east of west section line.

Ground-level elevation: 1,068.0 feet above mean sea level.

Started: May 16, 1979. Completed: May 17, 1979.

Total depth: 137.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample)..... | 0.0 | - | 3.0 |
| Clay, brown, silty..... | 3.0 | - | 17.0 |
| Clay, light brown, silty..... | 17.0 | - | 27.0 |
| Clay, light brown, silty, slightly sandy..... | 27.0 | - | 34.0 |
| Sand, very fine to fine, clayey..... | 34.0 | - | 44.0 |
| Silt, olive brown, sandy..... | 44.0 | - | 51.0 |
| Silt, gray..... | 51.0 | - | 52.0 |
| Silt, brown, clayey..... | 52.0 | - | 53.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Sheldon Member: | | | |
| Limestone, light tan, finely crystalline; contains brachiopods and chert..... | 53.0 | - | 54.0 |
| Jones Point Member: | | | |
| Shale, pale yellow..... | 54.0 | - | 57.0 |
| Shale, light tan..... | 57.0 | - | 60.0 |
| Shale, pale olive..... | 60.0 | - | 61.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Curzon Member: | | |
| Limestone, pale yellow, finely crystalline; contains brachiopods | 61.2 | 65.6 |
| Iowa Point Member: | | |
| Shale, olive yellow | 65.6 | 66.0 |
| Hartford Member: | | |
| Limestone, light brown, very finely crystalline; contains brachiopods | 66.0 | 66.9 |
| Calhoun Formation: | | |
| Shale, light gray | 66.9 | 68.3 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, light tan, very finely crystalline; contains brachiopods | 68.3 | 72.5 |
| Shale, pale olive | 72.5 | 74.9 |
| Limestone, light tannish gray, very finely crystalline; contains brachiopods, crinoids, fusulinids, bryozoans, and coral | 74.9 | 83.8 |
| Shale, black | 83.8 | 84.0 |
| Shale, olive gray | 84.0 | 86.2 |
| Limestone, olive gray, finely crystalline | 86.2 | 87.0 |
| Larsh Member: | | |
| Shale, black; contains carbonaceous material | 87.0 | 88.0 |
| Rock Bluff Member: | | |
| Limestone, tan, very finely crystalline; contains brachiopods and bryozoans | 88.0 | 90.0 |
| Oskaloosa - Rakes Creek Formations: | | |
| Shale, olive gray | 90.0 | 92.0 |
| Siltstone, pale yellow to light tan | 92.0 | 121.5 |
| Shale, reddish brown | 121.5 | 123.5 |
| Ost Member: | | |
| Limestone, light tannish gray, finely crystalline; interbedded with shale, pale olive | 123.5 | 129.0 |
| Shale, olive gray; interbedded with thin hard limy zones | 129.0 | 133.0 |
| Kenosha Member: | | |
| Shale, medium gray | 133.0 | 134.5 |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods | 134.5 | 137.0 |

## Test Hole 3-79

Location: Cass County, SW SE SW SE sec. 31, T. 9 N., R. 13 E. approximately 23 feet north of south section line and 1,750 feet west of east section line.

Ground-level elevation: 1,036.5 feet above mean sea level.

Started: May 17, 1979. Completed: May 17, 1979.

Total depth: 92.5 feet.

| Description | Depth, in feet From | To |
|---|---|---|
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Silt, brown, clayey | 2.0 | 12.0 |
| Silt, light tan, clayey | 12.0 | 18.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Lecompton Formation: | | |
| King Hill Member: | | |
| Shale, greenish gray | 18.0 | 19.5 |
| Beil Member: | | |
| Limestone, light tan to yellowish brown, very finely crystalline; contains brachiopods, crinoids, fusulinids, coral, and chert | 19.5 | 25.2 |
| Queen Hill Member: | | |
| Shale, light bluish gray | 25.2 | 28.0 |
| Shale, black | 28.0 | 31.9 |
| Big Springs Member: | | |
| Shale, medium gray; contains hard limy zones | 31.9 | 33.0 |
| Doniphan Member: | | |
| Shale, medium gray | 33.0 | 36.9 |
| Spring Branch Member: | | |
| Limestone, yellowish brown, very finely crystalline; contains brachiopods, fusulinids, and Osagia | 36.9 | 42.0 |
| Shale, medium gray; contains hard limy zones | 42.0 | 46.0 |
| Kanwaka Formation: | | |
| Stull Member: | | |
| Shale, light gray | 46.0 | 48.0 |
| Clay Creek Member: | | |
| Limestone, light tan, finely crystalline; contains brachiopods and algal material | 48.0 | 49.1 |
| Jackson Park Member: | | |
| Shale, olive | 49.1 | 50.0 |
| Oread Formation: | | |
| Kereford Member: | | |
| Limestone, yellowish brown, finely crystalline, pseudo-oolitic; contains crinoids and fusulinids | 50.0 | 55.7 |
| Heumader Member: | | |
| Shale, olive gray | 55.7 | 56.5 |
| Plattsmouth Member: | | |
| Limestone, light tan, very finely crystalline; pseudo-oolitic; contains brachiopods and Osagia | 56.5 | 62.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Shale, medium gray..... | 62.0 | - | 62.5 |
| Limestone, light tannish gray, very finely crystalline; contains brachiopods, crinoids, fusulinids, and coral..... | 62.5 | - | 70.4 |
| Heebner Member: | | | |
| Shale, tannish gray..... | 70.4 | - | 71.7 |
| Shale, black; contains carbonaceous material... | 71.7 | - | 74.5 |
| Leavenworth Member: | | | |
| Limestone, bluish gray, very finely crystalline; contains crinoids and fusulinids..... | 74.5 | - | 75.5 |
| Snyderville Member: | | | |
| Shale, light to medium gray..... | 75.5 | - | 81.5 |
| Shale, medium gray interbedded with greenish gray..... | 81.5 | - | 85.5 |
| Shale, reddish brown..... | 85.5 | - | 92.0 |
| Shale, greenish gray..... | 92.0 | - | 92.2 |
| Toronto Member: | | | |
| Limestone, light tan, very finely crystalline; interbedded with shale, greenish gray..... | 92.2 | - | 92.5 |

## Test Hole 4-79

Location: Cass County, SW SE SE SE sec. 31, T. 9 N., R. 13 E., approximately 20 feet north of south section line and 360 feet west of east section line.

Ground-level elevation: 1,011.0 feet above mean sea level.

Started: May 17, 1979. Completed: May 17, 1979.

Total depth: 62.5 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample)..... | 0.0 | - | 2.0 |
| Silt, brown, clayey..... | 2.0 | - | 12.0 |
| Clay, brown, silty..... | 12.0 | - | 17.0 |
| Silt, brown, sandy..... | 17.0 | - | 25.0 |
| Sand, medium to coarse, and gravel, very fine to coarse..... | 25.0 | - | 33.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Lecompton Formation: | | |
| Beil Member: | | |
| Limestone, light greenish gray, very finely crystalline; contains brachiopods, crinoids, and fusulinids..... | 33.0 - | 33.5 |
| Queen Hill Member: | | |
| Shale, greenish gray..... | 33.5 - | 36.0 |
| Shale, black; contains carbonaceous material... | 36.0 - | 40.0 |
| Big Springs Member: | | |
| Limestone, medium gray, finely crystalline; contains brachiopods, crinoids and bryozoans..... | 40.0 - | 41.0 |
| Doniphan Member: | | |
| Shale, medium gray..... | 41.0 - | 46.1 |
| Spring Branch Member: | | |
| Limestone, light tan, very finely crystalline; contains brachiopods..... | 46.1 - | 50.5 |
| Shale, medium gray; contains thin hard limy zones..... | 50.5 - | 54.5 |
| Kanwaka Formation: | | |
| Stall Member: | | |
| Shale, light gray..... | 54.5 - | 56.0 |
| Clay Creek Member: | | |
| Limestone, light tannish gray, very finely crystalline; contains brachiopods..... | 56.0 - | 57.4 |
| Jackson Park Member: | | |
| Shale, pale olive..... | 57.4 - | 58.5 |
| Oread Formation: | | |
| Kereford Member: | | |
| Limestone, tan, very finely crystalline; pseudo-oolitic in part; contains crinoids and fusulinids..... | 58.5 - | 62.5 |

## Test Hole 5-79

Location: Otoe County, NW SW NW NW sec. 8, T. 9 N., R. 13 E., approximately 770 feet south of north section line and 20 feet east of west section line.

Ground-level elevation: 1,090.5 feet above mean sea level.

Started: May 18, 1979. Completed: May 18, 1979.

Total depth: 182.5 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Silt, light tan, clayey | 2.0 | 10.0 |
| Silt, reddish brown | 10.0 | 40.0 |
| Silt, light olive, clayey | 40.0 | 41.0 |
| Sand, very fine to fine | 41.0 | 77.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| White Cloud Member: | | |
| Shale, olive gray | 77.0 | 78.0 |
| Shale, medium to dark gray | 78.0 | 82.0 |
| Shale, olive gray | 82.0 | 85.0 |
| Shale, greenish gray | 85.0 | 87.0 |
| Howard Formation: | | |
| Shale, greenish gray; interbedded with hard limy zones | 87.0 | 90.4 |
| Limestone, dark tan, very finely crystalline | 90.4 | 91.5 |
| Severy Formation: | | |
| Shale, olive | 91.5 | 93.0 |
| Shale, medium gray | 93.0 | 93.3 |
| Shale, olive | 93.3 | 100.0 |
| Shale, black; contains carbonaceous material | 100.0 | 101.0 |
| Shale, olive gray | 101.0 | 106.3 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline | 106.3 | 108.6 |
| Shale, medium gray | 108.6 | 109.0 |
| Limestone, light gray, finely crystalline; contains crinoids | 109.0 | 110.0 |
| Holt Member: | | |
| Shale, dark gray | 110.0 | 112.0 |
| Shale, black | 112.0 | 112.5 |
| DuBois Member: | | |
| Limestone, dark gray, finely crystalline; contains brachiopods and bryozoans | 112.5 | 113.8 |
| Turner Creek Member: | | |
| Shale, light greenish gray | 113.8 | 115.5 |
| Shelton Member: | | |
| Limestone, light tan, finely crystalline; contains brachiopods and algal material | 115.5 | 118.8 |
| Jones Point Member: | | |
| Shale, light gray | 118.8 | 121.5 |
| Curzon Member: | | |
| Limestone, light tan, irregular crystalline; contains brachiopods, crinoids, and algal material | 121.5 | 124.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Iowa Point Member: | | |
| Shale, medium gray | 124.5 | - 124.9 |
| Hartford Member: | | |
| Limestone, light gray, fine crystalline | 124.9 | - 126.0 |
| Calhoun Formation: | | |
| Shale, light gray | 126.0 | - 126.3 |
| Deer Creek - Tecumseh Formations: | | |
| Limestone, light tan, finely crystalline; contains brachiopods, crinoids and algal material | 126.3 | - 142.4 |
| Shale, medium gray | 142.4 | - 142.5 |
| Limestone, light tan, finely crystalline; contains, algal material and crinoids | 142.5 | - 144.5 |
| Shale, dark gray | 144.5 | - 145.5 |
| Limestone, light gray, finely crystalline; contains brachiopods and crinoids | 145.5 | - 146.5 |
| Larsh Member: | | |
| Shale, black | 146.5 | - 147.7 |
| Rock Bluff Member: | | |
| Limestone, tan, very finely crystalline; contains pyrite | 147.7 | - 150.0 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray | 150.0 | - 151.0 |
| Shale, light bluish gray | 151.0 | - 156.0 |
| Siltstone, light bluish gray | 156.0 | - 179.5 |
| Shale, olive gray | 179.5 | - 181.5 |
| Shale, reddish brown | 181.5 | - 182.5 |

## Test Hole 6-79

Location: Otoe County, SW SW SW SE sec. 5, T. 9 N., R. 13 E., approximately 18 feet north of south section line and 21 feet east of half section line.

Ground-level elevation: 1,104.5 feet above mean sea level.

Started: May 21, 1979. Completed: May 21, 1979.

Total depth: 212.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | - 2.0 |
| Silt, light brown, clayey | 2.0 | - 30.0 |
| Sand, very fine to medium, silty | 30.0 | - 40.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Clay, light brownish gray, silty | 40.0 | - 47.0 |
| Silt, dark brown, sandy | 47.0 | - 50.0 |
| Sand, very fine to medium | 50.0 | - 107.0 |
| Sand, very fine to coarse | 107.0 | - 127.3 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Shale, greenish blue | 127.3 | - 129.0 |
| Shale, reddish brown | 129.0 | - 131.0 |
| Shale, olive | 131.0 | - 132.0 |
| Shale, reddish brown | 132.0 | - 134.7 |
| Shale, medium gray | 134.7 | - 141.0 |
| Shale, dark gray; contains black carbonaceous material | 141.0 | - 142.0 |
| Shale, light to medium gray | 142.0 | - 193.4 |
| Howard Formation: | | |
| Shale, light gray; interbedded with hard limy zones | 193.4 | - 196.3 |
| Limestone, dark bluish gray, irregular crystalline; contains brachiopods, crinoids, algal material, and 'black inclusions" | 196.3 | - 197.5 |
| Severy Formation: | | |
| Shale, black | 197.5 | - 198.0 |
| Shale, light gray | 198.0 | - 198.5 |
| Shale, black | 198.5 | - 199.0 |
| Shale, light gray | 199.0 | - 203.0 |
| Coal, black | 203.0 | - 203.1 |
| Shale, medium gray | 203.1 | - 208.3 |
| Shale, medium gray; interbedded with hard limy zones | 208.3 | - 210.0 |
| Shale, medium gray | 210.0 | - 211.6 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods and crinoids | 211.6 | - 212.0 |

## Test Hole 7-79

Location: Otoe County, SE corner sec. 5, T. 9 N., R. 13 E., approximately 18 feet north of south section line and 61 feet west of east section line.

Ground-level elevation: 1,058.0 feet above mean sea level.

Started: May 21, 1979. Completed: May 21, 1979.

Total depth: 232.0 feet.

| Description | Depth, in feet From | To |
|---|---|---|
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Silt, light brown, clayey | 2.0 | 22.0 |
| Sand, very fine to medium | 22.0 | 47.0 |
| Sand, very fine to very coarse | 47.0 | 83.5 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Auburn Formation: | | |
| Shale, medium to dark gray | 83.5 | 90.0 |
| Shale, olive gray | 90.0 | 94.0 |
| Shale, varicolored, yellow, green, brown, and gray | 94.0 | 97.0 |
| Shale, pale yellow | 97.0 | 102.5 |
| Limestone, yellowish brown, very finely crystalline | 102.5 | 103.5 |
| Shale, pale olive | 103.5 | 108.0 |
| Wakarusa Formation: | | |
| Limestone, dark gray, very finely crystalline; contains crinoids | 108.0 | 110.0 |
| Soldier Creek Formation: | | |
| Shale, light gray | 110.0 | 114.8 |
| Limestone, light gray, very finely crystalline | 114.8 | 116.2 |
| Shale, light gray | 116.2 | 121.2 |
| Shale, olive | 121.2 | 122.5 |
| Shale, light to medium gray | 122.5 | 138.5 |
| Burlingame Formation: | | |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods and algal material; interbedded with shale, gray | 138.5 | 140.0 |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Shale, pale, reddish gray | 140.0 | 141.0 |
| Shale, medium gray | 141.0 | 142.0 |
| Shale, dark olive gray | 142.0 | 151.5 |
| Shale, dark greenish gray | 151.5 | 160.3 |
| Shale, reddish gray | 160.3 | 167.0 |
| Shale, reddish brown | 167.0 | 168.0 |
| Shale, greenish gray | 168.0 | 169.0 |
| Shale, medium to dark gray | 169.0 | 174.0 |
| Shale, light to medium gray | 174.0 | 226.5 |
| Howard Formation: | | |
| Limestone, tannish gray, very finely crystalline; contains brachiopods, crinoids, pyrite, and "black inclusions" | 226.5 | 230.7 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Severy Formation: | | |
| Shale, black; contains carbonaceous material... | 230.7 | - 231.4 |
| Shale, light gray..... | 231.4 | - 232.0 |

## Test Hole 8-79

Location: Otoe County, NW corner sec. 17, T. 9 N., R. 13 E., approximately 495 feet south of north section line and 21 feet east of west section line.

Ground-level elevation: 1,076.5 feet above mean sea level.

Started: May 21, 1979. Completed: May 21, 1979.

Total depth: 240.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Silt, tannish yellow, clayey..... | 0.0 | - 4.0 |
| Sand, very fine, silty..... | 4.0 | - 11.0 |
| Clay, yellowish tan, silty..... | 11.0 | - 17.0 |
| Sand, very fine to fine..... | 17.0 | - 58.0 |
| Silt, medium gray, sandy..... | 58.0 | - 62.0 |
| Sand, very fine, silty..... | 62.0 | - 77.0 |
| Silt, medium gray, clayey..... | 77.0 | - 127.5 |
| Silt, medium gray, sandy..... | 127.5 | - 133.5 |
| Sand, medium to very coarse, and gravel, very fine to medium, clayey, silty..... | 133.5 | - 138.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Shale, olive gray..... | 138.0 | - 139.0 |
| Shale, medium gray..... | 139.0 | - 173.0 |
| Limestone, light gray, finely crystalline; contains crinoids, brachiopods, and algal material..... | 173.0 | - 174.5 |
| Shale, medium gray..... | 174.5 | - 183.7 |
| Howard Formation: | | |
| Limestone, light to medium gray, finely crystalline; contains brachiopods, algal material, pyrite, and "black inclusions"..... | 183.7 | - 188.1 |
| Severy Formation: | | |
| Shale, medium gray..... | 188.1 | - 188.6 |
| Shale, black; contains carbonaceous material... | 188.6 | - 189.1 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium gray | 189.1 | - 189.6 |
| Shale, black | 189.6 | - 190.0 |
| Shale, medium gray | 190.0 | - 196.6 |
| Coal, black | 196.6 | - 197.0 |
| Shale, medium gray | 197.0 | - 199.1 |
| Limestone, dark gray, very finely crystalline | 199.1 | - 199.6 |
| Shale, dark gray | 199.6 | - 201.7 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods, crinoids, and pyrite | 201.7 | - 206.0 |
| Holt Member: | | |
| Shale, black, contains carbonaceous material | 206.0 | - 207.0 |
| DuBois Member: | | |
| Limestone, dark tannish gray, very finely crystalline; contains brachiopods and crinoids | 207.0 | - 208.3 |
| Turner Creek Member: | | |
| Shale, light gray to greenish gray | 208.3 | - 209.5 |
| Sheldon Member: | | |
| Limestone, light tan to white, very finely crystalline | 209.5 | - 214.7 |
| Jones Point Member: | | |
| Limestone, light tan, very finely crystalline; contains brachiopods, crinoids and fusulinids | 214.7 | - 218.0 |
| Shale, light gray | 218.0 | - 219.0 |
| Curzon Member: | | |
| Limestone, light tan, very finely crystalline; contains brachiopods, crinoids, and chert | 219.0 | - 222.0 |
| Iowa Point Member: | | |
| Shale, black | 222.0 | - 222.1 |
| Shale, medium gray; interbedded with hard limy zones | 222.1 | - 223.0 |
| Hartford Member: | | |
| Limestone, light tannish gray, very finely crystalline; contains algal material | 223.0 | - 224.0 |
| Calhoun Formation: | | |
| Shale, light gray | 224.0 | - 225.0 |
| Deer Creek Formation: | | |
| Ervine Creek Member: | | |
| Limestone, very light tan, very finely crystalline; contains brachiopods, crinoids, and algal material | 225.0 | - 232.0 |
| Shale, light gray | 232.0 | - 233.0 |
| Limestone, light gray, very finely crystalline; contains crinoids | 233.0 | - 234.1 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, dark tan, very finely crystalline; contains brachiopods and algal material..... | 234.1 | - 240.0 |

## Test Hole 9-79

Location: Otoe County, SW corner SE sec. 7, T. 9 N., R. 13 E., approximately 15 feet north of south section line and 56 feet east of half section line.

Ground-level elevation: 1,120.0 feet above mean sea level.

Started: May 22, 1979. Completed: May 22, 1979.

Total depth: 206.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample)..... | 0.0 | - 2.5 |
| Silt, light brown, clayey..... | 2.5 | - 12.0 |
| Sand, very fine to fine, clayey, silty..... | 12.0 | - 17.0 |
| Silt, reddish brown..... | 17.0 | - 24.0 |
| Silt, yellowish brown..... | 24.0 | - 37.0 |
| Silt, beige, sandy..... | 37.0 | - 48.0 |
| Silt, light to dark brown, clayey, sandy..... | 48.0 | - 70.0 |
| Silt, light to medium gray, clayey, sandy..... | 70.0 | - 160.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Shale, dark gray..... | 160.0 | - 172.0 |
| Shale, medium to dark gray..... | 172.0 | - 181.0 |
| Shale, light gray..... | 181.0 | - 183.5 |
| Shale, medium to dark gray..... | 183.5 | - 189.0 |
| Shale, light gray..... | 189.0 | - 190.0 |
| Howard Formation: | | |
| Limestone, medium gray to tannish gray, very finely crystalline; contains brachiopods, algal material, pyrite, and "black inclusions"..... | 190.0 | - 194.1 |
| Severy Formation: | | |
| Shale, light gray..... | 194.1 | - 194.6 |
| Shale, black..... | 194.6 | - 195.3 |
| Shale, light gray..... | 195.3 | - 195.7 |
| Shale, black..... | 195.7 | - 196.4 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, light gray | 196.4 | 202.8 |
| Coal, black | 202.8 | 203.3 |
| Shale, light gray, sandy | 203.3 | 206.0 |

## Test Hole 10-79

Location: Otoe County, NE corner sec. 5, T. 9 N., R. 13 E., approximately 90 feet south of north section line and 24 feet west of east section line.

Ground-level elevation: 1,064.0 feet above mean sea level.

