SURFACE TO SUBSURFACE CORRELATION OF PENNSYLVANIAN AND LOWER PERMIAN ROCKS ACROSS SOUTHERN NEBRASKA

R. R. Burchett

Nebraska Geological Survey
Report of Investigations No. 8

Conservation and Survey Division
Institute of Agriculture and Natural Resources
The University of Nebraska–Lincoln

REPORT OF INVESTIGATIONS

NUMBER 8 OCTOBER 1983

Surface to Subsurface Correlation of Pennsylvanian and Lower Permian Rocks Across Southern Nebraska

R. R. Burchett

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October 1983

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ABSTRACT

Recent studies of Pennsylvanian and lower Permian age rocks in Nebraska have added new detail to older correlations. This study presents a detailed correlation from the outcrop area in eastern Nebraska to the subsurface rocks of southwestern Nebraska. Letter designations used previously by the oil industry for Pennsylvanian limestone zones in southwestern Nebraska can be discarded and stratigraphic names used in their places. In descending order the relationship of surface stratigraphic names to subsurface zones is as follows: "A" zone--Cass Limestone Formation; "B" zone--Stanton Limestone Formation; "C" zone--Wyandotte Limestone Formation; "D" zone--Iola Limestone Formation; "E" zone--Sarpy Limestone Formation; "F" zone--Dennis Limestone Formation; "G" zone--Swope Limestone Formation; "H" zone--Hertha Limestone Formation.

FACTORS FOR CONVERTING ENGLISH UNITS TO THE INTERNATIONAL SYSTEM OF UNITS (SI)

Multiply English Units	By	To obtain SI Units
	Length	
inches (in)	25.4	millimeters (mm)
feet or foot (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
	Area	
acres	4047	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
	Volume	
acre-feet (acre-ft)	1233	cubic meters (m^3)
	Flow	
gallons per minute (gpm)	.00006309	cubic meters per second (m^3/s)

INTRODUCTION

Rocks of Pennsylvanian and Permian age outcrop in eastern Nebraska. These surface exposures have been measured, described, and correlated by various geologists for over one hundred years (Burchett, 1979, pp. 1, 4). More recent geological and geophysical studies in eastern Nebraska (Burchett, 1982; Burchett et al, 1983) have added new detail to the older correlations. However, surface to subsurface relationships need to be determined so that more accurate correlations can be established.

Subsurface correlations in southwestern Nebraska have been used by the oil industry based on a study written by Larson (1962) of the Lansing-Kansas City Group (Pennsylvanian). This study used letter designations for individual limestone zones. Other letter designations have been proposed by Morgan (1952) and Watney (1980) for northwestern Kansas and southwestern Nebraska. These letter designations are more detailed than Larson's and present terminology problems when discussing various beds within the Pennsylvanian because they are not correlative.

The purpose of this report is to present correlations of the Pennsylvanian and lower Permian rocks extending from the surface outcrop area in eastern Nebraska into the subsurface across the southern part of the state and ending in southwestern Nebraska (fig. 1, plate I). Special emphasis will be placed on formation correlations of the Shawnee, Douglas, and Lansing-Kansas City groups.

GEOLOGIC SETTING

Pennsylvanian rocks in Nebraska rest unconformably on rocks ranging in age from Precambrian to Mississippian. Generally, the unconformity is marked by a basal sand or detrital zone of angular quartz sand and weathered chert. The pre-Pennsylvanian

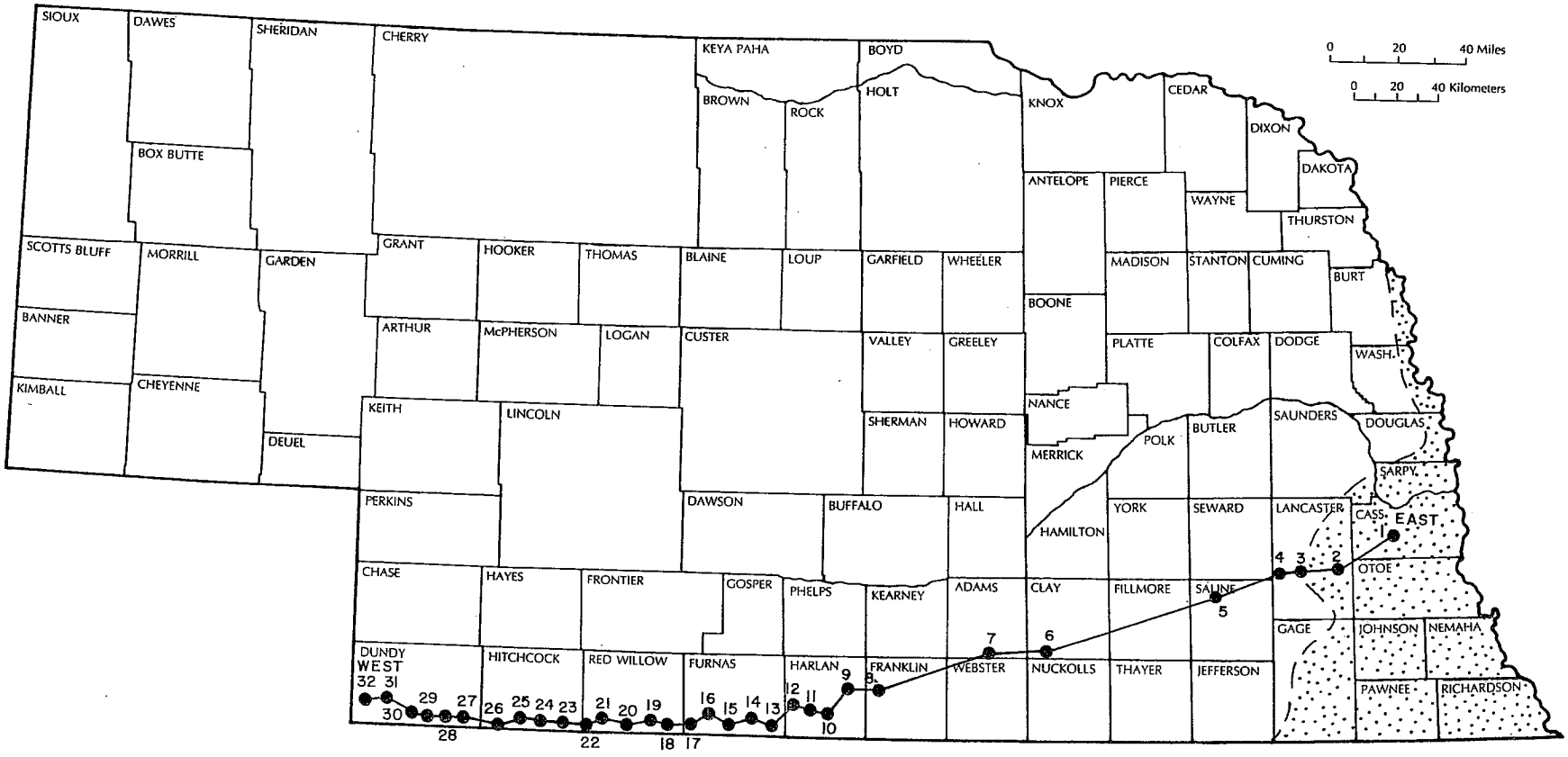

Fig. 1. Location of east-west cross section. Numbers refer to wells on cross section (pl. I). The stippled pattern indicates the generalized area where outcropping rocks of Pennsylvanian and Permian age may be found.

rocks have been studied in detail by Carlson (1963, 1970).

