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THE STRATIGRAPHY OF THE OREGONIA–FT. ANCIENT REGION, SOUTHWESTERN OHIO.

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The Oregonia-Ft. Ancient region is located in the vicinity of the villages of Oregonia and Ft. Ancient, along the Little Miami River in Warren County, southwestern Ohio. It has an area of approximately 50 square miles, and is enclosed principally within the Morrow quadrangle of the U. S. Geological Survey. The region has several times been referred to by geologists*, and the Mound Builders' work at Ft. Ancient is widely known, but there is in the literature no detailed treatment of the stratigraphy of the district.

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PHYSIOGRAPHY OF THE REGION.

The Oregonia-Ft. Ancient region is located in the Glaciated Plains section of southwestern Ohio. The upland of the region is a gently rolling plain, and the region is thoroughly dissected by a well established drainage system. The trunk stream of the district is the Little Miami River, which crosses our area from north to south in a relatively narrow and steep-sided valley. The distance from rim to rim of the valley is less than a mile, even where widest, and the depth is about 250 feet. Bordering

*Geol. Surv. Ohio, III, Part 1, pp. 381-391.
Proceedings of the U. S. National Museum, Vol. 70, Art. 22, pp. 1-18.
Bull. Scientific Lab., Denison Univ., Vol. XIX, June, 1919, pp. 65-81.

the major valley, there is a belt about one mile wide that is thoroughly dissected by gullies and ravines that are cutting back into the upland. Larger tributaries carry this dissection farther from the main valley, but with decreasing ruggedness, until it merges into the upland topography.

The upland of the region is mantled with glacial drift to an average thickness of about 35 feet. The streams and larger ravines of the district have cut through this mantle of drift, and are cutting into the bed rock beneath. It is along these stream courses that most of the exposures of bed rock in the region exist, but in general the ravines do not give continuous exposures for any considerable distance.

PLATE I.

VARIOUS CLASSIFICATIONS OF THE CINCINNATIAN SERIES.

ORTON (1873)	WINCHELL-ULRICH (1897)	NICKLES-FOERSTE (1905)		ULRICH-BASSLER (1906)		FOERSTE* (1910-11)		CUMINGS (1922)	
Lebanon	Richmond	Richmond	Saluda	Richmond Group	Saluda	Richmond	Elkhorn	Richmond	Elkhorn
			Whitewater		Whitewater		Whitewater		Whitewater
			Liberty		Liberty		Saluda		Saluda
			Waynesville				Liberty		Liberty
					Waynesville		Waynesville		Waynesville
					Arnheim		Armheim		Arnheim
Hill Quarry	Lorraine	Maysville	Arnheim	Covington Group		Maysville	Mt. Auburn	Maysville	Mt. Auburn
			Mt. Auburn		McMillan		Corryville		Corryville
			Corryville		Fairview		Bellevue		Bellevue
			Bellevue				Fairmount		Fairmount
			Fairmount				Mt. Hope		Mt. Hope
			Mt. Hope						
Eden	Utica	Eden			McMicken	Eden	McMicken	Eden	McMicken
			Upper		Southgate		Southgate		Southgate
			Middle		Economy		Economy		Economy
			Lower		Fulton		Fulton		

* Foerste, in the Geologic Map of Ohio, 1920, places the Maysville-Richmond division plane at the base of the Oregonia member of the Arnheim division.

STRATIGRAPHY.

The Oregonia-Ft. Ancient region is situated approximately on the crest of the Cincinnati Arch, and the strata are essentially horizontal and undeformed.

The strata of the region belong to the Ordovician system, and principally to the Richmond sub-series. The subdivisions and classification of the Cincinnatian series have suffered many changes and corrections during the last 50 years, and there is not yet complete agreement on all points. This is especially true of the Maysville-Richmond sub-series boundary, which is well exemplified in our region. It is with this question that this paper is primarily concerned.

The subdivisions of the Cincinnatian series as used by the several authors are shown and correlated on Plate I. The column of subdivisions used in this report, which is a composite from several published columns is as follows, the subdivisions exposed in the Oregonia-Ft. Ancient region being in *italics*. The thicknesses given are for the Oregonia-Ft. Ancient region.