Started: May 22, 1979. Completed: May 22, 1979.

Total depth: 200.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 1.0 |
| Silt, pale brown, clayey | 1.0 | 17.0 |
| Silt, light reddish brown, clayey, sandy | 17.0 | 58.0 |
| Sand, very fine to very coarse | 58.0 | 103.5 |
| Silt, medium gray, sandy | 103.5 | 105.8 |
| Sand, fine to coarse | 105.8 | 115.0 |
| Clay, dark gray | 115.0 | 116.0 |
| Silt, medium gray, sandy | 116.0 | 122.0 |
| Clay, medium gray, silty | 122.0 | 135.4 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Howard Formation: | | |
| Limestone, brown, irregular crystalline; contains crinoids, byrozoans, and algal material | 135.4 | 137.3 |
| Severy Formation: | | |
| Shale, olive | 137.3 | 138.7 |
| Shale, medium gray | 138.7 | 139.2 |
| Shale, black | 139.2 | 139.7 |
| Shale, medium gray | 139.7 | 145.5 |
| Coal, black | 145.5 | 145.7 |
| Shale, medium gray | 145.7 | 149.6 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shawnee Group: | | |
| Calhoun - Topeka Formations: | | |
| Coal Creek Member: | | |
| Limestone, medium gray, finely crystalline; contains brachiopods | 149.6 | - 150.2 |
| Shale, medium gray | 150.2 | - 152.3 |
| Limestone, medium to dark gray, finely crystalline; contains brachiopods and pyrite | 152.3 | - 155.1 |
| Shale, dark gray | 155.1 | - 155.7 |
| Limestone, dark gray, very finely crystalline; contains brachiopods | 155.7 | - 156.5 |
| Holt Member: | | |
| Shale, black | 156.5 | - 158.0 |
| DuBois Member: | | |
| Limestone, dark gray, very finely crystalline | 158.0 | - 160.2 |
| Turner Creek Member: | | |
| Shale, light gray to light greenish gray | 160.2 | - 162.0 |
| Sheldon Member: | | |
| Limestone, light tan, very finely crystalline pseudo-oolitic; contains Osagia | 162.0 | - 165.5 |
| Jones Point Member: | | |
| Shale, light gray | 165.5 | - 167.0 |
| Limestone, light gray, finely crystalline | 167.0 | - 169.0 |
| Shale, light gray | 169.0 | - 169.8 |
| Curzon - Calhoun Members: | | |
| Limestone, light tan, finely crystalline; contains Osagia | 169.8 | - 172.9 |
| Limestone, light tan, finely crystalline; contains crinoids; interbedded with shale, gray | 172.9 | - 174.0 |
| Deer Creek Formation: | | |
| Ervine Creek Member: | | |
| Limestone, light tannish gray, very finely crystalline; contains brachiopods and crinoids | 174.0 | - 186.0 |
| Limestone, light gray to dark brown, finely crystalline; contains brachiopods and fusulinids | 186.0 | - 196.5 |
| Larsh Member: | | |
| Shale, black; contains carbonaceous material | 196.5 | - 198.0 |
| Rock Bluff Member: | | |
| Limestone, tannish gray, very finely crystalline; contains pyrite | 198.0 | - 200.0 |

## Test Hole 11-79

Location: Cass County, NW corner sec. 33, T. 10 N., R. 13 E., approximately 19 feet south of north section line and 16 feet east of west section line.

Ground-level elevation: 1,044.0 feet above mean sea level.

Started: May 23, 1979. Completed: May 23, 1979.

Total depth: 172.2 feet.

| Description | Depth, in feet From | To |
|---|---|---|
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Silt, light brown, clayey | 2.0 | 17.0 |
| Silt, pale reddish brown, clayey | 17.0 | 24.0 |
| Clay, light brown, silty | 24.0 | 56.0 |
| Clay, light gray, silty | 56.0 | 64.5 |
| Sand, very fine to medium | 64.5 | 109.0 |
| Silt, medium gray, sandy | 109.0 | 122.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Lecompton Formation: | | |
| King Hill Member: | | |
| Shale, light greenish gray | 122.0 | 126.0 |
| Shale, reddish brown | 126.0 | 127.0 |
| Shale, light greenish gray | 127.0 | 128.5 |
| Beil Member: | | |
| Limestone, light gray, very finely crystalline; pseudo-oolitic in part; contains Osagia | 128.5 | 132.2 |
| Limestone, light gray, very finely crystalline; contains brachiopods; interbedded with shale, light gray | 132.2 | 136.0 |
| Queen Hill Member: | | |
| Shale, medium gray | 136.0 | 138.5 |
| Shale, black; contains carbonaceous material | 138.5 | 139.0 |
| shale, dark gray to black | 139.0 | 141.3 |
| Big Springs Member: | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods | 141.3 | 142.1 |
| Doniphan Member: | | |
| Shale, medium gray | 142.1 | 147.0 |
| Spring Branch Member: | | |
| Limestone, light gray, very finely crystalline; pseudo-oolitic in part; contains brachiopods, fusulinids and Osagia | 147.0 | 151.5 |
| Limestone, dark gray, very finely crystalline; interbedded with shale, gray | 151.5 | 156.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Kanwaka Formation: | | |
| Stull Member: | | |
| Shale, medium gray | 156.0 | - 157.3 |
| Clay Creek Member: | | |
| Limestone, light gray, very finely crystalline; contains brachiopods | 157.3 | - 158.6 |
| Jackson Park Member: | | |
| Shale, light greenish gray | 158.6 | - 159.5 |
| Oread Formation: | | |
| Kereford Member: | | |
| Limestone, light tan to white, very finely crystalline, pseudo-oolitic; contains fusulinids, Osagia, and chert | 159.5 | - 166.0 |
| Heumader Member: | | |
| Shale, light gray | 166.0 | - 166.7 |
| Plattsmouth Member: | | |
| Limestone, light gray, very finely crystalline; contains fusulinids | 166.7 | - 168.5 |
| Shale, medium gray | 168.5 | - 169.0 |
| Limestone, light gray, very finely crystalline; contains brachiopods and fusulinids | 169.0 | - 172.2 |

## Test Hole 12-79

Location: Cass County, SW corner NW sec. 33, T. 10 N., R. 13 E., approximately 50 feet north of half section line and 7 feet east of west section line.

Ground-level elevation: 1,061.0 feet above mean sea level.

Started: May 23, 1979. Completed: May 23, 1979.

Total depth: 175.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | - 2.0 |
| Silt, light brown, clayey | 2.0 | - 17.0 |
| Silt, pale reddish brown, clayey | 17.0 | - 51.0 |
| Silt, pale reddish brown, sandy | 51.0 | - 70.0 |
| Sand, very fine to fine | 70.0 | - 116.5 |
| Silt, brownish gray, clayey | 116.5 | - 130.0 |
| Gravel, very fine to coarse | 130.0 | - 135.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Tecumseh Formation: | | |
| Ost Member: | | |
| Shale, light gray | 135.5 | - 136.0 |
| Siltstone, olive gray | 136.0 | - 138.0 |
| Siltstone, reddish gray | 138.0 | - 139.0 |
| Siltstone, greenish gray | 139.0 | - 140.5 |
| Shale, dark gray | 140.5 | - 141.0 |
| Limestone, light gray, very finely crystalline, pseudo-oolitic in part; contains Osagia, algal material, and glauconite | 141.0 | - 144.3 |
| Kenosha Member: | | |
| Shale, medium gray | 144.3 | - 146.0 |
| Avoca Member: | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods, crinoids, and algal material | 146.0 | - 146.5 |
| Shale, dark gray | 146.5 | - 147.0 |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods and fusulinids | 147.0 | - 148.2 |
| King Hill Member: | | |
| Shale, light gray | 148.2 | - 149.0 |
| Shale, reddish brown | 149.0 | - 151.5 |
| Shale, light greenish gray interbedded with hard limy zones | 151.5 | - 155.3 |
| Beil Member: | | |
| Limestone, light tan, very finely crystalline; contains corals; interbedded with shale, greenish gray | 155.3 | - 162.2 |
| Queen Hill Member: | | |
| Shale, light greenish gray | 162.2 | - 164.5 |
| Shale, black | 164.5 | - 164.9 |
| Shale, dark gray | 164.9 | - 165.4 |
| Shale, black; contains carbonaceous material | 165.4 | - 167.5 |
| Big Springs Member: | | |
| Limestone, medium gray, finely crystalline; contains brachiopods, crinoids, fusulinids, and pyrite | 167.5 | - 168.8 |
| Doniphan Member: | | |
| Shale, medium gray | 168.8 | - 173.1 |
| Spring Branch Member: | | |
| Limestone, light gray, very finely crystalline; psuedo-oolitic in part; contains Osagia | 173.1 | - 175.0 |

## Test Hole 13-79

Location: Otoe County, NE corner NW sec. 4, T. 9 N., R. 13 E., approximately 28 feet south of north section line and 2,475 feet east of west section line.

Ground-level elevation: 998.0 feet above mean sea level.

Started: May 24, 1979. Completed: May 24, 1979.

Total depth: 152.0 feet.

| Description | Depth, in feet From | To |
|---|---|---|
| Quaternary System: | | |
| Soil, dark gray; contains organic material..... | 0.0 | 6.0 |
| Clay, dark brown, silty..... | 6.0 | 16.0 |
| Silt, light gray, clayey, sandy..... | 16.0 | 22.0 |
| Sand, very fine to coarse..... | 22.0 | 71.0 |
| Clay, light brown, silty, sandy..... | 71.0 | 77.0 |
| Sand, very fine to fine, silty..... | 77.0 | 85.0 |
| Silt, light gray, sandy..... | 85.0 | 92.0 |
| Sand, very fine to fine, silty..... | 92.0 | 100.0 |
| Silt, gray, clayey..... | 100.0 | 103.2 |
| Gravel, very fine to medium..... | 103.2 | 107.0 |
| Silt, gray..... | 107.0 | 110.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Shale, light to medium gray..... | 110.0 | 129.0 |
| Howard Formation: | | |
| Limestone, dark tannish gray, very finely crystalline; contains brachiopods, pyrite and "black inclusions"..... | 129.0 | 133.0 |
| Severy Formation: | | |
| Shale, black; contains carbonaceous material... | 133.0 | 135.0 |
| Shale, light gray..... | 135.0 | 141.5 |
| Shale, black; contains carbonaceous material... | 141.5 | 142.1 |
| Shale, medium gray..... | 142.1 | 144.5 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods..... | 144.5 | 149.3 |
| Shale, light gray..... | 149.3 | 150.0 |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods and crinoids..... | 150.0 | 150.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium to dark gray..... | 150.5 | - 151.0 |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods..... | 151.0 | - 151.5 |
| Shale, medium to dark gray..... | 151.5 | - 152.0 |

## Test Hole 14-79

Location: Otoe County, SW NW SW SE sec. 27, T. 10 N., R. 13 E., approximately 694 feet north of south section line and 20 feet east of half section line.

Ground-level elevation: 1,070.0 feet above mean sea level.

Started: May 24, 1979. Completed: May 24, 1979.

Total depth: 137.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample)..... | 0.0 | - 3.0 |
| Silt, pale yellowish brown, clayey..... | 3.0 | - 20.0 |
| Silt, pale reddish brown clayey..... | 20.0 | - 32.0 |
| Clay, pale brown, silty..... | 32.0 | - 37.0 |
| Silt, pale brown, clayey..... | 37.0 | - 42.0 |
| Silt, pale reddish brown, clayey, sandy..... | 42.0 | - 47.0 |
| Silt, pale yellowish brown, sandy..... | 47.0 | - 51.0 |
| Sand, very fine to coarse..... | 51.0 | - 56.0 |
| Clay, light tan, silty, sandy..... | 56.0 | - 58.0 |
| Gravel, very fine to medium..... | 58.0 | - 61.2 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Topeka Formation: | | |
| DuBois Member: | | |
| Limestone, olive brown, very finely crystalline; contains brachiopods and crinoids..... | 61.2 | - 62.5 |
| Turner Creek Member: | | |
| Shale, olive yellow..... | 62.5 | - 65.0 |
| Limestone, light gray finely crystalline; contains brachiopods..... | 65.0 | - 65.3 |
| Shale, dark olive..... | 65.3 | - 67.0 |
| Limestone, olive yellow, finely crystalline.... | 67.0 | - 68.0 |
| Shale, olive..... | 68.0 | - 69.0 |
| Shale, reddish brown..... | 69.0 | - 69.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Sheldon Member: | | |
| Limestone, light tan, very finely crystalline; pseudo-oolitic in part; contains brachiopods and Osagia | 69.8 | 73.1 |
| Jones Point Member: | | |
| Shale olive yellow | 73.1 | 77.2 |
| Curzon Member: | | |
| Limestone, olive gray, very finely crystalline; contains brachiopods, bryozoans, crinoids, and coral | 77.2 | 77.8 |
| Shale, olive gray | 77.8 | 78.2 |
| Limestone, tannish olive, very finely crystalline; contains bryozoans and crinoids | 78.2 | 78.5 |
| Shale, olive gray | 78.5 | 79.0 |
| Limestone, light tan, very finely crystalline; pseudo-oolitic in part; contains Osagia, fusulinids, crinoids, and chert; interbedded with shale, olive yellow | 79.0 | 84.0 |
| Iowa Point Member: | | |
| Shale, olive gray | 84.0 | 84.5 |
| Hartford Member: | | |
| Limestone, light tan, very finely crystalline; contains Osagia | 84.5 | 86.0 |
| Calhoun Formation: | | |
| Shale, olive | 86.0 | 86.3 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, light tan, irregular crystalline; pseudo-oolitic in part; contains brachiopods, fusulinids, and Osagia | 86.3 | 91.5 |
| Shale, olive brown | 91.5 | 91.7 |
| Limestone, light tan, very finely to irregular crystalline, contains brachiopods, algal material, Osagia, and chert | 91.7 | 102.0 |
| Shale, black | 102.0 | 102.5 |
| Limestone, tan, fine crystalline interbedded with shale, olive yellow | 102.5 | 104.2 |
| Larsh Member: | | |
| Shale, olive gray | 104.2 | 105.8 |
| Shale, black | 105.8 | 106.4 |
| Rock Bluff Member: | | |
| Limestone, dark brown, very finely crystalline | 106.4 | 108.1 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, dark gray | 108.1 | 109.0 |
| Siltstone, olive yellow to olive gray; interbedded with shale, olive gray | 109.0 | 130.0 |
| Shale, reddish brown | 130.0 | 130.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Ost Member: | | |
| Limestone, pale yellow, very finely crystalline | 130.8 | 134.1 |
| Shale, greenish gray; interbedded with limestone, yellowish brown, finely crystalline | 134.1 | 137.0 |

## Test Hole 15-79

Location: Cass County, NE NE SE NW sec. 34, T. 10 N., R. 13 E., approximately 1,625 feet south of north section line and 21 feet west of half section line.

Ground-level elevation: 1,091.0 feet above mean sea level.

Started: May 25, 1979. Completed: May 25, 1979.

Total depth: 152.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Clay, pale brown, silty | 2.0 | 19.0 |
| Silt, pale reddish brown, clayey | 19.0 | 45.0 |
| Clay, brownish gray | 45.0 | 47.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Emporia Formation: | | |
| Reading Member: | | |
| Limestone, yellowish brown, finely crystalline; contains brachiopods, crinoids, and Osagia | 47.0 | 47.7 |
| Shale, olive yellow | 47.7 | 48.6 |
| Limestone, yellowish brown, finely crystalline; contains brachiopods and crinoids | 48.6 | 49.0 |
| Auburn Formation: | | |
| Shale, reddish brown | 49.0 | 50.0 |
| Shale, olive gray | 50.0 | 52.0 |
| Shale, reddish brown | 52.0 | 52.4 |
| Shale, light olive | 52.4 | 53.2 |
| Shale, reddish brown | 53.2 | 55.0 |
| Shale, olive yellow | 55.0 | 56.0 |
| Shale, reddish brown | 56.0 | 56.5 |
| Limestone, olive brown, coarsely crystalline | 56.5 | 56.8 |
| Shale, olive yellow | 56.8 | 58.0 |
| Shale, reddish brown | 58.0 | 62.4 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Shale, olive | 62.4 | - | 64.0 |
| Shale, reddish brown | 64.0 | - | 65.5 |
| Shale, olive gray | 65.5 | - | 68.5 |
| Shale, reddish brown | 68.5 | - | 69.0 |
| Shale, olive gray | 69.0 | - | 70.0 |
| Shale, medium gray | 70.0 | - | 76.8 |
| Limestone, dark tannish gray, finely crystalline | 76.8 | - | 77.3 |
| Shale, medium gray | 77.3 | - | 81.2 |
| Wakarusa Formation: | | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods, crinoids and "black inclusions" | 81.2 | - | 82.0 |
| Shale, medium gray | 82.0 | - | 83.3 |
| Shale, black | 83.3 | - | 83.4 |
| Limestone, dark gray, finely crystalline; contains fusulinids | 83.4 | - | 84.1 |
| Shale, light gray | 84.1 | - | 88.0 |
| Shale, pale reddish brown | 88.0 | - | 88.3 |
| Limestone, light gray to tannish gray, finely crystalline; contains brachiopods and glauconite | 88.3 | - | 90.4 |
| Shale, medium gray | 90.4 | - | 92.4 |
| Shale, reddish brown | 92.4 | - | 92.7 |
| Shale, olive gray interbedded with greenish gray | 92.7 | - | 95.0 |
| Shale, light to medium gray | 95.0 | - | 114.5 |
| Burlingame Formation: | | | |
| Limestone, dark gray, irregular crystalline; contains brachiopods and algal material | 114.5 | - | 115.9 |
| Shale, greenish gray interbedded with light gray | 115.9 | - | 118.1 |
| Limestone, light gray to tannish gray, finely crystalline, "peppered" appearance | 118.1 | - | 119.2 |
| Scranton Formation: | | | |
| Cedarvale - White Cloud Members: | | | |
| Shale, olive gray | 119.2 | - | 122.0 |
| Shale, medium to dark gray | 122.0 | - | 127.0 |
| Shale, dark gray to black | 127.0 | - | 131.0 |
| Shale, light greenish gray | 131.0 | - | 139.0 |
| Shale, dark reddish brown | 139.0 | - | 145.5 |
| Shale, medium gray | 145.5 | - | 146.0 |
| Shale, reddish brown | 146.0 | - | 147.0 |
| Shale, medium gray | 147.0 | - | 152.0 |

## Test Hole 16-79

Location: Cass County, SE SE NE SE sec. 24, T. 10 N., R. 13 E., approximately 1,470 feet north of south section line and 18 feet west of east section line.

Ground-level elevation: 1,049.5 feet above mean sea level.

Started: May 29, 1979. Completed: May 29, 1979.

Total depth: 122.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample) | 0.0 | - | 3.0 |
| Clay, light brown, silty | 3.0 | - | 24.0 |
| Silt, pale reddish brown, clayey | 24.0 | - | 69.0 |
| Gravel, very fine to coarse, sandy | 69.0 | - | 70.5 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, tannish gray, finely crystalline; contains brachiopods and crinoids | 70.5 | - | 71.0 |
| Holt Member: | | | |
| Shale, olive yellow | 71.0 | - | 72.0 |
| Shale, black | 72.0 | - | 73.2 |
| DuBois Member: | | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods and pyrite | 73.2 | - | 74.0 |
| Turner Creek Member: | | | |
| Shale, light gray, interbedded with hard limy zones | 74.0 | - | 77.3 |
| Sheldon Member: | | | |
| Limestone, very light tan, finey crystalline; pseudo-oolitic; contains brachiopods, Osagia, and glauconite | 77.3 | - | 81.4 |
| Jones Point Member: | | | |
| Shale, light gray; interbedded with hard limy zones | 81.4 | - | 84.0 |
| Shale, medium gray | 84.0 | - | 85.2 |
| Curzon Member: | | | |
| Limestone, light to medium gray, very finely crystalline; contains brachipods, crinoids, and bryozoans | 85.2 | - | 86.1 |
| Shale, medium gray | 86.1 | - | 87.0 |
| Limestone, light gray, finely crystalline; contains ostracods and "black inclusions" | 87.0 | - | 89.0 |
| Shale, light bluish gray | 89.0 | - | 90.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light to medium gray, very finely crystalline, pseudo-oolitic in part; contains brachiopods, fusulinids, and Osagia..... | 90.5 | 92.3 |
| Iowa Point Member: | | |
| Shale black interbedded with olive..... | 92.3 | 93.1 |
| Hartford Member: | | |
| Limestone, light tan, very finely crystalline, pseudo-oolitic in part; contains brachiopods, crinoids, and Osagia..... | 93.1 | 94.2 |
| Calhoun Formation: | | |
| Shale, light gray..... | 94.2 | 94.4 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, light tan, very finely crystalline, pseudo-oolitic in part; contains brachiopods, crinoids, fusulinids, Osagia, and chert..... | 94.4 | 104.2 |
| Limestone, tannish gray, very finely crystalline; contains brachiopods, fusulinids, and crinoids..... | 104.2 | 108.0 |
| Limestone, light gray, very finely crystalline; contains brachiopods and crinoids; interbedded with shale, gray..... | 108.0 | 112.0 |
| Larsh Member: | | |
| Shale, black..... | 112.0 | 114.8 |
| Rock Bluff Member: | | |
| Limestone, tannish gray, very finely crystalline, contains brachiopods..... | 114.8 | 117.1 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray..... | 117.1 | 122.0 |

## Test Hole 17-79

Location: Cass County, SE SE NE NE sec. 25, T. 10 N., R. 13 E., approximately 80 feet north of north quarter section line and 18 feet west of east section line.

Ground-level elevation: 1,010.0 feet above mean sea level.

Started: May 29, 1979. Completed: May 29, 1979.

