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The Pennsylvanian Formations of Southeastern Nebraska

Geo E. Condra

University of Nebraska-Lincoln

N. A. Bengtson

University of Nebraska-Lincoln

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NEBRASKA PHYSICAL AND
SOCIAL SCIENCE SERIES

ADDISON E. SHELDON, Editor


Conservation & Survey Division
113 Nebraska Hall
University of Nebraska-Lincoln

THE PENNSYLVANIAN FORMATIONS OF
SOUTHEASTERN NEBRASKA

By GEO. E. CONDRA
AND
N. A. BENGTON,
The University of Nebraska

A summary report of papers given before the Nebraska
Academy of Sciences

OFFICERS NEBRASKA ACADEMY OF SCIENCES, 1914-1915

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Nebraska Academy of Sciences
Publications

Vol. IX

No. 2

*Deceased February 25, 1915

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EDITOR'S PREFACE

This pamphlet is a part of the quarter-centennial volume of the Nebraska Academy of Sciences now in progress of publication. The completed volume will contain numerous valuable monographs of original research in the field of the physical and social sciences within the borders of Nebraska. It will also contain historical sketches of the progress of each of these sciences in our state, from both view points, research and teaching, together with the names of the men and women who have had part in this work from the first beginnings of scientific work in Nebraska until the present time.

March 1, 1917, marks the first half century of Nebraska's existence as a state in the American Union. This quarter-centennial memorial volume of the Nebraska Academy of Sciences is designed to gather and put in concise, accurate and attractive form the record of Nebraska's achievements in the sciences as a contribution to the history of our state, an aid to the fit celebration of this first half century of our state's existence, and an incentive and inspiration for that splendid group of young scientists reared upon Nebraska soil, who are soon to take up the work of scientific progress so well begun by the pioneers. It is also designed to be a personal memorial to the life and labors of Dr. Charles E. Bessey, president of this Academy at the time of his death, February 25, 1915.

In this monograph by Dr. Condra and Professor Bengtson is contained a summary of research work extending over a period of seventeen years. The discoveries herein set forth are of a most important nature materially modifying earlier reports upon the geology of southeastern Nebraska and furnishing to the general public, as well as the expert geologist, information of great practical importance as well as scientific interest upon that section. A knowledge of the rocks of a region, their order, distribution and content, is of fundamental importance to the human society which lives above them, as the rocks themselves are to the physical

structure of the planet. The study of Nebraska structure herein contained is a large contribution to our physiographic knowledge and an incentive for further intensive study within our state.

Especially valuable and attractive are the original half-tone illustrations and charts which accompany this monograph. Only those who have labored with the camera, field notes and drafting instruments in this and similar fields can realize the amount of painstaking work in them.

University of Nebraska,
May 10, 1915.

Addison E. Sheldon,
Secretary.

THE PENNSYLVANIAN FORMATIONS OF
SOUTHEASTERN NEBRASKA

by

G. E. Condra and N. A. Bengtson
The University of Nebraska

Most members of this Academy have some acquaintance with the work of Meek, Hayden, Prosser, Broadhead, Haworth, Calvin, Todd and Beede. They and other geologists have studied the stratigraphy of southeastern Nebraska and adjacent areas of Kansas, Missouri and Iowa. Early geological work done in Nebraska is now recognized as good reconnaissance. Geologists have been slow, however, in completing a detailed survey of the Pennsylvanian formations of our state and not without cause. The delay has been due largely to conditions which make accurate field work more difficult here than in most regions. Much of the bed rock is covered with drift and loess, reducing the number of outcrops and making it difficult to trace constants. Other states have been slow to study their Pennsylvanian formations in similar areas. For example, in Kansas, the stratigraphy has been worked with great detail south of the drift, but the glaciated part remains practically untouched.

The reports we present are based on studies which have been in progress several years. It was the privilege of the senior author to determine the larger natural divisions of Nebraska's Pennsylvanian strata in 1898. Trips were made to Iowa, Missouri, Kansas and as far as Oklahoma for the purpose of correlation. Later, special stratigraphic problems were assigned to graduate students. Mr. E. L. Edwards studied the Platte section with considerable detail. His work has been checked and extended. Professor R. J. Scarborough of the Nebraska Wesleyan University mapped and described the stratigraphy of the Weeping Water Valley. The Missouri River and Nemaha sections were studied

by the authors and assistants. The correlation of the members of the different sections was the last part of our problem to receive attention.

The members of these sections persist over much wider areas than some have claimed. They do not dip gradually westward, as is generally believed. We find a structure basin in which the lowest points are in the vicinity of Nebraska City and Auburn, from which the strata rise southward, westward and northward. The members emerge from this basin at or near the state line on the south, in Otoe and Cass counties on the north and westward to a line between Oreapolis and Pawnee City, beyond which is a slight dip westward, the Pennsylvanian strata passing under the Permian, except where the Dakota formation lies unconformably on the former. A quite well defined anticline extends from Cass county to Pawnee County and beyond. The oldest exposed beds of our state are at the north part of this anticline. The strata are broken by a few small faults.

The Pennsylvanian beds exposed in the areas under consideration have a thickness of 800 to 900 feet. They form the following major natural divisions, beginning with the lowest.

I—SHALES AND LIMESTONES: Thickness, 80 to 90 feet as shown by exposures in the Weeping Water valley, the lower Platte, and at Plattsmouth. These exposures belong to the upper part of a well defined formation called the Andrew Shales in Iowa, and the Lawrence Shales in Kansas. This formation, as with others higher in the series, has been named at each end of the section because its continuity was not known.

Four limestones, each 6 to 12 feet thick, occur in these shales in Nebraska. We give them the ledge names, Nehawka, Sturm, Oreapolis, and Weeping Water, from the places near which are typical exposures. They are numbers 1 to 4 in the Nebraska section and appear to be distinct from lower members in the formation which outcrop in Missouri and Kansas.

II—PLATTSMOUTH LIMESTONE: Thickness, 20 to 30 feet, exposed in the lower Platte, at Plattsmouth and in the Weeping Water valley. This is the Plattsmouth limestone of Meek and

Hayden, and the Oread of the Kansas survey. It is number 5 in the Nebraska section.

III—SHALES AND LIMESTONES: Thickness, about 50 feet. The type exposures of the Platte and Missouri River sections were described by Meek and Hayden who gave the name Platte shales. What appear to be the equivalents of these in Kansas are known as the Kanwaka shale, Le Compton limestone and Tecumseh shales. The lower (Kanwaka) shale is only 13 or 14 feet thick in the Platte section. It is overlain by 4 to 8 feet of limestone, the Cullom ledge, which is number 6 of our section. Above this member are shale (6 to 8 feet), the second limestone (Cedar Creek) 2 to 7 feet, and shale, 13 to 16 feet. The Cedar Creek limestone is number 7 in the Nebraska section. The topmost shale of this division seems to be the northern extension of the Tecumseh shales of the Kansas survey.

IV—FORBES LIMESTONE: Thickness, 20 to 28 feet. This, number 8, is the upper heavy ledge of the Platte, Weeping Water and adjacent exposures of the Missouri River section. It is known as the Forbes limestone in Missouri, Iowa and Nebraska and as the Deer Creek in Kansas. This division dips below the Missouri River flood plain at Jones' Point and rises above near Iowa Point, Kansas, becoming high in the bluffs north of Nodaway, Missouri.

V—BRADYVILLE FORMATION: Thickness, 90 feet or more in the Platte section; less in Iowa, Missouri and Kansas. This formation contains well developed limestones and interbedded shales. Its members in Kansas are the Calhoun shales, Topeka limestone, Severy shale, and the Howard limestone. The limestones are more prominent in the Platte section than in Kansas. It is believed that with perhaps one exception, the Meadow or lowest ledge, the Nebraska limestone members cannot be correlated with those of Kansas. The heavy ledges in the Platte section thicken northwestward. We give the following ledge names and numbers for the Bradyville limestones: Meadow (9), Union (10), Louisville (11), South Bend (12), and Ashland (13). These are described in the Platte section. Ledge number 10, the Union,

occurs in the Weeping Water and adjacent Missouri River sections, but has not been definitely recognized in the Platte section.

VI—SHALES: Thickness, 90 to 125 feet. Exposed at Jones' Point east of Union, at Table Rock, in the southeast corner of Richardson County and thence southward across Kansas. This formation, consisting mainly of sand and clay shales, is known as the City Bluffs shales in Iowa and the Scranton shales in Kansas.

VII—LIMESTONES AND SHALES: Thickness, 110 to 130 feet. This formation includes five limestone and four shale members. It is best developed in the Big Nemaha valley with exposures between Tecumseh and Humboldt and between Falls City and Rulo. There are exposures between Union and Nebraska City, north of Rulo and at the mouth of the Big Nemaha. The name Nemaha is here proposed for this formation of limestones and shales, it being recognized that Tarkio and Burlingame are names used for members only. The limestone ledge names and numbers of the Nemaha formation are: Rulo (14), Burlingame (15), Fargo (16), Preston (17), and Tarkio (18). These are described in the Missouri River and Nemaha sections.

VIII—SHALES: Thickness, 95 to 120 feet. This division is prominently exposed at Nebraska City, Peru, Brownville, St. Deroin and south of Falls City. It consists mainly of clay and sand shales, but contains sandstone lenses and thin seams of coal.

This division is known as the McKissock Grove shales in Iowa and appears to be the lower part of the Admire formation of Kansas.

IX—SHALES AND LIMESTONES: Thickness, about 205 feet in the Big Nemaha section. This is a natural division extending from the McKissock Grove shales to and including the Cottonwood limestone. The lower half of the formation is mostly clay shales with several thin limestones. The upper part contains four fairly important limestones and interbedded shales. At the base of the formation is the Brownville limestone, number 19, which is $2\frac{1}{2}$ to 6 feet thick. Twelve to twenty feet above this member is

the Aspinwall ledge (number 20) and 18 to 27 feet higher is the Falls City limestone, number 21. Between the Falls City and member 22 are clay shales containing five or more thin layers of light colored limestone. Limestones 22 and 23 seem to be parts of the Elmdale formation of the Kansas geologists. Our member 24 is without much doubt the Neva of Kansas. It is the first prominent limestone below the Cottonwood. The shales between the Neva and Cottonwood are the Eskridge of Kansas. The well known Cottonwood limestone is ledge number 25. Further details in regard to Division IX are brought out in the Nemaha section.

Just what formation name Division IX should bear is not known. Furthermore, it may represent two formations. The lower part is largely the Admire of Kansas and the upper part is mostly the Elmdale.

X—THE GARRISON FORMATION: Only a few remnants of this outcrop in Nebraska. Thickness exposed, about 20 feet.

Reports on the Missouri River, Platte, Big Nemaha and Weeping Water sections follow. In each, the beds are described from the lowest upward, using the ledge numbers of the Nebraska section. This is done to show the correlation of members in the sections. The limestone ledges are shown in Arabic numerals and the overlying shales in corresponding Roman numerals.

THE MISSOURI RIVER SECTION

(Between LaPlatte, Nebraska, and Charleston Creek, Kansas)

The steep valley side bordering the Missouri River flood plain on the west is quite favorable for stratigraphic studies. Exposures are frequent and deformations slight. Well defined constants are traceable in the outcrops.

The Missouri River section in Nebraska forms a broad syncline with its lowest point in Nemaha County. The only marked deformation is at Jones' Point, Cass County, where a steep rise northward brings strata rapidly above the Missouri River level. The rise, though gentler farther north, causes the oldest beds of the section to be exposed in the vicinity of Plattsmouth.

The Plattsmouth and the Forbes limestones are the two prom-

inent constants. Their lithologic characteristics, fossil content, stratigraphic relations, and topographic effects are surprisingly uniform in northwest Missouri, northeast Kansas and in the northern part of the Nebraska section. The lowest bed of this section exposed in Nebraska is the Oreapolis limestone. Our general section is as follows. (See Plate I.)

ANDREW (LAWRENCE) SHALES

3. *Oreapolis Limestone*. Exposed in the bottom of the ravine about $\frac{1}{4}$ mile south of the Missouri River bridge at Plattsmouth. Only the upper part outcrops. The reported thickness of this member is 8 to 9 feet. The stone is fairly massive and light colored, but weathers into several yellowish beds.

III. *Shale*. This clay shale is best shown in a ravine about $\frac{1}{4}$ mile south of the Missouri River bridge at Plattsmouth. Thickness, 16 to 18 feet. The color varies from blue to maroon, the basal portion being predominantly maroon.

4. *Weeping Water Limestone*. This outcrops in the lower valley sides in the vicinity of Plattsmouth. Thickness, 6 to 8 feet; color, bluish gray, weathering yellowish to light brown. The stone is massive and breaks into large blocks. Its fossil content is principally crinoid stems, fusulina, bryozoa, and fragments of brachiopods.

IV. *Shale*. Exposed at Plattsmouth, and in the bluffs seven miles south of there. It is best observed near the mouth of a small creek south of the C. B. & Q. R. R. bridge at Plattsmouth. Thickness, 18 feet. This is a bluish green clay shale with interbedded calcareous seams. The upper part is carbonaceous in places.

