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THE RELATIONSHIPS OF THE OLENTANGY SHALE AND ASSOCIATED DEVONIAN DEPOSITS OF NORTHERN OHIO[1]

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In the flat glaciated region to the south and east of Sandusky there are few outcrops of the older rocks. The drainage is mostly by small, weak streams which have not yet had time to erode extensive valleys, and railroads have not been compelled to cut deeply in order to establish their grades. About seven miles south of Sandusky, however, where the land is a little higher than in the city and the mantle rock is exceedingly thin, some of the creeks have exposed small sections of bedrock which are somewhat exaggerated by a considerable local dip. Two of the more important of these are to be found along Plum and Pipe creeks. These sections have been discussed elsewhere,[2] but a recent study of the region has added some valuable facts to those formerly given and has made it possible to correlate this Ohio Hamilton with the Devonian deposits of the same age to the north of Lake Erie.

Plum Creek heads about nine miles southeast of Sandusky and flows, in a general northerly direction, to the lake. At a point about two miles east-northeast of Prout station, on the Baltimore & Ohio Railroad, it cuts into Huron shale, and a little farther north into the Hamilton beds, exposing the following section:

SECTION OF THE HAMILTON ROCKS AND HURON SHALE ALONG PLUM CREEK

	Thickness Ft.	In.
Huron Shale		
12. Shale, bituminous, black	4	0
Widder Beds		
11. Prout or Encrinal limestone. A very hard siliceous blue limestone containing a little chert and much pyrite. Silicified corals and crinoid stems are abundant, the latter especially in the middle layers	8	10

[1] Published with the permission of the Deputy Minister of Mines, Ottawa, Canada.

[2] *Geological Survey of Ohio, Bulletin No. 10*, 4th Series, 1909, pp. 119–22, Pls. VIII and IX.

FAUNA

Favosites billingsi, Zaphrentis prolifica, Fenestella sp., *Atrypa reticularis, Spirifer* sp., *Stropheodonta perplana*

Olentangy Shale

10.	Covered interval	6	0
9.	Limestone, soft, blue, very fossiliferous	0	6

FAUNA

Autodetus lindstroemi, Spirorbis angulatus, Streblotrypa hamiltonensis, Fistulipora corrugatus ?, *Hederella canadensis, Trematospira* sp., *Chonetes deflectus, Crania hamiltonensis, Leiorhynchus kelloggi, Leiorhynchus laura, Rhipidomella cyclas, Sprifer mucronatus, Stropheodonta demissa, Stropheodonta concava, Actinopteria boydi, Aviculopecten fasciculatus, Glosseletina triquetra, Leiopteri rafinesquii, Microdon bellistriatus, Modiomorpha subalata, Mytalarca oviforme, Pterinea flabellum, Pterinopecten vertumnus, Schizodus appressus, Tellinopsis subemarginata, Bembexia sulcomarginata, Cyrtonella mitella, Pleurotomaria capillaria, Orthoceras* sp., *Bairdia devonica, Bollia* sp., *Bythocypris indianensis, Primitiopsis punctulifera, Phacops rana,* Fish plates

8.	Shale, argillaceous, soft, blue	3	6

FAUNA

Chonetes deflectus, Chonetes setigerus, Crania crenistriata, Leiorhynchus kelloggi, Spirifer mucronatus, Styliolina fissurella, Bythocypris indianensis

7.	Limestone, quite hard, blue	0	6

FAUNA

Cystodictya hamiltonensis, Trematopora sp., *Chonetes deflectus, Leiorhynchus kelloggi, Leiorhynchus laura, Spirifer mucronatus, Actinopteria boydi, Platyceras erectum, Phacops rana*

6.	Shale, soft, blue	5	0

FAUNA

Chonetes deflectus, Bythocypris indianensis

5.	Limestone, blue, lower part shale, very fossiliferous	0	6

FAUNA

Ambocoelia umbonata, Chonetes deflectus, Leiorhynchus kelloggi, Stropheodonta demissa, Cypricardinia indenta, Glyptocardia speciosa, Grammysia arcuata, Grammysia bellatula, Grammysia bisulcata, Grammysia constricta, Modiomorphia subalata, Nucula corbuliformis, Nuculites oblongatus, Nuculites triqueter, Nyassa recta, Pholadella radiata, Schizodus appressus, Bellerophon lyra,

Pleurotomaria planodorsalis, Pleurotomaria rotalia, Orthoceras sp., *Bairdia devonica, Barchilina* sp., *Bollia* sp., *Primitiopsis punctulifera, Bythocypris punctatus, Phacops rana,* Fish plate