Pennsylvanian strata in Nebraska are overlain by rocks ranging in age from Permian to Quaternary. Where the Pennsylvanian-Permian contact is visible in southeastern Nebraska, a period of erosion without significant diastrophism is indicated; at least one sand-filled channel of Permian age cuts approximately 100 feet into Pennsylvanian rocks. Placement of the Pennsylvanian-Permian boundary has been summarized by Moore (1940, pp. 298-305; 1949, pp. 19-22) and by Mudge and Yochelson (1962, pp. 116-127).

The principal structural features of Nebraska are shown in figure 2 along with the location of an east-west electric-log cross section. Major movement on most of these structural features took place in late Mississippian and early Pennsylvanian time, accounting for the unconformable relation of Pennsylvanian strata to the older rocks.

STRATIGRAPHY

Pennsylvanian System

The thickness of Pennsylvanian rocks in Nebraska ranges from a featheredge in the northeastern part of the state to slightly more than 2,100 feet in the extreme southeastern part (fig. 3). Outcropping Pennsylvanian rocks have a combined thickness of about 900 feet, as shown in figure 4. Pennsylvanian thicknesses for the Central Nebraska Basin, Cambridge Arch, and Denver-Julesburg Basin are more than 1,200 feet, less than 500 feet, and more than 1,100 feet, respectively.

The Pennsylvanian sequence in Nebraska is characterized by a repetition of cycles of marine shale and limestone alternating with nonmarine sandstones and shales. Lateral lithologic changes occur within the formations, too.

Pennsylvanian rocks in Nebraska have been divided into five series. In ascending order, these are Morrow(?), Atoka, Des

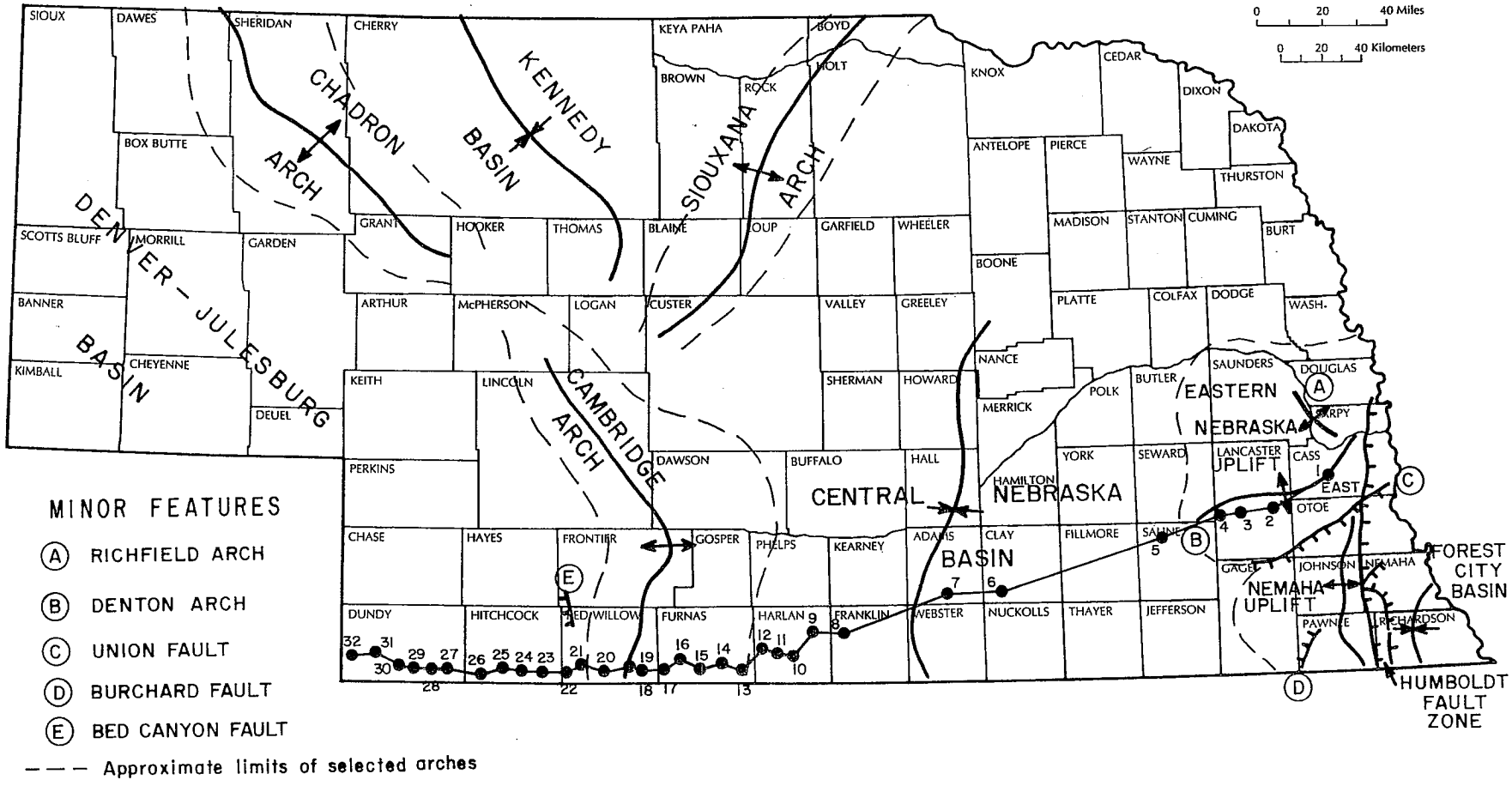

Fig. 2. Principal structural features of Nebraska and location of east-west cross-section.