Total depth: 160.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Silt, tannish brown, clayey | 0.0 | - | 10.0 |
| Silt, yellowish brown, clayey | 10.0 | - | 17.0 |
| Silt, pale reddish brown, clayey | 17.0 | - | 25.0 |
| Silt, olive gray, clayey | 25.0 | - | 32.0 |
| Silt, pale reddish brown, clayey | 32.0 | - | 47.0 |
| Silt, light brown, clayey | 47.0 | - | 63.0 |
| Sand, very fine to very coarse, and gravel, very fine to medium; contains reworked limestone | 63.0 | - | 72.2 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, olive gray, very finely crystalline; contains crinoids | 72.2 | - | 73.0 |
| Shale, olive yellow | 73.0 | - | 73.6 |
| Limestone, olive gray, very finely crystalline; contains brachiopods | 73.6 | - | 74.1 |
| Holt Member: | | | |
| Shale, black | 74.1 | - | 74.5 |
| Shale, dark gray | 74.5 | - | 76.2 |
| DuBois Member: | | | |
| Limestone, dark gray, very finely crystalline; contains abundant brachiopods | 76.2 | - | 76.3 |
| Turner Creek Member: | | | |
| Shale, light greenish gray | 76.3 | - | 77.0 |
| Limestone, light gray to light greenish gray, very finely crystalline to dense, shaley | 77.0 | - | 78.8 |
| Shale, light gray to light greenish gray | 78.8 | - | 82.0 |
| Sheldon Member: | | | |
| Limestone, light tan mottled with yellow brown, very finely crystalline; contains Osagia and algal material | 82.0 | - | 83.8 |
| Shale, light gray, hard and limy | 83.8 | - | 84.5 |
| Shale, light gray; interbedded with thin hard limy zones | 84.5 | - | 86.5 |
| Jones Point Member: | | | |
| Shale, medium gray; interbedded with thin hard limy zones | 86.5 | - | 91.1 |
| Curzon Member: | | | |
| Limestone, light gray to light tannish gray, very finely crystalline to dense | 91.1 | - | 91.8 |
| Shale, olive yellow | 91.8 | - | 92.3 |
| Limestone, yellowish tan, very finely crystalline; interbedded with shale, olive yellow | 92.3 | - | 95.0 |
| Iowa Point Member: | | | |
| Shale, olive | 95.0 | - | 96.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Hartford Member: | | |
| Limestone, tan, very finely crystalline; contains Osagia | 96.0 | 97.5 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, tan to brown, very finely crystalline, cherty; contains crinoids | 97.5 | 104.0 |
| Limestone, dark tannish gray, very finely crystalline, cherty; contains brachiopods and abundant Osagia | 104.0 | 109.0 |
| Limestone, medium gray, very finely crystalline, cherty; contains abundant fusulinids | 109.0 | 112.0 |
| Shale, medium gray | 112.0 | 112.2 |
| Shale, light gray | 112.2 | 113.0 |
| Limestone, light gray, finely crystalline, shaley | 113.0 | 114.1 |
| Larsh Member: | | |
| Shale, medium gray | 114.1 | 114.5 |
| Shale, black | 114.5 | 116.0 |
| Rock Bluff Member: | | |
| Limestone, tannish gray, very finely crystalline | 116.0 | 118.0 |
| Limestone, light gray, very finely crystalline; contains crinoids, fusulinids, and abundant "black inclusions" | 118.0 | 118.5 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray | 118.5 | 121.0 |
| Shale, light gray | 121.0 | 122.0 |
| Sandstone, light gray, soft and shaley | 122.0 | 123.8 |
| Siltstone, light gray; interbedded with thin sandstones | 123.8 | 139.1 |
| Shale, light gray | 139.1 | 141.5 |
| Siltstone, dark greenish gray | 141.5 | 143.0 |
| Ost Member: | | |
| Limestone, light greenish gray, very finely crystalline, shaley; contains crinoids and algal material | 143.0 | 145.7 |
| Shale, light greenish gray; interbedded with hard limy zones | 145.7 | 148.5 |
| Limestone, light greenish gray to tan, conglomeritic texture; interbedded with shale, light greenish gray, at 149.0 to 149.5 | 148.5 | 150.4 |
| Kenosha Member: | | |
| Shale, olive mottled with gray | 150.4 | 153.4 |
| Shale, medium gray | 153.4 | 157.0 |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, dark gray, very finely crystalline; contains crinoids and brachiopods | 157.0 | 157.8 |
| Shale, dark gray with black interbedded | 157.8 | 158.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, dark gray, very finely crystalline.. | 158.0 | - 159.0 |
| King Hill Member: | | |
| Shale, medium gray..... | 159.0 | - 160.0 |

## Test Hole 18-79

Location: Cass County, SE corner NE sec. 19, T. 10 N., R. 14 E., approximately 185 feet north of half section line and 22 feet west of east section line.

Ground-level elevation: 1,110.0 feet above mean sea level.

Started: May 30, 1979. Completed: May 30, 1979.

Total depth: 113.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample)..... | 0.0 | - 2.0 |
| Silt, light brown, clayey..... | 2.0 | - 36.0 |
| Silt, pale reddish brown, clayey..... | 36.0 | - 47.0 |
| Silt, pale reddish brown, clayey, sandy..... | 47.0 | - 56.0 |
| Silt, light tan to brown, clayey..... | 56.0 | - 60.0 |
| Silt, light tan to brown, clayey..... | 60.0 | - 68.0 |
| Clay, pale yellow, silty..... | 68.0 | - 76.0 |
| Clay, pale yellow with red iron staining; contains reworked limestone..... | 76.0 | - 80.1 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods..... | 80.1 | - 81.8 |
| Shale, pale olive yellow..... | 81.8 | - 82.3 |
| Limestone, dark olive gray, very finely crystalline; contains brachiopods..... | 82.3 | - 82.7 |
| Shale, olive yellow..... | 82.7 | - 83.5 |
| Limestone, dark olive gray, very finely crystalline; contains brachiopods and crinoids..... | 83.5 | - 83.7 |
| Holt Member: | | |
| Shale, dark olive..... | 83.7 | - 84.7 |
| Shale, dark olive with black interbedded..... | 84.7 | - 84.9 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Turner Creek Member: | | | |
| Shale, olive yellow..... | 84.9 | - | 86.4 |
| Limestone, olive gray, finely to very finely crystalline; contains brachiopods..... | 86.4 | - | 87.1 |
| Shale, olive yellow..... | 87.1 | - | 87.6 |
| Shale, dark olive..... | 87.6 | - | 88.0 |
| Sheldon Member: | | | |
| Limestone, olive yellow, very finely crystalline; interbedded with shale, dark olive..... | 88.0 | - | 88.1 |
| Limestone, yellow brown, very finely crystalline, cherty; contains Osagia and pseudo-oolities..... | 88.1 | - | 89.1 |
| Limestone, light tan, very finely crystalline, pseudo-oolitic; contains Osagia and brachiopods..... | 89.1 | - | 91.0 |
| Limestone, light gray, very finely crystalline..... | 91.0 | - | 93.0 |
| Jones Point Member: | | | |
| Shale, light greenish gray; interbedded with limestone, light greenish gray..... | 93.0 | - | 96.3 |
| Curzon Member: | | | |
| Limestone, gray, very finely crystalline; contains brachiopods..... | 96.3 | - | 97.0 |
| Shale, medium gray; interbedded with limestone, light gray..... | 97.0 | - | 98.0 |
| Limestone, light tan, very finely crystalline to dense, soft; interbedded with shale, pale olive..... | 98.0 | - | 100.0 |
| Shale, light gray..... | 100.0 | - | 100.5 |
| Limestone, light greenish gray, very finely crystalline..... | 100.5 | - | 101.0 |
| Shale, olive..... | 101.0 | - | 101.5 |
| Limestone, brown, very finely crystalline..... | 101.5 | - | 102.0 |
| Limestone, brown, very finely crystalline; contains chert..... | 102.0 | - | 103.0 |
| Limestone, light tannish gray, very finely crystalline; interbedded with shale, olive... | 103.0 | - | 104.1 |
| Iowa Point Member: | | | |
| Shale, olive; contains traces of black carbonaceous material..... | 104.1 | - | 105.0 |
| Hartford Member: | | | |
| Limestone, light tannish gray, very finely crystalline..... | 105.0 | - | 106.1 |
| Calhoun Formation: | | | |
| Shale, olive..... | 106.1 | - | 106.9 |
| Deer Creek Formation: | | | |
| Ervine Creek Member: | | | |
| Limestone, dark yellow brown, very finely crystalline..... | 106.9 | - | 109.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light tannish gray, very finely crystalline; contains pseudo-oolites, Osagia, brachiopods, and fusulinids..... | 109.5 | - 113.0 |

## Test Hole 19-79

Location: Cass County, SE corner sec. 19, T. 10 N., R. 14 E., approximately 125 feet north of south section line and 20 feet west of east section line.

Ground-level elevation: 1,084.0 feet above mean sea level.

Started: May 30, 1979. Completed: May 30, 1979.

Total depth: 160.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample)..... | 0.0 | - 2.0 |
| Silt, light brown, clayey..... | 2.0 | - 26.0 |
| Silt, pale reddish brown, clayey..... | 26.0 | - 42.0 |
| Silt, pale brown, clayey..... | 42.0 | - 52.0 |
| Silt, pale reddish brown, clayey..... | 52.0 | - 57.0 |
| Silt, pale brown, clayey..... | 57.0 | - 82.0 |
| Sand, orange brown with iron staining, very fine to coarse, silty..... | 82.0 | - 84.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Cedarvale - White Cloud Members: | | |
| Clay, light and dark olive to olive yellow, silty..... | 84.0 | - 92.0 |
| Clay, pale olive yellow..... | 92.0 | - 102.0 |
| Shale, dark gray..... | 102.0 | - 112.0 |
| Shale, medium gray..... | 112.0 | - 122.0 |
| Shale, medium to light gray..... | 122.0 | - 127.0 |
| Shale, medium to light gray; interbedded with thin sandstone at 129.0, thin limestones at 132.0 and 137.0..... | 127.0 | - 143.0 |
| Howard Formation: | | |
| Limestone, dark brown, very finely crystalline; contains brachiopods and crinoids..... | 143.0 | - 144.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, dark tannish gray, very finely crystalline; contains crinoids, brachiopods, and "black inclusions;" interbedded with thin shales at 144.1, 145.0, and 145.6..... | 144.0 | - 147.2 |
| Severy Formation: | | |
| Shale, medium gray..... | 147.2 | - 148.3 |
| Shale, black; contains carbonaceous material... | 148.3 | - 149.3 |
| Shale, medium gray..... | 149.3 | - 155.0 |
| Coal, black..... | 155.0 | - 155.4 |
| Shale, medium to dark gray..... | 155.4 | - 159.8 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone (no sample)..... | 159.8 | - 160.0 |

## Test Hole 20-79

Location: Cass County, SW corner NW sec. 29, T. 10 N., R. 14 E., approximately 280 feet north of half section line and 18 feet east of west section line.

Ground-level elevation: 1,068 feet above mean sea level.

Started: May 30, 1979: Completed: May 30, 1979.

Total depth: 197.5 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample)..... | 0.0 | - 2.0 |
| Silt, pale brown, clayey..... | 2.0 | - 17.0 |
| Silt, brown, clayey..... | 17.0 | - 28.0 |
| Silt, dark brown, clayey..... | 28.0 | - 32.0 |
| Silt, pale reddish brown, clayey..... | 32.0 | - 39.0 |
| Silt, light brown, clayey..... | 39.0 | - 59.5 |
| Silt, brown, clayey..... | 59.5 | - 62.0 |
| Silt, light brown, clayey..... | 62.0 | - 87.0 |
| Silt, light brown with pale red tint, clayey... | 87.0 | - 95.0 |
| Silt, very light brown to beige, sandy..... | 95.0 | - 100.0 |
| Sand, very fine to fine, silty..... | 100.0 | - 115.0 |
| Clay, light tan to beige, silty..... | 115.0 | - 122.0 |
| Sand, very fine to fine, silty..... | 122.0 | - 128.0 |
| Silt, beige, clayey..... | 128.0 | - 140.0 |
| Sand, very fine to fine, silty..... | 140.0 | - 145.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Silt, medium gray | 145.0 | - 160.0 |
| Gravel; contains reworked limestone; contains silt and clay | 160.0 | - 164.5 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| Shale, olive yellow | 164.5 | - 174.0 |
| Howard Formation: | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods, crinoids, and "black inclusions;" interbedded with thin shales, gray, at 176.5-176.8 | 174.0 | - 178.4 |
| Severy Formation: | | |
| Shale, medium gray | 178.4 | - 178.9 |
| Shale, black | 178.9 | - 179.4 |
| Shale, medium gray | 179.4 | - 180.0 |
| Shale, black; contains carbonaceous material | 180.0 | - 180.7 |
| Shale, medium gray | 180.7 | - 186.0 |
| Coal, black; interbedded with shale, black | 186.0 | - 186.3 |
| Shale, medium gray | 186.3 | - 189.3 |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods | 189.3 | - 189.8 |
| Shale, medium gray | 189.8 | - 191.0 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, dark gray, very finely crystalline; contains crinoids | 191.0 | - 192.1 |
| Limestone, dark gray, very finely crystalline; interbedded with shale, gray | 192.1 | - 192.4 |
| Limestone, dark gray, very finely crystalline; contains brachiopods | 192.4 | - 194.0 |
| Shale, dark gray | 194.0 | - 194.3 |
| Limestone, medium to dark gray, very finely crystalline; contains brachiopods and crinoids | 194.3 | - 194.9 |
| Shale, medium gray | 194.9 | - 195.3 |
| Limestone, light gray, very finely crystalline; contains brachiopods | 195.3 | - 195.7 |
| Holt Member: | | |
| Shale, medium gray | 195.7 | - 196.0 |
| Shale, dark gray with olive tint | 196.0 | - 196.5 |
| Shale, black; contains carbonaceous material | 196.5 | - 197.3 |
| DuBois Member: | | |
| Limestone, light gray, very finely crystalline | 197.3 | - 197.5 |

## Test Hole 21-79

Location: Cass County, NW SW NW NW sec. 23, T. 10 N., R. 13 E., approximately 755 feet south of north section line and 21 feet east of west section line.

Ground-level elevation: 1,001 feet above mean sea level.

Started: May 31, 1979. Completed: May 31, 1979.

Total depth: 77.0 feet.

| Description | Depth, in feet From | | To |
|---|---|---|---|
| Quaternary System: | | | |
| Silt, dark brown | 0.0 | - | 5.0 |
| Silt, tan, sandy | 5.0 | - | 11.0 |
| Silt, light brown, sandy | 11.0 | - | 17.0 |
| Silt, pale yellow, clayey | 17.0 | - | 21.5 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, brown, very finely to irregularly crystalline; contains brachiopods and algal material | 21.5 | - | 22.0 |
| Limestone, dark tannish gray, very finely crystalline; contains brachiopods | 22.0 | - | 23.6 |
| Shale, olive yellow | 23.6 | - | 24.5 |
| Limestone, dark olive gray, very finely crystalline; contains crinoids and brachiopods | 24.5 | - | 24.9 |
| Shale, pale olive | 24.9 | - | 25.6 |
| Limestone, dark olive gray, very finely crystalline; contains abundant crinoids | 25.6 | - | 26.1 |
| Holt Member: | | | |
| Shale, pale olive | 26.1 | - | 26.7 |
| Shale, dark brown | 26.7 | - | 28.3 |
| DuBois Member: | | | |
| Limestone, dark tannish gray, very finely crystalline; contains abundant brachiopods | 28.3 | - | 29.2 |
| Turner Creek Member: | | | |
| Shale, olive | 29.2 | - | 30.0 |
| Shale, light greenish gray | 30.0 | - | 32.0 |
| Sheldon Member: | | | |
| Shale, olive yellow | 32.0 | - | 33.0 |
| Limestone, light tan, very finely crystalline, pseudo-oolitic; contains brachiopods and Osagia | 33.0 | - | 35.4 |
| Jones Point Member: | | | |
| Shale, light gray, limy | 35.4 | - | 40.2 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Shale, medium gray..... | 40.2 | - | 40.8 |
| Curzon Member: | | | |
| Limestone, light tannish gray, irregularly crystalline; contains pseudo-oolites, pyrite, and abundant Osagia..... | 40.8 | - | 42.5 |
| Limestone, light gray to light tannish gray, very finely crystalline; contains brachiopods, pyrite, glauconite, and algal material..... | 42.5 | - | 44.5 |
| Iowa Point Member: | | | |
| Shale, pale olive..... | 44.5 | - | 45.6 |
| Hartford Member: | | | |
| Limestone, light tan, very finely crystalline; contains brachiopods and algal material..... | 45.6 | - | 46.6 |
| Calhoun Formation: | | | |
| Limestone, light tan, very finely crystalline; interbedded with shale, gray..... | 46.6 | - | 46.8 |
| Deer Creek - Tecumseh Formations: | | | |
| Ervine Creek Member: | | | |
| Limestone, medium gray, very finely to irregularly crystalline; contains brachiopods, crinoids, pseudo-oolites, and abundant algal material..... | 46.8 | - | 47.5 |
| Limestone, very light gray, very finely crystalline; contains Osagia and abundant pseudo-oolites..... | 47.5 | - | 49.5 |
| Limestone, medium gray, very finely crystalline; contains pseudo-oolites, Osagia, crinoids, and brachiopods..... | 49.5 | - | 52.0 |
| Limestone, light gray, very finely crystalline; contains pseudo-oolites and pyrite..... | 52.0 | - | 56.0 |
| Limestone, very light tannish gray, very finely crystalline; contains bryozoans, brachiopods, and chert..... | 56.0 | - | 59.5 |
| Limestone, dark tannish gray, very finely crystalline; contains Osagia and abundant pseudo-oolites..... | 59.5 | - | 62.0 |
| Limestone, medium gray, very finely crystalline..... | 62.0 | - | 63.2 |
| Shale, medium gray with traces of black at top..... | 63.2 | - | 66.4 |
| Limestone, light to medium gray, finely crystalline; contains crinoids and brachiopods..... | 66.4 | - | 67.3 |
| Larsh Member: | | | |
| Shale, medium gray..... | 67.3 | - | 68.5 |
| Shale, black; contains carbonaceous material... | 68.5 | - | 69.5 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Rock Bluff Member: | | | |
| Limestone, tannish gray, very finely crystalline; contains fusulinids and brachiopods | 69.5 | - | 71.2 |
| Oskaloosa - Rakes Creek Members: | | | |
| Shale, light to medium gray | 71.2 | - | 77.0 |

## Test Hole 22-79

Location: Cass County, SW corner NW sec. 14, T. 10 N., R. 13 E., approximately 113 feet north of half section line and 21 feet east of west section line.

Ground-level elevation: 1,055.0 feet above mean sea level.

Started: May 31, 1979. Completed: May 31, 1979.

Total depth: 137.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample) | 0.0 | - | 2.0 |
| Silt, light brown, clayey | 2.0 | - | 12.0 |
| Silt, brown with reddish tint, clayey | 12.0 | - | 22.0 |
| Silt, pale reddish brown, clayey | 22.0 | - | 32.0 |
| Silt, brown, clayey | 32.0 | - | 37.0 |
| Silt, pale reddish brown, sandy | 37.0 | - | 41.0 |
| Silt, very light tan, sandy | 41.0 | - | 44.0 |
| Sand, fine to coarse; and gravel, very fine to fine | 44.0 | - | 45.5 |
| Clay, light tan, silty | 45.5 | - | 59.0 |
| Clay, medium gray, silty | 59.0 | - | 68.0 |
| Silt, dark brown; contains black carbonaceous material | 68.0 | - | 71.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Shale, light blue gray; interbedded with siltstone | 71.0 | - | 72.0 |
| Holt Member: | | | |
| Shale, dark gray; contains black carbonaceous material | 72.0 | - | 73.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| DuBois Member: | | |
| Limestone, dark gray, very finely to finely crystalline; contains brachiopods..... | 73.8 | 74.2 |
| Shale, medium to dark gray..... | 74.2 | 74.8 |
| Limestone, light gray to light greenish gray, finely crystalline; contains green "inclusions"..... | 74.8 | 75.7 |
| Turner Creek Member: | | |
| Shale, light greenish gray..... | 75.7 | 77.8 |
| Sheldon Member: | | |
| Limestone, tan, irregularly crystalline; contains algal material, pseudo-oolites, and "black inclusions"..... | 77.8 | 78.2 |
| Limestone, light tan, finely crystalline; contains pseudo-oolites, brachiopods, and abundant Osagia..... | 78.2 | 80.2 |
| Limestone, light gray, finely crystalline; interbedded with shale, gray..... | 80.2 | 82.2 |
| Jones Point Member: | | |
| Shale, light gray; interbedded with limestone, light gray..... | 82.2 | 85.5 |
| Shale, light gray..... | 85.5 | 86.3 |
| Shale, light greenish gray..... | 86.3 | 87.0 |
| Curzon Member: | | |
| Limestone, light beige to cream, finely crystalline, cherty at 89.7-90.1; contains fusulinids..... | 87.0 | 91.1 |
| Iowa Point Member: | | |
| Shale, light gray..... | 91.1 | 92.1 |
| Shale, light gray; interbedded with shale, black..... | 92.1 | 93.2 |
| Calhoun Formation: | | |
| Shale, medium gray..... | 93.2 | 93.5 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, light tan, finely to irregularly crystalline; contains pseudo-oolites and abundant Osagia..... | 93.5 | 95.0 |
| Limestone, light gray, finely crystalline; contains brachiopods, crinoids, and abundant Osagia..... | 95.0 | 97.2 |
| Limestone, light gray, finely crystalline; interbedded with shale, light gray..... | 97.2 | 98.3 |
| Limestone, light tannish gray, very finely to finely crystalline; contains brachiopods and Osagia..... | 98.3 | 99.5 |
| Limestone, tannish gray, very finely to finely crystalline..... | 99.5 | 103.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, dark tan to brown, very finely crystalline; contains shale parting, dark gray, at 105.5 | 103.8 | 107.0 |
| Limestone, dark tan to brown, very finely crystalline; contains crinoids | 107.0 | 109.5 |
| Shale, light gray; interbedded with thin shale, black, at 110.5 | 110.0 | 111.0 |
| Limestone, light to medium gray, very finely to finely crystalline | 111.0 | 111.8 |
| Larsh Member: | | |
| Shale, medium gray | 111.8 | 112.2 |
| Shale, black; contains carbonaceous material | 112.2 | 113.7 |
| Rock Bluff Member: | | |
| Limestone, brown, very finely to finely crystalline | 113.7 | 115.9 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray | 115.9 | 118.0 |
| Shale, light gray, limy at 122.0-123.0 | 118.0 | 125.5 |
| Shale, dark gray | 125.5 | 128.0 |
| Shale, light greenish gray, silty | 128.0 | 131.4 |
| Shale, medium gray to medium greenish gray | 131.4 | 135.0 |
| Shale, reddish brown | 135.0 | 137.0 |

## Test Hole 23-79

Location: Cass County, NW SW NW NW sec. 22, T. 10 N., R. 13 E., approximately 750 feet south of north section line and 22 feet east of west section line.

