

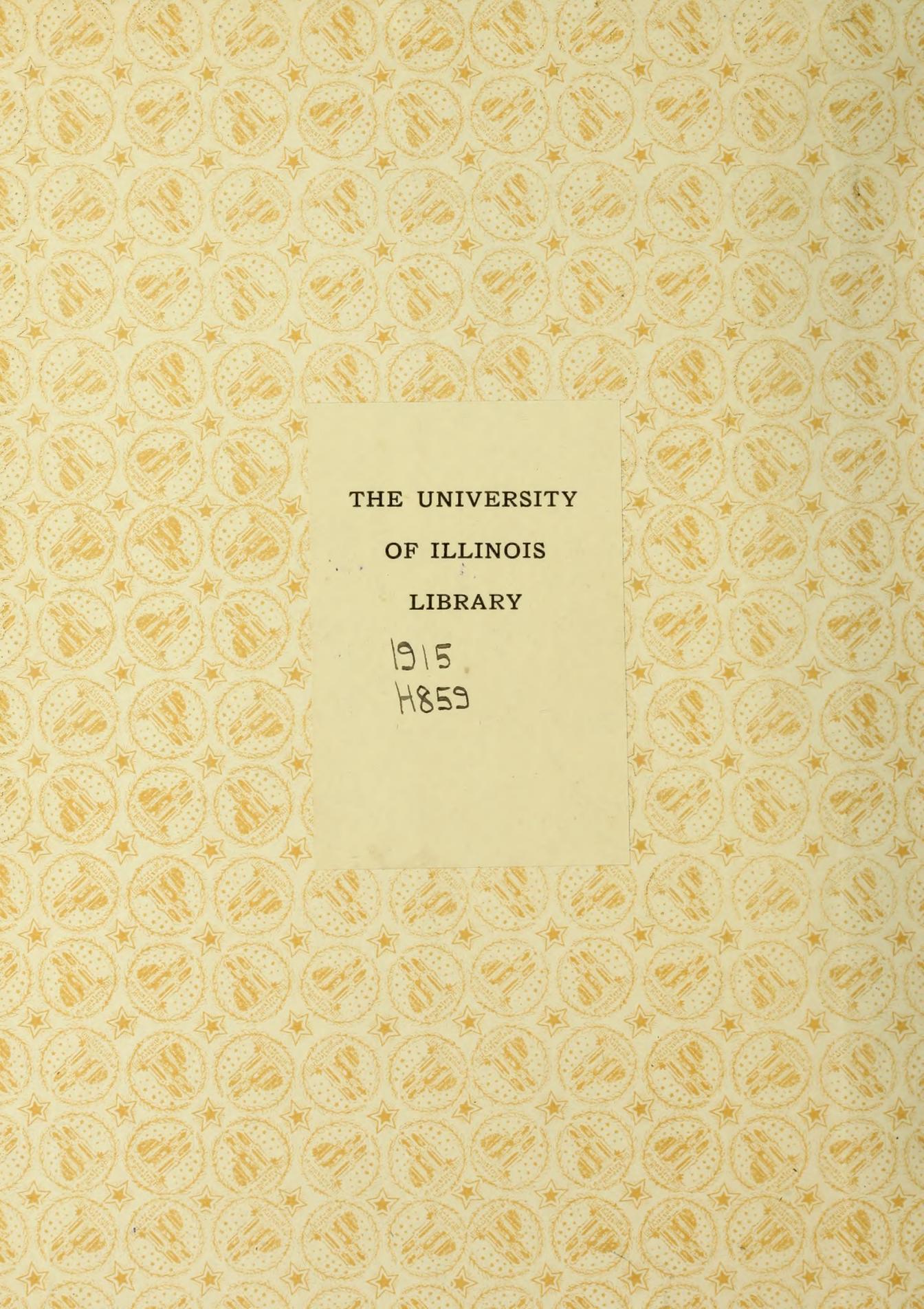
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A Comparison of the
Maquoketa Formation and its Fauna in
Eastern Wisconsin, Iowa and Illinois

Geology

A. M.

1915



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A COMPARISON OF THE MAQUOKETA FORMATION AND ITS
FAUNA IN EASTERN WISCONSIN, IOWA AND ILLINOIS

BY

TSUNG HAN HSÜ
A. B. University of Illinois, 1914

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF ARTS

IN GEOLOGY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1915

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ENTITLED A Comparison of the Maquoketa Formation and Its
Fauna in Eastern Wisconsin, Iowa and Illinois

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
DEGREE OF Master of Arts

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on
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*Required for doctor's degree but not for master's.

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INTRODUCTION.

The name MAQUOKETA Shale was first applied to this formation by C. A. White from the Little Maquoketa River in Dubuque County, Iowa, because this formation was well developed in that locality. The beds at first were considered to be equivalent to the Hudson River Shale of the State of New York; but Meek and Worthen showed that those shales in Iowa and Illinois are not equivalent to the Hudson River Shale in New York, so the name Hudson River group, as applied to this formation, was dropped and the name Cincinnati group was proposed, because the principal formations of this group or series are well exposed in the vicinity of Cincinnati, Ohio. The Maquoketa Shale is now known to be equivalent to only the Richmond or uppermost formation of the Cincinnati, for only the latter formation contains fossils similar to those which occur in the Maquoketa strata of Iowa and Illinois.

In 1870, Mr. C. A. White, then Iowa State Geologist of Iowa, was not satisfied with the name Cincinnati group for the strata under consideration, and he proposed the name Maquoketa Shale to designate this particular formation in Iowa and northern Illinois. This name today is well known among the geologists in this country, for the rocks in the upper Mississippi Valley that represent about the same time as the Richmond stage of Indiana and Ohio, but which were deposited in a sea that advanced into this area from the north or Arctic regions. The Maquoketa formation

occurs in Wisconsin, Minnesota, Iowa and Illinois, as is shown by the similarity of its fossils in these areas.

The Maquoketa in Wisconsin.

Location and Area of Occurrence.

The Maquoketa formation underlies a considerable area in Southeastern Wisconsin, but it outcrops only over a narrow belt, extending in a nearly north and south direction from Walworth to Lake Winnebago, and thence northeast from Lake Winnebago to Sturgeon Bay. The width varies in different places along this long, narrow belt, being two and one-half miles at Walworth, five miles near Hartford, one mile east of Lake Winnebago, and one and one-half miles south of Green Bay. From Green Bay to Sturgeon Bay the width is only about one-quarter of a mile.

Physiography of the Maquoketa Area in Wisconsin.

Bordering the east side of the Maquoketa area in Wisconsin is a very prominent ridge of Silurian limestone which has a steep slope on the west side and gentle slope on the east. The explanation of this feature is that the eastward dipping Silurian limestone overlies the Maquoketa Shale, the shales and clays are soft and easily eroded, and when the ice sheets moved over this region they eroded much more deeply the area over which the Maquoketa Shale formed the surface material than the area farther east where the surface material was underlain by the hard Silurian limestone. Since the Pleistocene period the many springs that issue at the top of the Maquoketa Shale, and the general agencies of

weathering, have still farther eroded this formation, in many places undermining the overlying limestone, huge blocks of which have fallen or crept down from above and have come to rest on the more gentle slope near the foot of the cliff.

The Maquoketa strata outcrop in the bed and banks of many of the streams between Green Bay and Lake Winnebago. The best localities in Wisconsin from which collections of Maquoketa fossils were made are Cascade Falls, about four and one-half miles east of De Pere, and along a stream east of Green Bay,

The beautiful Cascade Falls occurs along the channel of a stream which is very shallow above the falls where the water flows on the Silurian limestone, while below the falls the stream has cut a gorge through the limestone and oölitic iron ore bed into the soft underlying Maquoketa Shale. At the exposure east of Green Bay, there is formed a succession of rapids where the water runs over the limestone and greenish blue shales.

Previous Geological Work on the Maquoketa in Wisconsin.

In 1862, James Hall¹ and others made a reconnaissance survey of this region and referred to the Maquoketa and overlying Silurian limestone in eastern Wisconsin under the name of "Green and Blue Shales and Limestones". They described these strata as extending from southern Wisconsin to Little Sturgeon Bay. This report did not give much detail concerning the formations.