PLATTSMOUTH LIMESTONE

5. *Plattsmouth Limestone*. This formation is exposed between Plattsmouth and Rock Bluff, and passes below the flood plain about one mile south of Rock Bluff. It is high in the bluffs at Plattsmouth and forms a prominent cliff at Rock

Bluff Point. It rises above the flood plain about one mile northwest of the mouth of Mosquito Creek valley in Kansas, and becomes high in the valley side towards Charleston Creek forming a rock terrace. This formation is known as the Oread in Kansas. It is a prominent cliff former in all exposures studied. Thickness, 24 to 30 feet. The stone is hard, massive and light gray. The following is a typical section of this division at Rock Bluff, Nebraska:

Limestone, 1 foot 2 inches, in two beds.

Shale, 1 to 3 feet, carbonaceous and often mistaken for coal.

Shale, 3 inches to 1 foot, blue, argillaceous, not distinctly bedded, persistent, though thin.

Limestone, 16 feet 6 inches, in three divisions with shale partings. Contains many fusulina in the upper and middle zones, also some crinoid stems.

Shale, 4 feet 3 inches, yellowish, calcareous.

Limestone, 7 feet. A heavy ledge separated from a thin basal ledge by carbonaceous shale. Contains prominent dark flint nodules.

PLATTE SHALES

V. *Shale*. This member outcrops above the Plattsmouth limestone high in the bluffs between four miles south of Plattsmouth and Rock Bluff. The section at Rock Bluff shows: light colored clay shale, 6 feet; gray compact limestone, 6 inches; carbonaceous shale, 2 feet; and blue argillaceous shale, 4 feet. Total thickness, 10 to 13 feet.

6. *Cullom Limestone*. Exposed above shale number V. Thickness, 4 to 5 feet. The stone is light gray and contains many *Campophyllum torquium*. The section at Jones' Point, practically identical with beds at Rock Bluff, is as follows:

Limestone, 1 foot 7 inches, with many large cup corals in the upper part.

Shale, 8 inches, calcareous, with many large cup corals.

Limestone, 2 feet 4 inches, with many fragments of brachiopods, fusulina and other fossils.

VI. *Shale*. Exposed above the Cullom limestone. Thickness, 7 to 8 feet. This is a clay shale. The upper part is light col-

ored at Jones' Point and the base greenish. In exposures farther north, all of the member is greenish.

7. *Cedar Creek Limestone.* Exposed from about one mile north of Rock Bluff to Jones' Point. The stone usually is in one bed, producing a rock terrace. Thickness, 1 foot 6 inches to 2 feet 5 inches; color, dark gray.

VII. *Shale.* Exposed above the Cedar Creek limestone at Jones' Point northward to and beyond Rock Bluff. Thickness, 30 feet. This member grades between clay and sand shales. The middle zone is quite arenaceous, even a sandstone at places, as at Calumet Point (King Hill).

FORBES (DEER CREEK) LIMESTONE

8. *Forbes Limestone.* This formation is prominently exposed at Jones' Point, where it quickly rises from below the river. It forms the cap rock in the bluffs between this place and Rock Bluff. Similar exposures occur in Kansas and Missouri beginning about one-half mile below Iowa Point and extending southeastward along the Missouri River, becoming high in the valley sides. The Kansas name for this division is the Deer Creek. Thickness, 24 to 28 feet. A composite section from Jones' Point to Calumet Point (King Hill) follows:

Limestone, 5 inches, dark, hard, persistent.

Shale, 4 inches, dark, argillaceous.

Limestone, 1 foot 11 inches, massive.

Shale, 1 foot 7 inches, clay, yellowish.

Limestone, 10 inches, one bed.

Shale, 1 foot 8 inches, calcareous, the upper part dark, the lower lighter.

Limestone, 16 feet to 20 feet, massive, hard, compact, light colored, forms a cliff.

Shale, 2 feet 6 inches. Thickness varies from 1 foot 6 inches to 2 feet 6 inches. Color bluish except the carbonaceous base.

Limestone, 3 to 6 inches, massive, prominently jointed at right angles, weathers yellowish to brownish.

BRADYVILLE FORMATION

VIII. *Shale*. Well exposed above the Forbes limestone at Jones' Point. Thickness, 9 to 10 feet. The upper part is bluish and the basal part calcareous.

9. *Meadow Limestone*. This is the first distinct limestone member above the Forbes. It has wide distribution in Nebraska and apparently in Kansas and Missouri. The stone usually is in one bed, but forms two beds at places. It gives rise to large blocks. The color is light grayish blue, the upper part weathering light colored and the basal part, buff. Among the fossils are *Polypora elliptica*, *fusulina* and *allorisma*.

IX. *Shale*. Exposed above the Meadow limestone at Jones' Point. Thickness, 5 to 6 feet. This is a blue to greenish clay shale, somewhat calcareous, weathering yellowish.

10. *Union Limestone*. Exposed at Jones' Point and may be represented in the exposure below Iowa Point. Thickness, 6 to 8 feet. This member is recognized in Nebraska by its position, the rich blue color and white fossils. It contains some dark flint. Section at Jones' Point:

Limestone, 1 foot, in two beds of about equal thickness, rich in lamellibranchs and brachiopods.

Shale, 1 foot 2 inches, carbonaceous.

Limestone, 8 inches, blue, weathers buff, contains many *Rhombopora lepidodendroides* and crinoid stems.

Limestone, 4 feet, in five distinct beds. Color bluish, not changing much on weathering. Contains many lamellibranchs and large producti.

Shale, 1 inch, a mere parting but quite persistent.

Limestone, 1 foot 3 inches, brittle, weathers rusty, contains many lamellibranchs, some pinna, and gastropods. The dark flint nodules are a characteristic feature.

X. *Shales and Limestones*. Exposed at Jones' Point above the Union Limestone, is a bluish clay shale, somewhat calcareous, and 8 to 10 feet thick. Next above is a limestone, 5 to 6 feet thick, exposed at Jones' Point and probably

in Kansas. It occurs in four beds of nearly equal thickness and forms jagged outcrops. Color, dark blue, weathering light buff. The beds contain many fragmentary fossils of bryozoa and brachiopods. This limestone is not definitely correlated with any member in the Platte or Weeping Water sections. Its proven distribution is not sufficient to warrant giving it a number and name in the Nebraska section. It corresponds in position with Limestone 11, the Louisville ledge, but differs greatly lithologically. Nothing definitely corresponding with the Louisville, South Bend and Ashland limestones, 11, 12 and 13, of the Platte section has been found in the Missouri River section.

There may be other beds higher than the limestone member first above the Union ledge at Jones' Point. If so, they are deeply covered with drift and loess. Some members of this division outcropping in northeastern Kansas may correlate with the Calhoun, Topeka, Severy and probably with the Howard of the Kansas survey.

CITY BLUFFS (SCRANTON) SHALES

XIII. Shale. This, major division VI of the Nebraska section, is exposed at Jones' Point and from the Big Nemaha to White Cloud, Kansas. It consists largely of broad bands or zones of differently colored argillaceous, arenaceous, and carbonaceous shales and local lenses of very hard sandstone. Near the mouth of the Big Nemaha, it has one or more layers of poorly developed limestone in the upper part overlaid by about 12 feet of blue green clay shale containing a bed of coal 8 to 14 inches thick. Total thickness of the formation, about 125 feet near the Kansas line, less to the north.

NEMAHA FORMATION

14. *Rulo Limestone.* This is exposed at the base of the bluff south of Rulo, two miles north of Rulo and between that point and Winnebago Creek. The type locality is $2\frac{1}{2}$ miles north of Rulo. The stone is light colored, hard and

massive. Thickness, 1 foot 4 inches. Probably this limestone is not in the Jones' Point section. If present, it is poorly defined.

- XIV. *Shale*. Best exposed between Fargo and a point two miles north of Rulo, also in the spur south of Rulo and in the bluffs near the mouth of the Big Nemaha valley. Thickness, 8 to 12 feet. Color, bluish; texture, clayey. The exact equivalent of this member in the exposures near the mouth of the Weeping Water is not known.
15. *Burlingame Limestone*. Exposed at Jones' Point, and probably at Old Wyoming where it dips below the river. It rises above the river near Fargo and outcrops at different points practically to Kansas, becoming high above the river near the state line. Thickness, 5 feet 2 inches at the mouth of the Big Nemaha valley. Color, bluish, weathering brown. This is a hard massive ledge, or in two or three beds with thin shale partings. Crinoid stems are the principal fossils. They remain white in the weathered stone.
- XV. *Shale*. Prominently exposed near Fargo and to within about two miles of Rulo, also in the spur south of Rulo. It passes below the flood plain one-half mile north of Fargo and rises to the surface at Old Wyoming. Thickness, 30 to 32 feet. This shale ranges from clay to sand in texture.
16. *Fargo Limestone*. Exposed between the Weeping Water valley and Walnut Creek, from four miles northwest of Fargo to near Rulo, and in the spur south of Rulo. The stone makes a prominent cliff in the valley side near Fargo, the type locality. The section, one-half mile north of Fargo shows:
- Limestone, 1 foot 6 inches to 2 feet. Bluish, massive, brittle, it makes a natural riprap along the river bank.
 - Shale, 5 feet, dark blue, carbonaceous, clayey to sandy.
 - Limestone, 4 feet in three beds.
- XVI. *Shale*. Exposed at Old Wyoming and in the slopes north and south of Fargo. The best exposures are one mile

north of Fargo. This is a light blue clay shale, somewhat calcareous and 17 to 21 feet thick.

17. *Preston Limestone*. Exposed between Fargo and Cautier Creek. Thickness, 2 feet 6 inches to 3 feet. This dips below the flood plain about $4\frac{3}{4}$ miles northwest of Fargo where it forms a natural riprap along the shores of a cut-off lake. The stone is hard, massive, bluish and breaks into box-like blocks.

XVII. *Shale*. Exposed above the Preston limestone. This is an interbedded, argillaceous to sandy shale grading to a massive friable sandstone. Thickness, 30 to 40 feet or more.

18. *Tarkio Limestone*. Exposed from Weeping Water valley to Nebraska City, and from 4 miles southeast of St. Deroin to near the Big Nemaha valley. This is a mixed member as shown by the following typical section, $3\frac{3}{4}$ miles northwest of Fargo:

Limestone, 4 feet, gray, fairly massive, contains many large fusulina. These fossils are a distinguishing feature.

Shale, 3 feet 11 inches, clay texture.

Limestone, 6 inches, with many producti.

Shale, 6 inches, calcareous, light colored.

Limestone, 6 inches, one bed.

Shale, 16 inches, light colored, calcareous.

Limestone, 6 inches to 11 inches, grayish blue

MCKISSOCK GROVE SHALES

- XVIII. *Shale*. This formation is exposed between the mouth of Weeping Water Creek and 5 miles southeast of St. Deroin. It varies from sandstone to clay shale, and contains local limestone beds and thin seams of coal near St. Deroin, Aspinwall, Brownville, Peru and Nebraska City. The sandy characteristic is pronounced in many places. The sandstone makes prominent cliffs east of St. Deroin and between Honey Creek and Peru. Total thickness, 128 feet or more. This is major division VIII of the Nebraska section.

ADMIRE FORMATION (?)

19. *Brownville Limestone*. Exposed above the shales in the bluffs between Honey Creek valley near Peru and 4 miles southeast of St. Deroïn. Thickness, 2 feet 6 inches to 6 feet. Color, light bluish green, weathering lighter. The upper part of the stone is somewhat nodular, the lower part massive.
- XIX. *Shale*. Exposed between Honey Creek and Nemaha, near Aspinwall, and west of St. Deroïn. Thickness, 18 to 25 feet. It appears to thin northward. The basal part of this member is dark, but maroon in places. The middle zone is calcareous and contains small local fossiliferous limestones. The upper part is bluish.
20. *Aspinwall Limestone*. Exposed at places from between Peru and Brownville to Nemaha, at Aspinwall, $\frac{1}{2}$ mile west of St. Deroïn, and near Indian Cave. The type locality is at Aspinwall. Thickness, 1 to 2 feet. This ledge is massive and light brown mottled, weathering with little change in color. It is usually in one bed. Fossils are numerous, especially the pelecypods, crinoids and fragments of brachiopods. The stone is persistent, soft and easily worked.
- XX. *Shale*. Exposed generally above the Aspinwall Limestone, but best shown near Aspinwall, where the following section was observed:
- Clay shale, 12 feet, bluish to yellowish.
 - Limestone, 6 inches, bluish gray and hard.
 - Clay shale, 5 feet, bluish.
21. *Falls City Limestone*. This outcrops 75 feet above the river in the vicinity of Aspinwall and 130 feet above the flood plain at Indian Cave. Thickness, 3 feet 6 inches to 4 feet, usually in one massive bed. The stone has a brownish mottled color, is soft, resonous, and easily worked when freshly exposed, but hardens upon exposure. It is very fossiliferous, pelecypods predominating.
- All divisions in this section above the Brownville limestone

appear to belong to the Admire formation, which according to the Kansas Survey, may extend below what we call the Brownville ledge. It is evident, however, that what may be the Admire in Nebraska is not clearly set off from the Elmdale above, as is shown in the Nemaha section. Hence, we are not sure of the formation name for this division.

THE PLATTE SECTION

(Ashland to Plattsmouth)

The Pennsylvanian beds of this section are exposed between Plattsmouth and Ashland, a distance of 25 miles. Outcrops, though not continuous, are sufficiently numerous to afford constants between the exposures. Studies have been made of all outcrops on both sides of the valley and all the beds have been correlated. The section shown in Plate II represents the south side of the valley.