4. Shale, argillaceous, soft, blue. This shale contains numerous small pyrite concretions, some of which are beautifully twinned crystals. The fossils are probably rare in most of it and appear to be in streaks or layers. Mostly covered ..... 10± 0

FAUNA

Orbignyella monticula, Leiorhynchus laura, Spirifer mucronatus, Athyris spiriferoides

3. Shale, blue, with pyritized fossils ..... 0 6±

FAUNA (PYRITIZED)

Leiorhynchus sp., *Leda rostellata, Nuculites triqueter, Bactrites arkonense, Tornoceras uniangulare*

2. Shale, blue. Fossils rather abundant ..... 3± 0

FAUNA

Alveolites monroei, Aulopora cornuta, Aulopora serpens, Ceratopora rugosa, Zaphrentis prolifica, Spirorbis omphalodes, Acanthoclema hamiltonense, Ascodictyon stellatum, Batostomella obliqua, Fistulipora involvens, Fistulipora spinulifera, Hederella canadensis, Hederella filiformis, Heteronema monroei, Orbignyella monticula, Orbignyella tenera, Athyris spiriferoides, Chonetes coronatus, Chonetes deflectus, Crania hamiltoniae, Cryptonella planirostra, Cyrtina hamiltonensis, Leiorhynchus kelloggi, Philidostrophia iowaensis, Spirifer mucronatus, Stropheodonta demissa Tropidoleptus carinatus, Styliolina fissurella, Bairdia devonica, Primitiopsis punctulifera

1. Shale, soft blue, with some flat calcareous concretions. Fossils rare ..... 5± 0

The other important Ohio outcrop is along the south branch of Pipe Creek, one-fourth mile east of Bloomville and about three miles west of the one just given on Plum Creek. At that point the Prout limestone has been quarried to a limited extent, and is therefore well exposed, although the beds of shale below are pretty well sodded over.

SECTION OF THE HAMILTON BEDS ALONG SOUTH BRANCH OF PIPE CREEK

Widder Beds		Thickness Ft.	In.
4.	Prout or Encrinal limestone. An impure blue limestone some layers of which are very crinoidal and the upper one containing rather numerous corals	9	0

FAUNA

Baryphyllum verneuilanum, Cladopora canadensis, Cladapora roemeri, Cystiphyllum vesiculosum, Favosites alpenaensis, Favosites billingsi, Favosites placenta, Favosites radiciformis, Favosites turbinatus, Heliophyllum halli, Syringopora intermedia, Zaphrentis prolifica, Polypora; sp., *Atrypa reticularis, Athyris vittata, Chonetes mucronatus, Chonetes scitulus, Rhipidomella vanuxemi, Schizophoria striatula, Spirifer audaculus macronotus, Spirifer mucronatus, Stropheodonta demissa, Platyceras erectum, Phacops rana*

Olentangy Shale

3. Shale, blue, alternating with blue argillaceous limestone; very poorly exposed but weathered blocks of the limestone lie on the steep bank and numerous fossils have weathered out of the softer layers ..... 15± 0

FAUNA

Ceratopora rugosa, Zaphrentis prolifica, Spirorbis, angulatus, Spirorbis omphalodes, Acanthoclema hamiltonensis, Batostomella obliqua, Botryllopora socialis, Cystodictya hamiltonesnsis, Fistulipora spinulifera, Hederella filiformis, Orbignyella monticula, Polypora sp., *Ambocoelia umbonata, Atrypa reticularis, Chonetes deflectus, Chonetes scitulus, Crania hamiltonensis, Cryptonella planirostra, Leiorhynchus laura, Rhipodomella cyclas, Schizophoria striatula, Spirifer mucronatus, Stropheodonta demissa,* Fish plate

2. Shale, marly, blue, badly weathered and soil-covered ..... 10± 0
1. Shale, blue, with disk-like blue limestone concretions ..... 5± 0

The lower part of the shales in these sections is apparently not very fossiliferous. The same is usually true of the Lower Hamilton of Ontario and in many places of the similar deposits in New York. This is probably even more characteristic of the Olentangy shale in central Ohio. However, at Delaware, Winchell's type section of the Olentangy, a few poorly preserved fossils[1] were found which, although only given generic identification, are believed to be identical with others found in the shales of the Sandusky region. It was at Delaware also that the crinoid bed was found in the Olentangy shale—a lens corresponding in every way with the thin lenses of crinoidal limestone common in the lower shales of

[1] *Geological Survey of Ohio, Bulletin No. 10,* 4th series, 1909, p. 89.

the Hamilton beds exposed along Aux Sable River in Ontario. The general make-up, appearance, and physical properties of the shale below the Prout limetsone and the Olentangy shale are the same (Figs. 1, 2, and 3). Moreover, the Delaware limestone, which underlies this deposit at Delaware and at Sandusky, carries the

FIG. 1.—A weathered bank of fossiliferous Olentangy shale showing one of the common calcareous layers in this shale along Plum Creek, near Prout station.