1 Geological Survey of Wis., Vol.1, pp.170-177.

Figure I.



View of bed of obolitic iron ore, near middle of the picture, overlain by Silurian limestone, and underlain by Maquoketa shale, exposed at Cascade Falls, 4 miles east of DePere, Wisconsin.

In 1873-1877, T. C. Chamberlin,¹ the State Geologist of Wisconsin, made a careful study of the Maquoketa strata near the town of Eagle, on the south side of Pewaukee Lake; near Hartford and Iron Ridge, and in the vicinity of Green Bay.

In his report² Chamberlin published the following general section which gives a clear idea of the Maquoketa Shale:

1.	Hard, fine grained, compact, argillaceous limestone, in beds 10 inches in thickness-	Feet 9
2.	Similar, but harder limestone, marked with contrasted lamination, some clay layers interstratified - bluish-gray in color-	7
3.	Shales varying in color and texture-	16
4.	Thick bedded, blue, cherty limestone, with some impurities in the form of partings-	5
5.	Very similar to the above, but harder-	1
6.	Thin bedded, broken, irregular, cherty, calcareous layers-	3½

In this same report Mr. M. Strong; who had made a study of the strata in the lead region in southwestern Wisconsin,³ described the relation of the lead formations to the Maquoketa.

Stratigraphy.

The Maquoketa formation lies between the Galena limestone below and the Silurian limestone above. The Galena limestone is a yellowish-brown dolomite, between the layers of which are shaly leaves and partings which have bluish and greenish color.

1 Geological Survey of Wis., Vol. 2, pp. 314-326

2 Geological Survey of Wis., Vol. 2, pp. 319. 1877.

3 Geological Survey of Wis., Vol. 2, pp. 685-688

This formation unconformably underlies the Maquoketa Shale.

In some places a bed of iron ore immediately overlies the Maquoketa Shales and in other places limestone of Silurian age rests directly upon them. Exposures where the iron ore separates the shale below and the Silurian limestone above can be seen near Mayville and at Cascade Falls. At Mayville there is about 30 feet of oölitic iron ore which is overlaid by about 20 feet of Silurian limestone. Below the iron ore is the Maquoketa Shale, the thickness of which is not known in this locality. At Cascade Falls 30 feet of Silurian limestone overlies 5 feet of oölitic iron ore, the base of the latter being in contact with the Maquoketa Shale. A number of characteristic Maquoketa fossils were found in the more shaly bands in the lower part of the iron ore. It is thought that these fossils indicate the Maquoketa age of the bed of oölitic iron ore.

Certain horizons of the Maquoketa Shales are very fossiliferous but some of the species that are present in one place are often absent in another. An illustration of the above statement is the fact that many fossils that are found at the Brickyard on the east side of Lake Winnebago, and in exposures four miles east of Green Bay and four and one-half miles east of DePere, are absent in the shale near the town of Gardner, about twenty miles west of Sturgeon Bay. The masses of shale exposed along the foot of the cliff near the edge of the water at Green Bay show beautiful ripple marked surfaces. The thickness of the shale exposed above the level of the water is at least 100 feet, above which is a

Figure II.

View of the oölitic iron ore underlying
Silurian limestone, and overlying Maquoketa Shale,
at Neda, Wisconsin.

thickness of about 20 feet of Silurian limestone. In some places the shale is fine textured and shows delicate laminae and in other places it is full of cavities and contains numerous concretions. About one-half mile east of the bluff there is exposed a bed of oolitic iron ore, the thickness of which could not be determined. A few Maquoketa fossils were found near the iron ore exposure. The iron ore formation in this locality can be confidently correlated with that exposed south of Mayville and at Cascade Falls.

Detailed Sections and Fossil Lists.

Section of Maquoketa exposed at Brickyard, six miles south and a little west of High Cliff.

Silurian Limestone.

	<u>Feet</u>
8. Limestone, in layers one to three feet thick- - - - -	10

Maquoketa Shale.

7. Shale, covered by grass- - - - -	18
6. Shale, soft, with fossils- - - - -	12
5. Shale, with limestone fragments, containing many fossils- - - - -	96
4. Shale, yellowish, with thin bands of limestone- - - - -	5
3. Shale, dark gray- - - - -	15
2. Limestone, hard, dark gray, containing fossils, calcite, geods, and iron pyrite-	6
1. Shale, compact and dark- - - - -	35

The total thickness of the strata exposed at this place is 197 feet. The operator of the brick plant said that the thickness of the shale below the level of the water was about 50

feet. The brick company uses the shale from number one and three of the section in the manufacture of brick which appears to be of excellent quality.

Fossils from Number 2 of the Brickyard Section.

Glyptocrinus stems
Rafinesquina alternata
Strophomena wisconsensis
Hebertella occidentalis
Byssonychia radiata
Cyclonema sp.

Fossils from Numbers 5 and 6 of the Brickyard Section.

Streptelasma rusticum
Plectambonites sericea
Dalmanella testudinaria
Hebertella insculpta
Hebertella occidentalis
Platystrophia acutilirata
Rhynchotrema ainslei
Rhynchotrema anticostiensis
Rhynchotrema capax
Homoeospira sp.

The above lists show the difference in the fossils in the lower and upper beds of the Maquoketa in this locality. The genera Strophomena and Rafinesquina are common in the lower beds

and *Rhynchotrema* and *Platystrophia* are more common in the upper, and *Hebertella occidentalis* is common both in the upper and lower beds.

Section of Maquoketa strata four and one-half miles east of DePere, exposed in the bottom of the creek for a distance of one mile.

	<u>Feet</u>
5. Alternating layers of hard and soft limestone, 4 to 6 inches thick- - -	6
4. Alternating layers of shale and limestone- - - - -	3
3. Shale, impure- - - - -	8
2. Limestone, very soft and shaly- - -	5
1. Limestone, hard, shaly- - - - -	5

The following fossils were obtained from the Maquoketa strata at this place:

- Streptelasma rusticum*
- Rafinesquina alternata*
- Strophomena wisconsensis*
- Dalmanella testudinaria*
- Dinorthis subquadrata*
- Hebertella insculpta*
- Platystrophia acutilurata*
- Rhynchotrema capax*
- Rhynchotrema inaequivalvis*
- Orthoceras* sp.

An outcrop of Maquoketa strata, nearly one-half mile long, occurs about four miles east of Green Bay. The total thickness here exposed is about 30 feet. The upper part of the section

at this place corresponds to the lower part of that east of DePere. The rocks here furnished the following fossils:

- Rafinesquina alternata
- Plectambonites sericea
- Strophomena neglecta
- Hebertella occidentalis
- Platystrophia acutilirata
- Plectorthis whitfieldi
- Rhynchotrema anticostiensis
- Rhynchotrema capax
- Pterinea demissa

The following section is exposed at Cascade Falls, four and one-half miles east of DePere:

	<u>Feet</u>
3. Silurian limestone- - - - -	30
2. Oölitic iron ore, with shaly pebbles and a thin shaly band in the lower part, containing Maquoketa fossils- -	5
1. Hard, calcareous shale, in layers up to 14 inches in thickness, without fossils- - - - -	-10

The following fossils were collected from the iron ore bed at Cascade Falls:

- Cf Stenaster sp.
- Strophomena wisconsensis
- Dalmanella tersa
- ⁿ
Byssocy~~ch~~ia radiata
- Pterinea demissa
- Cf Liospira nucula

The above fossils are clearly Maquoketa species. It is possible that the iron ore bed is of Maquoketa age or it may be that the Maquoketa fossils were carried and deposited with the shale fragments by the streams that drained exposed areas of Maquoketa Shale and discharged into this part of the basin while the oolite was in process of accumulation.

The Maquoketa in Eastern Iowa.

Location and Area.

In the State of Iowa, the Maquoketa formation outcrops, along the Mississippi River, over a narrow area between Lyons and Bellevue. Its distribution extends in a southeast and northwest direction across portions of the counties of Clinton, Jackson, Dubuque, Clayton, Fayette, and Winneshiek. The width of outcrop of the formation seldom exceeds two miles, but its length in the state is more than one hundred miles. In Jackson and Dubuque counties it is exposed in the bluffs near the Mississippi River, while in Clayton, Fayette and Winneshiek counties its outcrop is several miles west of the River. The most southerly exposure is in the bluffs of the River, near Lyons, in Clinton County, and the most northerly one is in the western part of Winneshiek County.