Major divisions I to V of the Nebraska section are represented. The lowest bed exposed is the Oreapolis Limestone, shown just above the railroad track 2 miles west of Oreapolis where it appears to mark the axis of a well defined low fold. From this exposure the beds have a slight westward dip with local variations, causing low folds. One such is about 1 mile northeast of Louisville and another is 2 miles northwest of South Bend though not of sufficient magnitude to represent in drawing. The highest bed exposed in the section is a thin limestone a few feet above the track level 1 mile southwest of the Burlington station at Ashland.

The Pennsylvanian beds are, in places, overlain unconformably by the Dakota sandstones and clays. This condition is especially well shown along the south side of the valley at the mouth of Salt Creek, at the clay pits 1 mile northeast of Louisville, and at the Cedar Creek and Cullom gravel pits. On the north side of the valley the Dakota is best shown at the State Fish Hatcheries opposite South Bend, in the clay pits west of Meadow, and in the slopes southeast of Richfield.

A characteristic feature of the Pennsylvanian beds is the thick-

ness of the limestones of the Braddyville formation. This is much more pronounced than in the Weeping Water and Missouri River sections, and makes correlation of the upper members with those sections uncertain. The Forbes and the Plattsmouth limestones are prominent cliff formers. The detailed section follows:

ANDREW (LAWRENCE) SHALES

3. *Oreapolis Limestone*. Exposed at the base of the slope, $1\frac{1}{2}$ to 2 miles west southwest of LaPlatte and just above the railroad track 2 miles west of Oreapolis. The latter is the type locality. Thickness of member, 8 to 9 feet. The unweathered stone is light bluish gray and partly crystalline. The basal part weathers light gray and the upper 2 to 3 feet thin bedded and slightly yellowish. Fragmentary fossils, especially crinoids, are prominent.

III. *Shale*. Exposed above the Oreapolis limestone. Thickness, 7 to 9 feet. Texture clayey to calcareous. The maroon color is a characteristic feature of the basal 4 to 5 feet.

4. *Weeping Water Limestone*. Exposed west of LaPlatte and Oreapolis. Thickness, 11 to 12 feet. The stone is light colored, and produces a prominent cliff and bench. A typical section $2\frac{1}{4}$ miles west of Oreapolis shows:

Limestone, 5 feet 4 inches, one bed, blue gray, weathers yellowish and shatters badly, fossiliferous.

Shale, 1 foot, light colored and calcareous.

Limestone, 6 feet 2 inches, one bed unweathered, breaks into thin layers.

- IV. *Shale*. In the slopes $1\frac{1}{2}$ to 3 miles west of LaPlatte, but best shown in the valley side 2 to 3 miles west of Oreapolis. Thickness, 14 feet. A typical section two miles west of Oreapolis shows:

Shale, 5 feet, dark, thin bedded and platy, slightly carbonaceous.

Limestone, 1 foot 2 inches, bluish, hard, irregularly jointed.

Shale, 4 feet, bluish, upper part clayey, base partly carbonaceous and elastic.

Limestone, 1 foot 2 inches, bluish gray, two layers separated by a shale parting.

Shale, 1 foot 6 inches, blue, argillaceous.

PLATTSMOUTH LIMESTONE

5. *Plattsmouth Limestone.* This formation is exposed in the old quarries south of Richfield, in the "point" opposite Cullom, in the lower part of the cliff $1\frac{3}{4}$ miles northeast of Cedar Creek and in the upper valley side 2 to 3 miles west of Oreapolis. It has two or three main divisions with shale partings of variable thickness. Total thickness, 25 to 30 feet. The stone is light colored, massive and hard. It contains flint 10 to 11 feet below the top. In places the basal part consists of a carbonaceous shale 1 to 2 feet thick, underlain by an impure limestone 1 foot 6 inches thick. This carbonaceous basal part is well shown at the level of the railroad at the sharp bend northeast of Cedar Creek where the ledge gives rise to a cliff in the valley side.

PLATTE SHALES

- V. *Shales.* Exposed in the old Richfield quarries, in the valley side east of Cedar Creek, and below the upper quarry ledges east of Cullom. It is best shown above the Plattsmouth limestone northeast of Cedar Creek. Thickness, 13 to 14 feet. This is a bluish clay shale with a carbonaceous streak in places. A section at the cliff northeast of Cedar Creek shows:

Clay shale, 8 feet, bluish, jointed but indistinctly bedded.

Limestone, 6 inches, dark blue, one bed.

Shale, 1 foot 9 inches, dark.

Clay Shale, 3 feet, bluish green.

6. *Cullom Limestone.* Exposed above shale number V. Well shown in the upper part of the old quarries south of Richfield and in the upper part of the cliff northeast of Cedar Creek and is the basal ledge in the high quarries east of Cullom, the type locality. This ledge is just above the level of the railroad track at the National Stone Company crusher two miles northeast of Louisville. Thickness, 8 feet. The stone is massive, quite fossiliferous and forms a cliff.

- VI. *Shale*. Exposed west of the old quarries south of Richfield, at the National Stone Company crusher, in the cliff north-east of Cedar Creek, and high in the quarries east of Cullom. Thickness, 6 to 8 feet. The greenish color is the most pronounced feature.
7. *Cedar Creek Limestone*. Exposed in the slopes east of Meadow opposite Cedar Creek, and at the National Stone Company quarry. (1st below main ledge.) This is the upper ledge in the quarries high on the valley side east of Cullom. Thickness, 7 to 8 feet. The stone is light colored and quite massive except the upper part which is thin bedded.
- VII. *Shale*. Exposed below the floor of the National Stone Company quarry and westward to the old Stout quarry. Thickness, 13 to 16 feet. This clay shale is bluish to light colored and somewhat calcareous, with a thin layer of fossiliferous limestone near the middle.

FORBES (DEER CREEK) LIMESTONE

8. *Forbes Limestone*. This formation is exposed in the lower slopes west of Meadow and Louisville, and higher in the valley side east of Louisville until Cedar Creek valley is reached. It is the main quarry ledge at the Woodworth (West of Meadow), Murphy (East of Louisville), National (Northeast of Louisville), and Atwood quarries (Cedar Creek valley). A composite section shows:
- Limestone, 8 inches, dark bluish, usually not quarried, in one bed.
 - Shale, 1 foot to 1 foot 2 inches, with a carbonaceous streak near the middle.
 - Limestone, 6 inches, dark blue, usually not quarried.
 - Shale, 2 inches, fairly persistent.
 - Limestone, 10 inches to 1 foot, bluish, in one bed, usually not quarried.
 - Shale, 6 inches, fairly persistent.
 - Limestone, 20 to 22 feet, massive, upper 10 feet (approximately) very pure, light colored and hard. Basal portion less pure, darker and softer.
 - Shale, 6 inches to 2 feet, blue, argillaceous, bedded.

Limestone, 2 feet to 3 feet, blocky, weathers light.

Shale, 6 inches, blue, calcareous.

Limestone, 2 feet 10 inches to 4 feet, bluish, weathers brownish.

BRADDYVILLE FORMATION

VIII. Shale. Exposed one mile west of Louisville, in the Murphy and the old Stout quarries northeast of Louisville, and in the Atwood quarries. It is in the slopes west of Meadow but generally covered by talus. Thickness, 6 to 8 feet. This is a bluish, bedded, clay shale.

9. *Meadow Limestone.* This outcrops west of Meadow, west of Louisville, in the old Stout quarry, and at the Atwood quarries. Thickness, 2 feet 7 inches to 4 feet. Its greatest thickness is shown at the Atwood and Woodworth quarries. The stone is massive, hard, semi-crystalline and weathers light colored. It contains many *Polypora elliptica* at the old Stout quarry.

IX. Shale. This is exposed above the Meadow limestone. It is a bluish calcareous shale, 2 feet 8 inches to 3 feet thick.

Limestone. Exposed in the slopes west of Meadow and south of the Platte from the south bend of the river to beyond Louisville. It is well shown in the old Stout quarry northeast of Louisville. Thickness, 3 feet 8 inches to 4 feet. A typical section one mile west of Louisville shows:

Limestone, 1 foot 9 inches, light colored.

Shale, 11 inches, calcareous, maroon.

Limestone, 1 foot 6 inches, light colored, nodular.

This member has not been correlated with any member of the Missouri or Weeping Water sections. Its importance and proven distribution do not justify giving it a ledge name or number in the Nebraska section.

Shale. This forms part of the slope under the Louisville limestone. Its best exposure, in the rock ravine about one mile west of Louisville, is as follows:

Shale, 6 feet 3 inches, light colored, argillaceous, thin bedded, thin band near the top, carbonaceous.

Limestone, 6 inches, gray, blocky.

Shale, 1 foot 10 inches, light colored, dark at base, greenish when wet.

Limestone, 1 foot 4 inches, gray, in three beds with shale partings.

Shale, 4 inches, bluish green.

Limestone, 3 inches, gray, many fragments of brachiopods.

Shale, 2 feet 6 inches, blue, argillaceous.

The shales of this member are generally bluish.

11. *Louisville Limestone*. Exposed at the base of the slope west of South Bend and in the upper slopes eastward to Louisville. It is the main ledge in the upper Atwood quarry in the Cedar Creek valley, and in the north side of the Platte valley from the State Fish Hatcheries to Meadow. It is the main quarry ledge in the abandoned Murphy and Green quarries west of Meadow. Thickness, 10 to 12 feet. This member is thin bedded in its upper part, but most of it is massive, hard and compact. It is blue gray and weathers light.

XI. *Shale*. Exposed above the Louisville limestone. Thickness, 6 feet 6 inches to 10 feet. This is a maroon clay shale capped by ten to fifteen inches of blue clay shale.

12. *South Bend Limestone*. Exposed in the bed of Salt Creek southwest of the C. B. & Q. station at Ashland, at the track level near the mouth of Salt Creek, in the valley sides from Pawnee Creek to Louisville, and from the State Fish Hatcheries to Meadow. Thickness, 8 to 9 feet. A section along the railroad $\frac{1}{2}$ mile east of Pawnee Creek shows:

Limestone, 10 inches, light gray, one bed, hard.

Shale, 1 foot 3 inches, light colored, has calcareous concretions, fossiliferous.

Limestone, 2 feet 10 inches, light gray with many fusulina and brachiopods, a good building stone.

Shale, 1 foot 10 inches, light bluish gray, many fusulina.

Limestone, 2 feet 6 inches, contains large flint nodules. This is the most prominent flint horizon along the lower Platte.

- XII. Shale.* Exposed under the Ashland limestone at Ashland and in the slopes in the vicinity of Pawnee Creek. Total thickness, 16 to 18 feet. This is a clay shale, predominantly maroon, but having a purple band at the base.
13. *Ashland Limestone.* Exposed in the sides of the ravine $\frac{3}{8}$ mile southwest of the C. B. & Q. station at Ashland just below the level of the railroad track, in the small ravine northeast of the station at Ashland, and in the upper slopes of Pawnee Creek and vicinity. Thickness, 12 feet. This member forms very large blocks. The main body of the stone is light gray, massive and hard. The basal portion consists of interbedded limestones and shales to a thickness of $3\frac{1}{2}$ feet.

CITY BLUFFS (SCRANTON) SHALES

- XIII. Shale.* Exposed in the ravine and railroad cut southwest of the Ashland station. This is an argillaceous shale of variable color, part being maroon. Thickness, 19 feet. It is overlain by limestone 1 foot to 1 foot 6 inches thick. The stone is light colored and carries some calcite veins and crystals of pyrites of iron.

Just where this shale and limestone should be grouped is not definitely known. They resemble members of the Brad-dyville formation, but seem to be in the City Bluffs or Scranton horizon.

There may be other Pennsylvanian beds, higher in the Platte section, if so, they are concealed by the Dakota formation and mantle rock.

THE BIG NEMAHA SECTION

Conditions are quite favorable for stratigraphic studies in the Big Nemaha valley, because erosion has removed most of the loess mantle and part of the drift, making many outcrops of the bed rock.

The lowest and oldest strata of this section are exposed in the bluffs near the mouth of the Nemaha and in the vicinity of Table Rock. Major divisions VI to X inclusive of the Nebraska

beds outcrop in the Nemaha valley. The formations dip north-westward in the southeastern corner of Richardson county, then flatten out to near Salem, beyond which they are nearly level in an east-west section, remaining so to a north-south line just west of Humboldt. Between this line and Table Rock is a sharp up-bend of about 400 feet in which division VII rises in the upland and the upper surface of division VI reaches 35 to 40 feet above the C. B. & Q. station at Table Rock, to an altitude of about 1060 feet. The Nemaha formation (Division VII) is nearly horizontal between Table Rock and Pawnee City, beyond which the dip is westward to near the Big Blue. The Tarkio (Limestone 18) is prominently exposed in the uplands south of Table Rock. No doubt divisions higher in the section formerly extended across this part of the area. About 350 feet between the Tarkio and the Cottonwood have been removed by erosion. Add to this the Garrison formation or so much of it as occurs south of Humboldt, and the thickness is increased to about 370 feet.

The detailed description of the main divisions of the Nemaha section follows. (See Plates III, IV and V.)