FIG. 2.—A bank of Olentangy shale along the Olentangy River at Delaware, Ohio. The limestone disks in this bank contain an occasional fragmentary fossil. The lens of crinoidal limestone was found at this locality. This is Winchell's type locality for the Olentangy shale and shows its marked contrast to the Ohio or even to the blue bands occurring in the middle portion of the latter.

same fauna at both places and extends northward into Ontario. Whitfield found the lower part of the Delaware to be the western extension of the Marcellus shale, to which he considered it to be in part equivalent.[1] Wherever the Delaware limestone becomes

[1] R. P. Whitfield, *Proceedings of the American Association for the Advancement of Science*, XXVIII (1879), 298.

especially shaly, as is often the case, the fauna tends to revert to that of the more typical Marcellus, so that these forms are not limited to the basal portion. But the occurrence in it of certain fossil forms more characteristic of the true Hamilton beds of New York than of the Marcellus of that region has led to the use of Marcellus-Hamilton or Lower Hamilton for the Delaware. In this use of the Hamilton, it is the older and broader sense of that term, rather than the restricted present usage, that was intended. It would more properly be called the lower Erian. The Olentangy

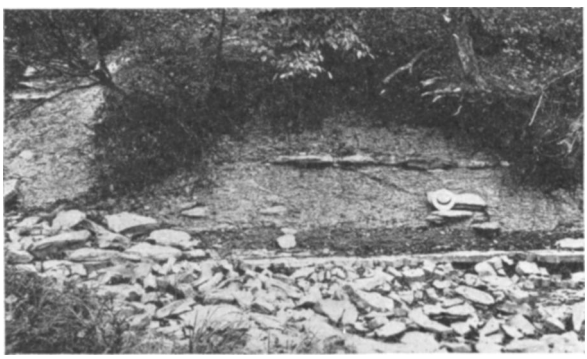

FIG. 3.—A bank of Olentangy shale downstream a short distance from the one illustrated in Fig. 2.

shale is overlaid by the Ohio shale in the central part of the state and by the Huron or lower Ohio shale at Sandusky. The stratigraphic position of the blue shale in question, therefore, suggests the same correlation that has been made on the meager fauna and the lithological similarity. When it is recalled that the regions in question lie within the same Devonian basin and that the deposits are a continuation of the same general line of Devonian outcrops, traceable by well-records in the covered interval between, this relationship seems worthy of consideration.

The relation of the Sandusky deposit to the Hamilton beds of Ontario is much more easily determined. In a memoir on the Devonian of southwestern Ontario, which was recently published by the Geological Survey of Canada, the correlation of the shale below the Prout limestone with the Olentangy has been adopted, and the

Hamilton beds have been divided, in descending order, into the Ipperwash limestone, the Petrola shale, the Widder beds, and the Olentangy shale. In the sections at Arkona, Lambton County, the two lower stages are well exposed. At no place in the province is the bottom of the Olentangy shale exposed, although well-records indicate that it rests directly upon the Delaware limestone. This latter formation is well shown in the excellent outcrops at St. Mary's and at several places in the vicinity of Brussels and Goderich. In the following section of the Hamilton beds in Rock Glen at Arkona, only the fauna of the Encrinal limestone and of the beds below are given, since the subsequent comparison is made with those portions of the section only.[1]

SECTION OF THE HAMILTON ROCKS AT ARKONA, ONTARIO

Widder Beds	Thickness Ft.	In.
11. Soil and drift	15	0
10. Limestone, argillaceous, massive, blue, partly cystalline, alternating with thin layers of shale. These beds form the falls at the old mill	10	8
9. Shale, soft, blue, with calcareous nodules or concretions	8	4
8. Limestone, argillaceous, blue	1	6
7. Shale, usually soft, blue, but some layers harder and more massive	17	5
6. Shale and shaly blue limestone	7	0
5. Coral zone. A decomposed blue or gray shale, often an impure shaly limestone, filled with corals	3	6
4. Encrinal limestone. A hard, pyritiferous, bluish-gray limestone which is full of crinoid segments, coral fragments, and other fossils. It includes some brownish shale near the base	2	4