In Clinton County the Maquoketa formation does not cover a large area, being confined to some places in the bluffs of the Mississippi and Elk rivers.

In Jackson County the Maquoketa covers a considerable area in the township of Bellevue. It appears in the bluffs of

the Mississippi River and along the valley of Morts Creek in Prairie Spring and Tete des Mort townships.

The Maquoketa has a wide distribution in Clayton County, forming the surface rock of the uplands in Jefferson, Volga, Read, Carnaville, Wagner, Farmersburg, Marion, and Grand Meadow townships

In Fayette County the Maquoketa covers nearly the whole area north of Turkey River, outcropping in the bed of Otter Creek from one to one and one-half miles east and one-half mile south of West Union, to the junction of this creek with the Turkey River. The Maquoketa Shale also fringes the channel of the Little Turkey River from Auburn Mills to Eldorado.

The Maquoketa shales occur in a large, irregular area south of the Upper Iowa River in Winneshiek County, covering parts of four townships south of the line through the northern part of Springfield and Frankville, and extending from the valley of the Turkey River to the line between Winneshiek and Howard counties.

Previous Geological Work on the Maquoketa in Iowa.

Clinton County: - The general characters of the Maquoketa formation were described in 1858 by J. D. Whitney¹ and James Hall². After this, W.J. McGee³ made extensive observations on this formation and published an account of his work in the Pleistocene History of Northeastern Iowa. In 1905 J. A. Udden⁴ made a detailed

1 Geology of Iowa, Vol.1, pp. 278-282

2 Geology of Iowa, Vol. 1, pp. 70-71

3 11th Annual Report U. S. Geol. Surv. Part 1.

4 Iowa Geol. Survey, Vol. 15, p. 373

study of the Maquoketa and described the occurrences, characters and thickness of the formation at different places in this county.

Jackson County: - The character and thickness of the Maquoketa Shale have been briefly described by C. A. White¹ and W. J. McGee². In 1905, a detailed study of the Maquoketa and other formations was made by T. E. Savage³. The strata of the Maquoketa stage in Jackson County represent the Upper Maquoketa beds only, and the thickness does not exceed 100 feet.

Dubuque County⁴: - On account of the presence of important ore deposits in Dubuque County many geologists visited this region in the early days. From 1750 to 1838 expeditions were made by LeSeuer, Pike, Schoolcraft, and Nicollet. These men made some geological observations, but published no description of the geology of the region. From 1839 to 1860 researches were made by Owen, Percival, Hall and Whitney. During this time the lead bearing area was defined and the theories of the ore deposition were proposed. From 1870 to 1880 this region was studied by Chamberlin and Strong. From 1890 down to the present detailed studies were made with the view of determining the extent and explaining the mode of deposition of the ores.

Clayton County: - The Maquoketa formation in this county

- 1 Geology of Iowa, Vol. 1, p. 80
- 2 11th Annual Report U.S. Geol. Surv., 1890
- 3 Iowa Geol. Survey, Vol. 16, p. 567
- 4 Iowa Geological Survey, Vol. 10, p. 386

was studied by A. G. Leonard in 1905. He made several detailed sections in different places, showing the occurrence and characters of the formation, and giving lists of fossils which it contained.

Fayette County: - F. W. Sardeson¹ has referred to a number of the Maquoketa exposures in this county, and G. F. Finch² also made some observations on the Maquoketa along the valley of the Turkey River and described the position of *Nileus Vigilans* that were found in these strata near Elgin. In 1906 T. E. Savage³ made an extensive study of the geology of this county including the Maquoketa. He divided the strata of the Maquoketa stage into three divisions - the Lower, the Middle, and the Upper beds, and gave typical sections indicating the character of the strata in each of these divisions, and listed the fossils occurring in each.

Winneshiek County: - In 1906 S. Calvin⁴ described the main characters of the Maquoketa strata in Winneshiek County. The characteristics of the Maquoketa vary very much in different localities. The features of the lower half of the Maquoketa in Dubuque County are not repeated in Fayette and Winneshiek counties. The lithological characters of the Maquoketa in Winneshiek County are not easily described because the beds of the same horizon often have different characters in passing from one locality to another. Calvin divided this formation into four members as follows:

- 1 American Geologist, Vol. 19, pp. 30-33
- 2 Proceedings Iowa Academy of Sci., Vol. 8, p. 204
- 3 Iowa Geological Survey, Vol. 15, p. 437
- 4 Iowa Geological Survey, Vol. 16, p. 94

4. Brainard shales
3. Fort Atkinson limestone
2. Clermont shales
1. Elgin shaly limestone.

Stratigraphic relations of the Maquoketa
formations in Iowa.

The Maquoketa strata in Iowa everywhere rest unconformably upon some horizon of the Salena limestone, or where that limestone was entirely eroded before the deposition of the Maquoketa, the latter formation may immediately overlie the Platteville or Trenton limestone.

The Maquoketa strata are usually followed above by some horizon of the Silurian system, from which it is separated by a break in sedimentation. Along the Mississippi River, in eastern Jackson County, Silurian strata corresponding to some part of the Edgewood limestone of the Alexandrian series immediately overlies the Maquoketa. Farther northwest, in part of Fayette County, the Maquoketa is succeeded by limestone which corresponds with some part of the Sexton Creek formation, which is the uppermost member of the Alexandrian series. Over the greater part of eastern Iowa, limestone of Niagara age rests unconformably upon the Maquoketa formation. In the northern part of the area of Maquoketa in Iowa, in northern Howard and Winneshiek counties, the Silurian limestone is overlapped by the Middle Devonian and the latter limestone directly overlies the Maquoketa beds.

General Section of the Maquoketa Formation in Iowa.

Upper Maquoketa Division.

Feet

13. Bed composed of bands of soft, bluish-gray shale, 2 to 4 inches thick, which alternate with thin layers of limestone 1 to 3 inches in thickness, having a band of reddish shale two feet in thickness at the base. The materials are fossiliferous throughout, containing colonies of a branching Manticuliporoid, Leptaena unicostata, Plectambonites sericea, Strophomena trilobata, Hebertella occidentalis, Rhynchotrema capax, Cyclonema bilix, Ambonychia radiata- - - 8-12
12. Bed of blue, plastic shale, without distinct planes of bedding; containing small concretions of iron pyrite in the upper part, and numerous large crystals of selenite in the lower; bearing no fossils- - - 95-110

Middle Maquoketa Division.

11. Transition beds from the middle to the upper Maquoketa; consisting of layers of yellowish, arenaceous-magnesian limestone, 3 to 8 inches thick, alternating with bands of dry, indurated, impure shale; without fossils- - - - - - - - - -3-5
10. Massive bed of yellow limestone, which in some places is dolomitic, sometimes showing indistinct planes of bedding that separate the ledge into imperfect layers, 6 to 12 inches in thickness, bearing a few fossils, and occasional concretions of chert- - - - - - - - - 5
9. Bed of impure limestone made up of quite regular layers, 2 to 6 inches thick, containing a large quantity of chert in the form of nodules and imperfect bands; bearing the fossils Streptelasma corniculum, Rafinesquina alternata, R. alternata var. laxorhytis, Leptaena unicostata, Rhynchotrema capax- - - 12-14

Figure III.



View of the dolomitic phase of the middle
Maquoketa, overlying the upper shale of the Lower
Maquoketa, at Clermont, Iowa.

- 8. Bed of fine-grained, impure limestone, in even layers 6 to 10 inches thick, consisting largely of chert nodules or of chert bands segregated along the planes of bedding; containing large individuals of *Rafinesquina alternata*, *Strophomena incurvata*, *Dalmanella testudinaria*, *Hebertella insculpta*, *Rhynchotrema capax*- - - - - 18-21
- 7. Massive bed of yellow, fine-grained dolomite, containing a number of chert nodules, and bearing *Lingula iowensis* and *Orthoceras* sp- - - - - 5-7

Lower Maquoketa Division.