Ground-level elevation: 979.0 feet above mean sea level.

Started: June 1, 1979. Completed: June 1, 1979.

Total depth: 101.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil, dark brown to black, silty; contains organic material | 0.0 | 4.0 |
| Silt, dark brown, clayey | 4.0 | 8.0 |
| Silt, light brown, clayey | 8.0 | 17.0 |
| Silt, very light brown with pink tint, clayey | 17.0 | 21.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Deer Creek - Tecumseh Formations: | | | |
| Ervine Creek Member: | | | |
| Limestone, light tan, very finely to finely crystalline; contains bryozoans..... | 21.0 | - | 23.2 |
| Limestone, tan, very finely to finely crystalline; contains crinoids, brachiopods, and Osagia..... | 23.2 | - | 27.4 |
| Limestone, tan, very finely to finely crystalline; contains algal material..... | 27.4 | - | 31.0 |
| Shale, dark gray..... | 31.0 | - | 31.2 |
| Limestone, medium gray, very finely crystalline; contains crinoids and abundant brachiopods..... | 31.2 | - | 33.0 |
| Shale, black..... | 33.0 | - | 34.0 |
| Shale, medium gray..... | 34.0 | - | 34.3 |
| Limestone, light gray, finely crystalline; contains brachiopods and abundant crinoids... | 34.3 | - | 35.4 |
| Larsh Member: | | | |
| Shale, medium gray interbedded with black at top..... | 35.4 | - | 36.0 |
| Shale, black; contains carbonaceous material... | 36.0 | - | 37.2 |
| Rock Bluff Member: | | | |
| Limestone, tan, very finely to finely crystalline; contains pyrite..... | 37.2 | - | 39.2 |
| Oskaloosa - Rakes Creek Members: | | | |
| Shale, medium to dark gray..... | 39.2 | - | 41.0 |
| Shale, light gray..... | 41.0 | - | 44.0 |
| Shale, medium gray..... | 44.0 | - | 47.0 |
| Shale, light gray, silty..... | 47.0 | - | 52.0 |
| Shale to siltstone, light bluish gray; interbedded with sandstone at 55.0-56.0..... | 52.0 | - | 60.0 |
| Shale, medium to dark gray..... | 60.0 | - | 63.5 |
| Shale, dark reddish brown..... | 63.5 | - | 64.2 |
| Ost Member: | | | |
| Limestone, gray, irregularly crystalline; contains crinoids and fusulinids; interbedded with shale, pale reddish brown and greenish gray..... | 64.2 | - | 67.3 |
| Shale, very light greenish gray..... | 67.3 | - | 70.0 |
| Shale, medium gray with pinkish tint..... | 70.0 | - | 70.5 |
| Limestone, light tan, finely crystalline..... | 70.5 | - | 71.5 |
| Kenosha Member: | | | |
| Shale, pale reddish brown interbedded with greenish gray..... | 71.5 | - | 73.0 |
| Shale, medium to dark gray..... | 73.0 | - | 76.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, medium gray, very finely crystalline; contains crinoids, brachiopods, and Osagia; interbedded with shale, dark gray, at 76.2-76.3 | 76.0 | 78.3 |
| King Hill Member: | | |
| Shale, gray to greenish gray | 78.3 | 79.0 |
| Shale, reddish brown | 79.0 | 82.2 |
| Shale, greenish gray | 82.2 | 84.8 |
| Beil Member: | | |
| Limestone, light tan, finely crystalline; contains brachiopods, Osagia, and pseudo-oolites | 84.8 | 87.0 |
| Limestone, light tan, finely crystalline; interbedded with shale, light greenish gray | 87.0 | 90.8 |
| Limestone, light tan, finely crystalline; contains coral, fusulinids, Osagia, and abundant brachiopods | 90.8 | 91.4 |
| Queen Hill Member: | | |
| Shale, greenish gray; contains thin hard limy zones | 91.4 | 93.0 |
| Shale, dark gray | 93.0 | 94.0 |
| Shale, black; contains carbonaceous material | 94.0 | 96.3 |
| Big Springs Member: | | |
| Limestone, medium gray finely crystalline; contains pyrite and abundant fusulinids | 96.3 | 98.3 |
| Doniphan Member: | | |
| Shale, medium gray; interbedded with thin limestone at 99.0 | 98.3 | 101.0 |

## Test Hole 24-79

Location: Cass County, SW SE SW SE sec. 2, T. 10 N., R. 13 E., approximately 20 feet north of south section line and 570 feet west of east quarter section line.

Ground-level elevation: 1,103.0 feet above mean sea level.

Started: June 1, 1979. Completed: June 1, 1979.

Total depth: 107.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil, dark brown, silty, clayey..... | 0.0 | - | 4.0 |
| Silt, yellowish brown, clayey..... | 4.0 | - | 8.0 |
| Silty, very light brown, clayey..... | 8.0 | - | 21.0 |
| Sand, very fine to very coarse; contains traces of gravel, fine..... | 21.0 | - | 32.0 |
| Sand, fine to very coarse; contains traces of gravel, fine..... | 32.0 | - | 36.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | | |
| Scranton Formation: | | | |
| White Cloud Member: | | | |
| Shale, medium gray with olive weathering on top..... | 36.0 | - | 41.0 |
| Howard Formation: | | | |
| Limestone, medium gray, very finely crystalline, contains brachiopods and black inclusions..... | 41.0 | - | 44.0 |
| Severy Formation: | | | |
| Shale, black with gray at top 1.0 and bottom 0.3..... | 44.0 | - | 46.0 |
| Shale, medium gray..... | 46.0 | - | 52.0 |
| Coal, black..... | 52.0 | - | 52.7 |
| Shale, medium gray..... | 52.7 | - | 55.3 |
| Limestone, medium gray, finely crystalline; contains crinoids and brachiopods..... | 55.3 | - | 55.6 |
| Shale, medium gray..... | 55.6 | - | 58.0 |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, medium gray, very finely crystalline; contains brachiopods..... | 58.0 | - | 59.3 |
| Shale, medium to dark gray..... | 59.3 | - | 59.8 |
| Limestone, medium gray, finely crystalline; contains crinoids and brachiopods; interbedded with shale at 60.6-61.3..... | 59.8 | - | 61.8 |
| Holt Member: | | | |
| Shale, medium gray..... | 61.8 | - | 63.8 |
| Shale, black, contains carbonaceous material... | 63.8 | - | 64.3 |
| DuBois Member: | | | |
| Shale (poor sample), medium gray; interbedded with limestone, medium gray; contains crinoids..... | 64.3 | - | 65.0 |
| Turner Creek Member: | | | |
| Shale, greenish gray; interbedded with limestone, light gray..... | 65.0 | - | 66.1 |
| Shale, greenish gray..... | 66.1 | - | 67.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Sheldon Member: | | |
| Limestone, very light tan, finely crystalline; contains pseudo-oolites, glauconite, and abundant Osagia..... | 67.2 - | 70.5 |
| Limestone, very light gray, finely crystalline; contains brachiopods and Osagia..... | 70.5 - | 71.4 |
| Jones Point Member: | | |
| Limestone, very light gray to light greenish gray, soft, shaley..... | 71. - | 74.5 |
| Limestone, very light gray; contains crinoids; interbedded with shale, light gray to light greenish gray..... | 74.5 - | 75.1 |
| Shale, greenish gray..... | 75.1 - | 76.0 |
| Curzon Member: | | |
| Limestone, very light gray to beige, finely crystalline; contains crinoids, Osagia, and algal material..... | 76.0 - | 78.0 |
| Shale, pale greenish gray..... | 78.0 - | 78.3 |
| Limestone, light tan, very finely crystalline, cherty lower 0.5..... | 78.3 - | 80.0 |
| Limestone, light tan, very finely crystalline; contains crinoids; interbedded with shale, pale greenish gray..... | 80.0 - | 81.2 |
| Iowa Point Member: | | |
| Shale, light gray to light greenish gray..... | 81.2 - | 81.9 |
| Shale, dark gray with traces of black..... | 81.9 - | 82.5 |
| Hartford Member: | | |
| Limestone, tannish gray, very finely crystalline; contains brachiopods and algal material..... | 82.5 - | 83.8 |
| Calhoun Formation: | | |
| Shale, medium gray..... | 83.8 - | 84.9 |
| Deer Creek Formation: | | |
| Ervine Creek Member: | | |
| Limestone, very light tan, very finely crystalline, pseudo-oolitic; contains abundant Osagia..... | 84.9 - | 85.8 |
| Limestone, very light bluish gray, very finely crystalline; contains pseudo-oolites, "black inclusions," and abundant Osagia..... | 85.8 - | 89.8 |
| Limestone, very light tan, very finely crystalline, pseudo-oolitic; contains crinoids and Osagia..... | 89.8 - | 94.0 |
| Limestone, dark tan, very finely crystalline; contains crinoids, brachiopods, and abundant fusulinids; contains shaley partings..... | 94.0 - | 98.0 |
| Limestone, tannish gray, very finely crystalline, contains coral, crinoids, and fusulinids..... | 98.0 - | 100.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium gray with traces of black at top | 100.2 | 101.5 |
| Limestone, light gray, very finely to finely crystalline | 101.5 | 102.4 |
| Larsh Member: | | |
| Shale, light to medium gray | 102.4 | 103.4 |
| Shale, black; contains carbonaceous material | 103.4 | 104.9 |
| Rock Bluff Member: | | |
| Limestone, dark tan, very finely crystalline; contains crinoids, brachiopods, and fusulinids | 104.9 | 106.8 |
| Oskaloosa Member: | | |
| Shale, light gray | 106.8 | 107.0 |

## Test Hole 25-79

Location: Cass County, SE corner SW sec. 3, T. 10 N., R. 13 E., approximately 22 feet north of south section line and 116 feet west of half section line.

Ground-level elevation: 1,120.0 feet above mean sea level.

Started: June 4, 1979. Completed: June 4, 1979.

Total depth: 117.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 4.0 |
| Silt, dark brown | 4.0 | 10.0 |
| Silt, dark brown, clayey | 10.0 | 14.0 |
| Clay, light tannish brown, silty | 14.0 | 21.0 |
| Silt, pale reddish brown, clayey | 21.0 | 26.0 |
| Silt, yellowish brown, sandy | 26.0 | 32.0 |
| Silt, yellowish brown and brownish gray; interbedded with traces of limestone gravel | 32.0 | 47.0 |
| Silt, light brown, sandy | 47.0 | 57.0 |
| Silt, medium gray, sandy | 57.0 | 61.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Severy Formation: | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods | 61.0 | 61.5 |
| Shale, medium gray | 61.5 | 63.8 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, dark gray, very finely to finely crystalline; contains brachiopods..... | 63.8 | - | 66.0 |
| Shale, dark gray..... | 66.0 | - | 66.5 |
| Limestone, light to medium gray, finely crystalline; contains brachiopods and crinoids..... | 66.5 | - | 67.3 |
| Shale, light to medium gray..... | 67.3 | - | 68.0 |
| Limestone, light gray, finely crystalline; contains abundant crinoids..... | 68.0 | - | 68.3 |
| Holt Member: | | | |
| Shale, dark gray..... | 68.3 | - | 69.5 |
| Shale, black..... | 69.5 | - | 70.5 |
| DuBois Member: | | | |
| Limestone, medium to dark gray, very finely crystalline; contains crinoids and abundant brachiopods..... | 70.5 | - | 71.4 |
| Turner Creek Member: | | | |
| Shale, light greenish gray to gray..... | 71.4 | - | 72.4 |
| Limestone, light greenish gray, sandy..... | 72.4 | - | 73.5 |
| Shale, light greenish gray..... | 73.5 | - | 75.5 |
| Sheldon Member: | | | |
| Limestone, light tan, very finely to finely crystalline; contains pseudo-oolites and abundant Osagia..... | 75.5 | - | 79.3 |
| Jones Point Member: | | | |
| Limestone, light tan, very finely to finely crystalline; interbedded with shale, light gray..... | 79.3 | - | 83.7 |
| Shale, medium gray..... | 83.7 | - | 84.1 |
| Curzon Member: | | | |
| Limestone, very light tan, very finely to finely crystalline; contains pseudo-oolites and abundant Osagia..... | 84.1 | - | 85.0 |
| Shale, light gray to white, hard and limy..... | 85.0 | - | 86.3 |
| Limestone, very light tan to beige, finely crystalline..... | 86.3 | - | 89.0 |
| Iowa Point Member: | | | |
| Shale, medium to dark gray with black interbedded..... | 89.0 | - | 90.7 |
| Hartford Member: | | | |
| Limestone, tannish gray very finely to finely crystalline..... | 90.7 | - | 91.8 |
| Calhoun Formation: | | | |
| Shale, medium gray..... | 91.8 | - | 92.3 |
| Deer Creek - Tecumseh Formations: | | | |
| Ervine Creek Member: | | | |
| Limestone, light gray to light tannish gray, very finely crystalline; contains chert..... | 92.3 | - | 96.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, very light gray, finely crystalline; contains fusulinids and chert..... | 96.0 | 98.5 |
| Limestone, tan, very finely crystalline; contains brachiopods, chert, and abundant fusulinids..... | 98.5 | 103.5 |
| Limestone, gray, very finely crystalline; contains brachiopods and abundant fusulinids..... | 103.5 | 105.9 |
| Shale, medium gray with black interbedded..... | 105.9 | 106.4 |
| Limestone, light gray, finely crystalline, contains fusulinids and abundant brachiopods..... | 106.4 | 108.0 |
| Larsh Member: | | |
| Shale, medium to light gray..... | 108.0 | 108.5 |
| Shale, black; contains carbonaceous material... | 108.5 | 109.6 |
| Rock Bluff Member: | | |
| Limestone, tannish gray, very finely crystalline; contains crinoids, brachiopods and fusulinids..... | 109.6 | 112.0 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray..... | 112.0 | 114.1 |
| Siltstone, light bluish gray; interbedded with thin sandstone at 114.1-114.2..... | 114.1 | 117.0 |

## Test Hole 26-79

Location: Cass County, SW SE SE SE sec. 4, T. 10 N., R. 13 E., approximately 21 feet north of south section line and 560 feet west of east section line.

Ground-level elevation: 1,084.5 feet above mean sea level.

Started: June 4, 1979. Completed: June 4, 1979.

Total depth: 47.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil, dark brown to black, clayey..... | 0.0 | 3.0 |
| Silt, pale brown, clayey..... | 3.0 | 11.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Sheldon Member: | | | |
| Limestone, light tan, finely crystalline, pseudo-oolitic; contains Osagia..... | 11.0 | - | 14.1 |
| Turner Creek Member: | | | |
| Shale, pale olive..... | 14.1 | - | 16.0 |
| Shale, pale olive; interbedded with limestone, pale olive, finely crystalline; contains brachiopods..... | 16.0 | - | 17.0 |
| Shale, olive..... | 17.0 | - | 18.2 |
| Curzon Member: | | | |
| Limestone, pale olive, finely crystalline; contains brachiopods; interbedded with shale, pale olive..... | 18.2 | - | 20.5 |
| Limestone, very light tan to cream, finely crystalline..... | 20.5 | - | 21.3 |
| Limestone, light bluish gray, finely crystalline; contains crinoids and abundant fusulinids..... | 21.3 | - | 23.0 |
| Iowa Point Member: | | | |
| Shale, dark gray with black interbedded..... | 23.0 | - | 23.8 |
| Hartford Member: | | | |
| Limestone, medium gray to tannish gray, finely crystalline..... | 23.8 | - | 25.2 |
| Calhoun Formation: | | | |
| Shale, dark gray..... | 25.2 | - | 25.5 |
| Deer Creek Formation: | | | |
| Ervine Creek Member: | | | |
| Limestone, very light gray to white, finely crystalline, pseudo-oolitic; contains abundant Osagia..... | 25.5 | - | 27.5 |
| Limestone, light bluish gray, very finely crystalline..... | 27.5 | - | 33.0 |
| Shale, light to medium gray; interbedded with limestone, light gray..... | 33.0 | - | 34.2 |
| Limestone, light gray, finely crystalline; contains crinoids and abundant fusulinids.... | 34.2 | - | 35.5 |
| Limestone, light tan, very finely crystalline; contains crinoids and abundant fusulinids; shaley at 35.5..... | 35.5 | - | 37.8 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains abundant fusulinids; shaley at 40.3-40.5..... | 37.8 | - | 42.4 |
| Shale, dark gray to black..... | 42.4 | - | 43.2 |
| Shale, dark gray..... | 43.2 | - | 43.8 |
| Limestone, light gray, finely crystalline; contains crinoids and fusulinids..... | 43.8 | - | 44.7 |
| Larsh Member: | | | |
| Shale, medium gray..... | 44.7 | - | 45.7 |
| Shale, black..... | 45.7 | - | 46.8 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Rock Bluff Member: | | | |
| Limestone, tannish gray, finely crystalline; contains pyrite..... | 46.8 | - | 47.0 |

## Test Hole 27-79

Location: Cass County, SE corner SW NW sec. 9, T. 10 N., R. 13 E., approximately 75 feet north of half section line and 25 feet west of west quarter section line.

Ground-level elevation: 1,134.0 feet above mean sea level.

Started: June 4, 1979. Completed: June 4, 1979

Total depth: 62.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample)..... | 0.0 | - | 2.0 |
| Silt, olive brown, clayey..... | 2.0 | - | 7.0 |
| Silt, brown, clayey..... | 7.0 | - | 12.0 |
| Silt, pale reddish brown, clayey..... | 12.0 | - | 19.0 |
| Silt, yellowish brown, with iron staining, sandy..... | 19.0 | - | 24.0 |
| Silt, pale olive, sandy..... | 24.0 | - | 31.4 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, dark gray, very finely crystalline; contains brachiopods..... | 31.4 | - | 33.5 |
| Shale, dark gray to black..... | 33.5 | - | 34.0 |
| Limestone, dark gray, very finely crystalline; contains brachiopods and crinoids..... | 34.0 | - | 36.1 |
| Holt Member: | | | |
| Shale, dark gray..... | 36.1 | - | 37.7 |
| Shale, black; contains carbonaceous material... | 37.7 | - | 38.2 |
| DuBois Member: | | | |
| Limestone, dark gray, very finely to finely crystalline; contains brachiopods; interbedded with shale, gray..... | 38.2 | - | 38.5 |
| Turner Creek Member: | | | |
| Shale, medium gray..... | 38.5 | - | 39.0 |
| Shale, light gray..... | 39.0 | - | 40.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Limestone, light to medium gray, finely crystalline, soft and sandy..... | 40.0 | - | 40.7 |
| Shale, light gray..... | 40.7 | - | 42.3 |
| Sheldon Member: | | | |
| Limestone, light tan, very finely crystalline, pseudo-oolitic; contains abundant Osagia..... | 42.3 | - | 46.3 |
| Jones Point Member: | | | |
| Shale, very light greenish gray..... | 46.3 | - | 48.2 |
| Shale, very light gray; interbedded with limestone, light gray..... | 48.2 | - | 49.4 |
| Shale, medium gray; interbedded with thin limestone, light tannish gray, very finely crystalline..... | 49.4 | - | 50.0 |
| Curzon Member: | | | |
| Limestone, light gray to white, very finely to finely crystalline, cherty at 52.5-55.5..... | 50.0 | - | 55.5 |
| Iowa Point Member: | | | |
| Shale, gray interbedded with black..... | 55.5 | - | 56.5 |
| Hartford Member: | | | |
| Limestone, light tannish gray, very finely crystalline; contains crinoids..... | 56.5 | - | 58.1 |
| Calhoun Formation: | | | |
| Shale, medium gray..... | 58.1 | - | 59.0 |
| Shale, greenish gray..... | 59.0 | - | 60.2 |
| Deer Creek Formation: | | | |
| Limestone, tannish gray, very finely to finely crystalline; contains brachiopods and Osagia..... | 60.2 | - | 62.0 |

## Test Hole 28-79

Location: Cass County, NW NW NE SW sec. 8, T. 10 N., R. 13 E., approximately 160 feet south of half section line and 650 feet west of half section line.

Ground-level elevation: 1,170.0 feet above mean sea level.

Started: June 5, 1979. Completed: June 5, 1979.