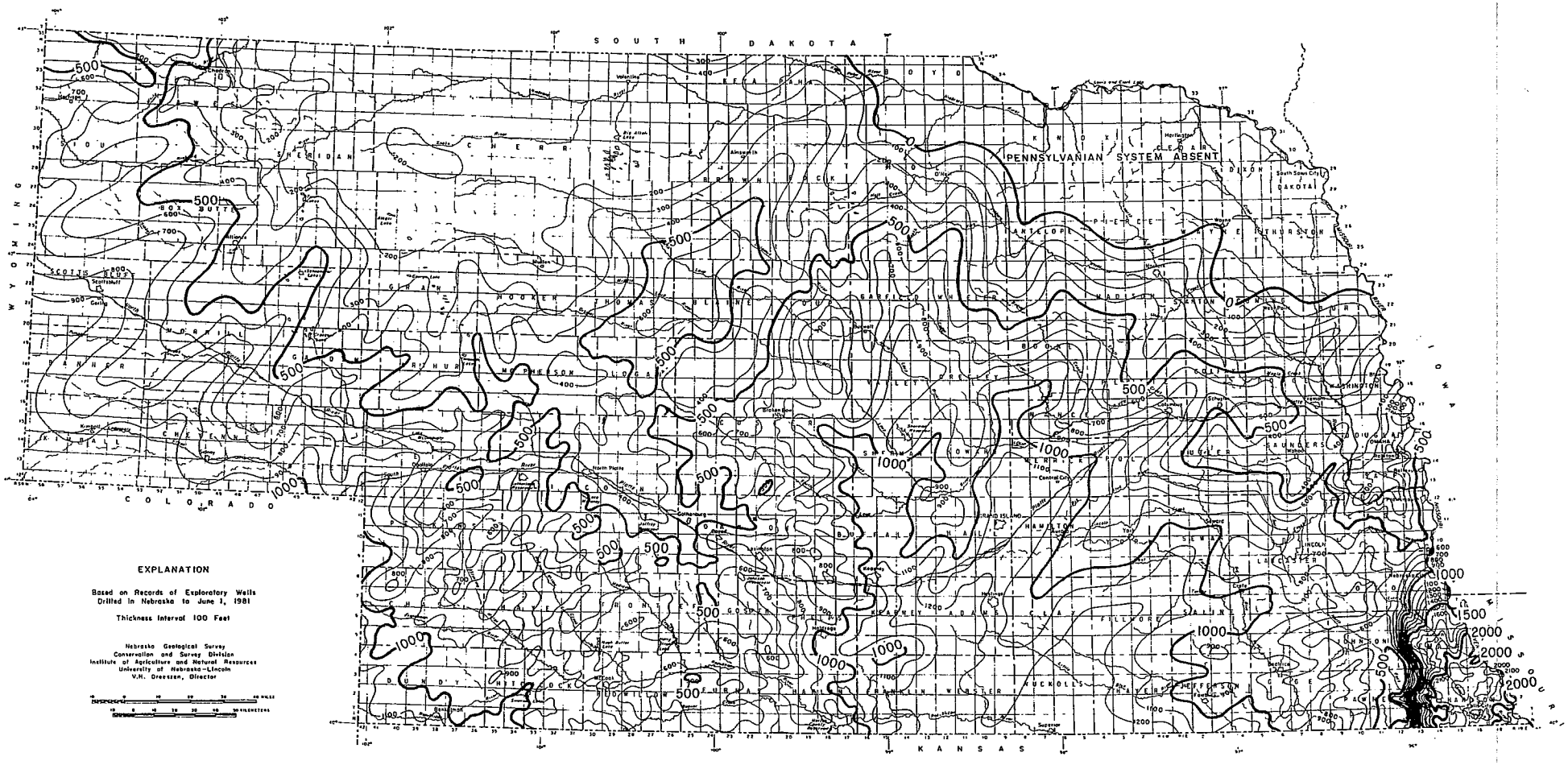

Fig. 3. Thickness of the Pennsylvanian System in Nebraska (from Burchett, 1982).

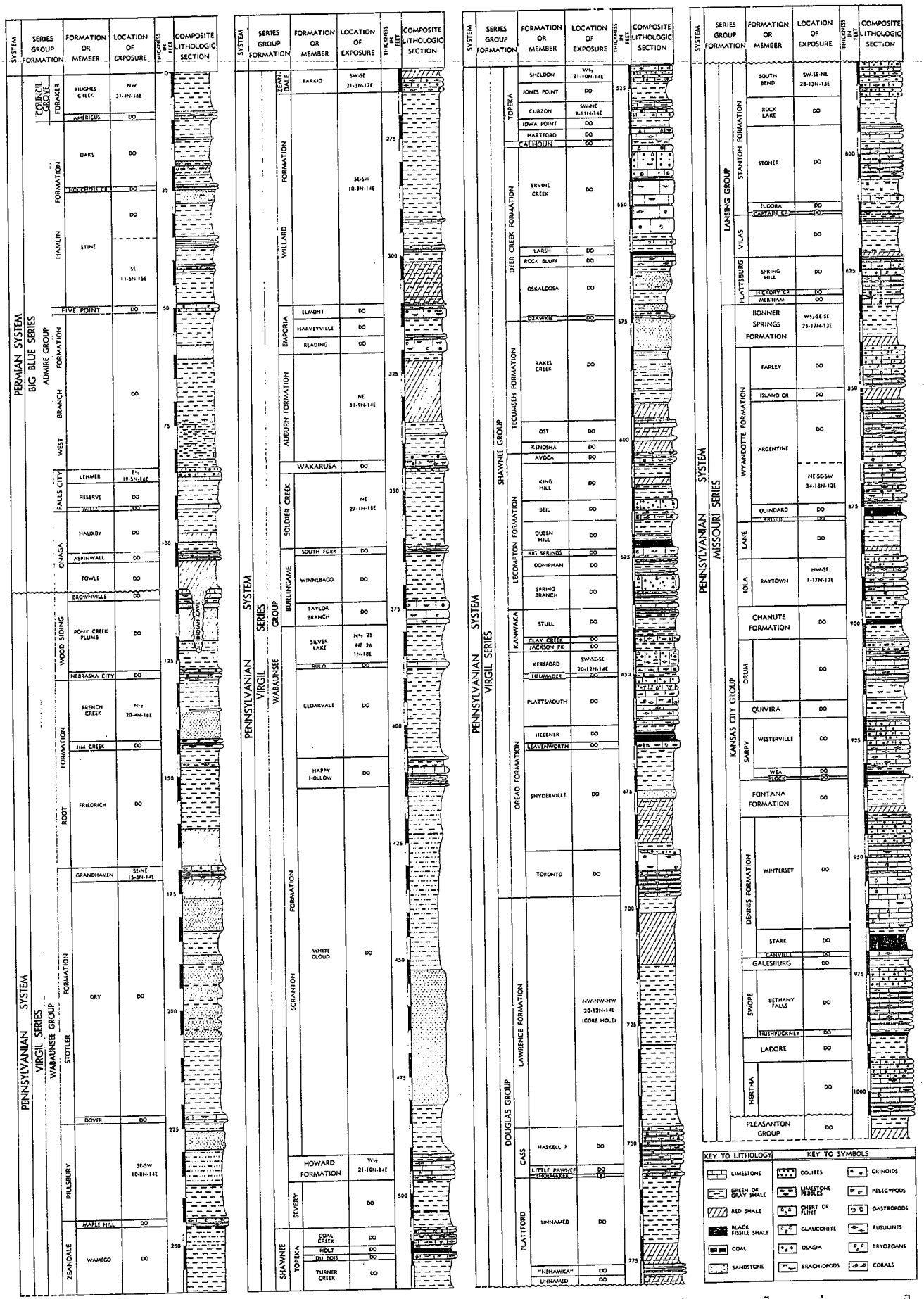

Fig. 4. Composite section of outcropping upper Pennsylvanian and lower Permian rocks in eastern Nebraska (from Burchett, 1971).

Moines, Missouri, and Virgil. Of these, only the rocks of the Missouri and Virgil Series are exposed (Burchett, 1982, p. 3).

Morrow(?) Series

The oldest Pennsylvanian rocks in Nebraska have been assigned to the Morrow(?) Series. They may be present in the southwestern part of the state, but definite age relationships have not been established. Rocks of the Morrow(?) Series are not present in the Forest City Basin, where each of the four other series have been identified.

Atoka Series

Strata assigned to the Atoka Series are the oldest Pennsylvanian rocks in southeastern Nebraska. In the Forest City Basin, they are about 300 feet thick and consist mostly of dark shale but include some sandstone layers. Because they do not crop out, they are known only from well samples and logs of drill holes.

Des Moines Series

Rocks of the Des Moines Series overlie those of the Atoka Series. They are about 750 feet thick in the deepest part of the Forest City Basin, and are very thin or absent in northeastern, west-central, and southeastern Nebraska (fig. 5). Thicknesses in the Central Nebraska Basin and Denver-Julesburg Basin are over 400 feet and over 500 feet, respectively. The series has been divided into the older Cherokee Group and the younger Marmaton Group. Like the Atoka Series, the Des Moines Series does not crop out and is known only from logs of drilled holes.