- 6. Bed of bluish, plastic, rather fine-grained shale; in places containing numerous fossils among them *Rafinesquina alternata*, *R. minnesotensis*, *Plectambonites sericea*, *Strophomena incurvata*, *Dalmanella testudinaria*, and *Rhynchotrema capax*- - - - - 10-14
- 5. Bed of lean, yellowish-gray shale, in places somewhat arenaceous; containing in the lower part, thin bands of impure limestone, 3 to 6 inches thick, and containing *Strophomena planumbona*, *Dinorthis subquadrata*, *Hebertella insculpta*, and *Plectorthis whitfieldi*- - - - - 10-13
- 4. Bed composed of layers of yellowish-gray shale, 3 to 6 inches thick, separated by bands of impure limestone about equal in thickness to the seams of shale, becoming more calcareous below; bearing numerous nodules of chert, and containing *Plectambonites sericea*, *Hebertella insculpta*, *Rhynchotrema inaequivalvis*, *Hormotoma gracilis*, *Pterygometopus callicephalus*, *Ceraurus pleurexanthemus*- 14-16
- 3. *Nileus vigilans* zone: consisting of a bed of gray colored limestone in layers 1 to 4 inches thick, which are separated from one another by thin bands of gray shale; containing *Nileus vigilans*, *Calymene senaria*, and *Pterygometopus callicephalus*- - - - - 13-16

Figure IV.



View showing exposure of Lower Maquoketa beds,
Elgin shaly limestone, in the south bank of Otter
Creek, in Elgin, Iowa.

- | | <u>feet</u> |
|--|-------------|
| 2. Bed of bluish shale, usually dry and indurated, in layers 2 or 3 inches thick, between which thin bands of limestone are intercalated; among the fossils are <i>Lophospira quadrisulcata</i> , and <i>Orthoceras bilineatum</i> - - - - - | 15-18 |
| 1. <i>Isotelus maximus</i> zone: composed of layers of bluish, fine-grained, argillaceous limestone 4 to 8 inches thick, alternating with bands of bluish-gray shale- - - - - | 14-16 |

Fossils of the Maquoketa Shale in Iowa,

Exclusive of bryozoa.

- Astylospongia ? sp. #
- Hindia parva Ulrich #
- Streptelasma corniculum Hall * ∅ #
- Streptelasm sp. #
- Lingula iowensis Owen ∅#
- Crania sp. *
- Rafinesquina alternata Conrad * ∅#
- Rafinesquina minnesotensis Winchell * ∅#
- Leptaena unicostata Meek & Worthen * #
- Plectambonites sericea Sowerby * ∅ #
- Strophomena planumbona Hall #
- Strophomena fluctuosa Billings #
- Strophomena incurvata Shepard ∅ #
- Strophomena trilobata Owen *
- Strophomena sp. #

Parastrophia sp. #
Dinorthis subquadrata Hall #
Dinorthis pectinella Hall #
Hebertella occidentalis Hall *
Hebertella insculpta Hall ∅ #
Plectorthis whitfieldi Winchell #
Plectorthis plicatella Hall #
Plectorthis fissicosta Hall #
Dalmanella testudinaria Dalman * ∅ #
Dalmanella hamburgensis Walcott #
Platystrophia acutilirata James *
Rhynchotrema capax Conrad * ∅ #
Rhynchotrema perlamellosa Whitfield #
Rhynchotrema inaequalis Castlenau #
Rhynchotrema neenah Whitfield #
Zygospira modesta (Say) Hall * #
Zygospira recurvirostra Hall #
Hormotoma gradlis Hall #
Lophospira quadrisulcata U. & S. #
Bellerophon bilobatus Sowerby #
Bellerophon sp. #
Helicotoma sp. *
Trochonema umbilicatum Hall #
Trochonema sp. #
Cyclonema bilix Conrad *
Tentaculites sterlingensis Meek & Worthen *

Pterinea demissa Conrad *

Ambonychia radiata Hall *

Ambonychia intermedia Meek & Worthen *

Orthoceras sociale Hall #

Orthoceras bilineatum Hall #

Cameroceras proteiforme Hall #

Cyrtoceras camarum ? Hall #

Gyroceras sp. #

Isotelus maximus Locke #

Nileus vigilans Meek & Worthen #

Calymene senaria Conrad * #

Ceraurus icarus Billings #

Ceraurus pleurexanthemus Green #

Pterygometopus callicephalus Hall #

Dalmanites sp. #

* Collected from the Upper Maquoketa beds
Ø Found in the Middle Maquoketa
Occur in the Lower Maquoketa

The upper part of the Maquoketa strata is well exposed in Jackson County, about 7 miles west of Preston, where on one side of a ravine it is unconformably overlain by Silurian limestone, and on the other by Pennsylvanian sandstone.

Section of strata exposed along a stream, about
seven miles west of Preston, Iowa.

	<u>feet</u>
2. Niagara limestone, with few or no fossils, in layers 4 to 12 inches thick- - - - -	40
1. Maquoketa Shale, in alternating layers of shale and limestone, representing the upper portion of the Maquoketa, and containing many fossils- - -	35

The following fossils were collected from the Maquoketa strata seven miles west of Preston, Iowa:

Streptelasma rusticum Billings

Rafinesquina alternata Conrad

Plectambonites sericea Sowerby

Leptaena unicostata Meek & Worthen

Strophomena neglecta Hall

Strophomena rugosa Blainville

Dalmanella tersa Sardeson

Dalmanella testudinaria Dalman

Hebertella insculpta Hall

Hebertella occidentalis Hall

Plectorthis whitfieldi Winchell

Pterinea demissa Conrad

Byssonychia radiata Hall

Modiolopsis concentrica Hall & Whitfield
Liospira cf. *subconcava* Ulrich
Hormotoma salteri Ulrich
Lophospira tropidophora Meek & Worthen
Conradella dyeri Hall
Cyclonema humerosum Ulrich
Tentaculites sterlingensis Meek & Worthen

The Maquoketa in Illinois

Location and Area

The Maquoketa formation was probably laid down continuously across the La Salle anticline in northern Illinois, but the higher portion of the axis of the anticline has since been eroded, exposing the Galena limestone and older rocks in that region.

At present the Maquoketa formation in northern Illinois occurs in two areas, separated by the Galena limestone and older rocks. The eastern portion extends from near Paxton in Ford County north to Big Foot Prairie in McHenry County, embracing parts of Ford, Iroquois, Kankakee, Will, Kendall, DeKalb, Boone, and McHenry counties. The length of this area is about 190 miles, but its width varies very much in different places, from 5½ to 33 miles.

The western area of Maquoketa has a somewhat regular shape extending in a narrow belt in a southeast and northwest direction from Van Orin, in Bureau County, to Fair Haven, in Carroll County. From Fair Haven up to the northwest border of the state, the Maquoketa exposures are entirely irregular occurring in

Figure V.



View showing characteristic Maquoketa topography,
with escarpment of Silurian limestone capping the hills.