FAUNA

Aulopora serpens, Ceratopora dichotoma, Cladopora canadensis, Cladopora roemeri, Craspedophyllum archiaci, Cystiphyllum vesiculosum, Favosites alpenaensis, Favosites placentus, Favosites turbinatus, Heliophyllum halli, Syringopora intermedia, Syringopora nobilis, Trachypora elegantula, Zaphrentis prolifica, Dolatocrinus liratus, Hederella filiformis, Streblotrypa hamiltonensis, Taeniopora exigua, Ambocoelia umbonata, Atrypa reticularis, Athyris vittata, Chonetes coronatus, Chonetes lepidus, Delthyris

[1] The fauna of the other beds may be found listed in the *Geological Survey of Canada Memoir* (No. 34, p. 164), on the Devonian of southwestern Ontario.

sculptilis, Leiorhynchus laura, Pholidops hamiltoniae, Pholidostrophia iowaensis, Productella productoides, Rhipidomella penelope, Rhipidomella vanuxemi, Schuchertella perversus, Spirifer divaricatus, Spirifer mucronatus, Stropheodonta concava, Stropheodonta demissa, Stropheodonta perplana, Pterinea flabellum, Platyceras erectum, Tentaculites bellulus, Phacops rana

Olentangy Shale

3. Shale, soft, gritless, blue, containing few fossils except in certain streaks or layers..... 19 0

FAUNA

Microcyclas discus, Arthracantha punctobranchiata, Chonetes lepidus, Pholidostrophia iowaensis, Platyceras erectum

2. Shale, soft, gritless, blue, with a few thin lenses of very fossiliferous crinoidal limestone. These beds include a thin zone in which the fossils are small and always pyritized..... 6 0

FAUNA (PYRITIZED)

Leda rostellata, Nucula lirata, Nuculites triqueter, Paracyclas lirata, Bactrites arkonensis, Tornoceras uniangulare

FAUNA (NON-PYRITIZED)

Arthracantha punctobranchiata, Gennaeocrinus arkonensis Palaeaster eucharis, Chonetes deflectus, Chonetes lepidus, Chonetes scitulus, Cyrtina hamiltonensis, Parazyga hirsuta, Productella spinulicosta, Schuchertella perversus, Spirifer mucronatus, Actinopteria boydi, Glypodesma erectum, Bellerophon triliratus, Platyceras erectum, Platyceras rarispinosum, Platyceras subspinosum, Pleurotomaria delicatula, Styliolina fissurella, Tentaculites attenuatus, Tentaculites bellulus, Primitiopsis punctulifera, Phacops rana

1. Covered interval to the level of the Ausable River..... 10 0

The most important point of similarity between the Ohio and Ontario sections is to be found in the fauna of the thin layer about 25 feet below the base of the Prout limestone, and at a similar distance below the Encrinal limestone of Ontario. In both cases the fossils are pyritized and of small size. Although the fauna of this layer is somewhat more limited in Ohio, the four species that have been found in it are identical with those of the similarly located layer of the Arkona section. At no other horizon has this fauna been found in Ohio, and three of the species have not been

found outside of it in Ontario, and even the fourth but sparingly. It seems certain, therefore, that this is the same horizon in both cases. From the prominence of *Bactrites arkonensis* in this layer at Arkona and Sandusky, it may be termed the Bactrites horizon.

The question next arises as to the relationship of the beds above the Bactrites horizon. In the Sandusky region the fossils of this portion of the formation seem to be more abundant in certain streaks or beds. To a limited extent the same is true of the shales below the Encrinal limestone in Ontario, but there the great body

FIG. 4.—The Prout or Encrinal limestone overlain by the Huron shale at Slate Cut along the Lake Shore and Michigan Southern Railway three miles east of Sandusky, Ohio.

of the deposit between the Bactrites layer and the Encrinal limestone is very sparingly fossiliferous. The Encrinal limestone may be described as several layers of a hard, pyritiferous, bluish-gray limestone which is often full of crinoid fragments—a description which fits equally well the Prout limestone (Fig. 4) in the sections here under consideration and especially the middle layers at Bloomingville. Along Eighteen Mile Creek, New York, one of the important fossils of the Encrinal limestone is *Delthyris sculptilis*. Grabau says: "This species is entirely restricted in this region to the Encrinal limestone, and may be regarded as the typical fossil of the fauna."[1] This is also the case in Ontario and probably led Shimer and Grabau to correlate the limestone in Ontario with

[1] *Bulletin of the Buffalo Society of Natural Science*, Vol. VI (1898), 32.

the similar one in western New York,[1] although many other forms are also common to the Encrinal limestone of the two regions.