Total depth: 167.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil, dark brown, silty, clayey..... | 0.0 | - | 2.0 |
| Silt, brown, clayey..... | 2.0 | - | 4.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Silt, brown with iron staining, clayey..... | 4.0 | - | 9.0 |
| Silt, light brown, clayey..... | 9.0 | - | 20.0 |
| Silt, pale reddish brown, clayey..... | 20.0 | - | 25.0 |
| Silt, light brown to tan, clayey, sandy..... | 25.0 | - | 34.0 |
| Silt, light tan; interbedded with sand and gravel..... | 34.0 | - | 38.0 |
| Silt, light tan to yellowish brown, sandy..... | 38.0 | - | 50.5 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Deer Creek - Tecumseh Formations: | | | |
| Ervine Creek Member: | | | |
| Limestone, light tan, very finely to finely crystalline; contains brachiopods and Osagia..... | 50.5 | - | 54.9 |
| Limestone, light to medium gray, finely crystalline, soft and shaley; contains abundant crinoids..... | 54.9 | - | 55.5 |
| Limestone, tannish gray, very finely to finely crystalline; contains crinoids and abundant fusulinids..... | 55.5 | - | 59.5 |
| Limestone, tannish gray, very finely to finely crystalline; contains fusulinids; interbedded with shale, dark gray..... | 59.5 | - | 60.0 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains crinoids and fusulinids..... | 60.0 | - | 62.0 |
| Limestone, light gray, very finely to finely crystalline; contains coral and fusulinids... | 62.0 | - | 64.2 |
| Shale, dark gray to black..... | 64.2 | - | 64.5 |
| Shale, light gray..... | 64.5 | - | 65.3 |
| Limestone, light to medium gray, finely crystalline; contains brachiopods, pyrite, and abundant crinoids..... | 65.3 | - | 66.5 |
| Larsh Member: | | | |
| Shale, medium gray..... | 66.5 | - | 66.9 |
| Shale, black, contains carbonaceous material... | 66.9 | - | 68.3 |
| Rock Bluff Member: | | | |
| Limestone, dark tannish gray, very finely to finely crystalline, "conglomeritic;" contains fusulinids and abundant brachiopods..... | 68.3 | - | 70.2 |
| Oskaloosa - Rakes Creek Members: | | | |
| Shale, medium gray..... | 70.2 | - | 72.5 |
| Shale, light greenish gray; interbedded with siltstone, greenish gray..... | 72.5 | - | 73.6 |
| Siltstone, pale yellow to yellow..... | 73.6 | - | 77.2 |
| Siltstone, olive gray..... | 77.2 | - | 78.0 |
| Siltstone, yellowish brown with iron staining, hard..... | 78.0 | - | 80.1 |
| Siltstone, olive gray, hard..... | 80.1 | - | 82.9 |
| Silt, olive yellow..... | 82.9 | - | 85.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Siltstone, olive gray; interbedded with silt, pale olive | 85.8 | 86.3 |
| Silt, light bluish gray | 86.3 | 90.0 |
| Silt, medium gray | 90.0 | 92.0 |
| Shale, reddish brown | 92.0 | 94.0 |
| Ost Member: | | |
| Limestone, gray, finely crystalline; contains crinoids; interbedded with shale, pale reddish brown | 94.0 | 98.2 |
| Shale, pale reddish brown; interbedded with limestone, gray, finely crystalline | 98.2 | 100.8 |
| Kenosha Member: | | |
| Shale, reddish brown | 100.8 | 103.4 |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, tan, finely crystalline; contains algal material, Osagia, and abundant crinoids | 103.4 | 104.9 |
| King Hill Member: | | |
| Shale, light to medium gray; interbedded with limestone, gray, at 104.9-106.3 | 104.9 | 107.0 |
| Shale, dark reddish brown | 107.0 | 110.0 |
| Shale, greenish gray; interbedded with siltstone, greenish gray, hard | 110.0 | 111.3 |
| Shale, greenish gray | 111.3 | 113.0 |
| Beil Member: | | |
| Limestone, very light gray, finely crystalline; contains crinoids, fusulinids, and Osagia | 113.0 | 117.4 |
| Limestone, very light gray to light greenish gray, finely crystalline; contains fusulinids, Osagia, and abundant crinoids | 117.4 | 119.2 |
| Queen Hill Member: | | |
| Shale, medium to dark gray | 119.2 | 121.7 |
| Shale, black; contains carbonaceous material | 121.7 | 124.0 |
| Big Springs Member: | | |
| Limestone, medium gray, very finely to finely crystalline; contains crinoids and abundant fusulinids | 124.0 | 125.3 |
| Doniphan Member: | | |
| Shale, medium gray; interbedded with thin limestones, light gray, finely crystalline | 125.3 | 131.0 |
| Spring Branch Member: | | |
| Limestone, light gray, very finely crystalline; contains pseudo-oolites, Osagia, fusulinids, brachiopods, and "black inclusions" | 131.0 | 136.1 |
| Shale, medium gray | 136.1 | 137.3 |
| Limestone, light to medium gray, finely crystalline; contains fusulinids, coral, brachiopods, and crinoids; interbedded with shale, gray | 137.3 | 139.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Kanwaka Formation: | | |
| Stull Member: | | |
| Shale, medium gray | 139.2 | - 140.1 |
| Clay Creek Member: | | |
| Limestone, dark tannish gray, very finely to finely crystalline; contains crinoids, brachiopods, and "black inclusions" | 140.1 | - 142.0 |
| Jackson Member: | | |
| Shale, light gray; interbedded with limestone, light gray, finely crystalline; contains algal material | 142.0 | - 144.0 |
| Shale, greenish gray | 144.0 | - 144.5 |
| Oread Formation: | | |
| Kereford Member: | | |
| Chert, bluish gray | 144.5 | - 145.8 |
| Limestone, light gray to light bluish gray, very finely crystalline, pseudo-oolitic; contains Osagia | 145.8 | - 148.3 |
| Limestone, very light gray, very finely crystalline, pseudo-oolitic; contains abundant fusulinids and Osagia | 148.3 | - 150.5 |
| Heumader Member: | | |
| Shale, light bluish gray; interbedded with limestone, very light gray, very finely crystalline | 150.5 | - 151.3 |
| Plattsmouth Member: | | |
| Limestone, light bluish gray, very finely crystalline, pseudo-oolitic in part; contains chert, pyrite, crinoids, Osagia, and abundant fusulinids; interbedded with shale, dark gray, at 155.9-156.1 | 151.3 | - 156.1 |
| Limestone, dark tannish gray, very finely crystalline; contains crinoids, fusulinids, and Osagia | 156.1 | - 160.0 |
| Limestone, tannish gray, very finely to finely crystalline | 160.0 | - 162.0 |
| Heebner Member: | | |
| Shale, medium to dark gray | 162.0 | - 163.0 |
| Shale, black; contains carbonaceous material | 163.0 | - 166.1 |
| Leavenworth Member: | | |
| Limestone, dark tannish gray, very finely crystalline; contains brachiopods, crinoids, and pyrite | 166.1 | - 167.0 |

## Test Hole 29-79

Location: Cass County, NW corner NE sec. 5, T. 10 N., R. 13 E., approximately 125 feet south of north section line and 19 feet east of half section line.

Ground-level elevation: 1,200.0 feet above mean sea level.

Started: June 5, 1979. Completed: June 5, 1979.

Total depth: 107.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample) | 0.0 | - | 2.0 |
| Silt, light brownish gray, clayey | 2.0 | - | 17.0 |
| Silt, pale reddish brown, clayey | 17.0 | - | 29.0 |
| Silt, tannish gray, clayey | 29.0 | - | 33.0 |
| Silt, very light tan with iron staining, clayey | 33.0 | - | 40.0 |
| Silt, light tan; interbedded with sand and gravel, pale yellow and tan | 40.0 | - | 45.0 |
| Silt, light brown, clayey | 45.0 | - | 49.0 |
| Silt, yellowish tan; interbedded with sand and gravel | 49.0 | - | 54.0 |
| Silt, light yellowish brown; interbedded with sand and gravel | 54.0 | - | 62.0 |
| Silt, light tannish gray; interbedded with sand and gravel | 62.0 | - | 70.0 |
| Clay, very dark tannish gray, silty | 70.0 | - | 71.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Lecompton Formation: | | | |
| Big Springs Member: | | | |
| Limestone, light tannish gray, very finely crystalline; contains brachiopods | 71.0 | - | 71.6 |
| Doniphan Member: | | | |
| Shale, light gray, hard and limy | 71.6 | - | 72.0 |
| Shale, olive, limy at 75.6-75.7 | 72.0 | - | 76.0 |
| Spring Branch Member: | | | |
| Limestone, dark gray, very finely to finely crystalline; contains brachiopods, algal material, and abundant "black inclusions" | 76.0 | - | 76.4 |
| Limestone, very light tannish gray, very finely to finely crystalline; contains algal material and Osagia | 76.4 | - | 78.0 |
| Limestone, light gray, very finely to finely crystalline; contains Osagia | 78.0 | - | 80.0 |
| Limestone, light gray, very finely to finely crystalline; contains Osagia | 80.0 | - | 80.7 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, light to medium gray; interbedded with limestone, medium gray, at 81.6 and 82.5..... | 80.7 | 83.0 |
| Kanwaka Formation: | | |
| Shale, medium gray..... | 83.0 | 84.0 |
| Oread Formation: | | |
| Kereford - Plattsmouth Members: | | |
| Limestone, light gray, very finely to finely crystalline; contains abundant fusulinids.... | 84.0 | 87.0 |
| Limestone, light gray, finely crystalline; contains abundant fusulinids; interbedded with shale, light gray..... | 87.0 | 89.2 |
| Limestone, very light bluish gray, very finely to finely crystalline; contains pseudo-oolites, Osagia, and abundant fusulinids..... | 89.2 | 92.0 |
| Limestone, very light bluish gray, finely crystalline; contains brachiopods and chert.. | 92.0 | 96.0 |
| Chert, dark gray, microfossiliferous..... | 96.0 | 96.4 |
| Limestone, light gray, finely crystalline; contains brachiopods..... | 96.4 | 97.6 |
| Shale, light gray; interbedded with limestone, light gray, finely crystalline..... | 97.6 | 98.0 |
| Limestone, light gray, finely crystalline; contains fusulinids, brachiopods, and chert.. | 98.0 | 99.0 |
| Limestone, medium gray, finely crystalline; contains brachiopods and glauconite..... | 99.0 | 101.0 |
| Heebner Member: | | |
| Shale, medium olive gray..... | 101.0 | 102.0 |
| Shale, black; contains carbonaceous material... | 102.0 | 105.0 |
| Leavenworth Member: | | |
| Limestone, light to medium brownish gray, very finely crystalline; contains brachiopods, crinoids, and fusulinids..... | 105.0 | 106.8 |
| Snyderville Member: | | |
| Shale, medium gray..... | 106.8 | 107.0 |

## Test Hole 30-79

Location: Cass County, NE corner NW sec. 3, T. 10 N., R. 13 E., approximately 22 feet south of north section line and 113 feet west of half section line.

Ground-level elevation: 1,179.0 feet above mean sea level.

Started: June 6, 1979. Completed: June 6, 1979.

Total depth: 152.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample) | 0.0 | - | 2.0 |
| Silt, tannish brown, clayey | 2.0 | - | 17.0 |
| Silt, brownish gray, clayey, sandy | 17.0 | - | 22.0 |
| Silt, reddish brown, clayey | 22.0 | - | 24.0 |
| Silt, light reddish brown, clayey | 24.0 | - | 28.0 |
| Silt, tannish brown, clayey, sandy | 28.0 | - | 32.0 |
| Silt, light tannish brown, clayey, sandy | 32.0 | - | 44.0 |
| Silt, yellowish tan to brown, clayey | 44.0 | - | 47.0 |
| Silt, tannish brown, clayey; interbedded with sand and gravel | 47.0 | - | 50.0 |
| Silt, yellowish tan to brown, clayey; interbedded with sand and gravel | 50.0 | - | 56.5 |
| Sand, very fine to coarse, and gravel, very fine to medium, light tan to brown | 56.5 | - | 57.4 |
| Silt, tannish brown with yellow iron staining, sandy | 57.4 | - | 62.0 |
| Silt, tannish tan to brown; interbedded with sand and gravel | 62.0 | - | 78.0 |
| Silt, brownish gray, clayey; interbedded with sand and gravel | 78.0 | - | 84.0 |
| Silt, yellowish tan, clayey; interbedded with sand and gravel | 84.0 | - | 89.1 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | | |
| Severy Formation: | | | |
| Limestone, yellowish brown, highly weathered; contains brachiopods and chert | 89.1 | - | 89.8 |
| Coal, black; interbedded with shale, black; contains carbonaceous material | 89.8 | - | 91.1 |
| Shale, olive gray | 91.1 | - | 92.0 |
| Shale, medium to dark gray | 92.0 | - | 96.0 |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, dark gray, very finely to finely crystalline; contains brachiopods, bryozoans, and pyrite | 96.0 | - | 96.8 |
| Shale, dark gray | 96.8 | - | 97.3 |
| Limestone, medium gray, finely crystalline | 97.3 | - | 98.4 |
| Shale, light gray | 98.4 | - | 99.1 |
| Limestone, light gray, finely crystalline | 99.1 | - | 99.4 |
| Holt Member: | | | |
| Shale, dark gray mottled with olive yellow | 99.4 | - | 101.2 |
| Shale, dark gray | 101.2 | - | 101.6 |
| DuBois Member: | | | |
| Limestone, dark gray, finely crystalline; contains brachiopods | 101.6 | - | 102.0 |
| Turner Creek Member: | | | |
| Shale, greenish gray | 102.0 | - | 103.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light gray, finely crystalline; interbedded with shale, greenish gray..... | 103.2 | - 104.3 |
| Shale, greenish gray..... | 104.3 | - 105.7 |
| Sheldon Member: | | |
| Limestone, light tan, very finely to finely crystalline; contains brachiopods and algal material..... | 105.7 | - 109.1 |
| Limestone, light gray, finely crystalline; contains brachiopods..... | 109.1 | - 110.0 |
| Jones Point Member: | | |
| Shale, light to medium gray, limy at 111.6..... | 110.0 | - 113.0 |
| Curzon Member: | | |
| Limestone, light bluish gray, finely crystalline; contains algal material; contains shaley partings..... | 113.0 | - 115.0 |
| Limestone light tannish gray, finely crystalline; contains bryozoans, pyrite, glauconite, and dark gray cherts..... | 115.0 | - 117.0 |
| Limestone, light gray, finely crystalline; contains crinoids, fusulinids, and pyrite.... | 117.0 | - 118.3 |
| Iowa Point Member: | | |
| Shale, medium to dark gray with black lower 0.3..... | 118.3 | - 119.4 |
| Hartford Member: | | |
| Limestone, tannish gray, finely crystalline; contains fusulinids and brachiopods..... | 119.4 | - 121.2 |
| Calhoun Formation: | | |
| Shale, medium gray..... | 121.2 | - 122.2 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, light brown, finely crystalline; contains algal material, fusulinids, and light brown cherts..... | 122.2 | - 123.0 |
| Limestone, light gray, finely crystalline; contains brachiopods and algal material..... | 123.0 | - 127.5 |
| Limestone, light gray, finely crystalline..... | 127.5 | - 130.0 |
| Limestone, light to medium gray, finely crystalline; contains abundant fusulinids, interbedded with shale, light gray, at 133.5-134.0..... | 130.0 | - 134.0 |
| Limestone, light gray, finely crystalline; contains brachiopods and crinoids; interbedded with shale, light gray..... | 134.0 | - 136.3 |
| Shale, light gray..... | 136.3 | - 137.4 |
| Limestone, light gray, finely crystalline; contains brachiopods..... | 137.4 | - 138.3 |
| Larsh Member: | | |
| Shale, medium gray..... | 138.3 | - 138.6 |
| Shale, black; contains carbonaceous material... | 138.6 | - 140.4 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Rock Bluff Member: | | |
| Limestone, light tan with medium brown and light gray mottling, finely crystalline; contains brachiopods, pyrite, and fusulinids | 140.4 | - 143.0 |
| Oskaloosa - Rakes Creek Members: | | |
| Siltstone, medium gray | 143.0 | - 147.0 |
| Silt, light greenish gray; interbedded with siltstone, medium gray | 147.0 | - 152.0 |

## Test Hole 31-79

Location: Cass County, NW corner NE sec. 4, T. 10 N., R. 13 E., approximately 21 feet south of north section line and 45 feet east of half section line.

Ground-level elevation: 1,179.0 feet above mean sea level.

Started: June 6, 1979. Completed: June 6, 1979.

Total depth: 131.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | - 1.0 |
| Silt, brown, clayey | 1.0 | - 6.0 |
| Silt, reddish brown, clayey | 6.0 | - 16.0 |
| Silt, light yellowish tan clayey, limy | 16.0 | - 22.0 |
| Silt, medium reddish brown | 22.0 | - 27.0 |
| Silt, yellowish brown, clayey | 27.0 | - 32.5 |
| Silt, pale olive to olive; contains weathered limestone gravel | 32.5 | - 33.5 |
| Limestone (erratic), light tan, finely crystalline | 33.5 | - 34.0 |
| Silt, yellowish olive to brown, clayey, sandy | 34.0 | - 41.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | |
| Deer Creek - Tecumseh Formations: | | |
| Rock Bluff Member: | | |
| Limestone, light tan to gray, finely crystalline; contains corals | 41.0 | - 42.5 |
| Limestone, light gray, finely crystalline | 42.5 | - 42.8 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, pale olive; interbedded with siltstone | 42.8 | - 48.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Silt, light greenish gray | 48.0 | - | 51.0 |
| Silt, light olive | 51.0 | - | 53.4 |
| Sandstone, light to medium gray, very fine grained | 53.4 | - | 55.7 |
| Silt, greenish gray | 55.7 | - | 62.3 |
| Silt, dark gray; interbedded with sand | 62.3 | - | 64.0 |
| Shale, reddish brown | 64.0 | - | 66.0 |
| Ost Member: | | | |
| Limestone, light gray, very finely crystalline | 66.0 | - | 67.4 |
| Shale or claystone, light gray with reddish tint | 67.4 | - | 68.0 |
| Shale, light gray; contains limy fragments | 68.0 | - | 69.0 |
| Shale, light gray | 69.0 | - | 69.6 |
| Limestone, light bluish gray, finely crystalline | 69.6 | - | 70.4 |
| Kenosha Member: | | | |
| Shale, reddish brown | 70.4 | - | 71.5 |
| Shale, reddish gray | 71.5 | - | 74.2 |
| Shale, varicolored, red, gray, and olive | 74.2 | - | 75.2 |
| Lecompton - Kanwaka Formations: | | | |
| Avoca Member: | | | |
| Limestone, light olive gray, finely crystalline; contains brachiopods, crinoids, and algal material | 75.2 | - | 76.4 |
| Shale, medium gray | 76.4 | - | 77.3 |
| Limestone, light to medium gray, finely crystalline; contains Osagia; interbedded with shale, gray, lower 0.3 | 77.3 | - | 78.0 |
| King Hill Member: | | | |
| Shale, reddish brown, limy at 81.2 | 78.0 | - | 82.3 |
| Shale, medium greenish gray | 82.3 | - | 84.0 |
| Beil Member: | | | |
| Limestone, light gray, very finely to finely crystalline, pseudo-oolitic; contains Osagia and foramanifera | 84.0 | - | 86.2 |
| Limestone, light gray, very finely to finely crystalline | 86.2 | - | 89.5 |
| Queen Hill Member: | | | |
| Shale, medium greenish gray | 89.5 | - | 91.8 |
| Shale, dark gray | 91.8 | - | 92.0 |
| Shale, black | 92.0 | - | 95.0 |
| Big Springs Member: | | | |
| Limestone, medium gray, very finely to finely crystalline; contains crinoids and fusulinids | 95.0 | - | 96.3 |
| Doniphan Member: | | | |
| Shale, medium gray, limy at 98.0 and 99.3 | 96.3 | - | 100.2 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Spring Branch - Jack Park Members: | | |
| Limestone, light gray, very finely to finely crystalline; contains pseudo-oolites and Osagia | 100.2 | 105.3 |
| Shale, medium gray | 105.3 | 107.0 |
| Shale, light gray; interbedded with limestone, light gray, finely crystalline; contains brachiopods and fusulinids | 107.0 | 109.0 |
| Oread Formation: | | |
| Kereford - Plattsmouth Members: | | |
| Limestone, light bluish gray, very finely crystalline; contains crinoids and abundant fusulinids; interbedded with shale at 112.0 | 109.0 | 112.0 |
| Limestone, light tan, finely crystalline; contains glauconite; cherty at 121.2 | 112.0 | 121.8 |
| Shale, dark gray | 121.8 | 124.4 |
| Heebner Member: | | |
| Shale, dark gray | 124.4 | 125.0 |
| Shale, black; contains carbonaceous material | 125.0 | 128.3 |
| Leavenworth Member: | | |
| Limestone, light to medium gray, finely crystalline; contains "black inclusions" | 128.3 | 130.2 |
| Snyderville Member: | | |
| Shale, light to medium gray | 130.2 | 131.0 |

## Test Hole 32-79

Location: Cass County, NW NW SW sec. 25, T. 10 N., R. 13 E., approximately 400 feet south of half section line and 115 feet east of west section line.

Ground-level elevation: 960.0 feet above mean sea level.

Started: June 6, 1979. Completed: June 6, 1979.