Cherokee Group.--The Cherokee Group consists mostly of varicolored shale but includes beds of sandstone, coal, and

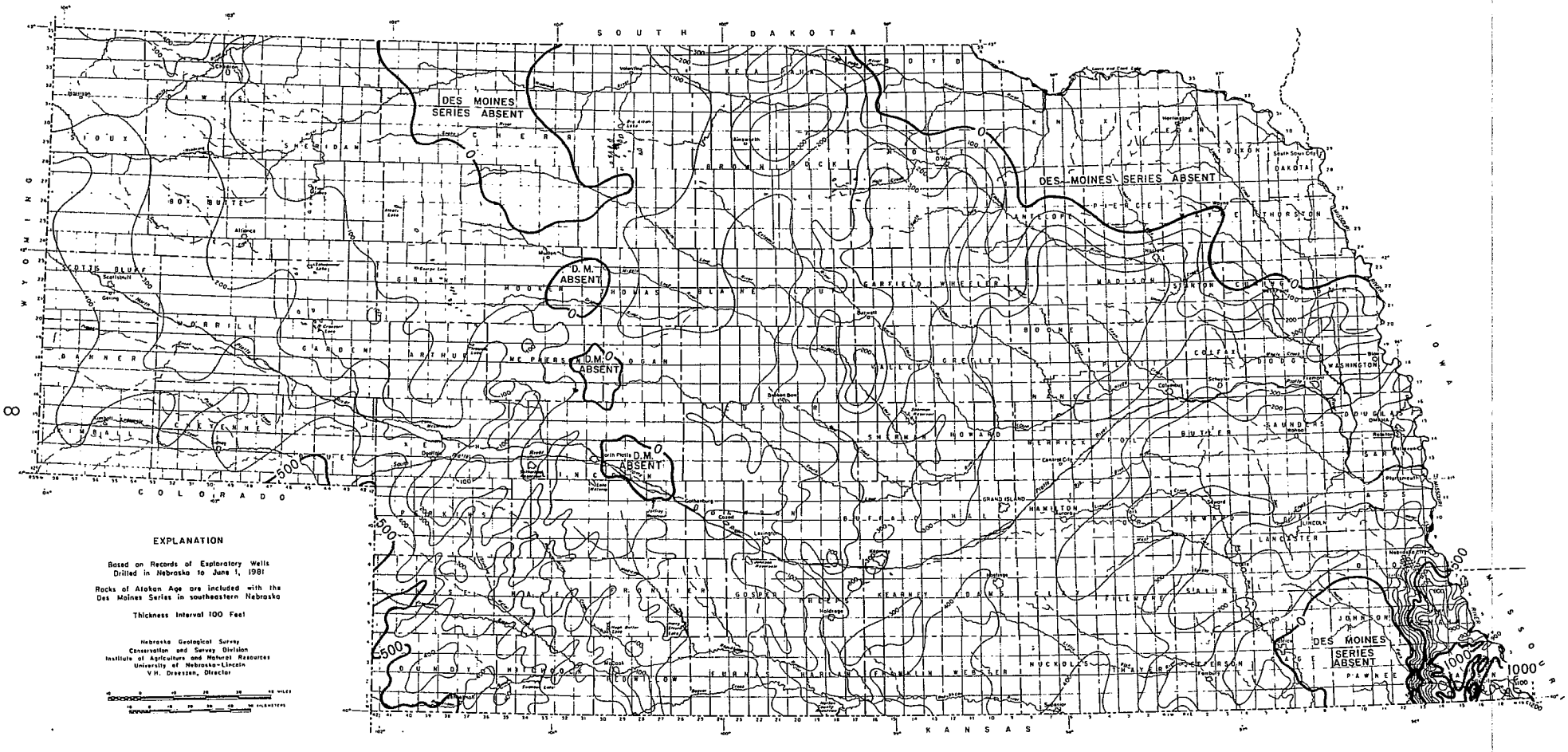

Fig. 5. Thickness of the Des Moines Series and older Pennsylvanian in Nebraska (from Burchett, 1982).

thin limestone. In the deepest part of the Forest City Basin, the group has a maximum thickness of about 575 feet. It is absent in northeastern, southeastern, and west-central Nebraska. Maximum thickness of the Cherokee in the Central Nebraska Basin is over 300 feet and maximum thickness in the Denver-Julesburg Basin, in southwestern Nebraska, is over 400 feet. Cherokee rocks do not crop out and are not divided into formations in Nebraska.

Marmaton Group.--Marmaton rocks in Nebraska, consisting in large part of varicolored shale, include considerable limestone, some sandstone, and few thin beds of coal. The Marmaton is partially present (pl. I, well 1-4 and 13-20) or absent over parts of eastern, northeastern, and west-central Nebraska. Thicknesses range from 30 to 160 feet, averaging about 150 feet. Although the Marmaton Group is somewhat difficult to divide in the subsurface of Nebraska, six formations have been tentatively identified. In ascending order, they are the Fort Scott Limestone, Labette Shale, Pawnee Limestone, Bandera Shale, Altamont Limestone, and Nowata Shale. An unconformity separating the Marmaton Group rocks from the overlying Missouri Series indicates that the upper Marmaton strata were eroded before deposition began again.

Missouri Series

The oldest outcropping rocks of Pennsylvanian age in Nebraska belong to the Missouri Series. They consist mainly of interbedded limestone and shale but include a few beds of sandstone. Individual beds of this series have a large areal extent and can be traced from one geographic area to another. The upper boundary of this series is unconformable with the overlying Virgil Series. The lower boundary is regionally disconformable with the underlying Des Moines Series. Thicknesses range from zero to 225 feet in the outcrop area to more than 250 feet in southwestern Nebraska (fig. 6). Three groups composing the