CITY BLUFFS (SCRANTON) SHALES

XIII. Shale. This is major division VI in the Nebraska section. The thickness is fully 125 feet between White Cloud, Kansas, and the mouth of the Big Nemaha, as shown in the Missouri River section. This division passes under the Nemaha formation and below the level of the flood plain southwest of Rulo. It rises above the valley floor at Otoe Siding southeast of Table Rock. About 40 feet of the upper part of the formation is exposed at Table Rock. The clay pits are in this part. A few outcrops occur between Table Rock and Elk Creek. A drilling made at Table Rock several years ago is reported to have extended about 200 feet in this shale and to have encountered a few seams of limestone. According to this record, the City Bluffs shale may be thicker here than at Rulo. We are not positive of this, however.

A thin seam of coal occurs in the upper part of the shale

at Table Rock. Here, as in the outcrops near Rulo, the shale grades quickly between clay and sand. At the mouth of the Nemaha the formation is composed of broad bands differing in texture and color.

THE NEMAHA FORMATION

The basal member of this formation comes in above the City Bluffs shale in the vicinity of Rulo and the top member passes below the flood plain south of Falls City. The upper part of the formation reappears $1\frac{1}{4}$ miles west of Humboldt, beyond which the members rise in succession to Otoe Siding and Table Rock, where the section is practically the same as at Rulo and Preston. The thickness of the formation is about 120 feet.

The following members are in the spur south of Rulo:

14. *Rulo Limestone*. It outcrops at the foot of the slope. This is a single bed, 12 to 20 inches thick, bluish in color, weathering light to brownish. The main fossils are crinoid stems, gastropods, and some corals.
- XIV. *Shale*. Thickness, 7 feet or more, argillaceous, color bluish.
15. *Burlingame Limestone*. Thickness, about 5 feet. Color bluish, weathering to a rusty brown. The stone forms large rectangular blocks. It is quarried at a number of places. Thin layers of limestone grade between the stone and shale above and below. There are several fossils of which crinoid stems are the most noticeable.
- XV. *Shale*. Thickness, 28 to 29 feet. Color bluish, except about two feet of the upper part which is chocolate colored. Two or three thin seams of limestone are in this shale.
16. *Fargo Limestone*. It is a hard, bluish stone in two or three beds. The thickness could not be accurately determined. Among the fossils are crinoids, brachiopods, bryozoa, and fusulina.
- XVI. *Shale*. Thickness, 30 to 34 feet, colors bluish and maroon.
17. *Preston Limestone*. This contains three beds, one light colored, and the others weathering brown. Thickness not determinable, but the main ledge is about four feet.

The Fargo, Preston and Tarkio ledges are well exposed north-east of the Nemaha bridge west of Rulo, at which place a local limestone is developed between the two upper members. The Tarkio caps the upland here and at Preston. It is light buff colored and contains myriads of large fusulina. The stone has been quarried at many places along its outcrops. The Preston ledge is well shown near the level of the railroad at the bridge west of Preston, the type locality. The main bed, 3 feet 9 inches thick, breaks into massive blocks.

The Tarkio outcrops at the level of the railroad in Pierson's Point, southeast of Falls City, where its main bed is more than 4 feet thick, massive, light gray and filled with fusulina. It contains several other fossils, as crinoid stems, brachiopods, and bryozoa; is underlain with blue shale, 7 feet exposed, and overlain with 15 feet of shale, near the top of which is a layer of low grade coal 8 to 12 inches thick. The upper part of this exposure consisting mostly of shale and sandstone, thickness, about 35 feet, belongs to the McKissock Grove shales.

The Tarkio is also well shown under the bridge south of Falls City in an exposure similar to that at Pierson's Point. Westward from there it disappears below the flood plain level and reappears in the east limb of the anticline west of Humboldt. The Tarkio is prominently exposed along the bluff lines from $1\frac{1}{4}$ miles west of Humboldt to Otoe Siding, at a number of places along the South Fork from 5 to 7 miles south of Humboldt, in the uplands south of Table Rock, and between $1\frac{1}{2}$ and 4 miles southeast of Tecumseh. Formerly the Tarkio of these outcrops was confused with the Cottonwood limestone, because of its structure and many fusulina.

A composite section of the Nemaha formation in the vicinity of Otoe Siding and Table Rock is about as follows:

15. *Burlingame Limestone*. Thickness, 20 inches. It is bluish, hard and breaks into large blocks.
- XV. *Shale*. Thickness, 11 to 12 feet, color blue to maroon. The texture varies from sandy to clayey.
16. *Fargo Limestone*. In two or three beds separated by shales. Thickness, 3 to 5 feet. In section it is about as follows:

Limestone, 7 inches; a seam of shale; limestone, 12 to 14 inches; thin shale; hard, brittle, slabby limestone. 12 inches.

XVI. Shale. Thickness, 14 to 18 feet. This is a maroon, clay shale with a thin seam of limestone 4 feet above the base.

17. *Preston Limestone.* Total thickness, including interbedded shales, 11 feet. The section at Otoe Siding shows: Limestone, 19 to 22 inches; bluish shale, 2 feet; massive brownish limestone, 24 to 28 inches; shale, 18 to 20 inches; hard bluish limestone in one or two beds, 18 to 20 inches; shale, a seam; hard, light colored limestone, 2 to 6 inches.

XVII. Shale. Thickness, 40 to 45 feet, including thin limestones.

18. *Tarkio Limestone.* Exposed high in the upland south of Table Rock. The main ledge is about five feet thick, massive, light buff colored, and filled with fusulina larger than those in the Cottonwood. Its large blocks weather rounded and pitted.

The cap rock southeast of Tecumseh is the Tarkio. About thirty feet lower in the section, where the railroad strikes the bluffs is the Preston ledge. The rock benches one to two miles northwest of Elk Creek contain the Preston limestone and lower members.

MCKISSOCK GROVE SHALES

XVIII. Shale. Thickness, about 100 feet. This appears above the Nemaha formation west of Preston and at Pierson's Point, becomes prominently exposed at the bridge south of Falls City and passes below the flood plain level at the foot of the high land southeast of Salem. It is not clearly exposed in the eastern limit of the anticline, except at a point about 6 miles south of Humboldt. Though we have not proved it, there may be a fault in the formations along a line between points six miles south and one mile west of Humboldt. If not, the dip may be greater than we now suppose.

The McKissock Grove shales contain much sand, several thin seams of coal, local developments of sandstone and thin layers of limestone. The sandy shale yields a good

many plant fossils. Resistant beds near the top produce rock benches.

As has been said, this formation may be part of what is known as the Admire of Kansas geologists.

FORMATION NAME (?)

(Admire, Elmdale, Neva, Eskridge, and Cottonwood). Probably most of the lower members grouped here belong to the Admire. Those higher in the division are of the Elmdale, Eskridge shales and Cottonwood Limestone. Combined they make a natural formation, over 200 feet thick, the base being the Brownville Limestone and the top the Cottonwood. The members are as follows:

19. *Brownville Limestone.* This is not well exposed at many places in the Big Nemaha valley. In 1911 a good section was taken in the slopes east of the Lehmer quarry, section 32, township 1 north, range 16 east, or 3 miles south and 2 miles west of Falls City. It is as follows:

Limestone, 2 feet, blue gray, weathering buff, one bed, quite fossiliferous in upper part, hard.

Shale and weathered limestone, 7 inches, shale bluish.

Limestone, 8 inches, dark blue, blocky, fossiliferous.

This out crop is now obscured by talus. The Brownville member is in the South Fork exposures, south of Humboldt, but it does not occur in a condition favorable for accurate measurements.

XIX. *Shale.* This is a bluish, calcareous clay shale 10 feet thick in the vicinity of the Lehmer quarry. It thickens westward.

20. *Aspinwall Limestone.* This is 16 inches or more thick, persistent, in a single bed, and breaks into large blocks. The stone is soft, but quite well suited for building purposes and closely resembles the Falls City Limestone. It outcrops in the vicinity of the Lehmer quarry and in the deformation along the South Fork, south of Humboldt.

XX. *Shale.* A bluish, calcareous, clay shale, 37 feet thick at the Lehmer quarry. Here, ten feet below the top, is a light limestone 6 inches thick.

21. *Falls City Limestone.* This caps the upland in sections 19, 20, 29, 32 and 33 of Township 1 north, Range 16 east, southwest of Falls City. The type locality is at the Lehmer quarry in section 32. Westward from this the Falls City lowers, capping a bench-like upland extending part of the way to near the foot of the high land southeast of Salem.

The stone, about $5\frac{1}{2}$ feet thick, forms a massive, persistent ledge not much jointed. It is soft, porous, easily worked, quite fossiliferous, and specked with rusty iron stain. A characteristic feature is its ringing sound when struck with a hammer.

This member is well exposed at points 3 and 7 miles south of Humboldt. The locations are in the southwest corner of section 32, Township 2 north, Range 13 east, and at the top of the hill between sections 9 and 10 of Township 1 north, Range 13 east. At these places is a steep eastward dip and probably some faulting.

XXI. *Shales.* This member is composed of bluish clay shales and thin limestones. It is well exposed at the foot of the steep uplands in the vicinity of Salem and on Sections 3 and 10 of Township 1 north, Range 13 east, located between 5 and 6 miles south of Humboldt. The total thickness is 40 to 50 feet.

22, 23, 24. *Limestones and Interbedded Shales.* Here are grouped three limestones and the interbedded shales. Thickness, about 35 feet. This division outcrops between Salem and Humboldt and between Salem and the anticline along the South Fork. There are good exposures one mile east of Humboldt and at the bridge south of Humboldt. The limestone beds range between 2 and 3 feet in thickness. The most distinct member, probably the Neva, caps much of the upland in the vicinity of Indian Hill, near Salem. It is hard compact stone and creeps badly on the plastic shales which it overlies. This condition has been confused with deformation proper. It may be that members 22 and 23 are parts of the Elmdale formation of Kansas.

XXIV. Eskridge Shales. These outcrop in the valley sides in which the Cottonwood limestone caps the upland, between Dawson and Humboldt, at Indian Hill, and many places along the South Fork. The member is composed mostly of clay shales, but has persistent seams of limestone. Debris from the Cottonwood above covers the slope in most outcrops. The upper 14 feet of shale is bluish with maroon bands and is very plastic when wet. Below this is a fine textured hard limestone 6 to 15 inches thick. It forms a light band in the shales and weathers into fine debris.

The lower division of the Eskridge consists of bands of greenish, bluish, purple, and maroon clay shales modified by 4 or 5 calcareous streaks. Total thickness, 30 to 48 feet.

25. *Cottonwood Limestone.* This occurs at many points between Salem and the anticline. It extends northward and is the cap rock in the upland of western Nemaha county. There the best exposures are between Johnson and Glen Rock. The stone has been quarried at many places. Thickness, 5 to 6 feet.

It is very light colored, massive, filled with small fusulina, and weathers slabby in the upper part. The main body of the ledge, however, breaks into large rough blocks. Concretions and geodes occur in parts of the ledge. They are small, of quartz and light to rose colored.

The Cottonwood limestone and the three members below the Eskridge shales form steep valley sides in the vicinity of Salem, between that point and Humboldt, and along the Little Nemaha in the western part of Nemaha county, giving a type of surface similar to that developed on the Nemaha formation.

THE GARRISON FORMATION

A few remnants of this lie on the Cottonwood south of Humboldt. Two divisions are shown, the Florena shales and the overlying limestone.

XXV. Florena Shale. This member is exposed above the Cotton-

wood south of the bridge at Humboldt and in the east half of section 3, Township 1 north, Range 13 east. It is a bedded, plastic, bluish to yellowish shale, 15 to 20 feet thick, containing many Chonetes.

26. *Limestone.* This caps the small areas of Florena shale. It is hard, granular, in one bed, 2 to 3 feet thick.

The Garrison is reported to be 140 feet thick in northern Kansas. Just how well it is developed in Nebraska is not known. The probable thickness immediately to the west of the Big Nemaha area is thought to be more than 100 feet. This, if added to the exposures in our general section, would make a total thickness of between 880 and 980 feet of Pennsylvanian beds in the state above the lowest outcrop.

Whether the Garrison should be grouped with the Pennsylvanian or the Permian is now questioned by some. It is generally regarded as being at the top of the Pennsylvanian. Lithologically and structurally it is very similar to the underlying beds.

THE WEEPING WATER SECTION

By R. J. Scarborough

Weeping Water Creek flows in a comparatively deep and steep-sided valley. The valley sides present favorable conditions for stratigraphic studies because the slopes do not carry a heavy mantle of debris. Exposures, while not continuous, are sufficiently numerous that correlation can be accomplished with accuracy. The data presented in this section are based on field studies of 127 exposures between Elmwood and the Missouri River and on topographic evidences associated with these exposures.

Major divisions I to V inclusive of the general Nebraska section are exposed in whole or in part in the Weeping Water valley. They dip to the southeast east of Nehawka and appear to have a slight westward dip in the western part of the section. The oldest beds are exposed in the North Branch Weeping Water valley two and one-half miles north of Nehawka and in the bed of

Weeping Water Creek two miles northwest of Nehawka. These exposures mark the axis of an anticline which appears to correspond to the one noted in the Platte section west of Oreapolis and in the Big Nemaha section near Table Rock. This stratigraphy causes Division V of the Nebraska series to be exposed low in the slopes at Union and east of Wabash while Division I is the basal formation 2 miles northwest of Nehawka. The detailed section follows giving numbers to limestones and shales in accordance with the plan followed for the general Nebraska section. (See Plate VI.)