The fossils in the beds immediately below the Prout limestone are more abundant than in the shale just below the Encrinal limestone of Ontario. In this respect the northern Ohio deposit shows more decided relationship to the western New York section. In fact, the upper part of it includes a portion of the fauna of the "Demissa bed," although it lacks *Spirifer granulosus* and some of the other prominent forms. However, this suggested relationship with the New York section is not fully substantiated.

In addition to the marked lithological similarity and stratigraphic relation of the Prout and Encrinal limestones, over 75 per cent of the fauna of the Prout limestone also appears in the Encrinal limestone of Ontario, and the upper layers contain many of the corals of the coral zone at Arkona, Ontario. It seems reasonably certain, therefore, that the Prout limestone is the Ohio representative of the Encrinal limestone to the north and perhaps to the east as well.

At Kettle Point, Ontario, the Devonian black shale rests upon a limestone of the Hamilton which lies about 150 feet above the Encrinal limestone, and well-records[2] show that this is the usual succession of beds in Lambton County, Ontario. In Middlesex and Kent counties, which lie to the south of Lambton, this limestone is sometimes present, but at other places is wanting,[3] as might be the case where erosion has taken place prior to the deposition of the black shale. The Huron, or basal portion of the Ohio, lies directly upon the Prout limestone at Sandusky. It therefore either represents the upper Hamilton shale and limestone of Ontario, or these deposits are wanting in northern Ohio and the Huron shale rests unconformably on the Encrinal limestone. On the basis of the fossils and the occurrence of spheroidal concretions in both deposits, Kindle has correlated the black shale at Kettle Point, Ontario, with the Huron shale of northern Ohio.[4] If this correlation

[1] *Bulletin of the Geological Society of America*, Vol. XIII (1902), 164, 166.

[2] H. P. H. Brumell, *Geological Survey of Canada, Ann. Rept.*, V, Part Q (1892), 61–70.

[3] *Ibid.*, pp. 52, 73, 74.

[4] *Geological Survey of Canada, Summary Report for 1912* (1914), pp. 287, 288.

is correct, as seems probable, the Huron shale does not represent the Upper Hamilton, but rests unconformably on the Prout or Encrinal limestone.

Mr. Allen R. Stuckey, who has drilled numerous wells in Crawford and adjoining counties, reports that at Bucyrus the drift ranges from 55 to 80 feet in thickness. Under this is 35 to 200 feet of black shale, which is usually succeeded below by about 10 feet of gray shale, so tough and sticky that it is difficult to drill. This gray shale immediately overlies the limestone, but in a few wells it has been found to be absent where the black shale rests

FIG. 5.—The Olentangy-Ohio shale contact at "Dripping Rock," near Liberty Church, Delaware County, Ohio. Here again there is an undulating contact.

directly upon the limestone. In the eastern part of this county, 30 feet of the gray shale is found at many places. It is evident, therefore, that in Crawford County the Olentangy shale is even more variable in thickness than it is in central Ohio and that the Prout limestone of the Sandusky region has disappeared. At "Dripping Rock" (Fig. 5), in Delaware County, where the Prout limestone is wanting and the Olentangy shale is only about 31 feet in thickness, the contact between it and the overlying Ohio shale is most marked and slightly undulating. The contact is equally marked at High Banks, near the Franklin-Delaware county line, and again in the town of Delaware (Fig. 6). At this latter place the basal Ohio shale is somewhat arenaceous. Near the Ohio River, at Kinkead Springs, Pike County, the Ohio extends down to the Silurian limestone and is firmly welded to it.

Southward from Kettle Point, Ontario, therefore, the Huron or lower portion of the Ohio shale rests on older and older beds to which its relationship must be that of unconformity (disconformity). This relation is not strikingly perceptible at any one place, but in southern Ohio the time interval between the Silurian and Devonian strata, which are in contact, is enormous. When it is recalled that the first effect of running water on a newly uplifted land surface is to roughen it, and that continued erosion tends to produce planeness, it is clear that, where little or no folding or tilting of the stratified rocks has taken place, slight (apparent) unconformities are likely to

FIG. 6.—The sharp and slightly undulating contact between the Ohio and the Olentangy shales in the clay pit at Delaware, Ohio.

represent great intervals of time, while conspicuous ones may stand for shorter intervals. Or, in other words, the greater the time interval which is represented by an erosional unconformity (disconformity) in undisturbed strata, the more evasive it is likely to be. This is probably one of the chief reasons for the marked differences in the interpretation of sections where such gaps in sedimentation occur. With the Hamilton beds at Sandusky and in central Ohio resting on the Delaware limestone (Lower Erian) and overlaid unconformably by the Ohio shale in both places, the advisability of calling the soft marly beds to the south of Sandusky, Olentangy shale seems to be justified, even though the faunal evidence may not be as conclusive as could be desired.