

THE CORRELATION OF THE MAQUOKETA AND RICHMOND ROCKS OF IOWA AND ILLINOIS

T. E. SAVAGE, UNIVERSITY OF ILLINOIS

The rocks of Richmond age in southeastern Iowa have been called the Maquoketa formation, or Maquoketa shale, from the Little Maquoketa River in Dubuque County, Iowa, along which they are well exposed. Corresponding strata also outcrop in the northwest part of Illinois.

The lower strata of Richmond age in southern and eastern Illinois have been correlated with the Fernvale¹ limestone. They are exposed in a number of places along the Mississippi River in the southwest part of the State, for example, near Thebes in Alexander County, and near Val Meyer in Monroe County. Outcrops of this limestone also occur in adjacent portions of Missouri, as at Cape Girardeau. Strata of corresponding age also outcrop in Will and Kendall counties, in the northeast part of the State. One of the localities in which they furnish an unusual number of bryozoa and other fossils in an excellent state of preservation is in the banks of Kankakee River at Wilmington, Illinois, where the exposed section is as follows:

SECTION OF RICHMOND STRATA IN THE VICINITY OF WILMINGTON

- | | |
|---|--------|
| 2. Shale, bluish-gray, with few fossils..... | 35 ft. |
| 1. Limestone, shaly to subcrystalline, in irregular layers that contain numerous fossils..... | 12 ft. |

The Richmond sediments were deposited on an eroded surface so that in some places in northeastern Illinois a thickness of 40 or 50 feet or more of shale of Richmond age underlies the limestone member exposed at Wilmington. This limestone is also in places thicker than in the Wilmington section. There are no fossils in the shale beneath the limestone by which its age can be determined. However, as the two members do not appear to be separated by an unconformity, the shale probably represents the initial deposits of the formation to which the limestone belongs.

¹Savage, T. E., The faunal succession and the correlation of the pre-Devonian formations of southern Illinois. Bull. No. 16, Ill. State Geol. Survey, pp. 315-318, 1910.

The more calcareous layers in the lower part of the section at Wilmington furnished the species of fossils listed below. In this list and those that follow the relative abundance of each species is indicated by the letters r—rare, c—common and a—abundant, placed after the name. If the species occurs in the Richmond strata of Indiana, the particular formation of the Richmond in which it is found in Indiana is indicated by the letters A—Arnheim; W—Waynesville; L—Liberty; Wh—White-water; and E—Elkhorn, following the name in the lists.

LIST OF FOSSILS FROM THE LOWER PART OF RICHMOND STRATA AT WILMINGTON

- Anolotichia ponderosa* Ulr. (a)
Anaphragma mirabile U. & B. (c)
Anaphragma mirabile n. var (r)
Arthroclema angulare Ulr. (c)
Atactoporella cf. *schucherti* Ulrich (r) W. Wh.
Batostoma prosseri C. & G. (c) W. L.
Batostoma variabile Ulr. (r) W. E.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Ceramoporella granulosa Ulr. (r) A. W.
Ceramoporella ohioensis (Nich) (r) Richmond
Ceramoporella whitei (James) (r) A. W.
Constellaria polystomella (Nich) (c) W. L.
Constellaria punctata (Whitfield) (c)
Crepipora hemispherica Ulrich (r)
Crepipora simulans Ulr. (r)
Cyclotrypa n. sp. (r)
Cyphotrypa stidhami (Ulr.) (c) Wh.
Cyphotrypa wilmingttonensis U. & B. (r)
Dicranopora emacerata (Nich.) (r) Richmond
Eridotrypa simulatrix (Ulr.) (c) W.
Favositella epidermata (Ulr.) (r-c)
Hallopora subnodosa (Ulrich) (r) Richmond
Helopora imbricata Ulr. (c)
Hemiphragma imperfectum (Ulr.) (aa)
Heterotrypa affinis (Ulr.) (c)
Heterotrypa prolifica Ulr. (r) W.
Heterotrypa singularis Ulr. (r) W.
Heterotrypa subramosa (Ulrich) (r) W.
Homotrypa cf. *communis* Bassler (r) W. L.
Homotrypa flabellaris Ulrich (r) W. L. Wh.
Homotrypa gelasinosa Ulr. (r)
Homotrypa cf. *similis* Foord (r)
Homotrypella rustica var. n. (c)
Mesotrypa orbiculata C. & G. (r) A.
Nicholsonella n. sp. (c)
Nicholsonella n. sp. (r-c)
Nicholsonella cumulata Ulr. (r)
Pachydictya elegans Ulr. (r-c)
Pachydictya fenestelliformis (Nich.) (a) W. L.
Pachydictya fenestelliformis corticula Ulrich (r)
Pachydictya firma Ulr. (a)