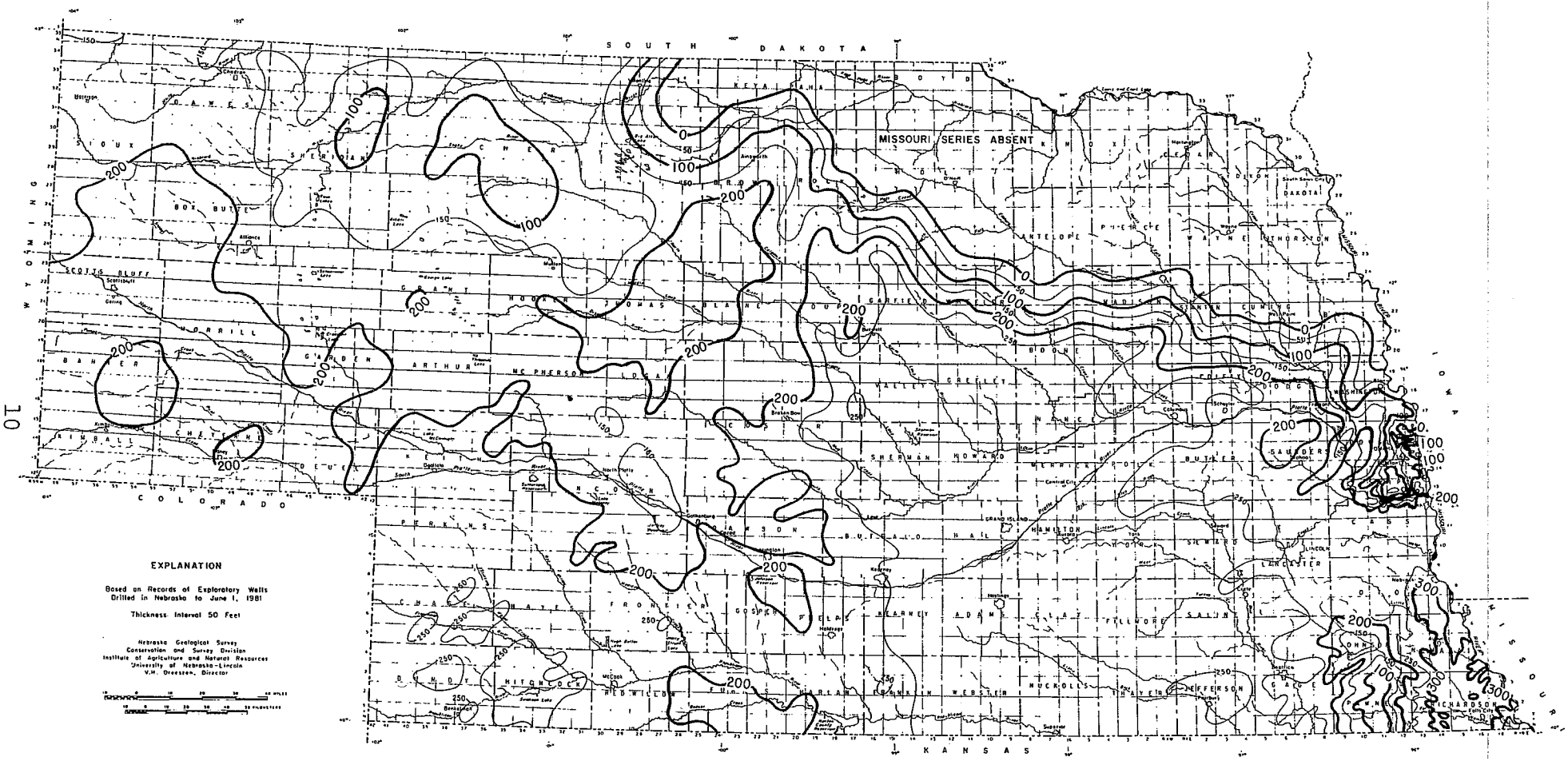

Fig. 6. Thickness of the Missouri Series (Pennsylvanian) in Nebraska (from Burchett, 1982).

series are, from oldest to youngest, the Pleasanton, Kansas City, and Lansing. Member names are shown in figure 4.

Pleasanton Group

Most of the rocks of the Pleasanton Group are mottled red and green shales; some sandstone or limestone also may be present. Resting unconformably on rocks of the Marmaton Group, only the upper few feet of these clastic sediments crop out in Nebraska. Thicknesses range from a featheredge to about 25 feet in drill holes of eastern Nebraska and thicken into the Forest City Basin. Rocks of the Pleasanton Group in central and western Nebraska are in this study either assumed to be absent or are combined with the Marmaton Group.

Kansas City Group

Rocks of the Kansas City Group consist of cyclically alternating limestone and shale. In Cass, Sarpy, Saunders, and Washington counties, where this group is exposed, its minimum thickness is about 170 feet. Average thicknesses in the Central Nebraska Basin, over the Cambridge Arch, and in the Denver-Julesburg Basin are 230, 160, and 260 feet, respectively. From oldest to youngest, the 14 formations comprising the group are as follows: Hertha Limestone, Ladore Shale, Swope Limestone, Galesburg Shale, Dennis Limestone, Fontana Shale, Sarpy Limestone, Quivira Shale, Drum Limestone, Chanute Shale, Iola Limestone, Lane Shale, Wyandotte Limestone, and Bonner Springs Shale (see fig. 4 for member names).

Lansing Group

Limestone and shale are the principal constituents of the Lansing Group. Where this group crops out in Douglas, Sarpy, and Saunders counties, it has a maximum thickness of about 50 feet. The thickness of the Lansing Group westward from the

outcrop area changes very little as it extends into the Central Nebraska Basin. Of the three formations composing this group, the Plattsburg Limestone is the oldest, the Vilas Shale is next oldest, and the Stanton Limestone is the youngest. Member names for these three formations are shown on figure 4. The upper surface of the Stanton is an unconformity that separates the Missouri Series from the overlying Virgil Series.

Virgil Series

The youngest exposed Pennsylvanian rocks in Nebraska constitute the Virgil Series. These rocks are marked at the upper and lower boundaries by unconformities and have a maximum thickness of over 800 feet in the southeastern corner of the state. The Virgil Series consists mainly of alternating beds of shale, limestone, sandstone, and thin beds of coal. Outcrops are widespread in southeastern Nebraska, having an aggregate thickness of 600 feet. Some of the upper beds have been removed by erosion in eastern Nebraska. Thicknesses of the Virgil Series in the Central Nebraska Basin are over 600 feet, with some thinning over the Cambridge Arch. Thickening again occurs into the Denver-Julesburg Basin to over 300 feet (fig. 7). The Virgil Series is divided into three groups in Nebraska. From oldest to youngest, these are the Douglas, Shawnee, and Wabaunsee groups. Member names are shown on figure 4.

Douglas Group

The Douglas Group consists mostly of shale interbedded with limestone but includes also some sandstone and a few beds of thin coal. It is about 60 feet thick where the group crops out in Cass and Sarpy counties, with approximately the same thickness in the Central Nebraska Basin. In ascending order, the Douglas Group is composed of the Plattford Shale, Cass Limestone, and Lawrence Shale formations. Individual member names are shown on figure 4.

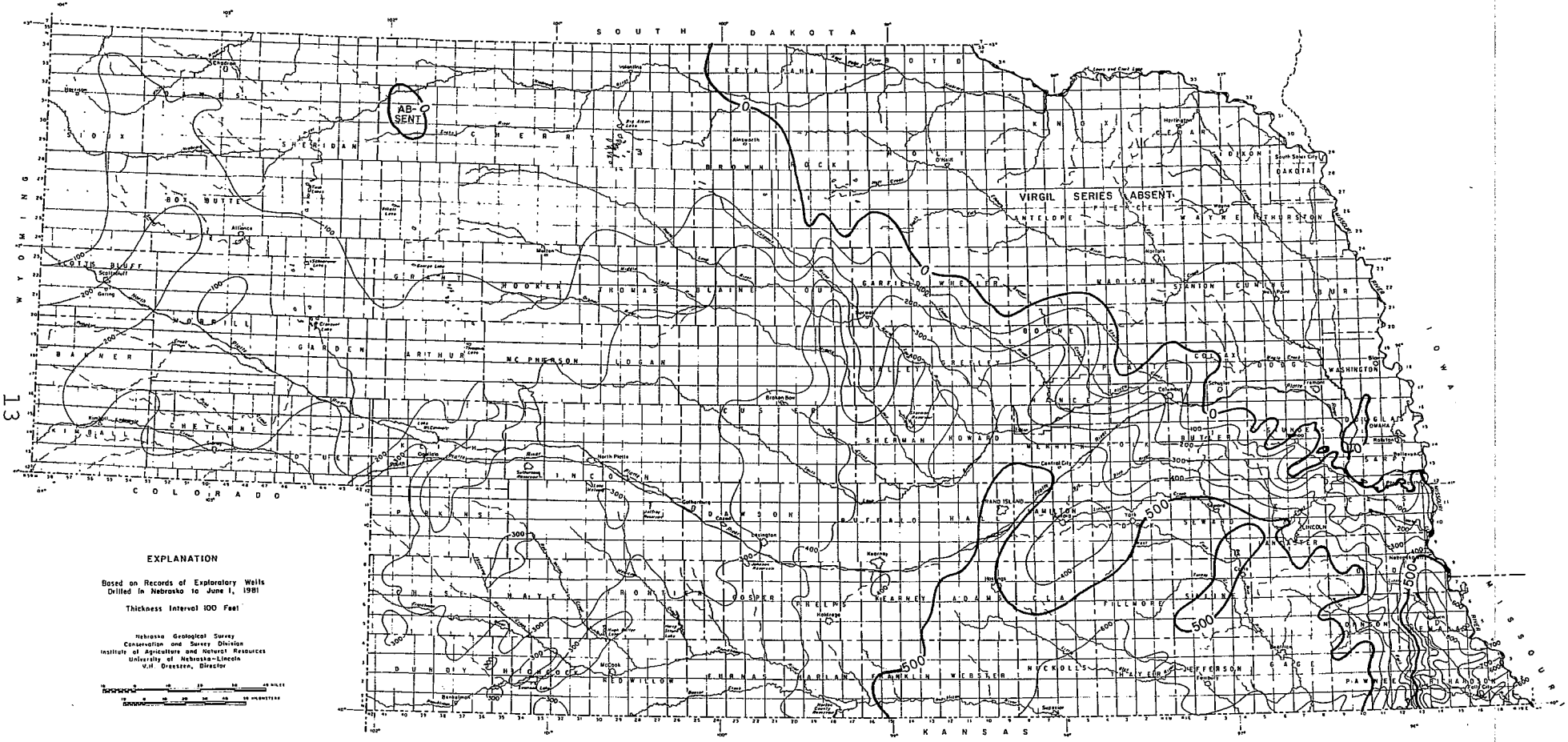

Fig. 7. Thickness of the Virgil Series (Pennsylvanian) in Nebraska (from Burchett, 1982).