ANDREW (LAWRENCE) SHALES

1. *Nehawka Limestone.* Exposed in the bed of the North Branch of the Weeping Water two miles north of Nehawka. Best shown in Section 6, Township 10 north, Range 13 east. Largest exposures show thickness of 4 feet 6 inches (under wagon bridge just north of center of section 6, Township 10 north, Range 13 east) but correlated neighboring exposures indicate a total thickness of 10 feet or more. The stone is hard, gray, and bedded, fossils remain light colored when weathered.
 - I. *Shale.* Exposed above the Nehawka limestone in the same localities. Thickness, 4 feet. This clayey, calcareous shale is light colored and weathers yellowish.
 2. *Sturm Limestone.* Exposed along the North Branch of Weeping Water Creek between points two and four miles north of Nehawka, with several good exposures near Sturm's school house, section 12, Township 10 north, Range 12 east. It is in the bed of Weeping Water Creek two miles west-northwest of Nehawka, where it is marked by a ford in the creek. Thickness, about 6 feet. The exact thickness is difficult to determine because of lack of complete exposures. The stone is light colored, bluish, impure and weathers into nodular, pellet-like forms.
- II. *Shale.* Exposed above the Sturm limestone in places along North Branch of the Weeping Water and at the ford in

Weeping Water Creek 2 miles west-northwest of Nehawka, Section 14, Township 10 north, Range 12 east. Thickness, 6 feet. It is clay shale with the basal part maroon and the upper part bluish.

3. *Oreapolis Limestone*. Exposed along the valley sides of Weeping Water Creek in SE $\frac{1}{4}$, Section 11, Township 10 north, Range 12 east, and NE $\frac{1}{4}$ Section 14, Township 10 north, Range 12 east, and along the North Branch valley between points one and two miles north of Nehawka. Thickness, 6 to 9 feet. The stone is bedded with shale parting in places. The color is bluish, weathering light. Lamellibranchs are the most common fossils.

III. *Shale*. Above the Oreapolis limestone is unmistakable evidence of a fairly well developed shale but the whole member is not exposed at any one place, making it difficult to determine the exact thickness. Partial exposures are found along the valley sides of the Weeping Water in Sections 11, 12, 13 and 14, Township 10 north, Range 12 east. Thickness, probably about 30 feet. The basal part is dark blue, middle part maroon, upper part light colored and calcareous.

4. *Weeping Water Limestone*. Exposed in the valley sides of Weeping Water Creek in Sections 4, 5, 6, 9 and 10, Township 10 north, Range 12 east, and along the west side of the North Branch valley about 1 mile northwest of Nehawka. It is the first limestone of any importance below the Plattsmouth. Thickness, 6 feet. The stone is light colored, massive, breaks down in large blocks and shows a tendency to weather into rough, nodular forms.

IV. *Shale*. Exposed in the same places as the Weeping Water limestone, and at the creek bed level at the junction of Cascade Creek and the Weeping Water. Thickness, 18 to 20 feet. The basal 6 feet is maroon. The middle zone is calcareous, capped by a hard gray limestone 1 foot 9 inches thick. The upper zone is carbonaceous in the lower

part, grading into calcareous shale above. This member causes a prominent slope below the Plattsmouth limestone where the latter is in position in the valley sides.

PLATTSMOUTH LIMESTONE

5. *Plattsmouth Limestone.* This formation is exposed in the creek bed at Weeping Water where it causes the cascades. It is in position in the valley sides from Weeping Water to near Nehawka. It is the prominent upper limestone along the east fork of the North Branch of Weeping Water Creek, and along the west valley side of the North Branch. Two miles east of Weeping Water this limestone produces a rock terrace which continues as a prominent feature to near Nehawka. It is the main quarry ledge in the "Old Swede" Quarry about three miles east of Weeping Water and also in the west Van Court quarry three miles northwest of Nehawka. Thickness, 20 to 22 feet. The stone is light colored, weathers grayish to brownish, and contains dark flint nodules, some more than six inches thick. *Fusulina* and *Campophyllum torquium* are abundant, other fossils not numerous.

PLATTE SHALES

- V. *Shale.* Exposed in the slopes above the Plattsmouth limestone at Weeping Water and thence down the valley. The exposures are infrequent because of the talus covering. There are good outcrops along the south side of the valley near the mouth of Cascade Creek. Thickness of shale, 13 to 14 feet. In general this member is a light colored calcareous shale, with thin limestones in places.
6. *Cullom Limestone.* Exposed along the south side of the Cascade Creek valley near its junction with the Weeping Water. It is found in the slopes of the Weeping Water valley from Nehawka westward to about one mile west of Weeping Water. Thickness, 4 feet 6 inches. The stone is light colored, in two members separated by a very fossiliferous calcareous shale parting. *Campophyllum torquium*

are abundant and serve to distinguish this member from the other thin limestones.

- VI. *Shale*. This member has practically the same range of exposures as given for the Cullom limestone. Thickness, 10 feet 6 inches. The color is yellowish at base and maroon in upper portion.
7. *Cedar Creek Limestone*. Exposed in the same places as the Cullom limestone. Thickness, 1 foot 6 inches, usually in two equal beds. The color is gray, weathering with but little change. Joints are far apart, tending to produce large slabby blocks when breaking down in the slope. No characteristic fossils were noted.
- VII. *Shale*. Exposed below the Forbes limestone west of Weeping Water and along the valley sides eastward to within two miles of Nehawka. Exposed in the valley sides one-half mile northeast of Nehawka below the quarries, and in the lower valley sides of the South Branch of the Weeping Water, 2 miles south of Nekawka. Thickness, 30 to 33 feet. It varies from argillaceous to arenaceous and contains thin limestone lenses in places. The color is predominantly light, with local variations to bands of blue, maroon or very dark, almost black.
8. *Forbes Limestone*. This is the most conspicuous formation in the Weeping Water valley. The upper part outcrops in the creek bed about $\frac{1}{2}$ mile east of Wabash. From there to Weeping Water the formation is in the valley sides, producing a prominent rock bench. It outcrops at many places. On the north side of the valley this bench extends only about 1 mile east of Weeping Water. The limestone seems then to have been eroded away and is not found until the quarries about $\frac{1}{2}$ mile northeast of Nehawka are reached where it is the main quarry ledge. There this ledge shows a decided dip to the southeast. It is again exposed in the quarry of the Nehawka Stone Company, one mile east of Nehawka, where it also constitutes the main quarry ledge. It is next exposed low in the valley side about 100 yards

east of the Missouri Pacific station at Union. There the upper part forms the basal ledge in an old quarry.

On the south side of the Weeping Water valley the bench formed by the Forbes can be followed from about one mile east of Wabash to a point six miles southeast of Weeping Water. It is high in the slopes from the vicinity of Weeping Water southeastward.

The Forbes is prominently exposed in the valley of the South Branch of Weeping Water Creek from the center of Section 28, Township 10 north, Range 12 east, to the west side of Section 28, Township 10 north, Range 13 east.

This formation has a total thickness of about 35 feet. The upper 10 feet is composed of an impure brownish limestone with a shale base. The middle zone, 20 feet thick, is a massive limestone of which the upper 10 to 12 feet is very hard and pure, and the basal portion darker. The lower five feet is made up of some thin, impure limestone separated by shale partings. The lowest zone is very persistent and uniform and is popularly known as rubble stone.

BRADYVILLE FORMATION

VIII. Shale. Exposed in the same locations as given for the Forbes. Thickness, 7 feet. This member is a clay shale of bluish color.

9. *Meadow Limestone.* Exposed in the bed of the creek east of Wabash, generally covered in the valley sides eastward but well shown in the East Van Court and the Nehawka Stone Company's quarries east of Nehawka. It is also exposed in the old quarry near the Missouri Pacific station at Union. Thickness, 2 feet 6 inches. The stone is light colored, hard, semi-crystalline in places and weathers light.

IX. Shale. Exposed above the Meadow limestone in the same localities. Thickness, 7 feet. The member is light colored, argillaceous and it contains thin impure limestones in the upper part.

X. Union Limestone. Exposed in the old quarry at Union, in the valley side in the NW $\frac{1}{4}$ Section 22, Township 10 north,

Range 13 east, and in the Nehawka Stone Company quarry. Some exposures occur along the valley sides of the South Branch of the Weeping Water about $1\frac{1}{2}$ miles southwest of Union in Sections 33 and 28, Township 10 north, Range 13 east. Thickness, 1 foot 8 inches. This ledge is characterized by its blue color, blue flint nodules in the basal part and the many fossils, especially brachiopods, which appear white in fresh exposures and remain so in weathered stone.

Above the Union limestone are interbedded limestones and shales. Apparently there are three or more limestones, thickness of each, 1 foot 6 inches to 2 feet 8 inches, separated by well developed shales. Exposures are few and widely scattered, hence the problem of following constants and securing exact measurements is extremely difficult.

The beds above the Forbes are probably all members of the Braddyville formation, although it is possible that the basal portions of the City Bluffs shale are in the slopes near Wabash and Elmwood. It is evident that the Braddyville does not contain as heavy, well developed limestones in this section as in the Platte valley.

CONCLUSIONS

The data presented in the foregoing sections show some facts of interest, among them:

1. That the Pennsylvanian beds of Nebraska fall into ten major natural divisions. Each has a general lithologic unity, and where it forms the surface bed rock, gives rise to a distinctive topography.

2. That there are twenty-six distinct limestones of extensive distribution, and several others of minor importance.

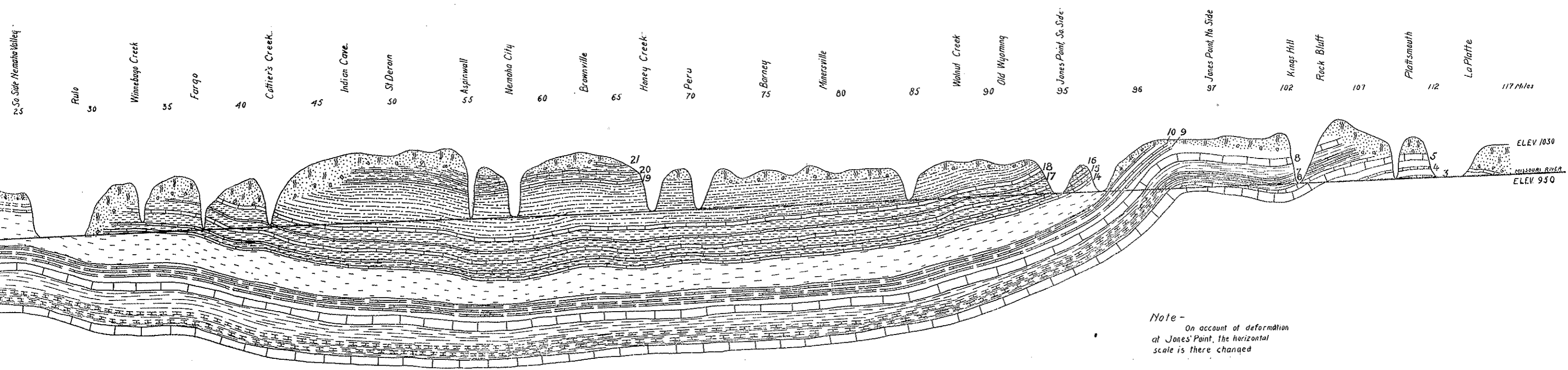
3. That the limestones and shales are remarkably uniform in thickness and character.

4. That a prominent anticline extends from west of Oreapolis to south of Table Rock.

5. That the oldest beds exposed in Nebraska are in the Weeping Water valley northwest of Nehawka.

These reports represent work done with care. Several persons have taken part, and they have done so because of their interest in science. The findings are presented upon their merits, subject to criticisms based on further accurate field work. There has been no purpose to agree or disagree with the work of anyone. The aim has always been to find and make known the facts. The work has been independent. The data have been carefully checked time and again and are thought to be approximately correct. For errors that may be found, the authors should be held responsible.

In conclusion, however, it is suggested that this work is only preliminary. It is hoped that members of the Academy will undertake studies in the stratigraphic paleontology, the economic possibilities of the different limestones and shales, and the detailed areal distribution of the Pennsylvanian beds of Nebraska. It is needless to suggest, such work is only begun.



STRUCTURE PROFILE, PENNSYLVANIAN FORMATIONS

LA PLATTE, NEBRASKA CHARLESTON CREEK, KANSAS.

[TOPOGRAPHY GENERALIZED]

Charleston, Kans.

0 Miles

Mosquito Creek

LaFayette

5

Wolf River Valley E.

Wolf River Valley W.