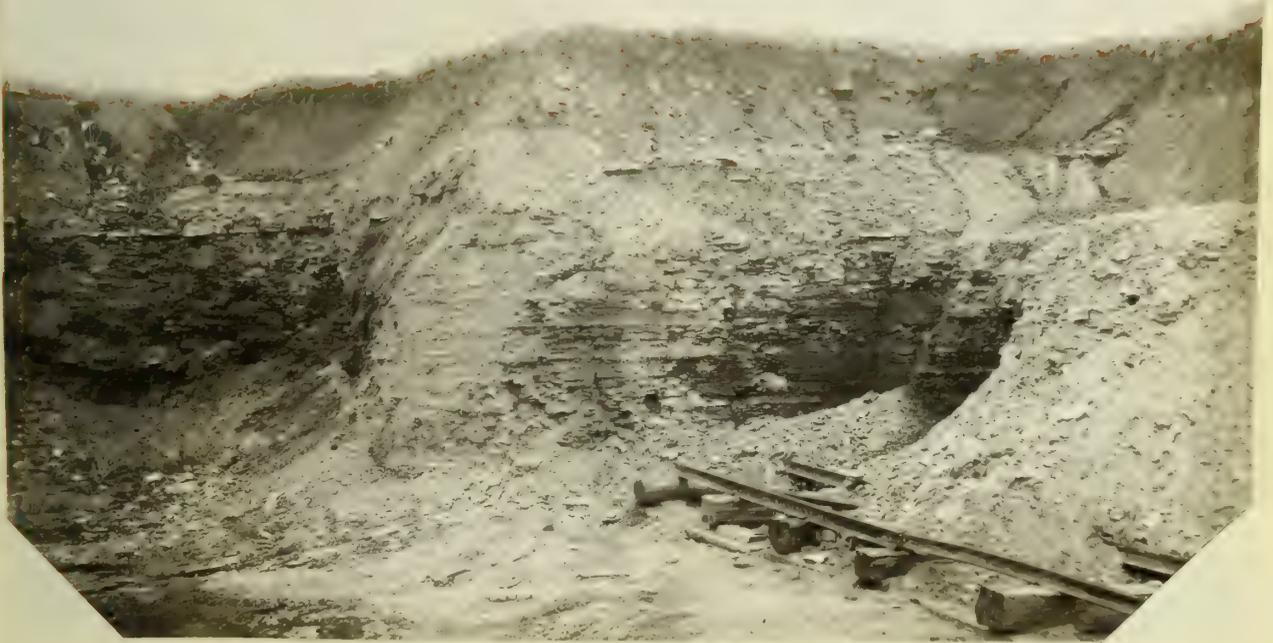
the lower part of the mounds and irregular patches where they have been protected by the overlying Silurian limestone. They are exposed along Plum Creek and Straddle Creek, in Carroll County, Yellow Creek in Stephenson County, and along Apple River, Smallpox Creek, Mill Creek, and Galena River, in Jo Davies County.

Earlier Geological Work on the Maquoketa in Illinois.

In 1870, Worthen, then State Geologist, studied the geology of Northern Illinois and gave a brief description of the Maquoketa formation in different localities. He mentions the Maquoketa strata in DeKalb County, on the north bank of the Kankakee River, where about 15 feet of inter-stratified green and blue shales and limestone beds are exposed. He also mentioned an exposure, about 30 feet in thickness, along the Fox River where the shaly beds contain many thin plates of limestone from which numerous characteristic fossils were collected including *Dinorthis subquadrata*, *Dalmanella testudinaria*, *Hebertella occidentalis*, *Rafinesquina alternata*, and other common species.

In Kendall County Worthen found the upper beds of the Maquoketa formation well exposed at Oswego, directly underlying the lower strata of Niagaran limestone. The Maquoketa strata here consist of hard, sub-crystalline, thin bedded limestone, containing many fossils, the most common of which are *Tentaculites oswegoensis*, *Rhynchotrema capax*, *Hebertella occidentalis*, *Rafinesquina alternata*, and many segments of crinoid stems.

Figure VI.



View of upper beds of Maquoketa, exposed in
the old shale pit, at Millsdale, Will County,
Illinois.

Along the Fox River, below Oswego, Worthen noted the Maquoketa Shale with thin bands of limestone, which contained *Rhynchotrema capax*, *Hebertella occidentalis*, *Plectambonites sericea*, and *Rafinesquina alternata*. He also described the almost continuous exposure of the Maquoketa along the banks of the river below Yorkville for about three miles, where the strata present the same appearance as those above Yorkville. He also found the fossiliferous Maquoketa shale and shaly limestone exposed on the AuSable Creek, in township 35, range 8, near the center of the west side of section 15.

The Maquoketa formation in Will County consists of shale in the upper and middle parts, and argillaceous limestone with some chert in the lower. About one-half mile east of DuPage the very fossiliferous thin bedded limestone, belonging to the lower part of the formation is exposed. In this county the green shaly clay forming the middle division of the Maquoketa has a homogeneous, fine-grained texture, and contains no fossils. Along the DesPlaines River it is about 50 feet thick. Above Wilmington it becomes more impure and thinner.

In 1873, Meek and Shaw made a study of the Maquoketa formation in Jo Daviess and Carroll Counties, and described the general characters of this formation in different localities. In Jo Daviess County the Maquoketa Shale underlies the mound-like elevations and is exposed on both sides of all the stream valleys.

Figure VII.



Maquoketa Shale exposed along Chicago,
Rock Island, and Pacific railroad, near the
mouth of Rock Run, in Will County, Illinois.

The lower strata contain many minute fossils as species of Nucula and Cleidophorus. The upper beds are rather thin and cream colored, while the lower ones are greenish-blue and are separated by thin bands of marly clay; still lower the shales are exceedingly hard with few fossils. In Carroll County outcrops of Maquoketa strata occur near the base of the bluffs, about one mile below Savanna, and about an equal distance above that town. Meek and Shaw state that a large amount of petroleum was obtained in the early days by distilling the black shales of this formation. Near Savanna and Tomlinson a part of the shale is as black as cannel coal and when burned gives out an oily bright flame for a considerable time.

In 1909, T. E. Savage studied the faunal succession, and made the correlation of the pre-Devonian formations of southern Illinois where he described a small area of Richmond (Maquoketa) strata in Alexander County. He separated the rocks in that region into three formations, the Fernvale limestone below, the Thebes sandstone and shale, and the Orchard Creek shale. Dr. Savage gave the detailed sections of the formations, and described the strata and their faunas, and correlated them with the Maquoketa stage in northeast Iowa and northwest Illinois.

Detailed sections: - There is given below a number of detailed sections of the Maquoketa strata in different parts of Illinois:

Section of strata exposed in the banks of
Kankakee River in the vicinity of
Wilmington, Illinois.

	<u>feet</u>
2. Shale, bluish-gray, with few or no fossils- - - - -	35
1. Limestone, shaly to sub-crystalline, in irregular layers, very fossili- ferous- - - - -	18

The following fossils were collected from the Maquoketa
strata at Wilmington, Illinois:

- Lingulasma schucherti
- Strophomena ^{maquoketa} incurvata W
- Rafinesquina Kingi
- Rafinesquina minnesotensis
- Rafinesquina alternata
- Strophomena planodorsata
- Plectambonites sericea
- Dalmanella tersa
- Dalmenella testudinaria
- Dinorthis proavita
- Dinorthis subquadrata W
- Hebertella insculpta W
- Hebertella occidentalis W
- Platystrophia acutilirata
- Parastrophia divergens
- Rhynchotrema capax
- Ambonychia amygdalina

Hormotoma bellicincta
Orthoceros sp.
Cameroceros proteiforme
Cyrtoceros houghtonia

Section of strata exposed along the bank of
Waubansia Creek, in Oswego, Illinois.

Silurian limestone.	feet
6. Shale, yellowish-gray- - - - -	$\frac{1}{2}$
5. Limestone, gray, dolomitic, in places crinoidal, weathered into thin bands 3 to 8 inches thick- - - - -	3 $\frac{1}{4}$
Maquoketa formation.	
4. Limestone, gray, massive- - - - -	6
3. Shale, calcareous, hard, bluish-gray- - -	2
2. Shale, bluish- - - - -	2/3
1. Shale, calcareous, bluish, in layers 6 to 18 inches thick- - - - -	13

The fossils listed below were collected from the

Maquoketa strata in Oswego, Illinois.

Strophomena planodorsata
Strophomena rugosa
Rafinesquina alternata
Plectambonites sericea
Dalmanella fairmountensis
Dinorthis proavita
Hebertella occidentalis
Hebertella sinuata

Platystrophia acutilirata
Rhynchotrema capax
Zygospira modesta
Tentaculites oswegoensis

A detailed section, with lists of species of fossils of the Maquoketa strata, exposed along the south bank of Fox River, one and one-half miles east of Yorkville, Illinois, is given below:

5. Limestone, hard, very fossiliferous, Feet Inches
containing the fossils listed
below- - - - - 9

Lingula deflecta
Lingula riciniformis
Rafinesquina alternata
Dalmanella fairmountensis
Zygospira modesta
Pterinea carianota
Raphistoma peracutum
Calymene christyi
Calymene fayettensis
Isotelus maximus

4. Shale, dark gray, containing the
following fossils- - - - - 1 8

Lingula sp.
Dalmanella fairmountensis
Pterinea carianota
Calymene fayettensis

	<u>feet</u>	<u>Inches</u>
3. Limestone, argillaceous, with the fossils given below- - - - -		5
<i>Dalmanella fairmountensis</i>		
<i>Pterinea carianota</i>		
<i>Calymene fayettensis</i>		
2. Alternating layers of shale and impure limestone, 3 to 6 inches thick, with fossils- - - - -		12
<i>Rafinesquina alternata</i>		
<i>Dalmanella testudinaria</i>		
<i>Byssonychia radiata</i>		
<i>Calymene fayettensis</i>		
1. Shale, dark colored, calcareous, with a thin calcareous band crowded with fossils- - - - -		2
<i>Lingula cf. iowensis</i>		
<i>Rafinesquina alternata</i>		
<i>Dalmanella fairmountensis</i>		
<i>Zygospira modesta</i>		
<i>Byssonychia radiata</i>		
<i>Calymene fayettensis</i>		

Section of Maquoketa strata exposed in the north bank of the river, one and one-fourth miles east of Sterling, Illinois.

