ON THE FAUNA OF THE NIAGARA AND UPPER SILURIAN ROCKS AS EXHIBITED IN MILWAUKEE COUNTY, WISCONSIN, AND IN COUNTIES CONTIGUOUS THERETO.

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It is stated as an axiom by high paleontological authority,—that “Since rocks are identified more by their fossil contents, than by their lithological character, a name descriptive of the latter is of less importance than formerly, when fossils were the subordinate characters of a mass;” and although paleozoic characters have assumed the supremacy over all others in distinguishing sedimentary strata, “still the lithological terms must not be overlooked; for if properly understood, they will be unerring guides in tracing the condition of the surface, for more than hundreds of miles in extent.”

Changes in the lithological features of a rock which may render observations unsatisfactory, are accompanied by greater or less variation in the nature of the fossils. It is therefore of the highest importance in the examination of sedimentary rocks to be governed by three essential facts, which are:

1st. The lithological character.
2d. The order of the superposition.
3d. The contained characteristic fossils.

By an observance of such precepts geologists have been enabled to form a reliable and a systematic geological history, which is arranged into natural distinctions of ages, periods, epochs, and eras, with the capability to trace from one portion of country to another, through all intricate phases, types and characters, the rocks containing remains, images or casts of paleozoic life.

It is thus we determine the first appearance in the world's history of organized beings, as exemplified in the commencement of
the Silurian age—usually termed the Lower Silurian, where by successive layers or strata of calcareous or siliceous sedimentary matter, we trace each order of life through distinctive periods, and epochs, until progressive organization culminated in the era of man.

The nomenclature adopted by tacit consent of paleontologists, to be applied to rocks, is that of the locality where the exposure of a specified rock exists in its best state of preservation and can be carefully examined and studied.

In this manner are the terms derived, Canadian, Trenton, Niagara, Salina, Lower and Upper Helderberg and Hamilton, with the subdivisions of Quebec, Galena, Waukesha, Racine and St. Claire.

But it is the three principal periods: the Trenton, Niagara and Salina which particularly interest a paleontologist when making collections of paleozoic remains from the eastern portions of Wisconsin, and therefore the foregoing explanatory observations seemed to be necessary to elucidate what seemed to befog or deter some of our leading state geologists in arriving at definite satisfactory conclusions.

For if you examine the strata of rocks, with their fossiliferous contents, as exhibited in various exposures by quarrying or from other causes in Milwaukee county within a radius of twenty miles, it is difficult to apply the foregoing mentioned, or geological axioms. In a single quarry containing a coralline limestone near Wauwatosa I have obtained several thousand specimens within the past twenty years, and from among them I can show you representative fossils delineated and described as belonging to the commencement of the primordial time or Lower Silurian age, intermingled with many fossils characteristic of the Upper Silurian, the Guelph and the beginning of the Devonian age. However, “Prof. Dana asserts that there is no evidence that a species existed in the latter half of the Upper Silurian, that was alive in the latter half of the Lower Silurian.” The fossils of the Niagara fauna being mostly casts of the interior, it is more of an exception to find the shell or testaceous covering in a perfect state of preservation thereby making our investigations accompanied with many
difficulties, nevertheless Eastern Wisconsin has a fauna which in variety, beauty, perfection and numbers cannot be excelled by a similar collection, within the same extent of country on either hemisphere.

Could the distinguished Prof. L. Aggasiz have examined our corals, Echinoderms, Brachiopoda, Lamellibranchs, Gasteropoda, Cephalopoda and Trilobita, no doubt he would have exclaimed, "why sir, the sight of this display would make an eastern naturalist crazy."

On one occasion after a recent excavation by blasting at Schoonmacker's quarry, I measured a coral disk about twenty feet in diameter, three feet in height, and more than sixty feet in circumference. The surface was made up of beautiful concentric layers, like the flattened whorls of a gasteropod, and were covered by very pretty Heleolites.

Cruising around such coral eminences, were the "lords of the invertebrates," the Orthoceratites, the straight variety of Cephalopoda, measuring over twelve feet in length and twenty inches in circumference, and having siphuncles so peculiar in shape and expansion, that Prof. H. A. Ward, notwithstanding his large experience and observation, declared these different from any species he had seen in the old or new world; because the pyrimidal-cone-shaped siphuncle of the base, or last chamber, resembled much the contour of a Belemnite.