Total depth: 92.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil, dark brown, silty, clayey | 0.0 | 4.0 |
| Clay, brown, silty | 4.0 | 17.0 |
| Clay, dark brownish gray, silty | 17.0 | 20.0 |
| Clay, dark gray to black, silty | 20.0 | 42.0 |
| Clay, medium gray, silty | 42.0 | 50.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Gravel, reworked limestone; interbedded with silt and clay..... | 50.0 | - | 53.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Topeka Formation: | | | |
| Iowa Point Member: | | | |
| Shale, olive to greenish gray..... | 53.0 | - | 54.0 |
| Hartford Member: | | | |
| Limestone, dark tannish gray, very finely crystalline; contains crinoids and brachiopods..... | 54.0 | - | 55.5 |
| Calhoun Formation: | | | |
| Shale, medium gray..... | 55.5 | - | 56.0 |
| Deer Creek - Tecumseh Formations: | | | |
| Ervine Creek Member: | | | |
| Limestone, tannish gray, very finely to finely crystalline; contains pseudo-oolites, Osagia, and abundant fusulinids..... | 56.0 | - | 58.2 |
| Limestone, yellowish brown, weathered; contains pseudo-oolites, Osagia, and fusulinids..... | 58.2 | - | 60.0 |
| Limestone, light gray, very finely to finely crystalline; contains pseudo-oolites, Osagia, and crinoids..... | 60.0 | - | 62.0 |
| Limestone, light gray, very finely to finely crystalline, contains Osagia, brachiopods, and abundant crinoids..... | 62.0 | - | 65.0 |
| Limestone, tannish gray, very finely to finely crystalline; contains brachiopods and Osagia slightly shaley at 71.0-71.5..... | 65.0 | - | 71.5 |
| Limestone, medium tannish gray, very finely to finely crystalline; contains brachiopods..... | 71.5 | - | 73.8 |
| Shale, light gray..... | 73.8 | - | 74.5 |
| Shale, black..... | 74.5 | - | 75.0 |
| Shale, medium gray..... | 75.0 | - | 75.4 |
| Limestone, medium gray, finely crystalline; contains crinoids..... | 75.4 | - | 76.0 |
| Larsh Member: | | | |
| Shale, dark gray to black..... | 76.0 | - | 76.3 |
| Shale, medium gray..... | 76.3 | - | 76.7 |
| Shale, black..... | 76.7 | - | 78.0 |
| Rock Bluff Member: | | | |
| Limestone, dark tan, very finely crystalline; contains brachiopods..... | 78.0 | - | 79.6 |
| Oskaloosa - Rakes Creek Members: | | | |
| Shale, medium gray..... | 79.6 | - | 81.0 |
| Shale, light gray..... | 81.0 | - | 87.8 |
| Shale, medium gray..... | 87.8 | - | 88.0 |
| Silt, light greenish gray..... | 88.0 | - | 92.0 |

## Test Hole 33-79

Location: Otoe County, NE NE SW sec. 6, T. 9 N., R. 13 E., approximately 250 feet south of half section line and 25 feet west of half section line.

Ground-level elevation: 1,050.0 feet above mean sea level.

Started: June 7, 1979. Completed: June 7, 1979.

Total depth: 57.5 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil, dark brown, silty, clayey..... | 0.0 | - | 2.5 |
| Silt, brown, clayey..... | 2.5 | - | 5.0 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Oread Formation: | | | |
| Kereford Member: | | | |
| Limestone, yellowish brown, finely crystalline, highly weathered; contains abundant fusulinids..... | 5.0 | - | 8.0 |
| Limestone, pale yellowish brown, finely crystalline, highly weathered; contains abundant fusulinids..... | 8.0 | - | 9.0 |
| Limestone, light yellowish tan, finely crystalline, highly weathered; contains fusulinids and coral..... | 9.0 | - | 10.5 |
| Heumader Member: | | | |
| Shale, olive..... | 10.5 | - | 11.3 |
| Plattsmouth Member: | | | |
| Limestone, light tannish gray, very finely crystalline, pseudo-oolitic; contains fusulinids and Osagia; cherty at 14.0-14.3... | 11.3 | - | 15.0 |
| Limestone, light tannish gray, very finely crystalline, pseudo-oolitic; contains Osagia..... | 15.0 | - | 17.0 |
| Limestone, light tannish gray, very finely crystalline, pseudo-oolitic; contains Osagia, fusulinids, and coral..... | 17.0 | - | 19.5 |
| Limestone, dark tannish gray, very finely crystalline; contains coral, fusulinids, crinoids, and algal material..... | 19.5 | - | 23.0 |
| Limestone, dark tannish gray, finely crystalline; contains crinoids and coral..... | 23.0 | - | 24.0 |
| Limestone, light gray, finely crystalline, shaley..... | 24.0 | - | 25.5 |
| Heebner Member: | | | |
| Shale, olive..... | 25.5 | - | 26.2 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Shale, medium to dark gray..... | 26.2 | - | 27.8 |
| Shale, black..... | 27.8 | - | 29.9 |
| Leavenworth Member: | | | |
| Limestone, tannish gray, very finely crystalline; contains brachiopods..... | 29.9 | - | 31.5 |
| Snyderville Member: | | | |
| Shale, light gray..... | 31.5 | - | 37.3 |
| Shale, light gray with trace of red mottling at 39.5..... | 37.3 | - | 41.0 |
| Shale, reddish brown..... | 41.0 | - | 47.0 |
| Toronto Member: | | | |
| Limestone, yellowish brown, finely crystalline; contains brachiopods; interbedded with shale, light gray, at 51.5-53.5..... | 47.0 | - | 53.5 |
| Lawrence Formation: | | | |
| Shale (no sample), probable reddish brown..... | 53.5 | - | 57.5 |

## Test Hole 34-79

Location: Otoe County, SW SW NW SE sec. 6, T. 9 N., R. 13 E., approximately 1400 feet north of south section line and 2650 feet west of east section line.

Ground-level elevation: 1,053.0 feet above mean sea level.

Started: June 7, 1979. Completed: June 7, 1979.

Total depth: 100.0 feet.

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Quaternary System: | | | |
| Soil (no sample)..... | 0.0 | - | 3.0 |
| Silt, dark yellowish brown, clayey..... | 3.0 | - | 5.0 |
| Silt, brown, clayey, sandy..... | 5.0 | - | 17.5 |
| Silt, pale reddish brown..... | 17.5 | - | 31.5 |
| Sand, fine to very coarse, and gravel, fine.... | 31.5 | - | 32.5 |
| Silt, pale olive tan..... | 32.5 | - | 35.5 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Deer Creek - Tecumseh Formations: | | | |
| Oskaloosa - Rakes Creek Members: | | | |
| Shale, olive..... | 35.5 | - | 38.0 |
| Shale, reddish brown..... | 38.0 | - | 38.8 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Ost Member: | | | |
| Limestone, olive yellow, finely crystalline.... | 38.8 | - | 39.7 |
| Limestone, olive tan, finely crystalline..... | 39.7 | - | 41.4 |
| Limestone, pale olive, finely crystalline; contains algal material..... | 41.4 | - | 42.0 |
| Shale, olive yellow..... | 42.0 | - | 42.3 |
| Shale, reddish brown..... | 42.3 | - | 42.8 |
| Shale, dark olive gray..... | 42.8 | - | 43.4 |
| Limestone, pale yellowish brown, finely crystalline; contains crinoids; interbedded with shale, yellow..... | 43.4 | - | 45.3 |
| Kenosha Member: | | | |
| Shale, reddish brown..... | 45.3 | - | 47.2 |
| Shale, reddish gray with olive at bottom..... | 47.2 | - | 49.3 |
| Lecompton Formation: | | | |
| Avoca Member: | | | |
| Limestone, olive tan, very finely crystalline; contains brachiopods, crinoids, and coral.... | 49.3 | - | 49.8 |
| Shale, olive..... | 49.8 | - | 50.4 |
| Limestone, dark orangish brown, very finely to finely crystalline; contains brachiopods.. | 50.4 | - | 51.0 |
| Shale, olive with traces of black..... | 51.0 | - | 51.8 |
| Limestone, dark olive gray, finely crystalline; contains crinoids and brachiopods..... | 51.8 | - | 52.9 |
| King Hill Member: | | | |
| Shale, dark olive gray..... | 52.9 | - | 54.7 |
| Siltstone, olive gray..... | 54.7 | - | 55.2 |
| Shale, pale reddish brown..... | 55.2 | - | 56.0 |
| Shale, dark reddish brown..... | 56.0 | - | 57.4 |
| Shale, olive gray..... | 57.4 | - | 57.9 |
| Limestone, olive yellow to gray, finely crystalline..... | 57.9 | - | 58.3 |
| Shale, olive gray..... | 58.3 | - | 60.5 |
| Limestone, light yellowish brown, finely crystalline; contains brachiopods..... | 60.5 | - | 60.8 |
| Shale, olive yellow..... | 60.8 | - | 61.3 |
| Beil Member: | | | |
| Limestone, light tan, finely crystalline; contains brachiopods and abundant crinoids... | 61.3 | - | 62.0 |
| Limestone, light tan, very finely crystalline.. | 62.0 | - | 63.5 |
| Limestone, light tan, very finely crystalline; contains crinoids; interbedded with shale, olive yellow..... | 63.5 | - | 65.0 |
| Limestone, light tan, very finely to finely crystalline; contains coral[illegible]te bedded with shale, olive..... | 65.0 | - | 67.0 |
| Shale, olive yellow; interbedded with limestone, light tan..... | 67.0 | - | 67.8 |
| Limestone, light tan, very finely to finely crystalline; contains algal material; interbedded with shale, olive yellow..... | 67.8 | - | 68.2 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Queen Hill Member: | | | |
| Shale, light gray | 68.2 | - | 70.3 |
| Shale, black | 70.3 | - | 70.9 |
| Shale, dark gray | 70.9 | - | 71.9 |
| Shale, black | 71.9 | - | 74.1 |
| Big Springs Member: | | | |
| Limestone, olive tan, finely crystalline; contains brachiopods and algal material | 74.1 | - | 75.3 |
| Shale, olive; interbedded with limestone, olive, tan, finely crystalline | 75.3 | - | 76.0 |
| Doniphan Member: | | | |
| Shale, medium gray, interbedded with thin limestones at 78.0 and 78.7 | 76.0 | - | 79.2 |
| Shale, olive | 79.2 | - | 80.6 |
| Spring Branch Member: | | | |
| Limestone, light tan, very finely crystalline; pseudo-oolitic; contains Osagia and chert | 80.6 | - | 84.0 |
| Limestone, light tan, very finely crystalline; contains brachiopods and fusulinids | 84.0 | - | 85.0 |
| Shale, medium to dark gray; interbedded with limestone | 85.0 | - | 87.0 |
| Limestone, light gray, finely crystalline; contains crinoids and brachiopods | 87.0 | - | 89.2 |
| Kanwaka Formation: | | | |
| Stull Member: | | | |
| Shale, light gray | 89.2 | - | 91.1 |
| Clay Creek Member: | | | |
| Limestone, tan, very finely crystalline, pseudo-oolitic; contains Osagia | 91.1 | - | 91.9 |
| Jackson Park Member: | | | |
| Shale, olive | 91.9 | - | 92.0 |
| Oread Formation: | | | |
| Kereford Member: | | | |
| Limestone, yellowish orange, very finely to finely crystalline; contains fusulinids | 92.0 | - | 93.8 |
| Limestone, pale orange, very finely to finely crystalline; contains fusulinids and crinoids; cherty at 96.0 | 93.8 | - | 97.7 |
| Heumader Member: | | | |
| Shale, olive yellow | 97.7 | - | 98.5 |
| Plattsmouth Member: | | | |
| Limestone, very light tan, very finely to finely crystalline; contains abundant pseudo-oolites | 98.5 | - | 100.0 |

## Test Hole 35-79

Location: Otoe County, SW NE SW sec. 6, T. 9 N., R. 13 E., approximately 1450 feet north of south section line and 1100 feet west of each section line.

Ground-level elevation: 1,102.0 feet above mean sea level.

Started: June 8, 1979. Completed: June 8, 1979.

Total depth: 121.8 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil (no sample) | 0.0 | 2.0 |
| Silt, light brown, clayey | 2.0 | 12.0 |
| Silt, brown, clayey | 12.0 | 16.0 |
| Silt, pale reddish brown, clayey | 16.0 | 23.0 |
| Silt, yellow brown, sandy | 23.0 | 32.0 |
| Silt, orangish brown with iron staining, sandy | 32.0 | 34.0 |
| Silt, gray mottled with brown, sandy | 34.0 | 43.0 |
| Silt, brown, sandy | 43.0 | 54.0 |
| Clay, light tan; interbedded with silt, brown | 54.0 | 62.0 |
| Silt, tannish gray, clayey, sandy | 62.0 | 78.0 |
| Silt, gray | 78.0 | 89.5 |
| Silt, dark gray, clayey, sandy | 89.5 | 92.0 |
| Silt, olive | 92.0 | 94.4 |
| Sand and gravel | 94.4 | 97.0 |
| Silt, olive gray | 97.0 | 100.0 |
| Sand and gravel | 100.0 | 101.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Howard Formation: | | |
| Limestone, medium gray, finely crystalline | 101.0 | 102.4 |
| Shale, olive gray | 102.4 | 102.6 |
| Limestone, medium gray, finely crystalline; contains brachiopods | 102.6 | 103.5 |
| Shale, olive | 103.5 | 103.8 |
| Limestone, tannish gray, very finely crystalline, "speckled;" contains brachiopods and algal material | 103.8 | 105.5 |
| Severy Formation: | | |
| Shale, olive gray | 105.5 | 105.7 |
| Shale, black | 105.7 | 106.4 |
| Shale, medium gray | 106.4 | 107.2 |
| Shale, black | 107.2 | 107.9 |
| Shale, medium gray | 107.9 | 113.6 |
| Coal, black; interbedded with shale, black | 113.6 | 114.4 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium gray..... | 114.4 | - 116.7 |
| Limestone, medium gray, finely crystalline; interbedded with shale, gray..... | 116.7 | - 117.3 |
| Shale, medium gray..... | 117.3 | - 117.8 |
| Limestone, dark gray, finely crystalline..... | 117.8 | - 119.6 |
| Shawnee Group: | | |
| Topeka Formation: | | |
| Coal Creek Member: | | |
| Limestone, medium to dark gray, very finely to finely crystalline; contains brachiopods, crinoids, and pyrite..... | 119.6 | - 121.8 |

## Test Hole 36-79

Location: Otoe County, NE corner sec. 12, T. 9 N., R. 12 E., approximately 27 feet south of north section line and 175 feet west of east section line.

Ground-level elevation: 1,030.0 feet above mean sea level.

Started: June 13, 1979. Completed: June 13, 1979.

Total depth: 107.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary Sytem: | | |
| Soil, dark gray, silty, clayey..... | 0.0 | - 7.0 |
| Clay, tannish gray, silty..... | 7.0 | - 14.0 |
| Silt, tannish gray, sandy..... | 14.0 | - 22.0 |
| Sand, medium to coarse, and gravel, very fine to coarse; contains limestone and granitic fragments..... | 22.0 | - 31.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Scranton Formation: | | |
| White Cloud Member: | | |
| Shale, light gray..... | 31.0 | - 35.0 |
| Shale, medium gray..... | 35.0 | - 45.0 |
| Howard Formation: | | |
| Limestone, medium gray, finely crystalline, shaley; contains brachiopods..... | 45.0 | - 47.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Limestone, tan, very finely to finely crystalline, highly weathered in part; contains pseudo-oolites, Osagia, and brachiopods..... | 47.0 | - | 49.7 |
| Severy Formation: | | | |
| Shale, medium gray..... | 49.7 | - | 49.9 |
| Shale, black..... | 49.9 | - | 50.1 |
| Shale, medium gray..... | 50.1 | - | 52.0 |
| Shale, black..... | 52.0 | - | 52.7 |
| Shale, medium gray..... | 52.7 | - | 58.5 |
| Coal, black..... | 58.5 | - | 59.4 |
| Shale, medium gray..... | 59.4 | - | 62.3 |
| Limestone, dark gray, very finely to finely crystalline; contains crinoids..... | 62.3 | - | 63.0 |
| Shale, medium gray..... | 63.0 | - | 64.3 |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, dark gray to tannish gray, very finely to finely crystalline; contains brachiopods..... | 64.3 | - | 66.5 |
| Shale, dark gray..... | 66.5 | - | 67.4 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains crinoids and fusulinids..... | 67.4 | - | 68.1 |
| Shale, light gray, limy..... | 68.1 | - | 68.4 |
| Limestone, light to medium gray, finely crystalline contains crinoids..... | 68.4 | - | 69.2 |
| Holt Member: | | | |
| Shale, dark gray..... | 69.2 | - | 69.5 |
| Shale, black..... | 69.5 | - | 71.0 |
| DuBois Member: | | | |
| Limestone, dark gray, finely crystalline; contains crinoids and pyrite..... | 71.0 | - | 71.6 |
| Turner Creek Member: | | | |
| Shale, medium gray; contains hard limy zones... | 71.6 | - | 72.0 |
| Limestone, light gray to light greenish gray, finely crystalline, shaley; contains brachiopods and crinoids..... | 72.0 | - | 73.6 |
| Shale, light greenish gray..... | 73.6 | - | 75.3 |
| Shale, olive with greenish gray interbedded.... | 75.3 | - | 75.5 |
| Sheldon Member: | | | |
| Limestone, very light tan to cream, very finely crystalline, pseudo-oolitic; contains brachiopods and abundant Osagia..... | 75.5 | - | 78.5 |
| Limestone, very light tan to cream, very finely crystalline, pseudo-oolitic; contains brachiopods, crinoids, and abundant Osagia; interbedded with shale, olive..... | 78.5 | - | 79.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Jones Point Member: | | | |
| Shale, light olive gray..... | 79.0 | - | 80.7 |
| Limestone, very light gray, finely crystalline; contains crinoids..... | 80.7 | - | 82.2 |
| Shale, light to medium gray..... | 82.2 | - | 83.0 |
| Curzon Member: | | | |
| Limestone, pale olive yellow, very finely crystalline..... | 83.0 | - | 86.0 |
| Limestone, pale olive yellow with orange tint, very finely to finely crystalline; contains crinoids..... | 86.0 | - | 86.4 |
| Limestone, light olive gray, very finely crystalline; contains crinoids, fusulinids, and ostracods..... | 86.4 | - | 87.6 |
| Iowa Point Member: | | | |
| Shale, dark gray with medium gray interbedded.. | 87.6 | - | 88.4 |
| Hartford Member: | | | |
| Limestone, light to medium tannish gray, very finely crystalline; contains algal material.. | 88.4 | - | 89.5 |
| Calhoun Formation: | | | |
| Shale, medium gray, limy..... | 89.5 | - | 90.2 |
| Deer Creek Formation: | | | |
| Ervine Creek Member: | | | |
| Limestone, very light gray, finely crystalline; contains pelecypods and fusulinids..... | 90.2 | - | 92.5 |
| Limestone, light olive yellow, very finely to finely crystalline; contains crinoids, bryozoans, and algal material..... | 92.5 | - | 95.0 |
| Limestone, light gray, finely crystalline; contains crinoids, fusulinids, and Osagia.... | 95.0 | - | 95.5 |
| Limestone, light gray, finely crystalline; contains pyrite and ostracods; interbedded with shale, light gray..... | 95.5 | - | 95.7 |
| Limestone, light to medium gray, finely crystalline; contains crinoids and pyrite.... | 95.7 | - | 96.8 |
| Limestone, tannish gray, very finely crystalline; contains brachiopods, fusulinids, bryozoans, and algal material.... | 96.8 | - | 99.0 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains crinoids, fusulinids, and chert..... | 99.0 | - | 106.5 |
| Shale, medium gray..... | 106.5 | - | 107.0 |

## Test Hole 37-79

Location: Otoe County, NE corner NW NE SW sec. 6, T. 9 N., R. 13 E., approximately 69 feet south of half section line and 700 feet west of east section line.

Ground-level elevation: 1,056.0 feet above mean sea level.

Started: June 13, 1979. Completed: June 13, 1979.

Total depth: 70.0 feet.

| Description | Depth, in feet From | | To |
|---|---|---|---|
| Quaternary System: | | | |
| Soil, reddish brown, silty, clayey..... | 0.0 | - | 4.0 |
| Soil, dark gray to black, silty, clayey..... | 4.0 | - | 10.0 |
| Soil, tan, silty, clayey..... | 10.0 | - | 12.0 |
| Silt, yellowish tan, sandy..... | 12.0 | - | 16.0 |
| Sand, medium to very coarse, and gravel, fine to medium; interbedded with silt, yellowish brown..... | 16.0 | - | 25.5 |
| Pennsylvanian System - Virgil Series - Shawnee Group: | | | |
| Lecompton Formation: | | | |
| Big Springs Member: | | | |
| Limestone, light to medium yellowish brown, finely crystalline, highly weathered; contains brachiopods..... | 25.5 | - | 26.0 |
| Doniphan Member: | | | |
| Shale, pale olive..... | 26.0 | - | 29.0 |
| Shale, light gray..... | 29.0 | - | 29.5 |
| Shale, pale olive..... | 29.5 | - | 33.0 |
| Spring Branch Member: | | | |
| Limestone, light tan mottled with yellowish brown, very finely to finely crystalline, pseudo-oolitic; contains algal material, Osagia, fusulinids, crinoids, and ostracods.. | 33.0 | - | 34.0 |
| Limestone, light yellowish brown to tan, very finely to finely crystalline; contains brachiopods, ostracods, Osagia, and abundant algal material..... | 34.0 | - | 36.5 |
| Shale, olive..... | 36.5 | - | 36.8 |
| Shale, medium gray..... | 36.8 | - | 40.2 |
| Shale, light gray..... | 40.2 | - | 42.0 |
| Kanwaka Formation: | | | |
| Shale, olive..... | 42.0 | - | 43.1 |
| Oread Formation: | | | |
| Kereford Member: | | | |
| Limestone, light gray, finely crystalline, shaley; contains brachiopods..... | 43.1 | - | 44.2 |

| Description | Depth, in feet From | To |
|---|---|---|
| Limestone, light tan, very finely crystalline; contains algal material | 44.2 | 45.7 |
| Limestone, yellowish tan, finely crystalline; contains brachiopods and algal material | 45.7 | 47.0 |
| Limestone, light tan with yellow tint, very finely to finely crystalline; contains crinoids and abundant fusulinids | 47.0 | 50.0 |
| Heumader Member: | | |
| Shale, light olive gray | 50.0 | 50.3 |
| Plattsmouth Member: | | |
| Limestone, tan, finely crystalline; contains fusulinids, Osagia, and abundant pseudo-oolites | 50.3 | 55.0 |
| Limestone, medium yellowish tan, finely crystalline; contains brachiopods and pseudo-oolites | 55.0 | 62.0 |
| Limestone, medium yellowish tan, finely crystalline, impure; contains crinoids and fusulinids | 62.0 | 63.7 |
| Heebner Member: | | |
| Shale, light gray | 63.7 | 65.0 |
| Shale, black; contains carbonaceous material | 65.0 | 67.8 |
| Leavenworth Member: | | |
| Limestone, light tan with yellow iron staining, finely crystalline; contains crinoids and fusulinids | 67.8 | 69.4 |
| Snyderville Member: | | |
| Shale (no sample) | 69.4 | 70.0 |

## Test Hole 38-79

Location: Otoe County, SE corner SW sec. 6, T. 9 N., R. 13 E., approximately 20 feet north of south section line and 152 feet west of half section line.