(System)	(Series)	(Sub-series)	(Formation)	(Member)	Thickness
Ordovician..	Cincinnatian	*Richmond*...	Elkhorn		
			Whitewater		24′ +
			Liberty		28′ 1″
			Waynesville....	*Blanchester*	35′ 1″
				Clarksville	24′ 8″
				Ft. Ancient	36′ 8″
			Arnheim.....	*Oregonia*	23′ 9″
				Sunset	35′
				Mt. Auburn	16′ 6″
		Maysville...	*McMillan*.....	*Corryville*	15′ 2″+
				Bellevue	
			Fairview.....	Fairmount	
				Mt. Hope	
				McMicken	
		Eden.....	Latonia.....	Southgate	
				Economy	
			Utica		
	Mohawkian				
	Canadian				

The Cincinnatian series is made up largely of shale, and subordinately of limestone. The general succession throughout the series is an alternation of layers of shale and limestone, the shale layers commonly being thicker. A composite geologic section of the Oregonia-Ft. Ancient region is as follows:

Thickness

THE RICHMOND SUB-SERIES.

THE WHITEWATER FORMATION: 24′ exposed; best exposed in Flat Fork.

42. Irregularly bedded, argillaceous limestone and relatively even-bedded, blue-gray shale..... 12′ 0″

The whole assumes a distinctive cream color upon weathering. Principal fossils are: *Byssonychia obesa, Strophomena sulcata, S. planumbona, Rafinesquina alternata, Rhynchotrema capax, Platystrophia acutilirata, Hebertella occidentalis, Dinorthis subquadrata, Monticulipora epidermata, Homotrypa wortheni, Bythopora delicatula, Batostoma variable, Streptelasma rusticum, S. divaricans* and *Protarea richmondensis.*

41. Alternating layers of irregularly-bedded, argillaceous limestone and nodular shale. Fauna essentially the same as that of Zone 42, except that *Streptelasma rusticum* is especially large and abundant at this horizon..... 6′ 8″

40. Alternating layers of limestone and shale between base of 3½-inch limestone layer at top of zone, and base of "Turkey Track" limestone layer below..... 5′ 4″

This Turkey Track layer is a hard, fine-grained, essentially barren limestone layer approximately 7 inches thick, the top of which bears impressions resembling turkey tracks. The base of this Turkey Track layer has been designated by Dr. George M. Austin as the plane of division between the Whitewater and Liberty formations in southwestern Ohio.

Above the Turkey Track layer is a series of hard, fine-grained relatively unfossiliferous limestone layers, most of which bear surface impressions of rill marks or seaweeds. Between these dense, unfossiliferous limestone layers, are layers of blue-gray shale that are relatively fossiliferous. This zone marks a sudden ingress of fossils unusual to the lower Richmond formations. The specimens are not abundant, but a close search will disclose numerous species, several of which are as yet undescribed. Chief among these unusual forms are curved and coiled Cephalopods of the *Gomphoceras, Cyrtoceras* and *Trochoceras* types. The Pelecypods *Whitella, Ischyrodonta* and *Opisthoptera* and others exist at this horizon.

THE LIBERTY FORMATION..... 28′ 1″

39. Alternating layers of fine-grained, blue shale and even-bedded limestone..... 8′ 5″

Principal fossils are: *Strophomena planumbona, Plectambonites richmondensis, Platystrophia annieana, Rhynchotrema capax, Rafinesquina alternata, Hebertella occidentalis, Dinorthis subquadrata, Rhombotrypa quadrata, Streptelasma rusticum, S. divaricans, Protarea richmondensis* and others. This zone, as well as the other ones of the Liberty formation, are best exposed in Flat Fork and Olive Branch.

38. Limestone zone which in most stream exposures caps a falls above the Isotelus shale zone..... 2′ 5″

37. Isotelus shale..... 5′ 11″

Even-bedded, plastic, blue shale with a few thin limestone partings. At this horizon, in the valley of Flat Fork, a very fine large specimen of the Trilobite *Isotelus brachycephalus* was found. This specimen is quite complete and measures 11¼ inches in length by 8 inches across at the posterior edge of the cephalon. Fragments of Isotelus are common at this horizon, but complete specimens are rare. The principal other fossils found in this zone are: *Calymene meeki, Rafinesquina alternata, Pterinea demissa, Ctenodonta, Lophospira bowdeni* and *Columnaria alveolata.*

36. Alternating layers of blue shale and thin limestone partings, which form a series of small falls in most stream exposures..... 11′ 4″

Fauna essentially the same as that of Zone 37, except that *Plectambonites richmondensis* is especially abundant near the top of this zone.