	<u>Feet</u>
3. Limestone, yellow to brown, dolomitic, in layers 4 to 10 inches thick, with few fossils- - - - -	28
2. Shale, bluish-gray, in layers alternating with calcareous, very fossiliferous bands- - - - -	6
1. Shale, sandy, with few fossils- - - - -	18

The Maquoketa strata, east of Sterling, furnished the fossils listed below:

- Strophomena incurvata
- Strophomena neglecta
- Leptaena unicostata
- Plectombonites sericea
- Hebertella insculpta
- Hebertella occidentalis
- Plectorthis whitfieldi
- Rhynchotrema capax
- Rhynchotrema neenah
- Zygospira modesta
- Byssonychia radiata
- Bellerophon bilobatus
- Cyclonema bilix

Section of the Maquoketa strata exposed in the
railroad cut, at Scales Mound, Illinois.

Maquoketa Shale	<u>Feet</u>
3. Shale, bluish gray, without fossils- -	32
2. Shale, blue, with a reddish zone near the base, and another about 8 feet above the base, containing several small fossils- - - - -	11
Calena limestone.	
1. Dolomite, yellow, in layers 6 to 18 inches thick- - - - -	6

The following fossils were collected from the lower portion of the Maquoketa formation, in the town of Scales Mound, Illinois:

Dalmanella testudinaria
Zygospira modesta
Ctenodonta fecunda
Ctenodonta obliqua
Clidophorus neglectus
Bellerophon sp.
Liospira micula
Lophospira pulchella
Pleurotomaria depauperata
Orthoceras sociale

Above member No. 3 of the section at Scales Mound the Maquoketa formation in this region consists of about 60 feet of bluish-gray, nonfossiliferous shale, which is followed above by about 28 feet of alternating shale and limestone layers containing very numerous fossils.

From the alternating layers of shale and limestone in the upper strata of the Maquoketa, two and one-half miles northeast of Scales Mound, Illinois, near the west side of section 19, township 29, north range 3 east, the following fossils were collected:

Strophomena neglecta
Strophomena wisconsinensis
Rafinesquina alternata
Plectambonites sericea
Dalmanella testudinaria
Dinorthis proavata
Plectorthis whitfieldi

Rhynchotrema capax

Rhynchotrema neenah

Modiolopsis concentrica *w*

Murchisonia sp.

In the vicinity of Savanna, Illinois, the Maquoketa strata consist of about 100 feet of bluish shale, with few or no fossils, above which occur about 18 feet of shale and shaly limestone in alternating layers 3 to 5 inches thick, the layers of shaly limestone containing very numerous fossils, the more common of which are listed below:

Streptelasma rusticum

Streptelasma sp.

Strophomena neglecta

Leptaena unicostata

Plectambonites sericea

Dalmanella fairmountensis

Dalmanella testudinaria

Platystrophia acutilirata

Plectorthis whitfieldi

Rhynchotrema anticostiensis

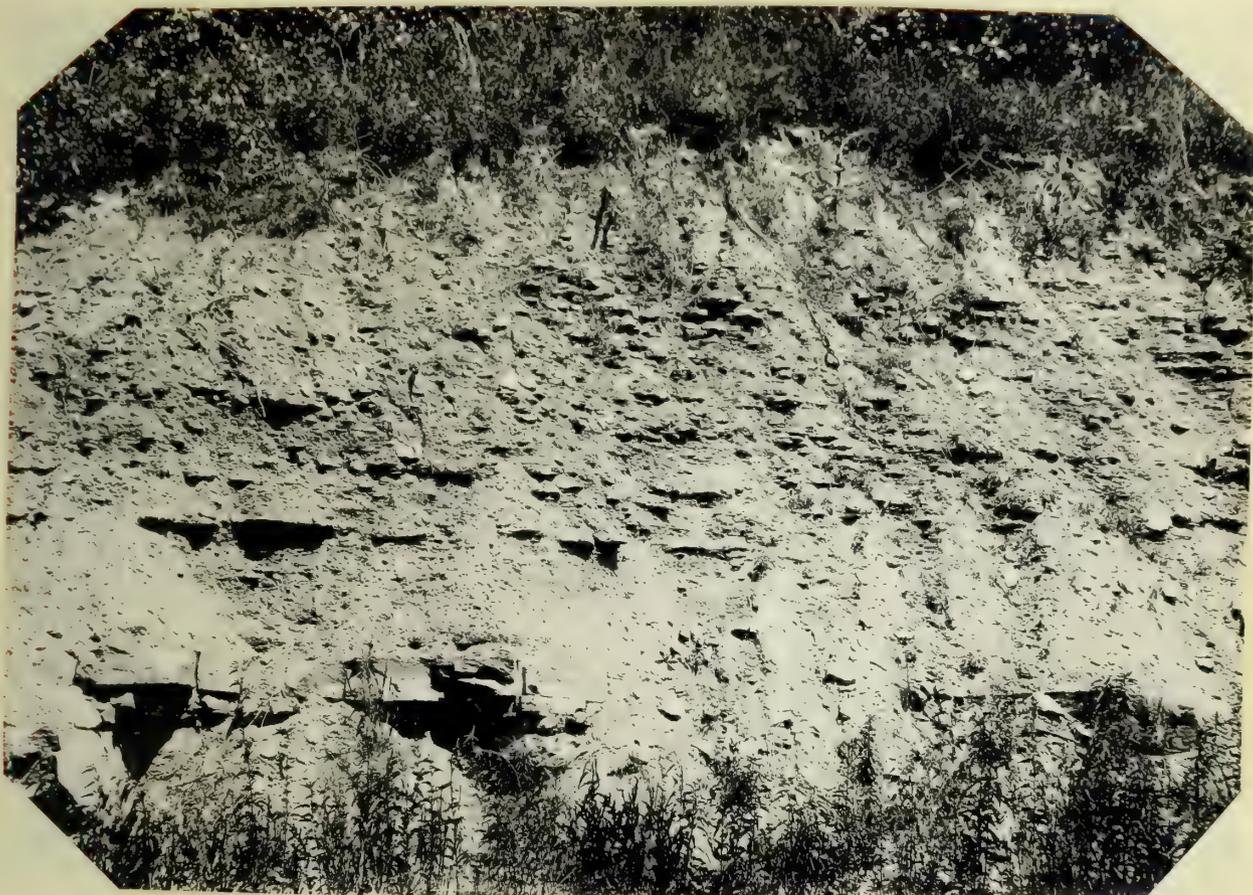
Rhynchotrema capax

Section of Maquoketa strata exposed near

Thebes, Illinois

	<u>Feet</u>
Orchard Creek shale member.	
4. Shale, bluish-gray, calcareous, in which thin bands of concretionary, shaly limestone, 1 to 2 inches thick occur 4 to 6 inches apart- - - -	17

Figure VIII.



View of Orchard Creek shale overlying
Thebes sandstone, in bluff of Mississippi
River, two and one-half miles north of Thebes
Illinois.

Figure IX.



View of exposure of Thebes sandstone
(Richmond or Maquoketa age) in southwest Illinois,
one-fourth mile south of Gale.

Thebes sandstone member.

Feet

3. Sandstone, yellowish to brown, rather fine grained, in layers 6 to 36 inches thick, containing *Climacograptus putillus*, and *Lingula covingtonensis*- - 73
2. Sandstone, yellowish, fine grained, in thin layers, containing the fossils *Climacograptus putillus*, *Lingula covingtonensis*, *Conularia* sp. and *Isotelus* sp.- - - - - 5

Fernvale limestone member.