Pachydietya gigantea Ulr. (a)
Pachydietya hexagonalis Ulr. (r)
Pachydietya magnopora Ulr. (c)
Pachydietya splendens Ulr. (r)
Peronopora decipiens Rom. (a) A. E.
Phenopora wilmingttonensis Ulrich (r)
Phenopora wilmingttonensis var. (r)
Protocrisina exigua Ulrich (r)
Ptilotrypa obliquata Ulrich (c)
Rhombotrypa crassimuralis (Ulrich) (r)
Rhombotrypa quadrata (Rominger) (c) W. L. Wh.
Rhombotrypa subquadrata (Ulrich) (r) W. L.
Stigmatella interporosa U. & B. (r) W.
Stigmatella sp. (r)
Stomatopora arachnoidea (Hall) (c)
Dalmanella tersa Sardeson (r)
Dalmenella testudinaria (Dalman) (c)
Dinorthis proavita (Winchell and Schuchert) (c)
Dinorthis subquadrata (Hall) (c) L. Wh.
Hebertella insculpta (Hall) (c) W
Hebertella occidentalis (Hall) (c) Richmond
Lingulasma schucherti Ulrich (r)
Parastrophia divergens Hall and Clarke (r)
Platystrophia cumingsi McE. (c) W.
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis kankakensis (McChesney) (c)
Rafinesquina alternata (Emmons) (c) Richmond
Rafinesquina kingi (Whitfield) (r)
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema perlamellosum (Whitfield) (c)
Strophomena neglecta (James) (c) W
Strophomena nutans (Meek) (r) W
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schubert (c)
Strophomena wisconsinensis (Whitfield) (c)
Ambonychia sp (r)
Hormotoma sp (r)
Orthoceras sp
Endoceras proteiforme Hall (r)
Cyrtoceras sp (r)

* Note: The bryozoa in this and the following lists were identified by Professors E. R. Cumings and J. J. Galloway.

Of the fossils in the foregoing list that are present also in the Richmond strata of Indiana, 12 species occur there in the Waynesville formation and do not appear in younger Richmond strata. Eleven other species occur in Indiana in both the Waynesville and the Liberty formations. Twelve of the species range from the Waynesville to the Whitewater formations. None of the species are restricted to the Liberty formation in Indiana, and only one of the number is found in Indiana only in the Whitewater formation. Such species as *Dinorthis subquadrata* that is not present in Indiana in the Waynesville, but occurs there in both the Liberty and White-

water formations, and *Cyphotrypa stidhami* that occurs in Indiana only in the Whitewater formation, are present in Illinois in the same layers that contain *Hebertella insculpta* and other species that in Indiana are restricted to the Waynesville formation. Such species do not indicate that the rock from which they come are Liberty or Whitewater in age, but they show that some of the species have a different vertical range in Illinois from what they do in Indiana. The range of the species indicated in the above list is conclusive evidence that the Fernvale limestone at Wilmington, Illinois, corresponds in age to that of the Waynesville more closely than to any other formation of the Indiana Richmond, and it is considered as Waynesville in age.

Another exposure of Richmond limestone occurs near the mouth of Rock Run, about six miles west of Joliet, where the section is as follows:

	Feet
Shale, bluish to yellowish, slightly sandy; few or no fossils.....	18
Concealed	4
Limestone, gray, subcrystalline, in rough layers 4 to 5 inches thick, alternating with bands of bluish-gray, calcareous shale. Fossils are numerous in the limestone layers.....	4
Limestone, gray, subcrystalline, in uneven layers 3 to 8 inches thick, containing many fossils.....	7

The fossils collected from the limestone layers at the Rock Run locality include the following species:

FOSSILS FROM THE RICHMOND STRATA ON ROCK RUN

- Anaphragma mirabile* U. & B. (r)
- Arthroclema angulare* Ulr. (r)
- Batostoma prosseri* C. & G. (r) W. L.
- Bythopora delicatula* (Nich.) (r-c) W. L. Wh.
- Bythopora meeki* (James) (a) W. L. Wh.
- Coeloclema oweni* (?) (James) (r)
- Dicranopora emacerata* (Nich.) (r) Richmond
- Eridotrypa simulatrix* Ulr. (r-c) W
- Favositella epidermata* (Ulr.) (r) Fernvale
- Helopora imbricata* Ulr. (r-c) Fernvale
- Hemiphragma imperfectum* (Ulr.) (r-c) Fernvale
- Mesotrypa patella* (Ulr.) Wh
- Nicholsonella cumulata* (r) Fernvale
- Nicholsonella punctata* (Whit.)
- Pachydietya fenestelliformis* (Nich.) (c) W. L.
- Pachydietya firma* Ulr. (c) Fernvale
- Pachydietya gigantea* Ulr. (a) Fernvale
- Pachydietya* sp. (c)
- Petigopora* sp. (r)
- Rhombotrypa quadrata* (Rom.) (a) W. L. Wh.
- Dinorthis subquadrata* (Hall) (c) L. Wh.

Dinorthis proavita Winch. and Schuchert (c) Fernvale
Hebertella insculpta (Hall) (c) W.
Platystrophia cumingsi McE. (c) W.
Plectorthis kankakensis (McC) (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) W. L. Wh.
Rhynchotrema perlamellosum (Whit.)
Strophomena neglecta (James) W.
Strophomena planumbona (Hall) W. L.

The species of fossils in the above list leave no doubt of the Fernvale age of the lower or limestone part of the Richmond section in the Rock Run locality.

Along the banks of Aux Sable creek for a distance of one and one-half to two and three-fourths miles northwest of Minooka, Illinois, fossiliferous strata belonging in the middle part of the Richmond, as there developed, are exposed in several places. They consist of alternating layers of shell limestone and calcareous shale in the lower part, grading upward into rather dense granular limestone; the strata are nearly horizontal, the entire thickness seen aggregating 10 to 15 feet. The species of fossils collected from this limestone along Aux Sable Creek are listed below:

LIST OF FOSSILS FROM LIMESTONE ALONG AUX SABLE
CREEK, NORTHWEST OF MINOOKA

Amplexopora ampla U. & B. (r)
Batostoma sp. (r)
Bythopora delicatula (Nich.) (r) W. L. Wh
Bythopora meeki (James) (aa) W. L. Wh.
Bythopora striata Ulr. (r) W.
Eridotrypa simulatrix Ulr. (r) W.
Hallopora cf. *onealli* (r)
Hallopora subnodosa (Ulr.) (c) Richmond
Hallopora cf. *subplana* (r)
Homotrypella rustica Ulr. (c) W. L. Wh.
Homotrypella rustica var. (c)
Mesotrypa orbiculata C and G. (r-c) A
Stigmatella crenulata U. & B. (r) W.
Stigmatella interporosa U. & B. (r) W
Stigmatella nicklesi U. & B. (r)
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa yorkvillensis (c)
Stomatopora arachnoidea (Hall) (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) L. Wh.
Dinorthis proavita (Winchell and Schuchert) (r)
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Platystrophia cumingsi McE. (r) W.
Plectorthis kankakensis (McC.) (r)

Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema perlamellosum (Whit.) (c)
Strophomena neglecta (James) (c) W.
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schuchert (c)
Zygospira modesta Hall (c) Richmond
Pterinea demissa (Conrad) (c) Richmond
Cyclonema sp. (c)
Calymene meeki Foerste (c) Richmond
Isotelus maximus Locke (c)
Synhomalonotus christyi (Hall) (c) W.

In the above list of fossils there are ten species that are not known to occur in Indiana in rocks younger than the Waynesville division of the Richmond, and all but one of these are there restricted to this division. There are no other species in this list that are confined to a single division of the Richmond in Indiana. There can be no doubt that they represent about the same time of deposition as the Waynesville beds of Indiana, and that the fauna corresponds with that of the Fernvale at Wilmington, above described. The species of trilobites, *Isotelus maximus* and *Synhomalonotus christyi*, occur in the lower more shaly strata, and are not found in the uppermost limestone layers.