Shawnee Group

Unconformably overlying the Douglas Group is a distinctive cyclic sequence, the Shawnee Group, consisting mainly of limestones interbedded with shales and a few sandstones. This group crops out in Cass, Otoe, Pawnee, and Saunders counties. Its thickness ranges from 175 feet in eastern Nebraska to more than 190 feet in the Central Nebraska Basin. From oldest to youngest, the Shawnee Group comprises the following seven formations: Oread Limestone, Kanwaka Shale, Lecompton Limestone, Tecumseh Shale, Deer Creek Limestone, Calhoun Shale, and Topeka Limestone. (See fig. 4 for member names.)

Wabaunsee Group

Although the Wabaunsee Group includes several thin persistent layers of limestone and a few very thin coal beds, it consists mostly of shale, sandy shale, and sandstone. Outcrops occur in Cass, Johnson, Nemaha, Otoe, Pawnee, and Richardson counties; wherever the basal beds are exposed, the Wabaunsee Group unconformably overlies the Shawnee Group. Exposures of the group's upper boundary indicate that a period of erosion preceded deposition of the overlying rocks of Permian age. Locally, channels incised as much as 100 feet into Wabaunsee rocks are filled with Permian sandstone. In northeastern Nebraska the upper part of the Wabaunsee Group either was not deposited or was removed by erosion. Maximum thickness of the Wabaunsee in the outcrop area is 400 feet, with a slight thickening as it extends into the Central Nebraska Basin. Thicknesses over the Cambridge Arch and Denver-Julesburg Basin are highly variable. From oldest to youngest, the following 14 formations constitute the Wabaunsee Group: Severy Shale, Howard Limestone, Scranton Shale, Burlingame Limestone, Soldier Creek Shale, Wakarusa Limestone, Auburn Shale, Emporia Limestone, Willard Shale, Zeandale Limestone, Pillsbury Shale, Stotler

Limestone, Root Shale, and Wood Siding (see fig. 4 for member names).

Permian System

Permian rocks in Nebraska are absent in the northeastern part of the state and have a maximum thickness of more than 1,500 feet in the south-central part (fig. 8).

The Permian is composed primarily of shale, limestone, and sandstone in the outcrop area of southeastern Nebraska. In the western part of the state, the Permian consists primarily of red shale, dolomitic limestone, anhydrite, gypsum, salt, and sandstone. Permian rocks in Nebraska are divided into three series. In ascending order, these are the Big Blue, Cimarron, and Custer. Only rocks of the Big Blue Series are exposed and only the lower portion of the Big Blue Series is discussed in this report.

Big Blue Series

Rocks of the Big Blue Series are exposed in southeastern Nebraska. Thickness of the series ranges from a featheredge in northeastern Nebraska to more than 800 feet in south-central Nebraska (fig. 9).

Big Blue Series rocks have been divided into three groups. In ascending order, these are the Admire, Council Grove, and Chase (Burchett, 1982, p. 3).

Admire Group.--Rocks of the Admire Group consist primarily of shales with interbedded thin limestones. The group is about 100 feet thick in eastern Nebraska, 140 feet thick in the Central Nebraska Basin, 120 feet thick over the Cambridge Arch, and from 65 to 125 feet thick in the Denver-Julesburg Basin.

In the outcrop area, five formations are recognized. These are in ascending order the Onaga Shale, Falls City Limestone, West Branch Shale, Five Point Limestone, and Hamlin Shale. (See

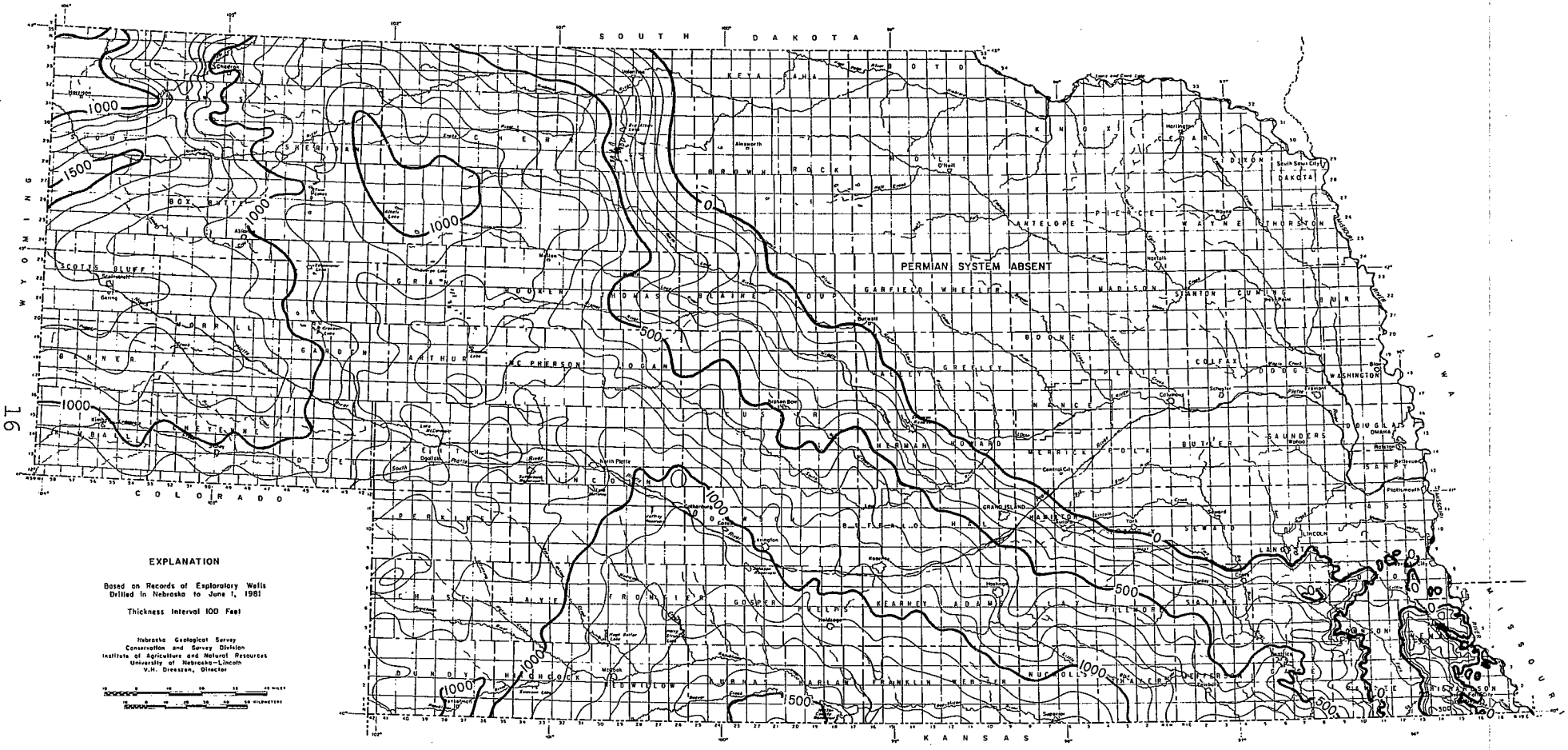

Fig. 8. Thickness of the Permian System in Nebraska (from Burchett, 1982).