1. Limestone, hard, gray, very fossiliferous- 1½

The following fossils were collected from the Fernvale limestone, and Thebes sandstone, near Thebes, Illinois:

Climacograptus putillus

Lingula covingtonensis

Strophomena planodorsata

Strophomena rugosa

Rafinesquina alternata

Plectambonites sericea

Dalmanella testudinaria

Dinorthis proavita

Dinorthis subquadrata

Hebertella insculpta

Hebertella sp.

Orthis tricenaria

Platystrophia acutilirata

Rhynchotrema capax

Vanuxemia sardesoni

Bellerophon sp.

Orthoceros sp.

Conularia sp.

Isotelus maximus

Isotelus sp.

Endymion sp.

The Maquoketa strata in the vicinity of Cape Girardeau, Missouri, are similar to those near Thebes, Illinois, with the exception that the Fernvale limestone member at the base is considerably thicker, reaching about 7 feet.

A list of species of fossils collected from the Fernvale limestone in the vicinity of Cape Girardeau, Missouri, is given below:

Streptelasma rusticum

Strophomena planodorsata

Rafinesquina alternata

Dalmanella testudinaria

Dalmanella meedsi

Dinorthis subquadrata

Hebertella insculpta

Hebertella sp.

Orthis tricenaria

Platystrophia acutilirata

Rhynchotrema capax

Vanuxemia sardesoni

Orthoceros sp.

Isotelus maximus

Comparative Table of Fossils.

The following table shows the species of fossils in the Maquoketa of the different areas. The names of those which occur in Wisconsin are indicated by "X" in the first column; those which occur in Iowa by an "X" in the second column; those which occur in Northern Illinois by an "X" in the third column; and those which occur in Southern Illinois by an "X" in the fourth column:

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Astylospongia sp.		X		
Hindia parva		X		
Climacograptus putillus				
Streptelasma rusticum		X	X	X
Stomotopora arachnoidea		X	X	
Corynotrypa inflata				
Protocrisina exigua			X	
Ceramopora				
Ceramoporella granulosa	X		X	
Ceramoporella ohioensis	X	X	X	
Ceramoporella whitei			X	
Coeloclema oweni			X	
Coeloclema sp		X		
Crepipara hemispherica	X		X	
Crepipora simulaus	X		X	
Analotichia ponderosa			X	

<i>Analotichia</i> sp.	X	
<i>Bythotrypa</i> epidermata		X
<i>Bythotrypa</i> laxata	X	
<i>Cyclotrypa</i> n. sp.		
<i>Peronopora</i> pavonia		X
<i>Homotrypa</i> communis		
<i>Homotrypa</i> flabellaris		X
<i>Homotrypa</i> gelasinosa		X
<i>Homotrypa</i> similis		X
<i>Homotrypella</i> rustica	X	X
<i>Mesotrypa</i> orbiculata		X
<i>Mesotrypa</i> patella		X
<i>Mesotrypa</i> sp.	X	
<i>Heterotrypa</i> affinis		X
<i>Heterotrypa</i> prolifica		X
<i>Heterotrypa</i> singularis	X	X
<i>Heterotrypa</i> subramosa	X	X
<i>Stigmatella</i> interperosa		X
<i>Stigmatella</i> nicklesi		X
<i>Stigmatella</i> spinosa	X	X
<i>Stigmatella</i> sp.	X	
<i>Petigopora</i> sp.	X	
<i>Atactoporella</i> schucherti		X
<i>Cyphotrypa</i> stidhami		X
<i>Cyphotrypa</i> wilmingttonensis		X
<i>Constellaria</i> punctata		X
<i>Constellaria</i> polystomella	X	X

Nicholsonella cumulata			X
Nicholsonella carnula			X
Nicholsonella punctata			X
Nicholsonella n. sp.			X
Bythopora delicatula			X
Bythopora meeki		X	X
Bythopora striata			X
Eridotrypa granulata	X		
Eridotrypa simulatrix			X
Lioclemella solidissima	X		X
Amplexopora ampla			X
Amplexopora sp.			X
Monotrypella quadrata			X
Rhombotrypa crassimuralis			X
Rhombotrypa quadrata		X	X
Rhombotrypa subquadrata		X	X
Rhombotrypa sp.			X
Hallopora crenulata	X		X
Hallopora subnodosa	X	X	X
Hallopora ramosa			X
Hallopora cf. subplena			X
Hallopora imbricata			X
Colloporella ? lens			X
Batostoma prosseri			X
Batostoma variable			X
Batostoma varioum	X		X
Hemiphragma imperfectum			X

<i>Diplotrypa</i> sp.				
<i>Monotrypa nodosa</i>	X			
<i>Monotrypa</i> sp.			X	
<i>Anophragma mirabile</i>		X	X	
<i>Tremotopora calloporoides</i>			X	
<i>Fenestella granulosa</i>	X			
<i>Arthroclema angulare</i>			X	
<i>Ptilotrypa obliquata</i>			X	
<i>Pachydictya elegans</i>		X	X	
<i>Pachydictya fenestelliformis</i>			X	
<i>Pachydictya firma</i>			X	
<i>Pachydictya gigantia</i>			X	
<i>Pachydictya hexagonalis</i>			X	
<i>Pachydictya magnopora</i>			X	
<i>Pachydictya splendens</i>			X	
<i>Helopora imbricata</i>			X	
<i>Phenopora wilmingtonensis</i>			X	
<i>Dicranopora emacerata</i>			X	
<i>Dicranopora fragilis</i>	X			
<i>Arthropora</i> cf. <i>shafferi</i>			X	
<i>Lingula covingtonensis</i>			X	X
<i>Lingula deflecta</i>				
<i>Lingula iowensis</i>	X			
<i>Lingulasma schucherti</i>			X	
<i>Crania</i> sp.		X		
<i>Rafinesquina alternata</i>	X	X	X	X

<i>Rafinesquina kingi</i>	X		X	
<i>Leptaena unicostata</i>	X	X	X	
<i>Plectombonites sericea</i>	X	X	X	X
<i>Strophomena fluctuosa</i>		X		
<i>Strophomena incurvata</i>		X	X	
<i>Strophomena neglecta</i>	X	X	X	
<i>Strophomena planodorsata</i>		X	X	X
<i>Strophomena planumbona</i>		X	X	
<i>Strophomena trilobata</i>		X		
<i>Strophomena wisconsinensis</i>	X		X	
<i>Parastrophia</i> sp.		X		
<i>Parastrophia divergens</i>			X	
<i>Dalmanella fairmountensis</i>			X	
<i>Dalmanella hamburgensis</i>		X		
<i>Dalmanella tersa</i>		X	X	
<i>Dalmanella testudinaria</i>		X	X	X
<i>Dinorthis subquadrata</i>	X	X	X	X
<i>Dinorthis proavita</i>			X	X
<i>Hebertella occidentalis</i>	X	X	X	
<i>Hebertella insculpta</i>	X	X	X	X
<i>Hebertella</i> sp.				X
<i>Hebertella sinuata</i>			X	
<i>Orthis tricenaria</i>				X
<i>Platystrophia acutilirata</i>		X		X
<i>Plectorthis whitfieldi</i>	X	X	X	
<i>Rhynchotrema anticostensis</i>	X	X	X	

<i>Rhynchotrema capax</i>	X	X	X	X
<i>Rhynchotrema inequivalvis</i>	X	X	X	
<i>Rhynchotrema neenah</i>	X	X	X	
<i>Rhynchotrema perlamellosa</i>	X	X	X	
<i>Zygospira modesta</i>	X	X	X	
<i>Zygospira recurvirostra</i>		X		
<i>Bellerophon bilobatus</i>		X	X	
<i>Bellerophon sp.</i>		X	X	X
<i>Pleurotomaria depauperata</i>				
<i>Lophospira pulchella</i>			X	
<i>Lophospira quadrisulcata</i>				
<i>Hormotoma bellicincta</i>			X	
<i>Hormotoma gracilis</i>	X	X	X	
<i>Helicotoma sp.</i>		X		
<i>Trochonema sp.</i>		X		
<i>Cyclonema bilix</i>	X	X	X	
<i>Tentaculites oswegoensis</i>			X	
<i>Tentaculites sterlingensis</i>		X		
<i>Conularia sp.</i>				X
<i>Ctenodonta fecunda</i>		X		
<i>Ctenodonta obliqua</i>				
<i>Clidophorus neglectus</i>		X		
<i>Vanuxemia sardesoni</i>				X
<i>Pterinea carianota</i>				