THE WAYNESVILLE FORMATION:

The Blanchester Member..... 35′ 1″

Well represented in Blacksmith Hollow, Flat Fork and Olive Branch.

35. Upper Hebertella insculpta zone ..... 5′ 7″

Top of zone marked by a 3 to 4 inch, more or less wave-marked limestone layer containing *Hebertella insculpta, Strophomena planumbona, Rhynchotrema capax* and other fossils. Below this uppermost layer of limestone is a 30 inch division composed principally of shale, relatively barren of fossils. The basal part of this zone is composed of alternating laters of shale and thin partings of limestone, and contains principally the Brachiopods *Hebertella insculpta* and *Strophomena planumbona.*

34. Blue shale with thin limestone partings containing fragments of *Isotelus, Calymene meeki, Pterinea demissa, Byssonychia radiata, Tetradium, Columnaria alveolata* and *Calapoecia cribriformis*..... 4′ 3″

33. Alternating blue shale and even-bedded limestone layers..... 10′ 1″

Eleven inches below top of zone is a one-inch, even-bedded limestone layer to which the Brachiopod *Plectorthis scovillei* is confined. Other fossils of the zone are: *Zygospira modesta, Rafinesquina alternata, Plectambonites richmondensis, Platystrophia cumingsi* (?), *Leptaena richmondensis, Hebertella occidentalis, Homotrypa dawsoni, Protarea richmondensis, Streptelasma rusticum, S. divaricans* and others.

32. Blue shale and thin limestone layers containing *Strophomena nutans* and *S. neglecta*..... 2′ 10″

31. Even-bedded, blue shale with a few thin limestone partings containing principally fragments of *Isotelus*, several species of *Pelecypods, Leptaena richmondensis, Dalmanella meeki* and *Bythopora meeki*..... 6′ 9″

30. Thin, irregularly-bedded limestone and nodular shale layers. Fossils jumbled and broken..... 5′ 8″

29. Lower Hebertella insculpta zone, the base of which marks the Blanchester-Ft. Ancient division plane..... 0′ 11″

The Clarksville member..... 24′ 8″

Best exposed in Stony Run, Blacksmith Hollow and Longstreth Branch.

28. Alternating thin limestone and blue shale layers..... 6′ 1″

Principal fossils are: *Strophomena planumbona, Leptaena richmondensis, Hebertella occidentalis, Dalmanella meeki* and *Streptelasma rusticum.*

27. Zone of the usual succession of shale and limestone, containing principally: *Zygospira modesta, Plectambonites richmondensis, Platystrophia clarksvillensis, Leptaena richmondensis, Dalmanella meeki* and *Streptelasma rusticum*..... 5′ 2″

26. Alternating shale and thin limestone layers, crowded with: *Strophomena planumbona, Platystrophia clarksvillensis, Hebertella occidentalis*, all more or less jumbled together..... 5′ 4″

25. Coarse-grained, irregularly-bedded limestone layers with thin partings of blue shale. *Dalmanella meeki* abundant, and jumbled together..... 2′ 8″

24. Fine-grained, even-bedded, blue shale commonly referred to as the Orthoceras duseri shale or the Trilobite Beds because of the relative abundance of *Orthoceras duseri* and *Calymene meeki* at this horizon. Other fossils common to the zone are: fragments of *Isotelus*, several species of *Pelecypods*, *Cyphotrypa clarksvillensis*, *Tetradium huronense* (?), and *Stromatocerium huronense* (?)..... 5′ 5″

This zone was formerly classified with the Ft. Ancient member, but Dr. Shideler places it in the Clarksville member because of the existence therein of Tetradium and Stromatocerium—Richmond forms not present in the Ft. Ancient member.