A fauna similar to that occurring along Aux Sable Creek is present in the Richmond strata near Oswego in Kendall county, 15 miles farther north. A practically complete section of these strata, from the contact at the top with the Silurian limestone, is exposed along Fox River between Oswego and Yorkville. The detailed section is as follows:

SECTION OF RICHMOND STRATA BETWEEN OSWEGO AND YORKVILLE		Ft.	In.
<i>Silurian system</i>			
Limestone, yellowish-gray, partly dolomitic in layers 2 to 4 inches thick.....	2		4
<i>Ordovician system</i>			
Richmond shale and limestone			
Shale, greenish, thin bedded, without fossils.....			3
Limestone, subcrystalline, in uneven layers 7 to 10 inches thick, with many fossils.....	6		..
Limestone, bluish, shaly.....	2		..
Shale, blue			3
Limestone, bluish, slightly shaly, in layers 1 to 8 inches thick, with occasional shale partings 4 to 6 inches thick	4		..

	Ft.	In.
Limestone, shaly, bluish, with bands of shale at different levels, containing many fossils....about	10	..
Shale, in bands 3 to 6 inches thick, alternating with limestone layers of about the same thickness, containing very many fossils.....	12	..
Shale, dark, calcareous, containing many shells of species of <i>Dalmanella</i> , <i>Rafinesquina</i> , <i>Pterinea</i> , <i>Isotelus</i> , and <i>Synhomalonotus</i>	2	..
Concealed	5	..

The fossils from the strata described in the last section are listed below:

LIST OF RICHMOND FOSSILS FROM ALONG FOX RIVER
BETWEEN OSWEGO AND YORKVILLE

- Arthropora shafferi* (Meek) (r)
Batostoma prosseri C. & G. (r) W. L.
Batostoma varians (James) (c) W. Wh. L.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Bythopora striata Ulr. (c) W.
Hallopora, cf. *onealli* (r)
Hallopora subnodosa (Ulr.) (r) Richmond
Hallopora cf. *subplana* (r)
Homotrypella rustica (r) W. L. Wh.
Perenopora decipiens Rom. (c) A. E.
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa var. (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) (r) L. Wh.
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Lingula deflecta Winchell and Schuchert, (r)
Plectambonites sericeus (Sowerby) (c) W. L.
Platystrophia cumingsi McE. (c) W.
Rafinesquina alternata (Emmons) (a) Richmond
Rhynchotrema capax (Conrad) (c) W. L. Wh.
Strophomena neglecta (James) (r) W.
Strophomena planodorsata W. and S. (c)
Strophomena planumbona Hall (c) W. L.
Zygospira modesta Hall (c) Richmond
Byssonychia radiata (Hall) (c) Richmond
Pterinea sp.
Tentaculites oswegoensis M. and W. (c)
Calymene meeki Foerste (c) Richmond
Synhomalonotus christyi (Hall) (c) W.
Isotelus maximus Locke (c)

In the foregoing list there are six species that in Indiana occur only in the Waynesville formation, and not a single one is present that in Indiana is diagnostic of a younger Richmond horizon.

About 35 miles still farther northwest, strata of Richmond age are exposed along a stream $1\frac{1}{2}$ miles west and $\frac{1}{4}$ mile north of Kingston, in DeKalb County. The strata at this locality consists of impure shaly

limestone which outcrops in the creek bank to a height of 8 to 10 feet. The horizon is not many feet below the base of the Silurian which was encountered in a water wall put down near the outcrop. The fossils collected at this locality include the species listed below:

FOSSILS FROM THE UPPER PART OF THE RICHMOND NEAR KINGSTON, ILLINOIS

- Amplexopora sp. (c)
- Arthropora shafferi (Meek) (r)
- Batostoma sp. (c)
- Bythopora delicatula (Nich.) (r) W. L. Wh.
- Bythopora meeki (James) (a) W. L. Wh.
- Bythopora striata Ulr. (r) W
- Hallopora subnodosa (Ulr.) (a) Richmond
- Hallopora cf. subplana (c)
- Perenopora decipiens Rom. (c) A. E.
- Stigmatella spinosa U. & B. (c) W.
- Stomatopora arachnoidea (Hall) (a) W.
- Lingula sp.
- Dalmanella testudinaria (Dalman) (c)
- Rafinesquina alternata (Emmons) (c)
- Pterinea sp.
- Calymene meeki Foerste (a)
- Isotelus maximus Locke (c)
- Synhomalonotus christyi (Hall) (a) W.