Here also was the gigantic Phragmoceras having a base twenty one inches in circumference, six inches deep, and a seven inches latitudinal aperture, and extremely macrochelius or long lip, for perfect specimens collected of five species of Phragmoceras make Prof. Hall's description of a single specimen of our species, comparatively a myth, and his Phragmoceras nestor is simply a description of a mutilated specimen of a Phragmoceras macrochelius. Prof. Hall's Gomphoceras septoris has the curvilinear figure of a Phragmoceras, or Cystoceras, and in general aspect much resembles a Phragmoceras callistoma (Barrande), delineated in Woodward's Modern and Fossil Shells. Of the four varieties of Gomphoceras, one may prove to be G. serinum or G. Marciyi of Winchell.

The gasteropoda of the Lower and Upper Silurian and Hamilton
cement are found much larger and in a more perfect condition than those pictured and described in reports of previous geological surveys. A magnificent and perfect Pleurotomaria perliata five inches in diameter, found in the Niagara shale, and also in the Guelph or Gault, a Trochoceras, Gebhardii, six inches in diameter, from the cement rocks, besides many others, claim honorable mention. In no other place are such unique lamellibranchiata to be found, particularly the Moceraunas and Amphicelia, Ambonychia, and Paleocardia. I have quite a number of perfect specimens, retaining the whole or parts of their beautiful striated shells.

It is in Schoonmaker's Quarry that several distinct species of trilobites belong which are not found elsewhere—in any fossiliferous formation.

Prof. J. Hall, in his description of the fauna of Wisconsin, was often obliged to make use of imperfect material, and in resorting to the very unsatisfactory mode of delineating restored parts, or "supposed differences," he would naturally be much disappointed and mortified to find his opinions erroneous upon the subsequent discovery of perfect specimens, which were heretofore entirely new, or but little known. On this account it is questionable whether Hall's synonyms for fossils like the Ichnus, Sphoerexochus, Phragmoceras, et cetera, when perfect specimens prove them to be so radically different from Hall's descriptions, should be "saddled" with the names he intended should be applied to them, especially when his opinions are based upon a single part or fragment of a perfect specimen, and also when the synonym is foreign to the idea suggestive of its character. For example, the pygidium of the Ichnus cuniculus is confounded with the Bridgeport and Waukesha Ichnus armatus, which is probably an adult specimen of Ichnus insignis, or Ichnus Worthmanus of Winchell, or Ichnus Springfieldensis, of Meek. There are other species of the Ichnus, or Asaphus, to which the glabella has a slight resemblance to Hall's description, but otherwise are totally different.

The pygidium of Hall's Sphoerexochus Romingeri is simply a mutilated specimen of a pygidium of S. mirus of Beyrich. I am induced to make these assertions after a careful comparison with perfect specimens in my cabinet. Allow me, also, to state
that I have never seen a single specimen of *Illoenus ioxus*, found in Schoonmaker’s Quarry, notwithstanding Prof. Hall’s mention that it is of frequent occurrence, and Prof. T. C. Chamberlain identifies it as belonging to this quarry.

A nearly perfect head and pygidium of an *Acidaspis Danae* make the specimen quite different from Winchell’s *Acidaspis Ida*.

Extraordinary sized *Ceraurus insignis* are occasionally found and well marked parts of *Bronteus Acmas, Harpes, Lichas, Dalmania*, new species of *Illoenus, Asaphus*, besides quite a number of as yet undetermined varieties of trilobites, which are “new or but little known.”

Fine specimens of *Illoenus ioxus* are found in Waukesha and and Greenfield, but it is in the Racine quarries that the grand patriarchial *ioxus* assumed his supremacy. Specimens of heads over five inches wide and three inches deep, and joined to thoracic segments, and pygidium will make full-sized specimens, more than one foot in length. The *Acidaspis* and several other very remarkable varieties of trilobites are also found, beautiful as well as unique, and unsurpassed. But it is in the the Wauwatosa quarries that the best documents are produced to illustrate the comparative anatomy and physiology of the trilobite. A critical examination of fossil specimens of this invertebrate animal reveals a bundle of contradictions on account of its possessing many attributes belonging to several orders, which cause the trilobite to assume as uncertain a position among the invertebrates as a Cheiroptera does among vertebrates “which can claim a habitation neither with birds or beasts.”