10

Jawa Point

15

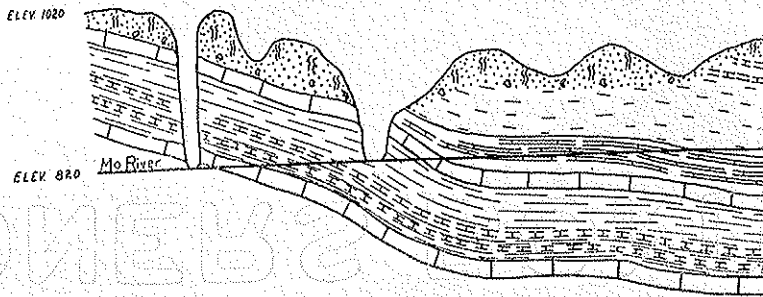
White Cloud

20

ELEV. 1020

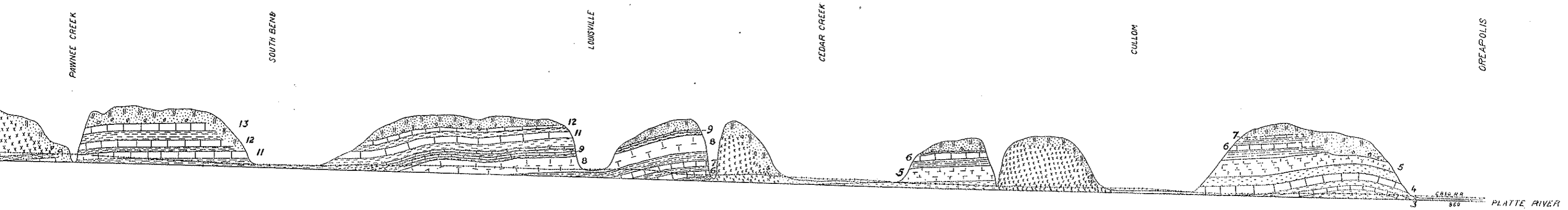
ELEV. 820

Mo River



LEGEND

- | | |
|------------------------------|----------------------------|
| 3 == Orenpolls Limestone | 14 == Rulo Limestone |
| 4 == Weeping Water Limestone | 15 == Burlingame Limestone |
| 5 == Plattsmouth Limestone | 16 == Fargo Limestone |
| 6 == Cullom Limestone | 17 == Preston Limestone |
| 7 == Cedar Creek Limestone | 18 == Tarkio Limestone |
| 8 == Forbes' Limestone. | 19 == Brownville Limestone |
| 9 == Meadow Limestone | 20 == Aspiwall Limestone |
| 10 == Union Limestone | 21 == Falls City Limestone |



STRUCTURE PROFILE, LOWER PLATTE VALLEY

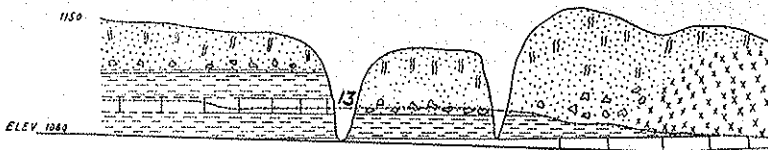
ASHLAND — OREADPOLIS

[Topography Generalized]

- LEGEND
- 3 Oreadpolis Limestone
 - 4 Weeping Water ..
 - 5 Plattsmouth ..
 - 6 Cullom ..
 - 7 Cedar Creek ..
 - 8 Forbes ..

- LEGEND
- 9 Meadow Limestone
 - 11 Louisville ..
 - 12 South Bend ..
 - 13 Ashland ..
 - ☒ Dakota Sandstone
 - ☒ Drift and Loess

ASHLAND



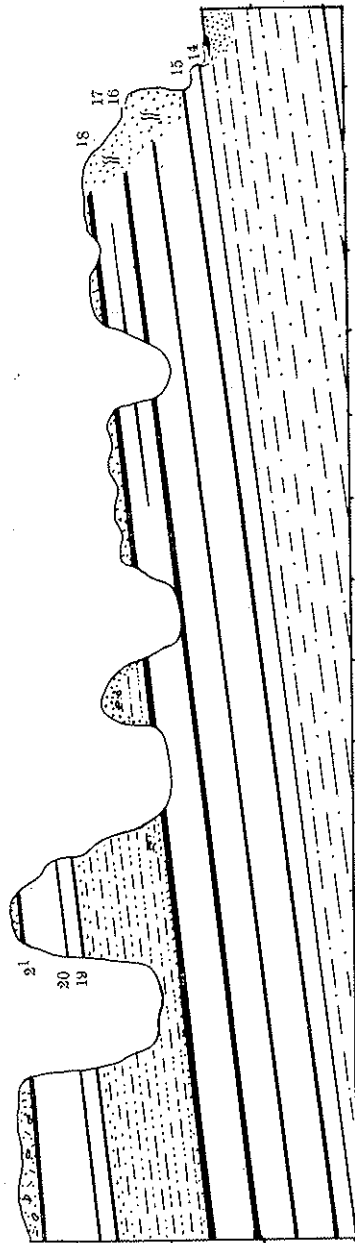


Fig. 1. Structure profile from Lehmer Quarry, southwest of Falls City, to Rulo.

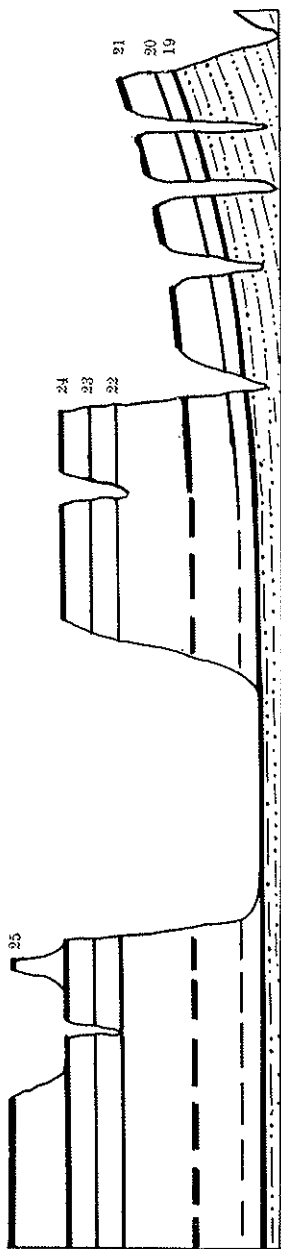


Fig. 1. Structure profile, from Section 6, T. 1. N. R. 15 E., to N. E. of Section 29, T. 1. N., R. 16 E., i.e., from the upland west of Salem to the upland $2\frac{1}{2}$ miles S. W. of Falls City.

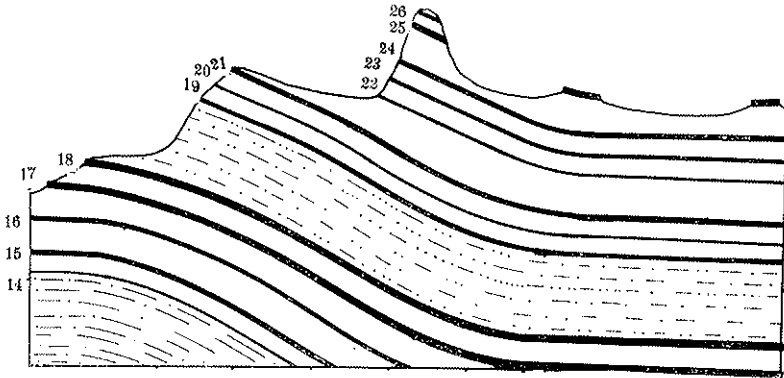


Fig. 1. Structure profile from N. E. Section 17, T. 1 N., R. 13 E. to N. E. Section 1, T. 1 N., R. 13 E., crossing a north-south line seven miles south of Humboldt.

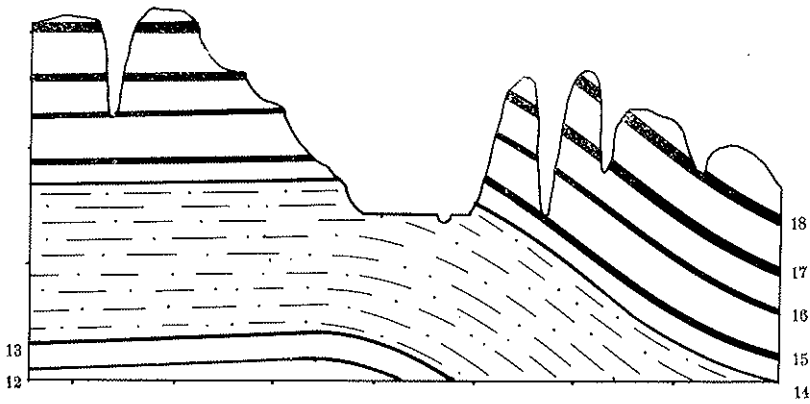


Fig. 2. Structure profile from two miles south of Table Rock eastward to the upland one-half mile north of Otoe Siding.

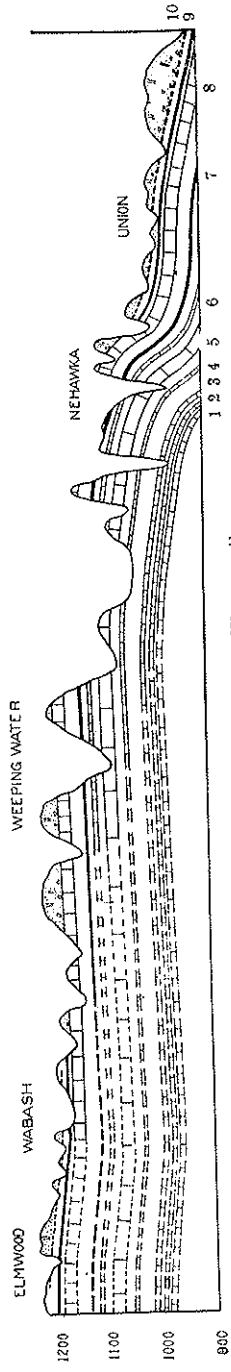


Fig. 1. Structure profile of Weeping Water valley.

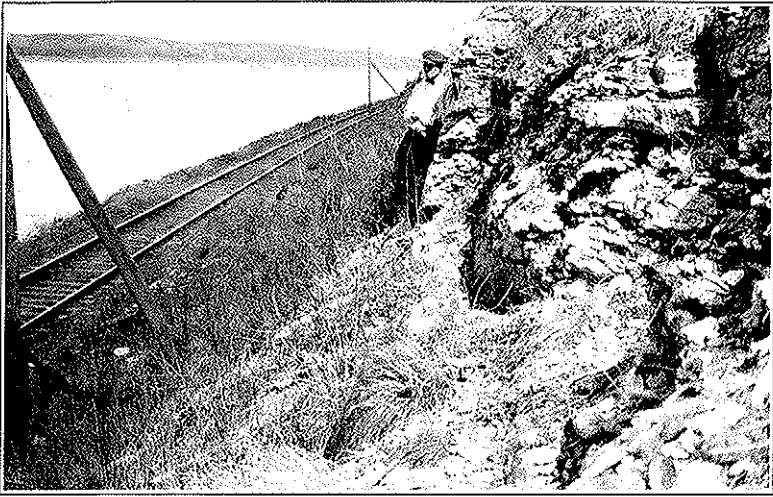


Fig. 1. The Oreapolis Limestone exposed in the lower part of the valley side, $2\frac{1}{4}$ miles west of Oreapolis. The basal part of the ledge is hidden by talus.



Fig. 2. The Weeping Water Limestone in the valley side about 2 miles west of Oreapolis.

Plate VIII

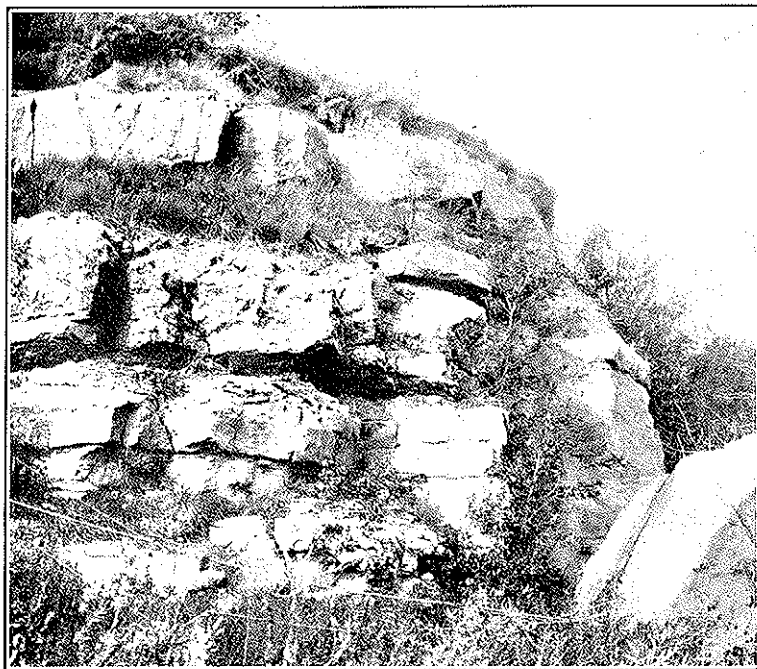


Fig. 1. The Plattsmouth Limestone at the base of the slope at Rock Bluff Point (Queen Hill). Thickness 26 feet.

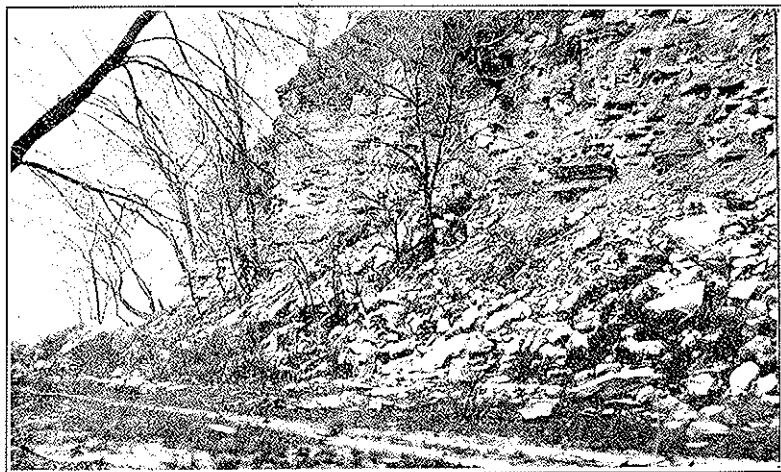


Fig. 2. The Plattsmouth Limestone in the valley side north of the Platte River opposite Cullom.