An exhaustive collection of fossils was not attempted at this place on account of their poor preservation, but the species indicate clearly the Waynesville division of the Richmond, and show also the close correspondence of the Richmond at this locality with that in the vicinity of Oswego, and northwest of Minooka. The trilobites, *Isotelus maximus* and *Synhomalonotus christyi*, came from a level a few feet below the upper, more calcareous strata from which the greater number of the bryozoa species were collected, as they did in the Fox River and Aux Sable Creek localities.

West of the LaSalle anticline in the northwest part of Illinois, the lower Richmond (Maquoketa) shale is well exposed in a cut along the Illinois Central Railroad a short distance west of the station at Scales Mound, in Jo Daviess County, where it is immediately underlain by Galena limestone. The detailed section is given below:

SECTION OF RICHMOND STRATA AT SCALES MOUND, ILL.

	Ft.
Maquoketa shale	
Shale, bluish-gray, without fossils.....	32
Shale, blue, with a reddish zone near the base, and another about 8 feet above the base; containing several small fossils.	11
Galena limestone	
Dolomite, yellowish-brown, in layers 6 to 18 inches thick.....	6

The following species of fossils were collected from the lower portion of the shale exposed in the railroad cut at Scales Mound. These are peculiar in that they are all of small size, and consist mainly of mollusks. Brachiopods, and especially bryozoa, are exceedingly rare.

LIST OF FOSSILS FROM THE LOWER PART OF THE MAQUOKETA SHALE AT SCALES MOUND

- Dalmanella testudinaria (Dalman) (c)
- Zygospira modesta Hall (c) Richmond
- Ctenodonta fecunda (Hall) (c)
- Ctenodonta obliqua (Hall) (c)
- Clidophorus neglectus Hall (c)
- Bellerophon sp.
- Liospira micula (Hall) (c)
- Lophospira pulchella Ulrich and Scofield (c)
- Pleurotomaria depauperata (Hall) (c)
- Orthoceras sociale Hall (a)

The fauna listed above is conspicuous in that it is not a typical Richmond fauna. Only one of the species, *Zygospira modesta*, is listed by Cumings from the Richmond strata of Indiana, and that has a wide range, both geographical and vertical, and is of no value in stratigraphy. The fauna resembles the lower Maquoketa fauna found near Graf, in Dubuque County, Iowa, and doubtless represents a corresponding horizon.

In the vicinity of Scales Mound, the Maquoketa formation, above the shale exposed in the railroad cut, consists of 50 to 75 feet of bluish-gray, non fossiliferous shale in which are occasional thin bands of earthy dolomite. This is overlain by about 28 feet of alternating layers of calcareous shale and limestone that contain numerous fossils among which are many bryozoa. These upper, calcareous and fossiliferous beds outcrop along the wagon road two and one-half miles northeast of Scales Mound, near the west side of sec. 19, T. 29 N., R. 3 E. from which locality the fossils listed below were collected.

LIST OF FOSSILS FROM UPPER MAQUOKETA STRATA 2½ MILES NORTHEAST OF SCALES MOUND

- Amplexopora sp. (a)
- Batostoma sp. (a)
- Bythopora meeki (James) (r) W. L. Wh.
- Constellaria polystomella (Nich.) (r-c) W. L.
- Corynotrypa inflata (Ulr.) (c) Richmond
- Dicranopora emacerata (Nich.) (r) Richmond

Eridotrypa sp. (c)
Hallopora ramosa (d'Or.) (c)
 Hallopora subnodosa (Ulr.) (c) Richmond
Monotrypa sp. (a)
Nicholsonella sp. (c)
Pachydictya fenestelliformis (Nich.) (r) W. L.
Peronopora decipiens (Rom.) (r) A. E.
Rhombotrypa crassimuralis (Ulr.) (r-c) Fernvale
Stomatopora arachnoidea (Hall) (c)
 cf. *Glyptocrinus decadactylus* Hall (r)
Dalmanella testudinaria (Dalman) (c)
Hebertella insculpta (Hall) (c) W.
Dinorthis proavita Winchell and Schuchert (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis whitfieldi (Winchell) near *P. kankakensis* (McC) (c)
Rafinesquina alternata (Conrad) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema neenah (Whitfield) (c)
Strophomena neglecta (James) (c) W.
Strophomena wisconsinensis Whitfield (r)
Modiolopsis concentrica Hall and Whitf. (c) W.
Hormotoma sp.