All the parts of the trilobite, as found at Wauwatosa, being “casts of the interior,” reveal an internal mechanism which requires no more stretch of the imagination to localize and impute certain actions to different parts, than for an anatomist to explain definitely and intelligently the properties and powers pertaining to the skeleton of a vertebrate.

Precisely in similar manner do the casts of the trilobite illustrate its organism, habits and locomotion. Like some species of Entomostraceans, it was capable of being dismembered into several parts and had the attributes of Crustaceans, Mollusks and Worms. Its ambulatory movements were performed in a similar
manner to the larvae of insects, but its exterior covering of crustacean segments, united by chitine, enabled it to move rapidly in the water similar to the molluscan *Chiton*. It also possessed the same natatory powers as the Crustacean Macurans, or it could assume a spherical form like an Isopod, or lepidoptera hairy larva. By the action of its extension or flexor muscles, the trilobite was enabled to elongate or contract its size from several inches in length to one-third its longitudinal extension capacity, and did not possess a single attribute of an arachnoid. If a name were required for such an organization, it would be one suggestive of three orders of genera, combined in one, indicative of an annelid, a Mollusk, and a Crustacean. Such a proposition is the result of a careful examination of many thousand specimens of several genera and species of trilobites, and I am induced to believe that this peculiar invertebrate lived, at certain distinct periods of time, so well defined, as to indicate a sufficient reason for making a change in the ages of Geological History. For instead of classifying the Silurian age as one of Mollusks, and the Devonian as one of Fishes, substitute a Trilobite age. For Mollusks existed through all ages, and fishes first appeared in the later part of the Silurian, and assumed a prominence in subsequent ages, like the Devonian, Carboniferous, etcetera, but the Trilobite is identified at the commencement, and became extinct at the close of paleozoic life. In a paper like this, treating of a miscellaneous fauna, I can only thus give a brief synopsis of the component parts of Trilobite, which, like the Crustacea, by aid of muscular action could be "sessile or stalked eyed," and its having a chitine carapace united by sutures, was provided with processes, and sinuses for the attachment and action of muscles, and it could be readily dismembered at its dissolution into cheeks, glabellae, hypostoma, thoracic segments and pygidium, that were held in proper position by a chitinoid bond of union, which enabled the trilobite to perform its wormlike motions by expansion, adhesion and contractions, or to fold its extremeties together as the caterpillar larva, or wood louse when alarmed, or if attacked as a means of defense, or could move swiftly through the water, like the Molluscous *Chiton* or Crustacean crawfish.

After many years of patient research and with the aid of
largely magnifying optical instruments, I have been unable with the single exception of the seta filaments at the extremities of the thoracic segments of Calymene — to discover any appearance having the slightest resemblance to the strong jointed legs; characteristic of the limulus group.

Since preparing this society paper, I have received from Mr. C. D. Wolcott, Curator State Museum Natural History, Albany, N. Y., two pamphlets on the organism of the trilobite, entitled “a preliminary notice of the discovery of the natatory and branchial appendages of the trilobite,” also an explanatory letter from the author respecting the uncertainty of his discoveries, but hopeful of a final satisfactory result.

A copy of the twenty-eighth Regents' New York Report by Prof. Hall, with reference to plate 84, fig. 14, illustrating points of attachment for supposed natatory organs, also fig. 13, which might be a sub-section in conjunction with other parts of a folded specimen, could be readily construed into a semblance of strong jointed legs, resembling the limuloid species. Mr. Wolcott's theories are formed from incised specimens of “casts of the exterior,” while my conclusions are the result of examinations made of “casts of the interior.”

In our investigations, Mr. Wolcott and myself may be in a chameleon sense, right or wrong, as to the opinions we may form, being largely influenced by the circumstances which govern our actions in a similar manner — as several years ago — a diversity of opinion existed between Professors Billings, Woodward, Verrill and Dana.

 Permit me to simply state that I think I have conclusive evidence, that “trilobites did not swim on their backs,” they did not have stout jointed legs, they did not rest with their dorsal surface downwards, and they did not belong to the higher order of entomostracans. But more extended and fully explanatory views concerning the trilobite, will appear in a work I am now preparing for the press.