The Ft. Ancient member.....36′ 8″

Most completely represented in Blacksmith Hollow, Longstreth Branch and Stony Run.

23. Alternating shale and thin limestone layers containing principally *Rafinesquina alternata* and *Dalmanella meeki*..... 3′ 0″

22. Even-bedded, blue shale with thin limestone partings. Base of zone marked by a three-inch, wave-marked limestone layer. Most abundant fossils are: *Pterinea demissa*, *Modiolopsis concentrica*, *Byssonychia radiata*, *Anomalodonta gigantea*, *A. alata*, *Zygospira modesta*, *Rafinesquina laternata* and *Dalmanella meeki*.. 8′ 0″

21. Blue shale with a few thin limestone partings; fossils essentially the same as in zone above..... 8′ 8″

20. Zone of nodular shale and thin, argillaceous limestone layers, with a three-inch dense limestone layer at top of zone. Fossils jumbled and broken..... 3′ 6″

Rafinesquina alternata and *Dalmanella meeki* predominate in number, almost to the exclusion of other forms.

19. Alternating layers of irregularly-bedded, argillaceous limestone and nodular, blue shale containing principally jumbled and broken specimens of *Calymene meeki*, *Cornulites sterlingensis* (?), *Zygospira modesta*, *Rafinesquina alternata* and *Dalmanella meeki*..10′ 6″

18. Irregularly-bedded limestone layers with thin shale partings. Shale relatively barren of fossils, and limestone layers composed chiefly of fossil fragments and jumbled specimens of *Dalmanella meeki*..... 3′ 0″

THE ARNHEIM FORMATION:

Best exposed in Blacksmith Hollow and Longstreth Branch.

The Oregonia member.....23′ 9″

17. Conspicuous zone of nodular, irregularly-bedded, argillaceous limestone layers that weather into lumps. Fossil fragments are abundant throughout the zone, indicating shallow water conditions of deposition, but the only unbroken specimens found were a few *Pterinea demissa*, *Anomalodonta gigantea*, *A. alata*, *Cornulites sterlingensis* (?) and a single *Strophomena concordensis*..... 5′ 6″

16. Alternating layers of coarse-grained, irregularly-bedded limestone and nodular shale. Fossils include those of Zone 17, plus *Cyclonema bilix*, *Rafinesquina alternata*, *Dalmanella meeki*, *Peronopora decipiens*, *Mesotrypa orbiculata*, *Homotrypa bassleri*, *Ceramoporella ohioensis*, *Batostoma varians* and many microscopic size specimens of Pelecypods, Gastropods, Brachiopods and Bryozoa, several of which are undescribed.....12′ 8″

15. Zone of shale and limestone layers; top marked by even-bedded limestone layer with nodules of Pyrite..... 1′ 2″

14. Dinorthis carleyi zone..... 4′ 5″
Thin layers of shale and limestone containing *Dinorthis carleyi, Trematis millipunctata, Leptaena richmondensis, Stigmatella crenulata, Rhopalonaria venosa* and *Batostoma varians.* The first appearance of the Brachiopod Dinorthis carleyi marks the base of the Oregonia member.—(A. F. Foerste, Ohio Naturalist, XII, Jan. 1912, p. 436.)