<i>Pterinea demissa</i>	X	X		
<i>Byssonychia intermedia</i>	X	X		
<i>Byssonychia radiata</i>	X	X		
<i>Orthoceras bilineatum</i>		X		
<i>Orthoceras sociale</i>		X		
<i>Orthoceras</i> sp.				X
<i>Cyrtoceras camurum</i>		X		
<i>Cyrtoceras houghtoni</i>				
<i>Cameroceras proteiforme</i>		X		
<i>Gyroceras</i> sp.		X		
<i>Nileus vigilans</i>		X		
<i>Isotelus maximus</i>		X	X	X
<i>Isotelus</i> sp.		X		X
<i>Calymene christyi</i>		1		
<i>Calymene fayettensis</i>		X		
<i>Calymene senaria</i>	X	X		
<i>Ceraurus icarus</i>		X		
<i>Ceraurus pleurexanthemus</i>		X		
<i>Dalmanites</i> sp.		X		
<i>Pterygometapus callicephalus</i>		X		
<i>Endymion</i> sp.				X

Distribution of Species and Its Significance.

It will be noted that a much larger number of species in the above table are listed from Northern Illinois, than from Iowa or Wisconsin. This is on account of the fact that collections of Maquoketa fossils have been made from several more localities in Northern Illinois, than in Iowa or Wisconsin. It will be seen that almost every species listed from either Iowa or Wisconsin appears also in the list for Northern Illinois. This is interpreted as indicating that the Maquoketa strata in Northern Illinois, Iowa, and Wisconsin belong to the same geological province, which means that they were deposited in an epicontinental sea that had the same ocean connection. The Maquoketa sea that covered northern Illinois, Iowa and Wisconsin advanced from the Arctic regions, as is known from the presence of the characteristic fossils of the above list, farther northwest in Canada.

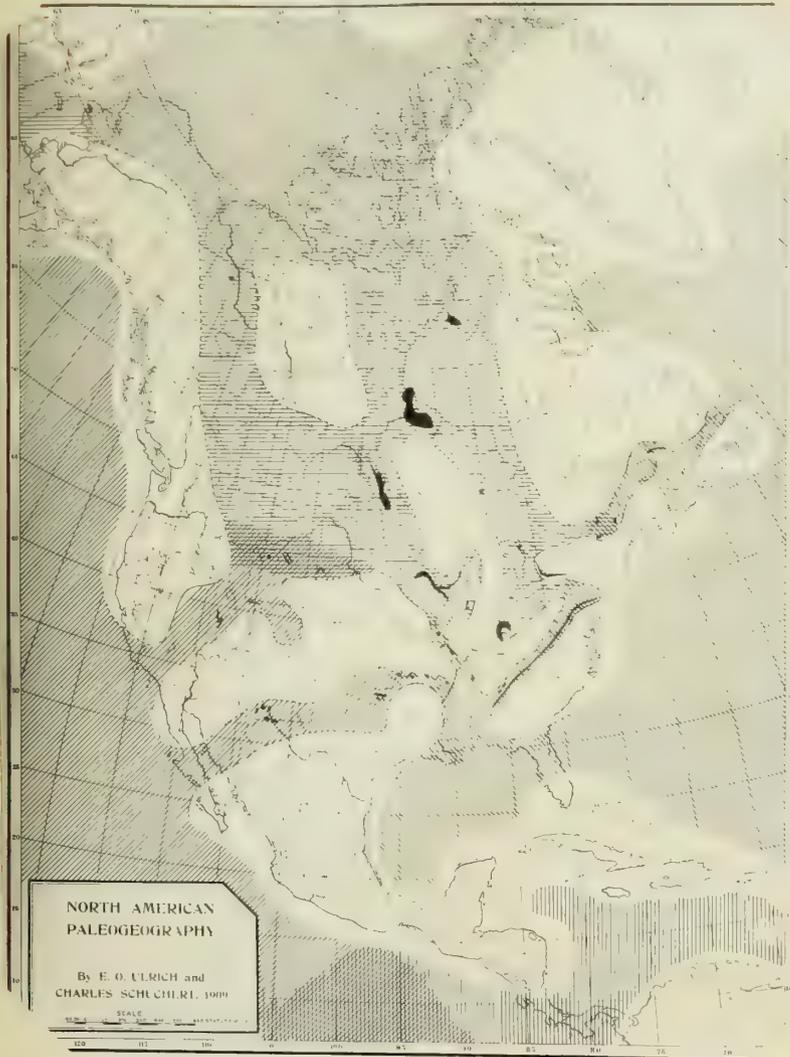
The fossils that came from the rocks of this age in Southwest Illinois include the following species that do not occur in Northern Illinois, Iowa or Wisconsin: *Climacograptus putillus*, *Lingula covingtonensis*, *Hebertella* sp., *Orthis tricenaria*, *Conularia* sp., *Endymion* sp., and *Isotelus* sp. This marked difference in the fauna of rocks of the same general age as the Richmond formation in Southwest Illinois compared with the fossils of the Maquoketa formation in Northern Illinois, Iowa and Wisconsin, is interpreted as indicating that the strata of this age in Southwest Illinois belong to a geological province different from that of the Maquoketa

farther north in the Mississippi Valley. This southern province is thought to have had sea connection southward with the Gulf of Mexico. It is probable that during early Maquoketa time the seas in these two provinces, one from the Arctic region and the other from the Gulf of Mexico region, mingled over a belt in central Illinois and northern Missouri, but in middle and late Maquoketa time these seas were probably separated by a land barrier in the region of central Illinois and northern Missouri. The relations of these provinces may be seen on the Paleographic map of Richmond time, shown in figure 10.

In Indiana and Ohio the Richmond strata are equivalent in age to the Maquoketa of the upper Mississippi Valley, as shown by the large number of characteristic fossils common to both areas, but the Indiana Richmond strata contain many species of fossils that are not known in northern Illinois, Iowa, Minnesota, or Wisconsin, or in the southwest Illinois province. The fauna of the Richmond strata in Indiana and Ohio resemble that of the Maquoketa in the northern Illinois province much more closely than that of the strata of similar age in southern Illinois, but they also contain many distinctive species that are wanting in the Maquoketa strata of the Upper Mississippi Valley, such as *Agelacrinus faberi*, *Ectenocrinus simplex*, *Catazyga headi*, *Dinorthis retrorsa*, *Rhynchotrema dentata*, and *Comadella dyeri*. The following species are common in northern Illinois, but are not found in the Richmond of Indiana and Ohio: *Plectorthis whitfieldi*, *Rhynchotrema anticostenensis*, *R. nennah*, *Tentaculites sterlingensis*,

Figure X.

CINCINNATIC (LATE RICHMOND)



Map showing areas of land and sea in North America during Richmond time. The Maquoketa basin is in the Upper Mississippi Valley, indicated by horizontal lines.

Nileus vigilans, and *Platymetopus larrabeei*. These differences in the fossils of the Richmond strata of Indiana from those of the Maquoketa formation in the northern Illinois province support the view of a barrier between these areas, as shown on the map, figure 10, such as would prevent the ready migration of the fauna of one of these basins into the other, both basins being connected at the north with the sea that advanced from the Arctic region. Such a land barrier between these basins during Maquoketa time is also indicated by the fact that records of some deep wells near the east border of Illinois do not show any strata of Richmond or Maquoketa age to be present in that region, which is thought to indicate that a belt of land in that region extending in a general north-south direction was not submerged during this period, and so served as a barrier that separated the Indiana and northern Illinois basins of deposition.

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In concluding this thesis, the writer wishes to express his gratitude to Professor T. E. Savage, under whose direction the work has been done, for the assistance in interpreting the data and in checking the identification of the fossils, and for the many suggestions that have been of great assistance in connection with this work.





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