But whatever the result may be of our persevering labors, natural science will no doubt be benefited by our efforts to solve what have been so long problematical statements.
It is said to be a trite saying of the Icelander, that the "sun shines on no country equal to his own." In like manner we may boast or as Virgil, "sing praises," not of "men and arms," but of the richness and variety of the "paleozoic treasures of Milwaukee County, and other counties contiguous thereto," for a naturalist will examine with ecstastic delight, the unexcelled crinoids, as found in the quarries of Racine, Waukesha, Bridgeport and Greenville. Probably in no other fossiliferous localities are there to be found such rich collections of Silurian echinodermata. Quite a number of them are delineated and described in part 3 of Hall's Paleontology of Wisconsin, 1871.

But since the publication of that work, more perfect specimens and new genera and species have been added to private collections, like that of our worthy president, Dr. P. R. Hoy.

If I claim to have unravelled some of the many perplexing and doubtful theories concerning the organism of the trilobite, President Hoy can claim equal success as regards the habits and internal structures of Wisconsin Niagara Echinoderms.

Although a large proportion of the crinoidea may be found at Racine, a majority of the Cystidea are found in Waukesha and Milwaukee counties.

For Racine, besides her unsurpassed Echinoderms, has a wonderful genera, and species of other paleozoic fossils, trilobite heads and pygidia, equal to the largest size yet published or described. Specimens are found of the very peculiar Acidaspis, Dalmanites, Bronteus, Lichas, Sphaerocochus, Illenus, Calymene and Asaphus Harpes.

Exquisitely beautiful is the internal structure of several varieties of Cephalopods, that of the Orthoceras abnorme, with a siphuncle, having a central siphuncle, composed of minute cylindrical ramifications which reach to the outer walls of the siphon. Also several varieties of the Orthocera, like the O. angulatum, O. columnare, O. crebescens, O. Laphani, on account of their peculiarly constructed chambers, bases or siphuncles, have some resemblance to Endoceras.

Quite a number of the Gasteropods claim our attention, as the Pleurotomaria occidens, Trochoceras costatum, Tremannotus, Tremannotus alphenus, Pleurotomarial Hoyi and P. Halli.
Principal among the Brachiopods are the *Oostus conrudi*, *Spirifer nobilis*, *Spirifer plicatella*, *Strophodonta profunda*, *Pentamarella ventricosus*, *Pentamarius oblongus*. In an inspection of the fossils of Eastern Wisconsin, it is naturally expected by every votary of natural science, that an identity of fossiliferous bearing rocks should be established with some age or period.

But it appears from the published expressed opinions of those appointed to execute the geological state surveys, that there are many complications and difficulties intervening, in localizing, in accordance with established rules and methods, definite ages and periods, for the strata of rocks as exhibited in Eastern Wisconsin.

In 1862, the first plausible or rational theories were published by Wisconsin legislative enactments concerning the parallelism of New York paleontology, with the same fossiliferous bearing rocks of the northwestern states,—more particularly the eastern portions of Wisconsin,—especially Milwaukee, Racine and Waukesha counties.

Notwithstanding the conclusions reached were far from satisfactory, still some system was established, which enabled the student of Paleontology to profit by his investigations, and may have been the means of stimulating such inquiries and experiments, as resulted in establishing a great commercial and profitable branch of industry, which may give to Milwaukee a reputation for hydraulic cement products, second to none in the Union, and eventually first in the world.

No doubt this most gratifying success was accomplished through the suggestions and persevering investigations of the late Dr. L. A. Lapham, one of the chief pioneers of natural history.

**SCIENCE IN WISCONSIN.**

Yet, a certain amount of credit is due to the Superintendent of the Geological Survey of Wisconsin (Prof. James Hall) of 1862, for the opinions he expressed in that work, and also for the theories similarly advanced in Vol. III, Paleontology of New York, and part 3d, Paleontology of Wisconsin, 171, in the introductory chapters, having reference to the hydraulic cement character, of
the calciferous formations of the Upper Silurian age of rocks, as exhibited in the vicinity of Milwaukee.