The Sunset member.....35′

13. Lumpy shale and thin, irregularly-bedded limestone layers. The Brachiopod *Leptaena richmondensis* first appears in the Richmond division at this horizon..... 1′ 6″
12. Alternating blue shale and thin limestone layers, relatively barren of fossils..... 2′ 3″
11. Irregularly-bedded limestone and nodular shale layers..... 1′ 9″
10. Zone of nodular blue shale and thin limestone layers. Characteristic fossils are: *Rafinesquina alternata, Delmanella meeki, Stigmatella crenulata, Rhopalonaria venosa, Peronopora decipiens, Mesotrypa orbiculata, Homotrypa libana, H. flabellaris, Hallopora subnodosa* and *Ceramoporella ohioensis*..... 5′ 6″
9. Covered interval.....15′ 8″
8. Even-bedded, blue-gray shale with thin limestone layers containing principally: *Calymene meeki, Dalmanella meeki, Stigmatella crenulata, Peronopora decipiens, Homotrypa libana, H. flabellaris, Hallopora subnodosa* and *Ceramoporella ohioensis*..... 7′ 4″
Practically all of these are typical Richmond forms, not found in the underlying Mt. Auburn division. The characteristic Maysville fossils, with but few exceptions, either do not continue into the Richmond division, or are recognizably modified. At least half of the species that do survive are hardy forms that have lived on since Bellevue time.
7. Alternating layers of coarse-grained, very irregularly-bedded limestone layers with thin shale partings..... 1′ 0″
The fossils in this zone are jumbled and broken, indicating shallow-water conditions of deposition. Traced southward into Brown and Adams counties, Ohio, this horizon exhibits strongly developed cross-bedding. And in Kentucky, these strata are ripple-marked, sun-cracked and marked with raindrop impressions, indicating not only shallow water conditions, but a definite period of emergence between the deposition of the Maysville and Richmond subseries in that province.*
The base of this zone is regarded as the plane of division between the Richmond subseries above, and the Maysville subseries, below. Dr. Ulrich would make this horizon the systemic boundary between the Silurian and Ordovician systems.

THE MAYSVILLE SUB-SERIES.

THE MT. AUBURN FORMATION.....16′ 6″

6. Blue-gray, even-bedded shale with thin partings of limestone, in which the fossils lie undisturbed in a practically horizontal position. The principal fossils of the zone are: *Zygospira modesta, Rafinesquina alternata,* the distinctive Mt. Auburn Bryozoan *Homotrypa pulchra, Heterotrypa frondosa* and *Ceramoporella ohioensis*..... 2′ 5″
5. Irregularly-bedded limestone and nodular shale layers in which exist *Rafinesquina alternata, Homotrypa pulchra, Heterotrypa frondosa, Hallopora rugosa* and *Ceramoporella ohioensis,* all more or less jumbled together..... 4′ 7″

*Personal communication from Dr. W. H. Shideler, Miami University.

4. Alternating layers of irregularly-bedded argillaceous limestone with nodular shale layers..... 4′ 10″
Platystrophia ponderosa auburnensis, the characteristic Mt. Auburn Brachiopod, is abundant in this zone, but was not found in the zones above.

3. Lumpy shale and irregularly-bedded limestone layers..... 4′ 8″
Fossils jumbled and broken. Principal species are: *Byssonychia radiata, Cyclonema bilix, Rafinesquina alternata* abundant, *Platystrophia ponderosa* present but relatively scarce.

THE CORRYVILLE FORMATION.....15′ 2″ exposed

2. Irregularly-bedded, argillaceous limestone layers and lumpy shale..... 8′ 8″
Fossils jumbled, with *Rafinesquina fracta* most abundant; other forms are: *Pterinea demissa, Zygospira modesta* and the characteristic Corryville Bryozoan *Chiloporella flabellaris*. No Platystrophia ponderosa exist in this zone, the first appearance of this species in the zone immediately above marking the base of the Mt. Auburn division.

1. Alternating layers of shale and limestone containing *Chiloporella flabellaris* and *Rafinesquina fracta*, the latter occurring as jumbled masses at several horizons within the zone..... 6′ 6″

SUMMARY AND CONCLUSIONS.

The bed rock of the Oregonia-Ft. Ancient region includes Cincinnatian strata ranging in age from the Corryville member of the Maysville sub-series, to the Whitewater formation of the Richmond division, inclusive.

Regarding the controversial Maysville-Richmond sub-series boundary; the preponderance of evidence shows conclusively that it should be placed at the top of the Mt. Auburn division. In our region, indications at this horizon point to a shoaling of the Maysville sea. Traced southward through Ohio and into Kentucky, we find evidence of very shallow water conditions and even temporary withdrawal of the sea at this horizon. There is also a marked faunal break at this horizon. The characteristic Maysville forms, with but few exceptions, fail to pass this stratigraphic break between the Mt. Auburn and Sunset divisions; and those that do survive the transition are hardy forms that have lived on since Bellevue time. And even these surviving forms are recognizably modified. Moreover, the first fossiliferous strata in the Arnheim division carry a characteristic Richmond fauna; forms that for the most part do not exist in the underlying Maysville sub-series, but are typically developed in the succeeding Richmond sub-series.