The species of fossils in the foregoing list indicate the same horizon as that which furnished the fossils from Aux Sable Creek, and that in the vicinity of Oswego, and Wilmington. Three of the species in the list are restricted to the Waynesville division of the Richmond in Indiana, and not one of them is confined to any other member of the Indiana Richmond. The only species in the list that were not found in the Wilmington, Oswego and Aux Sable Creek localities are *Corynotrypa inflata*, which ranges throughout the Richmond, *Hallopora ramosa*, which occurs in the Maysville of Indiana, and *Modiolopsis concentrica*, which is restricted to the Waynesville formation in the Ohio-Indiana region. These upper Maquoketa strata are thought to represent Waynesville time, and to correspond in age with the Fernvale limestone present at Wilmington, and in the vicinity of Oswego, and northwest of Minooka.

Another excellent exposure of the upper strata of the Maquoketa is in the north bank of Rock River, one and one-fourth miles east of the railroad station at Sterling, Illinois. The detailed section of the outcrop at this place is given below:

SECTION OF STRATA EXPOSED IN THE NORTH BANK OF
 RIVER 1¼ MILES EAST OF STERLING

Silurian limestone

Ft.

Limestone, yellow to brown, dolomitic, in layers 4-10 inches
 thick, with few fossils..... 28

Maquoketa shale

Ft.

Shale, bluish-gray, in layers 3 to 6 inches thick, alternating with calcareous, very fossiliferous bands.....	10
Shale, sandy with few fossils.....	18

The species of fossils collected from the upper member of the Maquoketa at this place are listed below.

LIST OF FOSSILS FROM 1¼ MILES EAST OF STERLING, ILL.

<i>Anolotichia</i> sp. (r)	
<i>Anaphragma mirabile</i> U. & B. (c)	
<i>Batostoma prosseri</i> C. & G. (c) W. L.	
<i>Batostoma varians</i> (James) (c) W. L. Wh.	
<i>Bythopora delicatula</i> (Nicholson) (c) W. L. Wh.	
<i>Bythopora meeki</i> (James) (c) W. L. Wh.	
<i>Bythopora striata</i> Ulr. (r-c) A.	
<i>Dicranopora emacerata</i> (Nich.) (r) Richmond	
<i>Dicranopora fragilis</i> (Bill.) (c)	
<i>Favositella epidermata</i> (Ulr.) (r)	
<i>Hallopora subnodosa</i> (Ulr.) (r) Richmond	
<i>Hallopora</i> cf. <i>subplana</i> (Ulr.) (r)	
<i>Hemphragma imperfectum</i> (Ulr.) (c)	
<i>Mesotrypa</i> sp. (r)	
<i>Nicholsonella</i> sp. (c)	
<i>Rhombotrypa quadrata</i> (Rom.) (c) W. L. Wh.	
<i>Stomatopora arachnoldea</i> (Hall) (c)	
<i>Dalmanella testudinaria</i> (Dalman) (c)	
<i>Hebertella insculpta</i> (Hall) (c) W.	
<i>Hebertella occidentalis</i> (Hall) (c) Richmond	
<i>Leptaena unicosata</i> (Meek and Worthen) (c)	
<i>Platystrophia cumingsi</i> McE. (c) W.	
<i>Plectambonites sericeus</i> (Sowerby) (c) W. L.	
<i>Plectorthis whitfieldi</i> (Winchell) near <i>P. kankakensis</i> (McC) (c)	
<i>Rhynchotrema capax</i> (Conrad) (c)	
<i>Rhynchotrema neenah</i> (Whitfield) (c)	
<i>Strophomena neglecta</i> (James) (c) W.	
<i>Strophomena planodorsata</i> Winchell and Schuchert (c)	
<i>Strophomena planumbona</i> Hall (c) W. L.	
<i>Byssonychia radiata</i> (Hall) (r) Richmond	
<i>Bellerophon</i> sp.	
<i>Cyclonema</i> sp.	
<i>Tentaculites sterlingensis</i> (M. and W.) (c)	