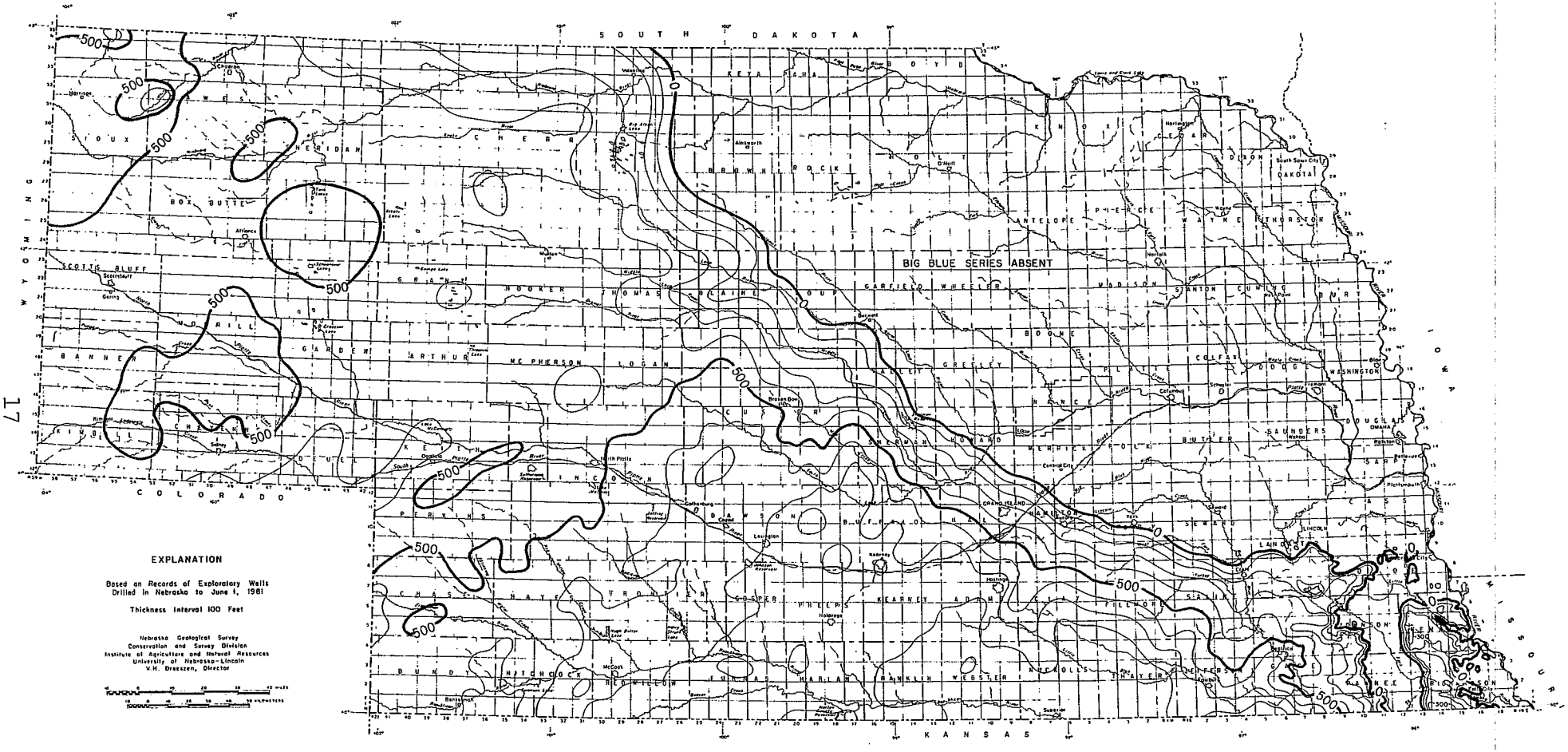

Fig. 9. Thickness of the Big Blue Series (Permian) in Nebraska (from Burchett, 1982).

fig. 4 for member names.)

Council Grove Group.--The Council Grove Group consists primarily of shale, limestone, and gypsum in the outcrop area. Farther west the group consists of dolomitic limestone, red shale, anhydrite, gypsum, and sandstone.

The Council Grove Group is divided into 14 formations (Condra and Reed, 1943, pp. 33-36), the youngest of which is the Foraker, the only one discussed in this report because it is easily recognized in the subsurface on electric logs.

The Foraker consists primarily of shale interbedded with thin limestone in the outcrop area, grading to the west into limestone or dolomitic limestone interbedded with thin shale. The formation averages about 50 feet in thickness along the cross section.

CORRELATION

The cross section presented in this study (pl. I) shows the correlation of Pennsylvanian and lower Permian rocks from the outcrop belt in eastern Nebraska to the subsurface of southwestern Nebraska. The top of the easily recognized Heebner Shale (Oread Formation) is used as a datum.

Correlation between the outcrop area of eastern Nebraska into the Central Nebraska Basin seems to reflect only subtle changes in the individual beds of Pennsylvanian and Permian age (pl. I, wells 1-12). The most change occurs where individual identifiable beds pinch out over the Cambridge Arch, giving rise in the past to miscorrelation.

In 1962, Larson used an alphabetic nomenclature as a substitute for stratigraphic names of individual limestone beds in the Ackman Oil Field in Red Willow County, Nebraska. This use of letter designations for various limestones in the Pennsylvanian has been modified and widely used by the oil and gas industry.

However, this letter designation system has proven unsatisfactory when used between the states of Nebraska and Kansas because different letter designations have been applied to the same stratigraphic units. Correlations can be carried from eastern Nebraska into southwestern Nebraska and stratigraphic names can be used instead of the letter designations.

No attempt was made to correlate the Pleasanton Group west of the composite section (no. 1) on plate I. Rocks of Pleasanton Group thicken into the Forest City Basin, but for this study they are either assumed to be absent in central and western Nebraska or combined with the Marmaton Group.

Almost all the beds in the Kansas City Group are present and traceable from the outcrop area into the Central Nebraska Basin. (See pl. I, wells 1-12.) Some of the beds of the Kansas City Group pinch out over the Cambridge Arch and do not appear in the Denver-Julesburg Basin. Examples of these pinchouts are shown on plate I in well 13, where the Drum Limestone is absent; well 14, where the Hertha Limestone is absent locally but is present in wells 15-32; well 15, where the Plattsburg Limestone is absent; and wells 16-32, where the upper part of the Wyandotte Formation (Farley Limestone Member) is absent.

The Plattsburg Limestone is absent in well 15, plate I, and farther west, thus merging the Lansing-Kansas City into one group. The upper member of the Stanton Formation (South Bend Limestone) is absent in wells 19-32 with an unconformable contact between the Lansing and overlying Douglas Group.

The upper boundary of the Douglas Group becomes uncertain west of well number 15, plate I, because the lower Oread (Toronto Limestone) is absent, thus creating an unconformable contact between the Douglas Group (Lawrence Shale) and Shawnee Group (Snyderville Shale).