Ground-level elevation: 1,045.5 feet above mean sea level.

Started: June 20, 1979. Completed: June 25, 1979.

Total depth: 500.0 feet.

| Description | Depth, in feet From | To |
|---|---|---|
| Quaternary System: | | |
| Soil, dark brown, silty, clayey | 0.0 | 4.0 |
| Silt, brown, clayey | 4.0 | 5.0 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Silt, light brown, clayey..... | 5.0 | - | 10.0 |
| Silt, light brownish gray, clayey..... | 10.0 | - | 16.5 |
| Silt, pale reddish brown, clayey, sandy..... | 16.5 | - | 22.0 |
| Silt, very light tannish gray, clayey..... | 22.0 | - | 30.0 |
| Sand, medium to very coarse, and gravel, very fine to coarse..... | 30.0 | - | 32.5 |
| Silt, light tannish gray, clayey, silty..... | 32.5 | - | 35.0 |
| Clay, light gray, silty..... | 35.0 | - | 37.0 |
| Clay, dark gray, silty..... | 37.0 | - | 44.0 |
| Clay, light gray, silty..... | 44.0 | - | 47.5 |
| Sand, fine to very coarse, and gravel, very fine to medium; contains limestone fragments..... | 47.5 | - | 52.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | | |
| Scranton Formation: | | | |
| White Cloud Member: | | | |
| Shale, pale olive..... | 52.0 | - | 56.5 |
| Shale, dark gray with traces of olive mottling..... | 56.5 | - | 62.0 |
| Shale, medium gray..... | 62.0 | - | 66.6 |
| Howard Formation: | | | |
| Limestone, medium gray very finely to finely crystalline, shaley; contains pyrite..... | 66.6 | - | 68.2 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains brachiopods, algal material, and abundant ostracods..... | 68.2 | - | 70.6 |
| Severy Formation: | | | |
| Shale, dark gray..... | 70.6 | - | 71.0 |
| Shale, black..... | 71.0 | - | 72.0 |
| Shale, medium gray..... | 72.0 | - | 72.3 |
| Shale, black..... | 72.3 | - | 72.9 |
| Shale, medium to light gray..... | 72.9 | - | 79.5 |
| Coal, black..... | 79.5 | - | 80.1 |
| Shale, light gray..... | 80.1 | - | 81.7 |
| Limestone, dark gray, finely crystalline..... | 81.7 | - | 83.4 |
| Shale, medium gray..... | 83.4 | - | 84.8 |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, dark gray, finely crystalline..... | 84.8 | - | 85.2 |
| Limestone, medium gray, finely crystalline; contains fusulinids and pyrite; interbedded with shale, dark gray, at 86.0-86.1..... | 85.2 | - | 87.2 |
| Shale, dark gray..... | 87.2 | - | 87.6 |
| Limestone, medium to dark gray, finely crystalline; contains brachiopods and abundant crinoids..... | 87.6 | - | 88.5 |
| Shale, medium gray, limy..... | 88.5 | - | 89.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, medium gray, finely crystalline; contains crinoids and brachiopods..... | 89.0 | - 89.4 |
| Holt Member: | | |
| Shale, dark gray..... | 89.4 | - 90.1 |
| Shale, black..... | 90.1 | - 91.3 |
| DuBois Member: | | |
| Limestone, medium to dark gray, finely crystalline; contains brachiopods and pyrite..... | 91.3 | - 91.8 |
| Shale, medium to dark gray, limy..... | 91.8 | - 92.3 |
| Limestone, light gray to light greenish gray, finely crystalline, shaley; contains crinoids..... | 92.3 | - 93.0 |
| Turner Creek Member: | | |
| Shale, light to medium gray..... | 93.0 | - 94.8 |
| Sheldon Member: | | |
| Limestone, very light tan, finely crystalline; pseudo-oolitic; contains Osagia, brachiopods, and gastropods..... | 94.8 | - 99.4 |
| Jones Point - Iowa Point Members: | | |
| Shale, light gray; interbedded with thin limestones..... | 99.4 | - 102.0 |
| Shale, medium gray; interbedded with thin limestones..... | 102.0 | - 103.5 |
| Hartford Members: | | |
| Limestone, very light gray, very finely to finely crystalline; contains crinoids, glauconite, and abundant fusulinids..... | 103.5 | - 105.5 |
| Calhoun Formation: | | |
| Shale (no sample)..... | 105.5 | - 105.6 |
| Deer Creek - Tecumseh Formations: | | |
| Ervine Creek Member: | | |
| Limestone, very light tan, very finely to finely crystalline; contains gastropods..... | 105.6 | - 107.3 |
| Limestone, light tannish gray, very finely to finely crystalline; contains brachiopods, algal material, and bryozoans..... | 107.3 | - 111.0 |
| Limestone, very light gray to white, very finely crystalline; contains coral, fusulinids and pyrite..... | 111.0 | - 115.4 |
| Limestone, dark tannish gray, finely crystalline; contains crinoids and fusulinids..... | 115.4 | - 121.1 |
| Shale, medium to dark gray, hard, contains fusulinids and crinoids..... | 121.1 | - 121.9 |
| Limestone, light to medium gray, finely crystalline; contains crinoids..... | 121.9 | - 123.3 |
| Shale, medium gray..... | 123.3 | - 124.6 |
| Limestone, light gray, finely crystalline; contains crinoids..... | 124.6 | - 125.3 |
| Larsh Member: | | |
| Shale, medium gray..... | 125.3 | - 125.8 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, dark gray to black | 125.8 | - 126.4 |
| Rock Bluff Member: | | |
| Limestone, medium tan, very finely crystalline; contains brachiopods and fusulinids | 126.4 | - 129.2 |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray | 129.2 | - 131.6 |
| Silt, light bluish gray | 131.6 | - 142.0 |
| Silt, light bluish gray; interbedded with sandstone, light bluish gray, at 143.0-144.0 | 142.0 | - 147.0 |
| Silt, light bluish gray; interbedded with sandstone, light bluish gray, at 151.6 | 147.0 | - 157.0 |
| Shale, medium to light gray | 157.0 | - 158.5 |
| Shale, reddish brown | 158.5 | - 161.3 |
| Ost Member: | | |
| Limestone, light gray to light greenish gray, very finely to finely crystalline; interbedded with shale, reddish brown | 161.3 | - 164.5 |
| Shale, pale reddish gray; interbedded with thin limy zones | 164.5 | - 165.0 |
| Limestone, very light greenish gray, finely crystalline, shaley | 165.0 | - 165.8 |
| Kenosha Member: | | |
| Shale, reddish brown with traces of gray to greenish gray | 165.8 | - 169.0 |
| Shale, gray to greenish gray with traces of reddish brown | 169.0 | - 170.0 |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, tannish gray, finely crystalline, shaley; contains crinoids | 170.0 | - 171.2 |
| Limestone, dark gray, finely crystalline, shaley; contains crinoids and fusulinids | 171.2 | - 171.4 |
| Limestone, medium gray, finely crystalline; contains crinoids and fusulinids | 171.4 | - 174.0 |
| King Hill Member: | | |
| Shale, medium gray | 174.0 | - 175.0 |
| Shale, reddish brown | 175.0 | - 177.5 |
| Limestone, brown, finely crystalline, shaley | 177.5 | - 178.0 |
| Shale, greenish gray | 178.0 | - 180.3 |
| Beil Member: | | |
| Limestone, light tan, very finely crystalline, pseudo-oolitic in part; contains Osagia, algal material, and fusulinids | 180.3 | - 183.3 |
| Limestone, light tan, very finely crystalline; contains pyrite, brachiopods, and crinoids; interbedded with shale, greenish gray | 183.3 | - 185.0 |
| Limestone, light tan, very finely crystalline; contains crinoids, brachiopods, fusulinids, and pyrite | 185.0 | - 187.4 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Queen Hill Member: | | |
| Shale, light gray | 187.4 | - 188.0 |
| Shale, dark gray | 188.0 | - 189.0 |
| Shale, black; contains carbonaceous material | 189.0 | - 192.3 |
| Big Springs Member: | | |
| Limestone, tannish gray, very finely to finely crystalline, impure; contains fusulinids, crinoids, and brachiopods | 192.3 | - 194.1 |
| Doniphan Member: | | |
| Shale, light to medium gray; interbedded with thin limy zones at 195.0 and 196.0 | 194.1 | - 197.0 |
| Spring Branch Member: | | |
| Limestone, light tan, finely crystalline; contains crinoids and algal material; interbedded with shale, greenish gray | 197.0 | - 198.3 |
| Limestone, light gray, very finely crystalline; contains crinoids, algal material, and glauconite | 198.3 | - 202.6 |
| Shale, dark gray | 202.6 | - 203.4 |
| Shale, light gray, limy | 203.4 | - 204.6 |
| Kanwaka Formation: | | |
| Stull Member: | | |
| Shale, light gray | 204.6 | - 206.0 |
| Clay Creek Member: | | |
| Limestone, medium gray, finely crystalline, shaley; contains crinoids and abundant brachiopods | 206.0 | - 206.7 |
| Jackson Park Member: | | |
| Shale, medium gray | 206.7 | - 207.8 |
| Oread Formation: | | |
| Kereford Member: | | |
| Limestone, light gray to tannish gray, finely crystalline; contains ostracods | 207.8 | - 209.7 |
| Limestone, very light tan, very finely crystalline; contains fusulinids, ostracods, pyrite, and glauconite | 209.7 | - 212.0 |
| Limestone, very light gray to white, very finely to finely crystalline; contains brachiopods, pyrite, and abundant fusulinids | 212.0 | - 215.2 |
| Heumader Member: | | |
| Shale, light gray, limy | 215.2 | - 215.5 |
| Plattsmouth Member: | | |
| Limestone, light gray to very light tan, very finely to finely crystalline, pseudo-oolitic; contains fusulinids and chert | 215.5 | - 219.8 |
| Limestone, medium gray to tannish gray, finely crystalline; contains chert and abundant fusulinids | 219.8 | - 223.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, tannish gray, finely crystalline, impure; contains abundant fusulinids and abundant algal material | 223.0 | - 227.0 |
| Limestone, tannish gray, finely crystalline; contains crinoids, glauconite, and "black inclusions" | 227.0 | - 229.8 |
| Heebner Member: | | |
| Shale, medium gray | 229.8 | - 231.9 |
| Shale, black | 231.9 | - 233.9 |
| Leavenworth Member: | | |
| Limestone, medium tannish gray, very finely crystalline; contains fusulinids, crinoids, brachiopods, gastropods, and "black inclusions" | 233.9 | - 235.7 |
| Snyderville Member: | | |
| Shale, light gray | 235.7 | - 242.0 |
| Shale, light greenish gray | 242.0 | - 244.5 |
| Shale, reddish brown | 244.5 | - 250.4 |
| Toronto Member: | | |
| Limestone, very light tan to white, very finely crystalline; contains brachiopods, algal material, chert, and pyrite | 250.4 | - 257.5 |
| Limestone, very light tan to white, very finely crystalline; contains fusulinids; interbedded with shale, gray, greenish gray, and reddish brown | 257.5 | - 260.0 |
| Douglas Group: | | |
| Lawrence Formation: | | |
| Shale, light gray | 260.0 | - 262.0 |
| Shale, reddish brown | 262.0 | - 273.0 |
| Shale, varicolored, reddish brown, gray, and greenish gray | 273.0 | - 278.5 |
| Shale, medium gray | 278.5 | - 294.0 |
| Shale, black | 294.0 | - 294.5 |
| Shale, medium gray | 294.5 | - 303.6 |
| Cass Formation: | | |
| Haskell Member: | | |
| Limestone, medium gray, finely crystalline, impure; contains crinoids, brachiopods, and abundant fusulinids | 303.6 | - 306.6 |
| Little Pawnee Member: | | |
| Shale, medium gray | 306.6 | - 307.5 |
| Shale, black | 307.5 | - 308.3 |
| Shoemaker Member: | | |
| Limestone, dark gray, finely crystalline; contains brachiopods, crinoids, and fusulinids | 308.3 | - 309.4 |
| Plattford Formation: | | |
| Unnamed Member: | | |
| Shale, light to medium gray | 309.4 | - 311.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, light gray to light greenish gray..... | 311.0 | - 311.6 |
| Shale, reddish brown..... | 311.6 | - 317.5 |
| Nehawka Member: | | |
| Limestone, very light tan, very finely crystalline; contains brachiopods and crinoids..... | 317.5 | - 324.0 |
| Shale (no sample)..... | 324.0 | - 325.2 |
| Missouri Series - Lansing Group: | | |
| Stanton Formation: | | |
| South Bend Member: | | |
| Limestone, very light tan, very finely crystalline, contains crinoids..... | 325.2 | - 326.6 |
| Rock Lake Member: | | |
| Shale, reddish brown; interbedded with limestone, very light tan..... | 326.6 | - 329.0 |
| Limestone, very light tan, very finely crystalline; contains fusulinids and brachiopods..... | 329.0 | - 330.0 |
| Shale, greenish gray interbedded with reddish brown and gray..... | 330.0 | - 332.0 |
| Stoner Member: | | |
| Limestone, very light gray to white, very finely crystalline; contains crinoids, fusulinids, bryozoans, and algal material.... | 332.0 | - 337.0 |
| Limestone, very light greenish gray, very finely crystalline; contains brachiopods and crinoids..... | 337.0 | - 342.0 |
| Limestone, very light greenish gray, very finely crystalline..... | 342.0 | - 347.0 |
| Limestone, very light bluish gray, very finely crystalline; contains fusulinids..... | 347.0 | - 348.0 |
| Shale, light greenish gray, limy..... | 348.0 | - 349.0 |
| Limestone, light greenish gray, very finely crystalline; interbedded with shale, light greenish gray..... | 349.0 | - 352.9 |
| Eudora Member: | | |
| Shale, greenish gray; interbedded with limestone, light greenish gray, very finely crystalline..... | 352.9 | - 354.3 |
| Captain Creek Member: | | |
| Limestone, greenish gray, finely crystalline; interbedded with shale, greenish gray..... | 354.3 | - 355.6 |
| Vilas Formation: | | |
| Shale, greenish gray..... | 355.6 | - 356.0 |
| Limestone, greenish gray, finely crystalline; contains crinoids; interbedded with shale, greenish gray..... | 356.0 | - 357.0 |
| Shale, black..... | 357.0 | - 357.4 |
| Shale, reddish brown..... | 357.4 | - 359.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, greenish gray | 359.0 | - 359.1 |
| Limestone, light tan, very finely crystalline; contains brachiopods | 359.1 | - 359.7 |
| Shale, dark gray to black | 359.7 | - 360.0 |
| Shale, medium gray | 360.0 | - 362.0 |
| Shale, greenish gray to medium gray | 362.0 | - 362.3 |
| Plattsburg Formation: | | |
| Limestone, very light tan with greenish tint, very finely to finely crystalline; contains fusulinids and gastropods | 362.3 | - 366.7 |
| Shale, light greenish gray, limy | 366.7 | - 368.0 |
| Limestone, very light gray, very finely crystalline | 368.0 | - 371.5 |
| Kansas City Group: | | |
| Bonner Springs Formation: | | |
| Shale, light bluish gray to greenish gray | 371.5 | - 376.5 |
| Wyandotte Formation: | | |
| Farley Member: | | |
| Limestone, light tan, very finely to finely crystalline; contains crinoids, fusulinids, and algal material | 376.5 | - 377.0 |
| Shale, light greenish gray, limy | 377.0 | - 377.6 |
| Limestone, very light tan, very finely crystalline; contains pyrite | 377.6 | - 383.2 |
| Limestone, very light tan, very finely crystalline; interbedded with shale, light greenish gray | 383.2 | - 388.3 |
| Island Creek Member: | | |
| Limestone, light tan to light greenish gray, very finely crystalline; interbedded with shale, greenish gray to white | 388.3 | - 390.0 |
| Argentine Member: | | |
| Limestone, light tan to white, very finely to finely crystalline | 390.0 | - 407.0 |
| Limestone, very light tan to white, very finely crystalline; contains fusulinids and pyrite | 407.0 | - 415.4 |
| Quindara Member: | | |
| Shale, dark gray to black | 415.4 | - 416.9 |
| Frisbie Member: | | |
| Limestone (electric log) | 416.9 | - 418.2 |
| Lane Formation: | | |
| Shale, dark greenish gray; interbedded with thin limestone seams | 418.2 | - 436.0 |
| Iola Formation: | | |
| Limestone, shaley (electric log) | 436.0 | - 438.5 |
| Limestone, light tannish gray to white with light greenish gray tint; very finely crystalline; contains algal material | 438.5 | - 443.5 |
| Shale (electric log) | 443.5 | - 444.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone (electric log) | 444.5 | 445.5 |
| Chanute Formation: | | |
| Shale, greenish gray | 445.5 | 451.5 |
| Drum Formation: | | |
| Limestone interbedded with shale (electric log) | 451.5 | 467.5 |
| Quivera Formation: | | |
| Shale (electric log) | 467.5 | 473.0 |
| Sarpy Formation: | | |
| Westerville Member: | | |
| Limestone (electric log) | 473.0 | 483.5 |
| Fontana Formation: | | |
| Shale (electric log) | 483.5 | 490.8 |
| Dennis Formation: | | |
| Winterset Member: | | |
| Limestone (electric log) | 490.8 | 500.0 |

## Test Hole 39-79

Location: Cass County, SW corner sec. 2, T. 10 N., R. 13 E., approximately 21 feet north of south section line and 42 feet east of west section line.

Ground-level elevation: 1,065.0 feet above mean sea level.

Started: June 26,1979. Completed: June 29, 1979.

Total depth: 503.0 feet.

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Quaternary System: | | |
| Soil, dark gray, silty, clayey | 0.0 | 4.0 |
| Silt, brown, clayey, sandy | 4.0 | 13.0 |
| Sand, very fine to coarse, and gravel, very fine to medium | 13.0 | 15.0 |
| Pennsylvanian System - Virgil Series - Wabaunsee Group: | | |
| Severy Formation: | | |
| Shale, olive yellow | 15.0 | 18.0 |
| Shale, black | 18.0 | 19.0 |
| Shale, dark gray | 19.0 | 20.3 |
| Coal, black | 20.3 | 21.0 |
| Shale, medium gray | 21.0 | 22.8 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Limestone, medium to dark gray, finely crystalline | 22.8 | - | 24.0 |
| Shale, medium gray | 24.0 | - | 26.2 |
| Shawnee Group: | | | |
| Topeka Formation: | | | |
| Coal Creek Member: | | | |
| Limestone, medium to dark gray, finely crystalline; contains crinoids and pyrite | 26.2 | - | 28.0 |
| Shale, dark gray, hard | 28.0 | - | 28.5 |
| Limestone medium gray, very finely to finely crystalline | 28.5 | - | 29.1 |
| Shale, medium gray | 29.1 | - | 29.9 |
| Limestone, medium gray, finely crystalline; contains crinoids, pyrite, and pelecypods | 29.9 | - | 30.2 |
| Holt Member: | | | |
| Shale, dark gray to black, hard | 30.2 | - | 32.0 |
| Shale, black, hard | 32.0 | - | 32.3 |
| DuBois Member: | | | |
| Limestone, medium to dark gray, very finely to finely crystalline; contains brachiopods | 32.3 | - | 32.7 |
| Shale, medium gray; interbedded with limestone, medium gray | 32.7 | - | 32.8 |
| Limestone, medium gray, finely crystalline, impure; contains brachiopods and "black inclusions" | 32.8 | - | 33.4 |
| Turner Creek Member: | | | |
| Shale, light gray | 33.4 | - | 34.9 |
| Sheldon Member: | | | |
| Limestone, light tan, finely crystalline, pseudo-oolitic | 34.9 | - | 36.0 |
| Limestone, light tan, finely crystalline, pseudo-oolitic; contains Osagia | 36.0 | - | 38.9 |
| Limestone, light tan, finely crystalline, shaley; contains algal material | 38.9 | - | 39.5 |
| Jones Point Member: | | | |
| Shale, light gray to light greenish gray, hard and limy | 39.5 | - | 42.0 |
| Shale, light greenish gray to medium gray, limy | 42.0 | - | 42.6 |
| Shale, light greenish gray to medium gray, hard and limy | 42.6 | - | 42.9 |
| Shale, medium greenish gray; interbedded with thin, hard, limy zones | 42.9 | - | 44.6 |
| Curzon Member: | | | |
| Limestone, very light gray to white, very finely to finely crystalline, shaley upper 1.0 | 44.6 | - | 46.1 |
| Shale, light gray, hard | 46.1 | - | 46.5 |