Fig. 1. The Plattsmouth Limestone outcrops in the valley sides 2 miles west of Oreapolis. The basal part of the ledge forms a prominent cliff, and the upper part has been eroded.



Fig. 2. The Cullom Limestone forms a blocky rip-rap along the Missouri River at Chris Beal's, 5 miles north of Jones' Point, Cass County. The Cedar Creek Limestone is shown higher in the slope.

Plate X



Fig. 1. Exposure in the old quarries, high in the slopes east of Cullom. The ledge at the base is the Cullom Limestone. Above it is a greenish shale. The upper member is the Cedar Creek Limestone.

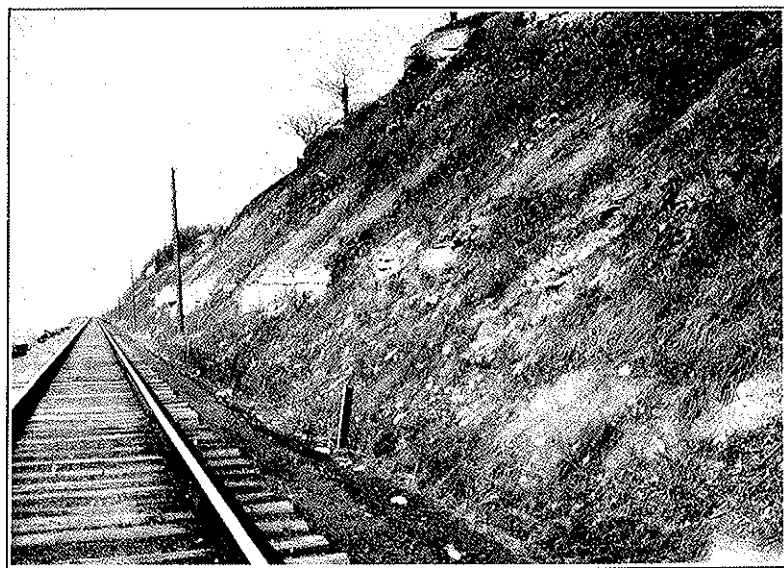


Fig. 2. The Platte Shales are exposed in the valley side northeast of Louisville. The base of the Forbes Limestone shows in the upper part of the slope.

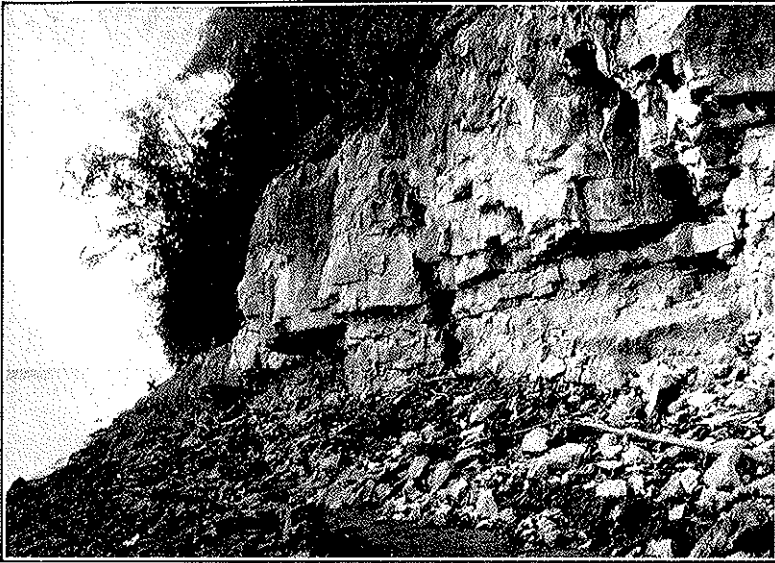


Fig. 1. The Forbes Limestone at Jones' Point, Cass County. It dips under the Missouri River at X.



Fig. 2. The Forbes Limestone is high in the valley sides at Weeping Water.
(49)

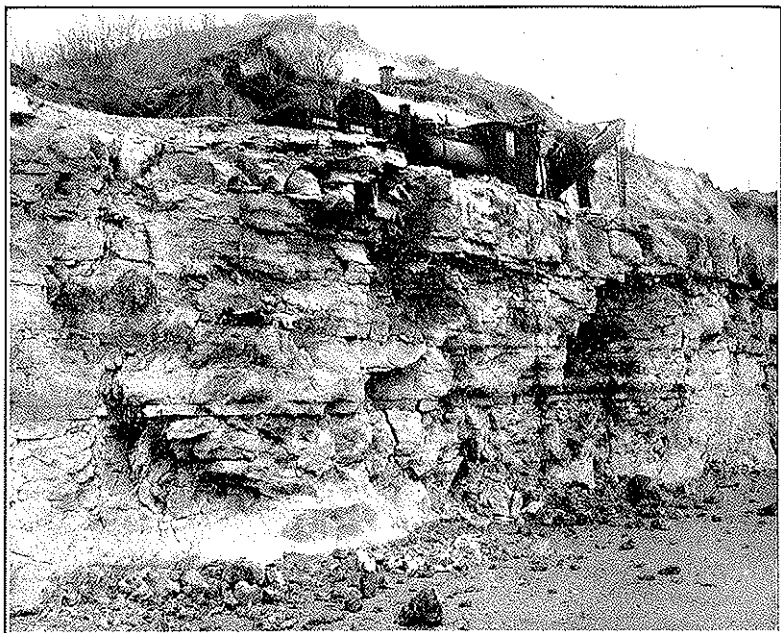


Fig. 1. The Forbes Limestone is the main ledge in the National Stone Company's quarry 2 miles northeast of Louisville.

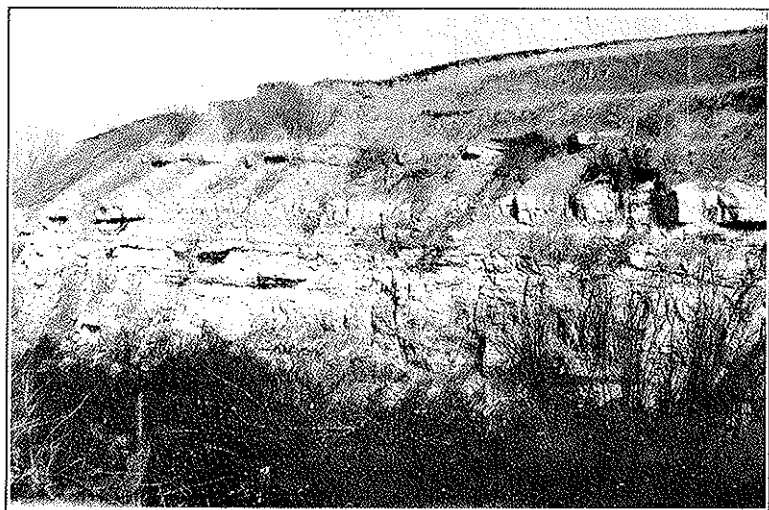


Fig. 2. An exposure in the old Stout quarry near Louisville. The basal heavy ledge is the Forbes. In the slope above it, can be seen blocks of the Meadow Limestone.

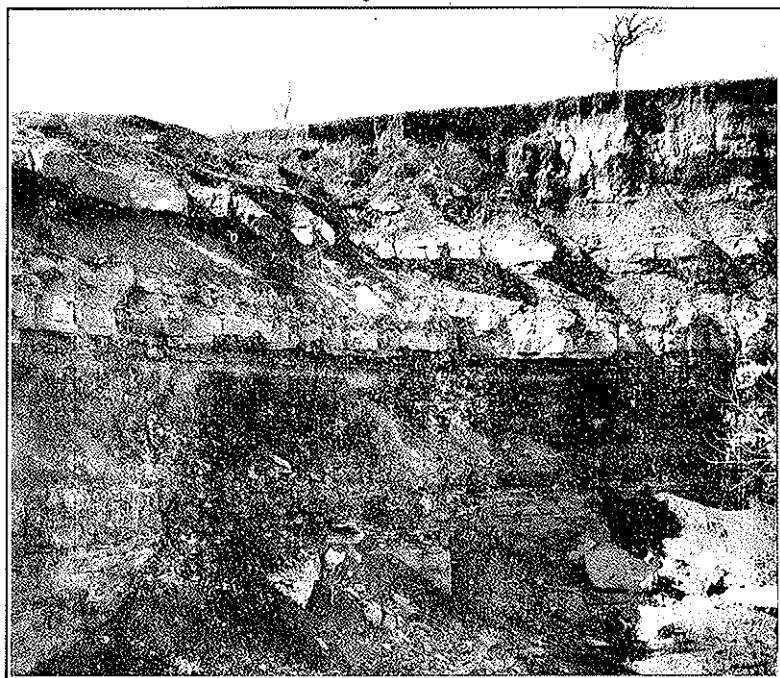


Fig. 1. The abandoned Green quarry west of Meadow. The basal ledge is the Louisville. The two-fold ledge is the South Bend Limestone, the upper part of which has prominent flint nodules.



Fig. 2. The upper bed of the South Bend Limestone. The flint nodules near the middle are characteristic of this bed.

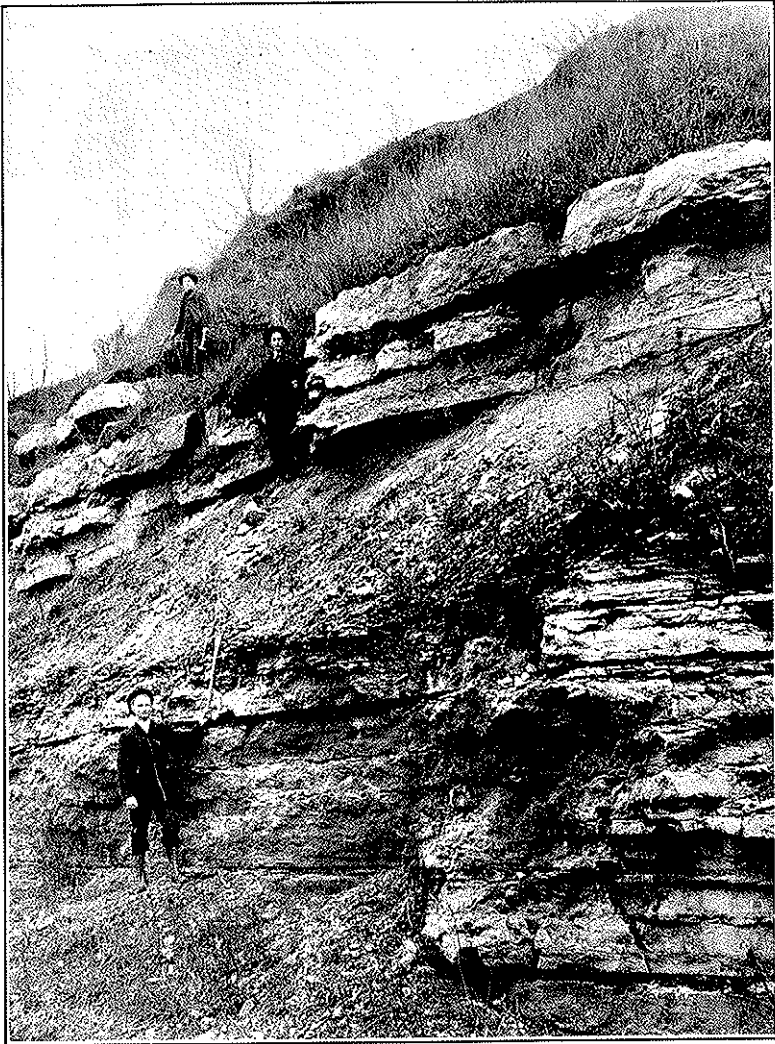


Fig. 1. The Louisville (lower) and South Bend (upper) Limestones 2 miles northwest of South Bend. The South Bend Limestone is thicker and better developed here than at Mendow. Compare with Plate XIII, Fig. 1.



Fig. 1. The South Bend Limestone in the type exposure along the C. B. & Q. track about 2 miles northwest of South Bend. The upper bed contains flint nodules.

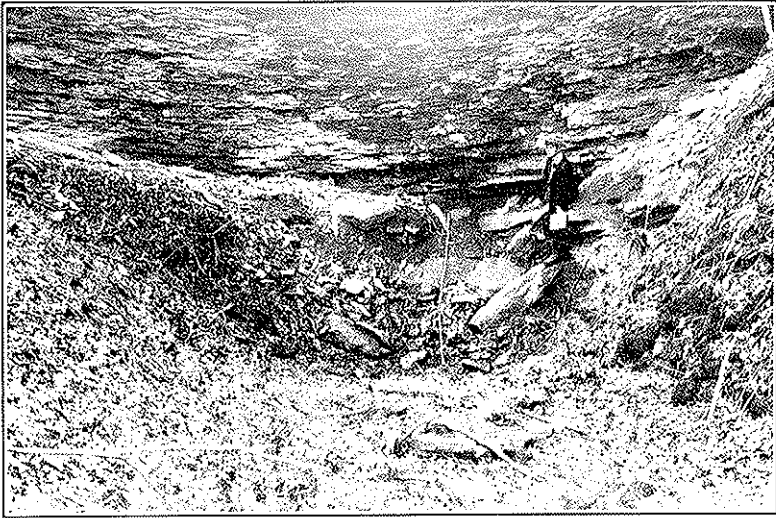


Fig. 1. The base of the Ashland Limestone exposed in a ravine about one-half mile east of Pawnee Creek valley, northwest of South Bend.