Formations and members (fig. 4) of the Shawnee Group are persistent from the outcrop area into the Central Nebraska Basin. The upper and lower parts of the Shawnee Group are absent or missing over the crest of the Cambridge Arch. The lower member of the Oread Limestone (Toronto Limestone) is absent in wells

16-32, plate I. Also the upper formation of the Shawnee (Topeka Limestone) is eroded or absent in wells 14-27, plate I, but is present in the Denver-Julesburg Basin in wells 28-32.

Correlation of the individual members of the Wabaunsee and Admire groups in the subsurface of southwestern Nebraska was not attempted in this study.

An electric log used on the cross section (pl. I, well 20) has been expanded and reproduced as figure 10. The relationship of subsurface classification in southwestern Nebraska to the named surface stratigraphic equivalents of eastern Nebraska is shown in the figure. In descending order, the relationship of surface stratigraphic names to subsurface zones in southwestern Nebraska is as follows: "A" zone--Cass Limestone Formation; "B" zone--Stanton Limestone Formation; "C" zone--Wyandotte Limestone Formation; "D" zone--Iola Limestone Formation; "E" zone--Sarpy Limestone Formation; "F" zone--Dennis Limestone Formation; "G" zone--Swope Limestone Formation; "H" zone--Hertha Limestone Formation. The Foraker Limestone is included on the cross section because it has a distinctive electric-log signature and seems to be very persistent across the area of study.

Several unpublished theses have been written on individual beds of the Pennsylvanian in southwestern Nebraska and Kansas in the last few years. These theses give many of the detailed descriptions of the cores and samples of stratigraphic units referred to in this study. Busch (1977) studied the "B" zone (Stanton Limestone Formation) in Red Willow County, Nebraska. An "E" zone (Sarpy Limestone Formation) study of Hitchcock County was written in 1979 by Dubois. Prather (1981) made a detailed study of the "D" zone (Iola Limestone Formation) in Hitchcock County. In 1982, two theses were written on southwestern Nebraska, one by Frankforter on the "C" zone (Wyandotte Limestone Formation) and the other by Bolitho on the "A" zone (Cass Limestone Formation) in Red Willow County. Two other theses in progress (1983) are by Bruce Kintner on the "F" zone (Dennis Limestone Formation) in Hitchcock County, and Steve Callaway on the "D" zone (Iola Limestone Formation) of Red Willow County.

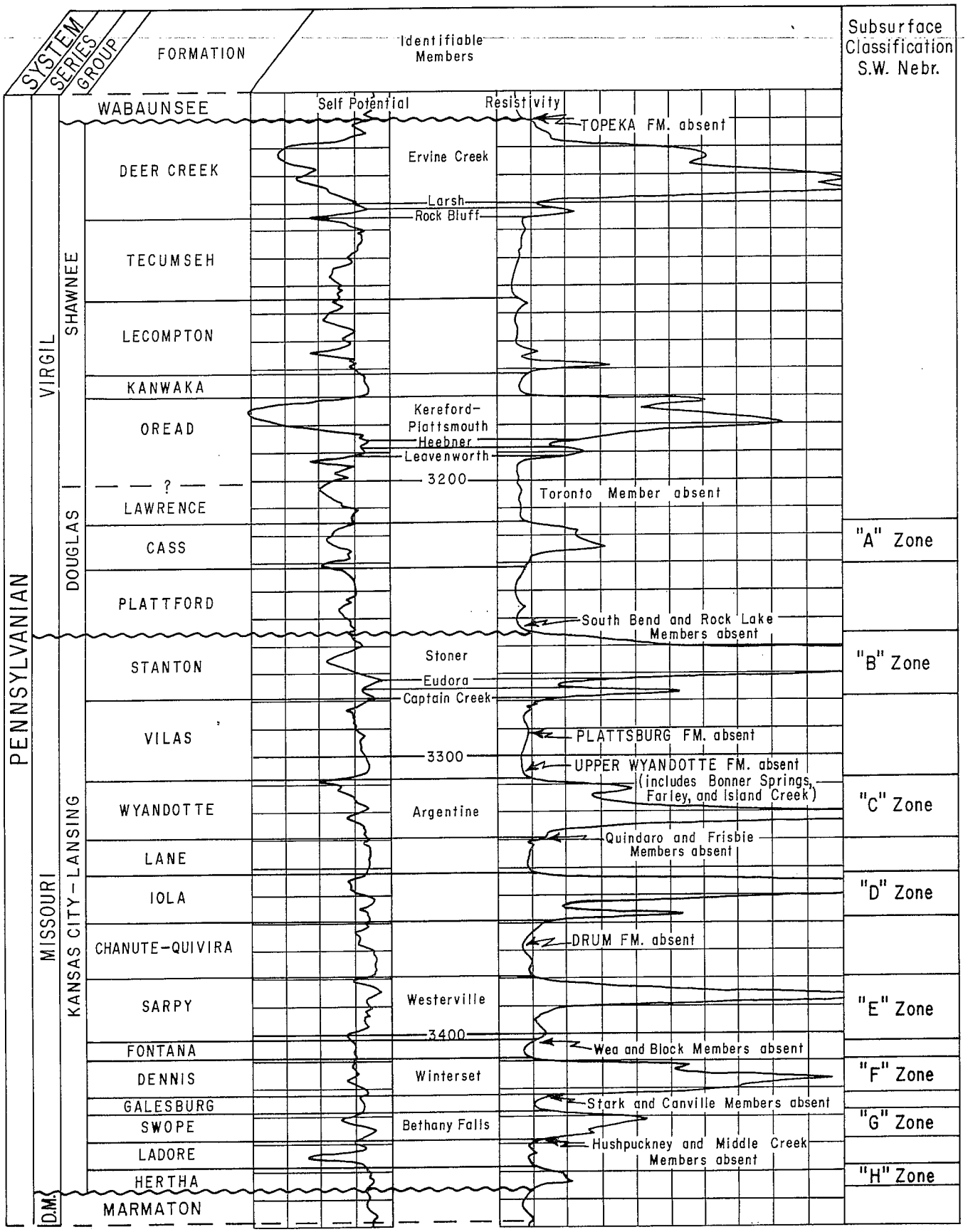

Fig. 10. Electric log (pl. I, well 20) C SE NW, sec. 26, T. 1 N., R. 28 W., from Red Willow County, Nebraska, showing the relationship of subsurface classification to the named stratigraphic equivalents of the outcrop area in eastern Nebraska.

SUMMARY

Pennsylvanian rocks in Nebraska, resting unconformably on rocks ranging in age from Precambrian to Mississippian, are overlain by rocks ranging in age from Permian to Quaternary.

Pennsylvanian and Permian rocks are absent in northeastern Nebraska. Maximum thickness of the Pennsylvanian rocks is slightly over 2,100 feet in the southeastern corner of the state. The Permian rocks have a maximum thickness of slightly over 1,500 feet in south-central Nebraska.

Stratigraphic units of the Pennsylvanian and lower Permian rocks can be traced from the outcrop area of eastern Nebraska into the subsurface zones of southwestern Nebraska. These units, shown in figure 10 and plate I, are summarized as follows:

- Pennsylvanian System
  - Virgil Series
    - Wabaunsee Group
    - Shawnee Group
    - Douglas Group
      - Cass Limestone Formation--"A" zone
  - Missouri Series
    - Lansing Group
      - Stanton Limestone Formation--"B" zone
    - Kansas City Group
      - Wyandotte Limestone Formation--"C" zone
      - Iola Limestone Formation--"D" zone
      - Sarpy Limestone Formation--"E" zone
      - Dennis Limestone Formation--"F" zone
      - Swope Limestone Formation--"G" zone
      - Hertha Limestone Formation--"H" zone

During the last few years, several theses have been written on rocks of Pennsylvanian age in Nebraska. These and future studies should provide more detail on the geologic development of Nebraska.

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