| Description | Depth, in feet | | |
|---|---|---|---|
| | From | | To |
| Limestone, very light tan, very finely crystalline; contains abundant chert, light bluish gray; contains sponge spicules..... | 46.5 | - | 48.0 |
| Limestone, light tan to gray, finely crystalline; contains fusulinids and crinoids..... | 48.0 | - | 49.4 |
| Iowa Point Member: | | | |
| Shale, medium greenish gray, limy..... | 49.4 | - | 49.8 |
| Shale, light to medium greenish gray, limy..... | 49.8 | - | 50.0 |
| Shale, dark gray to black, hard..... | 50.0 | - | 50.3 |
| Shale, medium greenish gray..... | 50.3 | - | 50.5 |
| Hartford Member: | | | |
| Limestone, medium brown, finely crystalline; contains dark gray and white "inclusions".... | 50.5 | - | 52.0 |
| Calhoun Formation: | | | |
| Shale, dark gray..... | 52.0 | - | 53.0 |
| Deer Creek - Tecumseh Formation: | | | |
| Ervine Creek Member: | | | |
| Limestone, light to medium brown, very finely to finely crystalline, vuggy or "reef-like" texture; contains brachiopods and gastropods..... | 53.0 | - | 56.0 |
| Limestone, light gray mottled with tan, very finely crystalline; contains brachiopods and chert..... | 56.0 | - | 57.0 |
| Limestone, light tan, very finely crystalline.. | 57.0 | - | 59.3 |
| Limestone, medium to dark brown, very finely to finely crystalline, "speckled;" contains algal material..... | 59.3 | - | 60.0 |
| Limestone, light tan to light gray, very finely crystalline; contains algal material and ostracods..... | 60.0 | - | 60.3 |
| Limestone, light gray to light tan, irregularly crystalline, impure; contains brachiopods, pyrite, and ostracods..... | 60.3 | - | 60.8 |
| Limestone, medium brown, finely crystalline; contains fusulinids..... | 60.8 | - | 65.0 |
| Limestone, medium brown, finely crystalline; contains abundant fusulinids..... | 65.0 | - | 67.6 |
| Shale, dark greenish gray..... | 67.6 | - | 68.4 |
| Shale, medium gray with greenish tint..... | 68.4 | - | 69.0 |
| Limestone, light tannish gray, finely crystalline; contains pyrite..... | 69.0 | - | 69.9 |
| Larsh Member: | | | |
| Shale, medium greenish gray..... | 69.9 | - | 71.0 |
| Shale, black, hard..... | 71.0 | - | 72.0 |
| Rock Bluff Member: | | | |
| Limestone, light to medium brown, very finely crystalline; contains fusulinids and dark brown "inclusions"..... | 72.0 | - | 72.5 |
| Limestone, light to medium brown, very finely crystalline; contains fusulinids..... | 72.5 | - | 74.1 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Oskaloosa - Rakes Creek Members: | | |
| Shale, medium gray | 74.1 | 74.5 |
| Shale, light to medium gray, limy | 74.5 | 79.0 |
| Sandstone, light greenish gray, very finely grained | 79.0 | 85.0 |
| Sandstone, light greenish gray, very fine grained, silty | 85.0 | 93.6 |
| Shale, light greenish gray | 93.6 | 95.5 |
| Shale, light greenish gray, limy | 95.5 | 98.3 |
| Shale, reddish brown, hard | 98.3 | 99.0 |
| Ost Member: | | |
| Limestone, light tan speckled with medium gray, irregularly crystalline; contains ostracods | 99.0 | 100.0 |
| Limestone, light greenish gray, very finely crystalline | 100.0 | 102.0 |
| Shale, light reddish brown | 102.0 | 103.5 |
| Shale, medium gray with reddish tint | 103.5 | 105.5 |
| Shale, light to medium gray | 105.5 | 106.0 |
| Limestone, light tannish gray, finely crystalline; interbedded with shale, light to medium gray | 106.0 | 106.5 |
| Kenosha Member: | | |
| Shale, olive | 106.5 | 108.5 |
| Shale, medium gray | 108.5 | 109.4 |
| Lecompton Formation: | | |
| Avoca Member: | | |
| Limestone, light to medium greenish gray, very finely crystalline; contains crinoids and fusulinids | 109.4 | 110.5 |
| Shale, dark gray to black | 110.5 | 110.7 |
| Limestone, dark tannish gray, very finely to finely crystalline; contains Osagia | 110.7 | 112.0 |
| Limestone, medium to dark tannish gray, very finely to finely crystalline; contains crinoids and abundant fusulinids | 112.0 | 112.5 |
| King Hill Member: | | |
| Shale, light greenish gray | 112.5 | 113.5 |
| Shale, reddish brown | 113.5 | 116.8 |
| Shale, reddish olive | 116.8 | 118.0 |
| Shale, light greenish gray, limy | 118.0 | 120.0 |
| Beil Member: | | |
| Limestone, light tan, very finely crystalline | 120.0 | 121.3 |
| Limestone, light tannish gray, very finely to finely crystalline; contains coral, brachiopods, and fusulinids | 121.3 | 122.0 |
| Limestone, light tannish gray, finely crystalline; contains abundant coral | 122.0 | 123.6 |
| Limestone, light tannish gray, very finely to finely crystalline; contains coral | 123.6 | 124.1 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light to medium greenish gray, finely crystalline; contains brachiopods and pyrite | 124.1 | - 125.2 |
| Queen Hill Member: | | |
| Shale, light to medium greenish gray | 125.2 | - 127.4 |
| Shale, dark olive gray | 127.4 | - 128.5 |
| Shale, black, hard | 128.5 | - 130.4 |
| Big Springs Member: | | |
| Limestone, medium tannish gray, very finely to finely crystalline; contains pyrite and crinoids | 130.4 | - 131.7 |
| Doniphan Member: | | |
| Shale, medium greenish gray | 131.7 | - 135.3 |
| Spring Branch Member: | | |
| Limestone, light to medium tan, irregularly crystalline, impure, conglomeritic-like texture; contains "black inclusions" | 135.3 | - 136.0 |
| Limestone, light tannish gray, irregularly crystalline, conglomeritic-like texture; contains "black inclusions" | 136.0 | - 137.2 |
| Limestone, light tan, finely crystalline; contains brachiopods and algal material | 137.2 | - 138.0 |
| Limestone, light tannish gray, very finely to finely crystalline; contains algal material | 138.0 | - 139.7 |
| Limestone, light tan with gray tint, very finely to finely crystalline; contains brachiopods | 139.7 | - 141.5 |
| Shale, olive brown | 141.5 | - 142.0 |
| Shale, dark olive to black | 142.0 | - 144.0 |
| Shale, medium gray (may be poor sample) | 144.0 | - 145.0 |
| Kanwaka Formation: | | |
| Stull Member: | | |
| Shale, medium gray, hard and limy | 145.0 | - 147.8 |
| Clay Creek Member: | | |
| Limestone, light tan, finely crystalline; contains brachiopods and "black inclusions" | 147.8 | - 148.6 |
| Jackson Park Member: | | |
| Shale, light to medium olive gray | 148.6 | - 150.0 |
| Oread Formation: | | |
| Kereford Member: | | |
| Limestone, medium tan, finely crystalline | 150.0 | - 150.1 |
| Chert, medium brown with light blue mottling, very microfossiliferous; interbedded with limestone, medium tan, finely crystalline; contains fusulinids | 150.1 | - 150.7 |
| Limestone, very light tan, finely crystalline; contains brachiopods and abundant fusulinids | 150.7 | - 155.3 |
| Heumader Member: | | |
| Shale, medium gray, limy | 155.3 | - 156.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Plattsmouth Member: | | |
| Limestone, light to medium tan, very finely to finely crystalline; contains fusulinids, Osagia, and abundant algal material | 156.0 | - 160.0 |
| Limestone, medium gray, very finely to finely crystalline; contains abundant fusulinids | 160.0 | - 161.8 |
| Limestone, medium tan mottled with light tan, very finely to finely crystalline; contains fusulinids | 161.8 | - 165.0 |
| Limestone, light to medium gray, finely crystalline; contains crinoids, pyrite, and fusulinids | 165.0 | - 167.0 |
| Heebner Member: | | |
| Shale, medium gray | 167.0 | - 168.0 |
| Shale, black, hard | 168.0 | - 171.3 |
| Leavenworth Member: | | |
| Limestone, medium tannish gray, very finely crystalline; contains fusulinids | 171.3 | - 173.1 |
| Snyderville Member: | | |
| Shale, light to medium greenish gray | 173.1 | - 178.5 |
| Shale, light to medium gray with traces of pale reddish brown | 178.5 | - 179.0 |
| Shale, light to medium greenish gray | 179.0 | - 181.0 |
| Shale, reddish brown | 181.0 | - 189.0 |
| Shale, medium greenish gray, limy | 189.0 | - 189.8 |
| Toronto Member: | | |
| Limestone, light tan, very finely to finely crystalline | 189.8 | - 191.1 |
| Limestone, light greenish gray, very finely crystalline; contains pyrite and algal material | 191.1 | - 191.8 |
| Limestone, light tan, very finely crystalline; contains chert, gray | 191.8 | - 193.0 |
| Limestone, light greenish gray, very finely to finely crystalline, impure, conglomeritic-like texture | 193.0 | - 194.3 |
| Limestone, light greenish gray with traces of pale red, very finely to finely crystalline | 194.3 | - 195.5 |
| Shale, reddish brown, limy | 195.5 | - 198.2 |
| Limestone, light greenish gray mottled with tan, finely crystalline; contains brachiopods and abundant pseudo-oolites | 198.2 | - 198.8 |
| Douglas Group: | | |
| Lawrence Formation: | | |
| Shale, reddish brown | 198.8 | - 209.0 |
| Shale, reddish brown mottled with olive | 209.0 | - 214.0 |
| Shale, light to medium greenish gray | 214.0 | - 214.5 |
| Shale, olive | 214.5 | - 216.0 |
| Shale, olive gray | 216.0 | - 218.0 |
| Shale, medium gray | 218.0 | - 229.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium gray; interbedded with sandstone, medium gray, fine grained | 229.0 | - 229.7 |
| Shale, medium gray | 229.7 | - 235.6 |
| Shale, black, hard | 235.6 | - 235.9 |
| Shale, light gray | 235.9 | - 240.0 |
| Shale, light gray with olive tint | 240.0 | - 240.6 |
| Shale, medium gray with olive tint | 240.6 | - 243.0 |
| Shale, medium gray | 243.0 | - 246.0 |
| Cass Formation: | | |
| Haskell Member: | | |
| Limestone, medium gray mottled with dark gray, finely crystalline; contains brachiopods and crinoids | 246.0 | - 247.3 |
| Limestone, medium gray mottled with dark gray, finely crystalline, shaley | 247.3 | - 247.8 |
| Limestone, medium gray mottled with dark gray, finely crystalline; contains brachiopods, crinoids, and glauconite | 247.8 | - 250.6 |
| Little Pawnee Member: | | |
| Shale, dark gray interbedded with black in middle | 250.6 | - 252.3 |
| Shoemaker Member: | | |
| Limestone, medium to dark gray, finely crystalline | 252.3 | - 253.4 |
| Plattford Formation: | | |
| Unnamed Member: | | |
| Shale, medium gray | 253.4 | - 258.0 |
| Shale, medium gray with olive tint | 258.0 | - 258.5 |
| Shale, medium brown with red tint | 258.5 | - 264.5 |
| Nehawka Member: | | |
| Limestone, light tan mottled with white, very finely crystalline; contains brachiopods and pyrite | 264.5 | - 270.6 |
| Unnamed Member: | | |
| Shale, medium gray | 270.6 | - 272.8 |
| Missouri Series - Lansing Group: | | |
| Stanton Formation: | | |
| South Bend Member: | | |
| Limestone, light gray with tannish tint, very finely crystalline; contains fusulinids and Osagia | 272.8 | - 273.9 |
| Rock Lake Member: | | |
| Shale, light to medium gray, limy | 273.9 | - 277.6 |
| Shale, reddish gray with green tint, limy | 277.6 | - 277.9 |
| Shale, light to medium greenish gray | 277.9 | - 282.0 |
| Stoner Member: | | |
| Limestone, light gray, finely crystalline; contains pyrite | 282.0 | - 282.8 |
| Limestone, very light tan, very finely to finely crystalline; contains fusulinids | 282.8 | - 285.6 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, very light tan to white, very finely crystalline | 285.6 | - 290.0 |
| Limestone, light greenish gray, very finely to finely crystalline | 290.0 | - 301.6 |
| Limestone, light greenish gray, very finely crystalline; interbedded with shale, light to medium gray | 301.6 | - 303.0 |
| Limestone, medium greenish gray, very finely to finely crystalline; contains fusulinids; interbedded with shale, light to medium gray | 303.0 | - 303.7 |
| Limestone, medium gray, very finely to finely crystalline | 303.7 | - 305.0 |
| Eudora Member: | | |
| Shale, medium gray | 305.0 | - 306.0 |
| Shale, black | 306.0 | - 306.8 |
| Captain Creek Member: | | |
| Limestone, medium gray with tan tint, finely crystalline; contains ostracods | 306.8 | - 307.2 |
| Vilas Formation: | | |
| Shale, dark gray to black | 307.2 | - 308.0 |
| Limestone, medium gray, very finely to finely crystalline, impure | 308.0 | - 308.6 |
| Shale, dark gray | 308.6 | - 310.3 |
| Limestone, medium to dark gray, very finely to finely crystalline; contains brachiopods | 310.3 | - 310.8 |
| Shale, light to medium greenish gray | 310.8 | - 313.5 |
| Plattsburg Formation: | | |
| Limestone, medium tan, finely crystalline; contains abundant algal material | 313.5 | - 314.7 |
| Limestone, light greenish gray, finely crystalline; contains ostracods and abundant algal material; interbedded with shale, light greenish gray | 314.7 | - 315.0 |
| Limestone, light gray, very finely crystalline; contains chert, fusulinids, crinoids, ostracods, and abundant algal material | 315.0 | - 318.0 |
| Limestone, medium tannish gray, very finely to finely crystalline, shaley | 318.0 | - 318.6 |
| Limestone, light tan, very finely to finely crystalline; contains chert and pyrite | 318.6 | - 321.0 |
| Limestone, light gray, very finely to finely crystalline; contains chert and brachiopods | 321.0 | - 323.2 |
| Limestone, dark gray, very finely crystalline; shaley; contains crinoids | 323.2 | - 325.4 |
| Limestone, dark greenish gray, very finely crystalline; contains brachiopods | 325.4 | - 327.1 |
| Kansas City Group: | | |
| Bonner Springs Formation: | | |
| Shale, medium to dark gray | 327.1 | - 330.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Shale, medium greenish gray..... | 330.0 | - 332.3 |
| Wyandotte Formation: | | |
| Farley Member: | | |
| Limestone, light tan, finely crystalline; contains pyrite..... | 332.3 | - 334.0 |
| Limestone, light tan, finely cyrstalline; contains chert, light blue to light tan..... | 334.0 | - 337.0 |
| Limestone, light gray, very finely to finely crystalline..... | 337.0 | - 340.2 |
| Island Creek Member: | | |
| Shale, light to medium gray, limy..... | 340.2 | - 341.1 |
| Argentine Member: | | |
| Limestone, very light tan, very finely crystalline; contains fusulinids..... | 341.1 | - 345.0 |
| Limestone, very light tan, very finely crystalline; contains brachiopods..... | 345.0 | - 355.4 |
| Limestone, light tan, very finely crystalline; contains brachiopods, crinoids, and fusulinids..... | 355.4 | - 356.0 |
| Limestone, light gray, very finely crystalline; contains crinoids and brachiopods..... | 356.0 | - 357.0 |
| Limestone, light gray, very finely crystalline; contains brachiopods..... | 357.0 | - 361.9 |
| Shale, medium gray; interbedded with limestone, light gray, very finely crystalline..... | 361.9 | - 369.3 |
| Quindaro Member: | | |
| Shale, medium gray..... | 369.3 | - 370.0 |
| Shale, black..... | 370.0 | - 370.8 |
| Frisbie Member: | | |
| Limestone, medium gray, very finely crystalline; contains fusulinids and abundant brachiopods..... | 370.8 | - 371.3 |
| Lane Formation: | | |
| Shale, light to medium gray..... | 371.3 | - 374.7 |
| Limestone, medium gray, very finely crystalline; contains brachiopods, pelecypods, and pyrite..... | 374.7 | - 375.2 |
| Shale, medium gray..... | 375.2 | - 385.4 |
| Iola Formation: | | |
| Limestone, light to medium greenish gray, very finely crystalline..... | 385.4 | - 387.0 |
| Limestone, light tan, very finely crystalline..... | 387.0 | - 391.3 |
| Limestone, light to medium greenish gray, very finely crystalline; contains crinoids; interbedded with shale, medium gray..... | 391.3 | - 392.5 |
| Limestone, light tan, very finely to finely crystalline; contains glauconite and abundant algal material..... | 392.5 | - 393.5 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Chanute Formation: | | |
| Shale, medium gray | 393.5 | - 395.1 |
| Shale, black | 395.1 | - 396.0 |
| Shale, medium gray | 396.0 | - 399.4 |
| Drum Formation: | | |
| Limestone, light to medium gray with tannish tint, very finely crystalline; contains Osagia; interbedded with shale lower 0.5 | 399.4 | - 401.5 |
| Limestone, light to medium tannish gray, very finely to finely crystalline; contains fusulinids, ostracods, and brachiopods | 401.5 | - 404.5 |
| Limestone, medium gray, very finely to finely crystalline, shaley; contains crinoids, and abundant fusulinids | 404.5 | - 404.9 |
| Limestone, light to medium tan, very finely to finely crystalline; contains brachiopods and fusulinids | 404.9 | - 408.3 |
| Limestone, medium gray, very finely crystalline; contains brachiopods and abundant fusulinids; interbedded with shale, gray | 408.3 | - 410.4 |
| Limestone, medium tannish gray, very finely to finely crystalline; contains pelecypods and abundant fusulinids | 410.4 | - 414.0 |
| Shale, dark greenish gray, limy | 414.0 | - 415.3 |
| Limestone, dark gray, very finely crystalline; contains "black inclusions" | 415.3 | - 416.1 |
| Quivira Formation: | | |
| Shale, medium greenish gray | 416.1 | - 418.3 |
| Sarpy Formation: | | |
| Westerville Member: | | |
| Limestone, very light to light greenish gray, very finely crystalline, shaley | 418.3 | - 419.6 |
| Limestone, light gray, finely crystalline; contains fusulinids | 419.6 | - 427.4 |
| Limestone, light gray, finely crystalline; contains abundant fusulinids; contains shaley partings | 427.4 | - 429.5 |
| Wea Member: | | |
| Shale, black, hard | 429.5 | - 432.1 |
| Fontana Formation: | | |
| Shale, medium greenish gray | 432.1 | - 436.0 |
| Dennis Formation: | | |
| Winterset Member: | | |
| Limestone, light gray, very finely to finely crystalline; contains pseudo-oolites | 436.0 | - 442.0 |
| Limestone, light gray, very finely crystalline | 442.0 | - 448.1 |
| Shale, medium gray | 448.1 | - 450.0 |
| Limestone, light to medium tannish gray, very finely crystalline; contains fusulinids | 450.0 | - 454.6 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light to medium tannish gray, very finely crystalline, shaley; contains pyrite.. | 454.6 | - 456.5 |
| Limestone, light to medium tannish gray, very finely crystalline; contains brachiopods..... | 456.5 | - 458.1 |
| Limestone, medium tannish gray, very finely crystalline; contains crinoids and brachiopods; contains shaley partings..... | 458.1 | - 460.0 |
| Stark Member: | | |
| Shale, medium gray, limy..... | 460.0 | - 460.8 |
| Shale, black, hard..... | 460.8 | - 463.4 |
| Canville Member: | | |
| Limestone, dark tannish gray, very finely to irregularly crystalline; contains brachiopods, crincids, Osagia, pseudo-oolites, and abundant algal material..... | 463.4 | - 464.1 |
| Galesburg Formation: | | |
| Shale, greenish gray..... | 464.1 | - 466.3 |
| Siltstone, light greenish gray..... | 466.3 | - 471.8 |
| Swope Formation: | | |
| Bethany Falls Member: | | |
| Limestone, light tan, very finely crystalline; contains pseudo-oolites and abundant algal material..... | 471.8 | - 474.0 |
| Shale, very light greenish gray; contains hard limy zones..... | 474.0 | - 474.8 |
| Limestone, light tan, very finely to finely crystalline; contains chert, light bluish gray..... | 474.8 | - 477.2 |
| Shale, light gray..... | 477.2 | - 478.0 |
| Limestone, light tan, very finely to finely crystalline; contains crinoids..... | 478.0 | - 481.3 |
| Limestone, gray, irregularly crystalline, shaley; contains brachiopods, crinoids, algal material, and glauconite..... | 481.3 | - 481.7 |
| Hushpuckney Member: | | |
| Shale, dark gray..... | 481.7 | - 482.3 |
| Ladore Formation: | | |
| Shale, medium gray..... | 482.3 | - 486.3 |
| Hertha Member: | | |
| Limestone, light to medium gray, finely to irregularly crystalline, pseudo-oolitic; contains brachiopods, bryozoans, and abundant algal material..... | 486.3 | - 488.9 |
| Shale, light to medium gray..... | 488.9 | - 491.0 |
| Shale, pale reddish brown..... | 491.0 | - 491.8 |
| Shale, dark gray to black..... | 491.8 | - 492.9 |
| Shale, reddish brown..... | 492.9 | - 493.7 |
| Shale, greenish gray, limy..... | 493.7 | - 498.0 |

| Description | Depth, in feet | |
|---|---|---|
| | From | To |
| Limestone, light to medium tannish gray, very finely to irregularly crystalline; contains brachiopods, algal material, pseudo-oolites, and foraminifera..... | 498.0 | - 498.5 |
| DesMoines Series - Marmaton Group: | | |
| Shale, reddish brown..... | 498.5 | - 503.0 |

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This report presents and interprets information that pertains to the geology, structure, tectonics, and seismicity of eastern Nebraska with emphasis on the vicinity of the intersection of the Union and Humboldt Fault zones. Some of the information presented results from a combination of studies begun in earlier years but the greater part results from studies begun in 1978.

The scope of the studies is summarized as follows:

1. Rock outcrops in southeastern Cass and northeastern Otoe counties were reexamined and reevaluated, and 39 test holes were drilled to determine the altitude of the upper surface of the Kereford Limestone of Pennsylvanian age;
2. Three new seismographs were installed in eastern Nebraska;
3. Gravity surveys in eastern Nebraska were extended;
4. Ground magnetic surveys in southeastern Cass and northeastern Otoe counties were made and evaluated.

Discussion of the results of these studies constitute the remainder of this report.

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