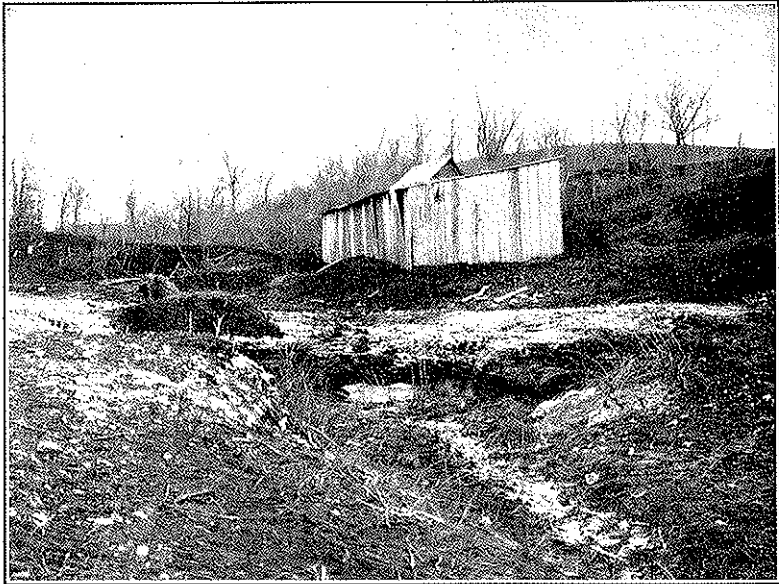


Fig. 2. The Ashland Limestone in a ravine about five-eighths mile northeast of the C., B. & Q. station at Ashland.

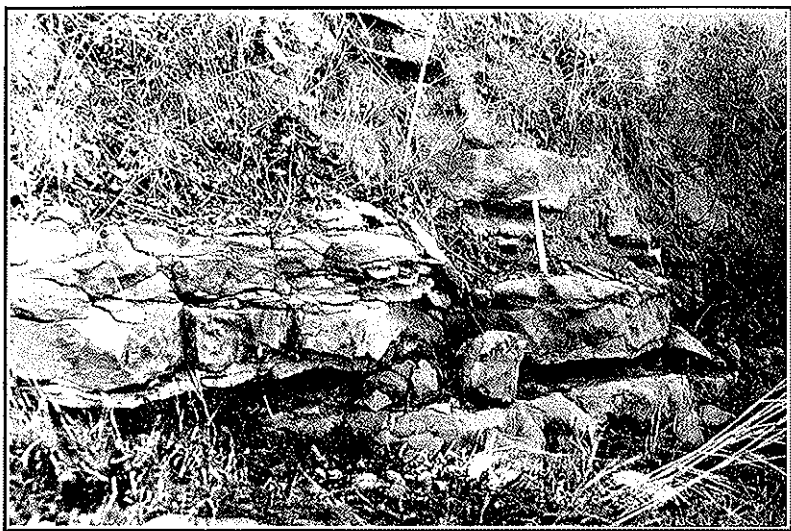


Fig. 1. The Union Limestone in a partial exposure at Jones' Point, Cass County.

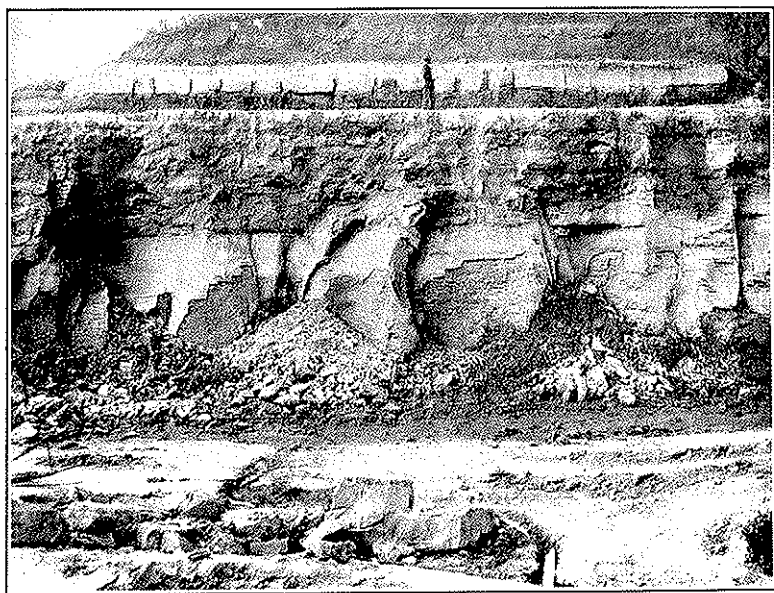


Fig. 2. The City Bluffs shales exposed in a clay pit southeast of Table Rock. What appears to be the Itulo Limestone shows in the upper part of the figure.
(56)



Fig. 1. Exposures in Winnebago Creek valley about $3\frac{1}{4}$ miles north of Rulo. The basal ledge is the Rulo Limestone, and the upper ledge, the Burlingame Limestone.

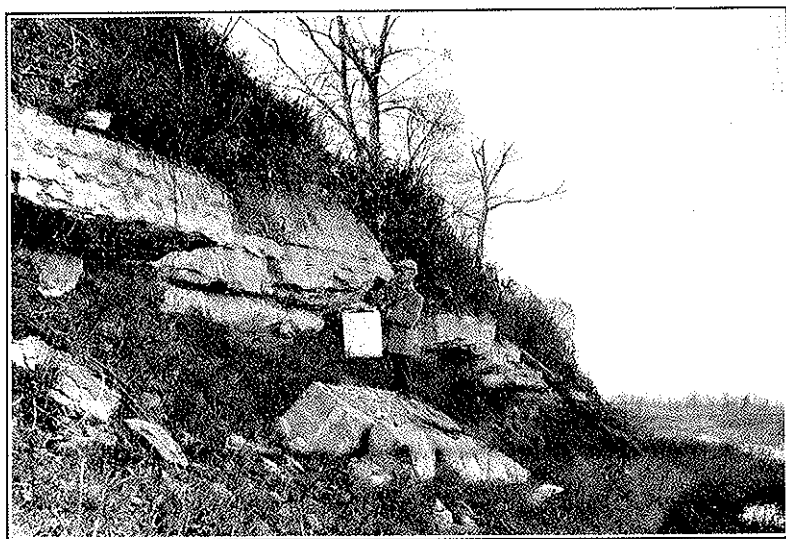


Fig. 2. The Fargo Limestone in the lower valley side, $\frac{1}{4}$ mile north of Fargo, Richardson County.

Plate XIX



Fig. 1. The Preston Limestone in the exposure along east bank of Nemaha river one mile west of Preston.

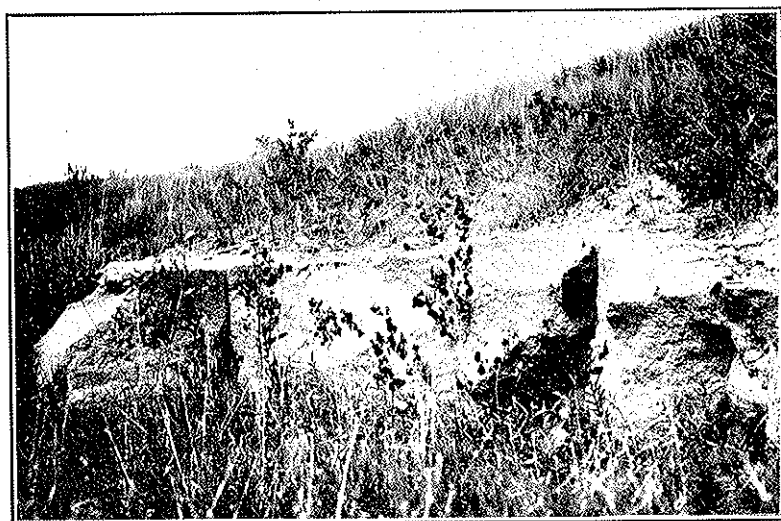


Fig. 2. The Tarkio Limestone in an old quarry southeast of Tecumseh.

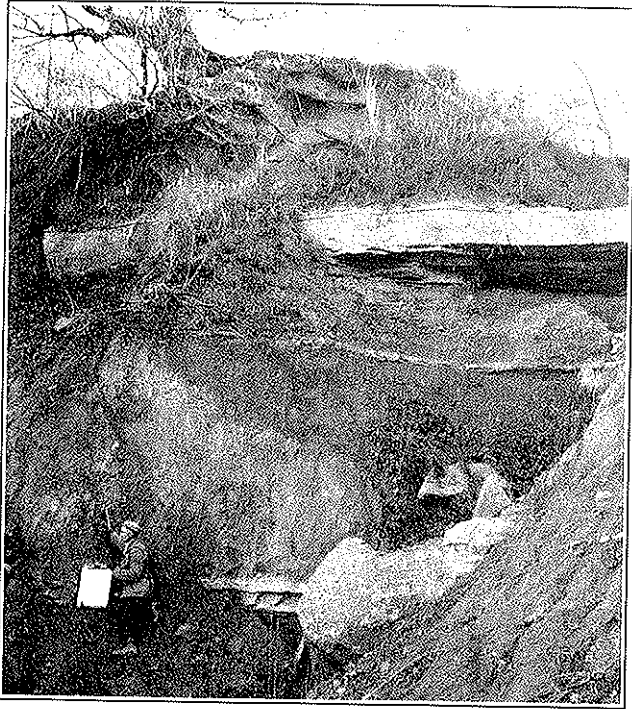


Fig. 1. This exposure is near Aspinwall. The upper ledge shown is the Aspinwall Limestone. The lower ledge, near the man, is the Brownville Limestone, only the upper part of which is exposed. The Falls City Limestone outcrops higher in the slopes, but farther back.

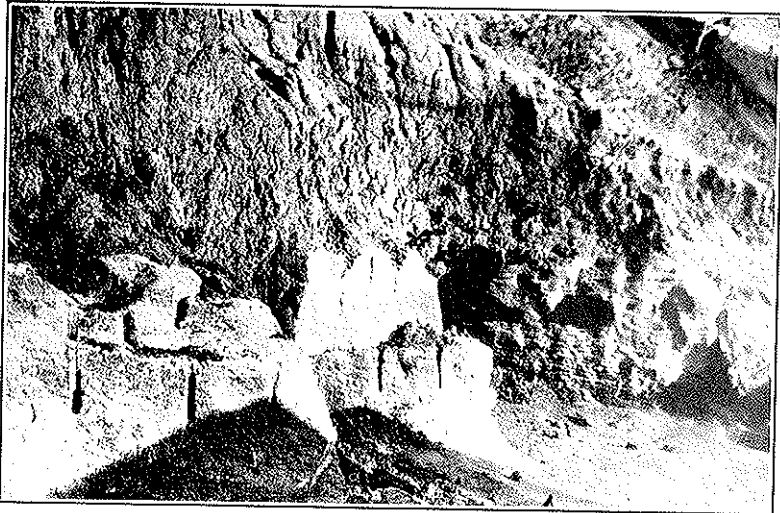


Fig. 2. The Falls City Limestone in the Minor quarry (formerly Lehmer) southwest of Falls City.

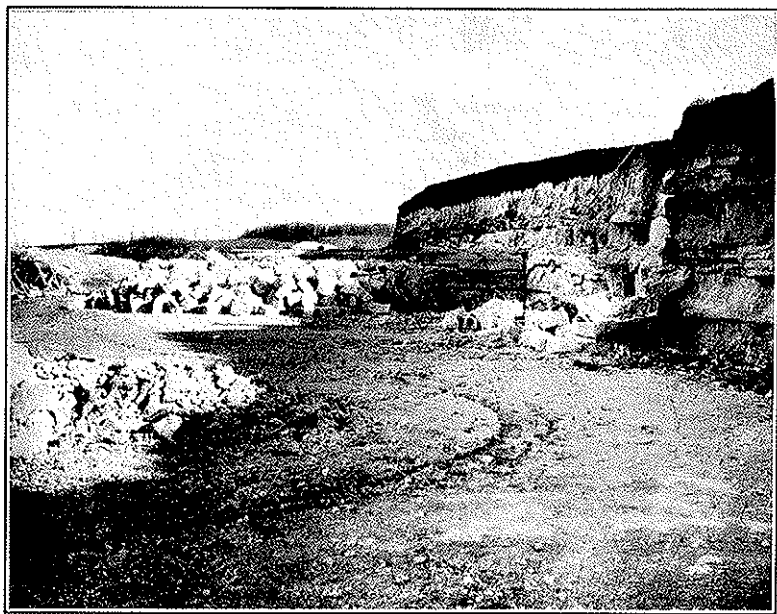


Fig. 1. The Cottonwood Limestone in the quarry between Johnson and Glen Rock.

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