The species of fossils in the above list clearly represent a fauna that corresponds with that from the upper Maquoketa strata northeast of Scales Mound, and with those found in the Richmond strata along Aux Sable Creek, in the vicinity of Oswego, and at Wilmington. Four of the species do not occur above the Waynesville beds in Indiana, and not one of them is restricted to a post-Waynesville formation in the Richmond of Indiana. On the Mississippi River, at Savanna, Illinois, 30 miles northwest of Sterling, the Upper Maquoketa strata also consist of alternating shale and limestone layers which furnished fossils similar to the species listed from east of Sterling, and certainly represent a corresponding

horizon. In some places in northern Illinois and north-eastern Iowa the upper, very fossiliferous beds of the Maquoketa were removed by erosion before the overlying Silurian strata were deposited. In other places a thickness of 25 to 50 feet of non-fossiliferous shale overlies this calcareous, and very fossiliferous horizon. The latter can be traced clearly from northern Illinois across the northeast part of Iowa, in spite of the erosional unconformity at the top which results in different levels of the Maquoketa occurring immediately beneath the Silurian limestone.

An excellent outcrop of these upper Maquoketa strata occurs along a stream 7 miles west of Preston, in Jackson County, Iowa, where the following section was made:

SECTION OF STRATA EXPOSED 7 MILES WEST OF PRESTON, IA.
Ft.

Silurian limestone

Limestone, dolomitized, in rather even layers 4 to 12 inches thick, containing few fossils..... 40

Maquoketa shale

Shale, bluish-gray, in thin layers. Those in the upper part alternating with limestone bands, containing many fossils... 35

The following species were collected from the Maquoketa shale at this locality:

FOSSILS FROM THE UPPER PART OF THE MAQUOKETA,
7 MILES WEST OF PRESTON, IA.

1. *Anolotichia* sp. (r-c)
2. *Anaphragma mirabile* ? (c)
3. *Batostoma* sp. (c)
4. *Bythopora meeki* (James) (r) W. L. Wh.
5. *Ceramoporella ohioensis* (Nich.) (r) Richmond
6. *Coeloclema* sp. (r)
7. *Corynotrypa inflata* (Hall) (c) Richmond
8. *Eridotrypa simulatrix* (r) W.
9. *Hallopora subnodosa* (Ulr.) (c) Richmond
10. *Hallopora* sp. (c)
11. *Homotrypella rustica* ? (r) W. L. Wh.
12. *Mesotrypa* sp. (c)
13. *Peronopora decipiens* (Rom) (r) A. E.
14. *Petigopora* sp. (c)
15. *Stigmatella spinosa* (r) W.
16. *Stigmatella* sp. (c)
17. *Stomatopora arachnoidea* (Hall) (r)
18. *Rhombotrypa quadrata* (Rom.) (r) W. L. Wh.
19. *Rhombotrypa subquadrata* (Ulr.) (r) W. L.
20. *Streptelasma rusticum* Billings (r) W. L. Wh. E.
21. *Dalmanella tersa* Sardeson (r)
22. *Dalmanella testudinaria* (Dalman) (c)
23. *Dinorthis subquadrata* Hall (r) L. Wh.

24. *Hebertella insculpta* (Hall) (c) W.
25. *Hebertella occidentalis* (Hall) (c) Richmond
26. *Leptaena unicostata* (Meek and Worthen) (c)
27. *Plectambonites sericeus* (Sowerby) (c) W. L.
28. *Plectorthis whitfieldi* (Winchell) near *P. kankakensis* (McC)
(c)
29. *Rafinesquina alternata* (Conrad) (c) Richmond
30. *Strophomena neglecta* (James) (c) W.
31. *Stromphomena planumbona* (Hall) (c) W. L.
32. *Byssonychia radiata* (Hall) (r) Richmond
33. *Modiolopsis concentrica* (Hall and Whitf.) (r) W.
34. *Pterinea demissa* (Conrad) (r) Richmond
35. *Conradella* sp.
36. *Cyclonema* sp.
37. *Hormotoma* sp.
38. *Liospira* sp.
39. *Lophospira* sp.
40. *Tentaculites sterlingensis* M and W. (c)

In the fauna from the upper Maquoketa beds seven miles west of Preston, Iowa, there are five species that in Indiana are restricted to the Waynesville formation of the Richmond, and not one of the species is diagnostic of a higher horizon in the Indiana and Ohio Richmond. The fauna clearly corresponds with that from the upper Maquoketa east of Sterling, and with the fauna listed from the localities above described in Illinois. These very fossiliferous upper Maquoketa strata are also well exposed in the bed of a stream where it joins the Mississippi River about two miles south of Bellevue, in Jackson county, and at Patterson's Spring, one mile north of Brainard, in Fayette county, and at several other places in northeast Iowa where they contain a fauna similar to that listed from seven miles west of Preston.

If this correlation is correct, the conclusion follows that the uppermost fossiliferous strata of the Maquoketa in Iowa and northwest Illinois are of Fernvale age, and they represent the time of Waynesville deposition in Indiana and Ohio. The earlier Maquoketa strata in Iowa lack many of the characteristic early Richmond species of fossils present in Indiana and Ohio, and they contain a number of species that are more distinctly northwest Richmond forms such as *Dicranopora fragilis*, *Dinorthis proavita*, and *Leptaena unicostata*, that do not occur in the Indiana-Ohio basin. It is thought that the sea in which the lower and middle Maquoketa strata were deposited advanced from the northwest into Iowa and

northwest Illinois, and adjacent portions of Minnesota and Wisconsin. During upper Maquoketa time this sea was joined by the transgression toward the northwest of the Fernvale sea from the south during lower Waynesville time.

Foerste¹ has shown that the oldest Richmond deposits in the Ontario and Quebec region are of upper Waynesville age, and contain, among others, such species as *Stromatocerium huronense*, *Tetradium huronense*, *Columnaria alveolata*, *Calapoecia huronensis*, *Catazyga headi*, *Strophomena sulcata*, and *Zygospira kentuckiensis*. It is very significant that not one of these species occurs in the Fernvale or Maquoketa of Illinois, Iowa, Minnesota, or Wisconsin. It is thought that the great transgression of the sea in Waynesville time, in which the Fernvale sediments were deposited in the Mississippi valley basin, was from the south, and that it occurred before the oldest Richmond fauna of the Ontario-Quebec region had reached the Ohio-Indiana area.

CONCLUSION

The fauna of the uppermost calcareous strata of the Richmond in northeast Illinois, and of the Maquoketa in northwest Illinois, Iowa, Minnesota, and Wisconsin indicates that these strata are of Waynesville age. They also show that the Fernvale limestone of northeastern and southern Illinois is of practically the same age as the Waynesville. This Fernvale-Upper Maquoketa sea is thought to have advanced from the south, since strata of corresponding age are known to the south in Monroe and Alexander counties in Illinois, and in southern Tennessee, and they are not known in the northern part of the continent.

During early Richmond (pre-Waynesville) time, it is thought that a sea advanced from the northwest into the upper Mississippi valley, in which were laid down the sediments comprising the lower and middle Maquoketa strata of Iowa, Minnesota, northwest Illinois and Wisconsin. During lower or middle Waynesville time, a southern sea invaded the Mississippi valley and Ohio

¹ Foerste, Aug. F., Upper Ordovician formations in Ontario and Quebec. Geol. Surv. of Canada, Memoir 83, 1916.

basins in which there accumulated the sediments that make up the Fernvale limestone. This sea transgressed far to the north and northwest, overlapping the former areas of Maquoketa, and united with the northern sea in northwest Illinois, northeast Iowa, and Wisconsin and Minnesota. In this sea there was a mingling of the aboriginal or older Maquoketa faunas with the invading faunas from the south. However, the invading species were dominant and left the strongest impress on this youngest fauna of Richmond age in the Maquoketa basin. It is thought that these uppermost calcareous and very fossiliferous strata of the Maquoketa were deposited before the invasion of the sea from the northeast into the Indiana-Ohio basin which occurred during upper Waynesville time. A late Richmond sea advanced from the south into Illinois and Missouri, in which was deposited the Thebes sandstone which rests unconformably upon the Fernvale limestone at Thebes, Illinois, and Cape Girardéau, Missouri. This Thebes sandstone deposition may have taken place at the same time the sandy sediments of the Saluda member were deposited farther east, but it was probably somewhat later. The non-fossiliferous shale that in places overlies the calcareous and fossiliferous horizon in the Wilmington, Minooka, and Maquoketa areas described in this paper was probably deposited at the time of the Thebes submergence.