Prof. Hall, also in his statements in Vol. I, Geology of Wisconsin, represents the strata of rocks lying above the Niagara, as the equivalent of the Salina or Onondaga Salt group of New York, or the Guelph, or Gault, of Canada, and the Le Claire, of Iowa. Notwithstanding, he was unable to trace the characteristic fossil, Eurypterus remipes of the Water-Lime Group. Similar views are expressed by him in his prefatory remarks in his paleontology of Wisconsin, also see Paleontology of New York, Vol. III. Likewise what are called, on page 72, Vol. I, Geology of Wisconsin, the upper Helderberg and Hamilton groups, have proved to be what is Geology of the Hamilton cement, of Devonian age, in Vol. II. of now termed Wisconsin.

An analytical examination of the expressed sentiments of the authors in Volumes first and second of Geology of Wisconsin, concerning the lithological character of the rocks containing the fauna of Wisconsin, especially its eastern portion, shows no very marked distinction or discrepancy, for their final summation respecting the area, the age, and periods, embracing the characteristic epochs, as generally admitted in American Geology.

To the general student of Natural History, the previous classification established by Hall, on 447 page, of Vol. I, of Geology of Wisconsin, comprehensively covers the synonymous terms of Mayville and Byron beds, and upper and lower coral beds, lying below the Waukesha limestone. For the Hamilton cement, the Le Claire, the Racine and Waukesha limestones, embrace all the fauna belonging to that portion of the Upper Silurian, equivalent to the Salina, Lower Helderberg and Hamilton.

Such an increase of synonyms has a tendency to embarrass the student in his study of pæleozoic life, notwithstanding. Prof. Chamberlin, while reiterating the ideas advanced by Prof. Hall, has invested them, in a fuller and more interesting phraseology. But some facts concerning the quarries in Milwaukee county do not substantiate the correctness of Prof. Chamberlin's views, that the three classes of limestone, Mayville, Waukesha and Racine, lying above the Trenton period of rocks, were formed simultaneously.
If we examine the lowest depths of the sole of Schoonmaker's quarry, we find the same characteristic rock, containing the *Terebratulous fossil, Gypidean occidentalis*, belonging to the Byron division of the Mayville bed. This formation was quarried to some extent, and formed dressed stones, for bases to grave-stones, and window caps and sills.

This stratum terminated abruptly in an ancient river bed, the bottom of which is smooth and polished, grooved and scratched by the drift of the glacial action or era, for huge granite boulders were excavated during the process of quarrying.

Above this stratum, are regular even layers of a glazed, compact, metallic ringed, cherty limestone, of several inches in thickness, which is quarried in regular rectangular forms, and is utilized as a durable pavement on the side walks, or macadamized streets of Milwaukee and Waukesha. This formation was covered with animal life, similar to that, so extensively intermixed in the strata or groups overlying it, and is well exhibited at every exposure of this rock, in all the quarries in Milwaukee, Racine and Waukesha counties. But the fauna which covered the surface of the Waukesha limestone, at Cook's, Hadfield's and Pelton's, in Waukesha county, or Trimbome's, Swan's, Busack's, Schwackhart's and Story's in Milwaukee county; or Ives', Horlick's and others, in Racine county; or Cook and McHenry counties in Illinois, are in an exceedingly compressed stratum, and in many instances the fossils are in such a state as to be but little better defined, than well marked outlines of the original plant or invertebrate animal. In several of the quarries, as Story’s, Schewickhart’s, Busack’s and Cook’s, the Bryozoa, Cephalopoda, Gasteropoda, Brachiopoda and Crustacea, are so intensely compressed and distorted and glazed, as often to give the appearance of different genera or species.

In seeking an elucidation of the age and character of the dolomite formations in eastern Wisconsin, and in taking into consideration the totality of their surroundings, a plausible, perhaps a correct theory is established from these facts. Adopting the axioms, that the predominating fossil contents of rocks determine their age and character, we find lying above the regular stratified rocks of the Niagara period, and termed the Waukesha lime-
stone, soft, porous, and in places, easily disintegrated coral formations, termed by Prof. Hall and Chamberlin, coral reefs, which were formed on the top of sedimentary rocks, less than one hundred feet deep, in an ancient sea.

That these coral reefs extended from the south of Kewaunee, Wisconsin, in a southerly direction, below Bridgport, Illinois; a distance of more than two hundred miles, and westerly, to Le Claire, Iowa.

That at certain points in Milwaukee, Waukesha, and Racine, these coral reefs became more prominent and formed, as termed by Prof. J. Dana, atolls, bordering on lagoons, which upon the receding of the ancient sea, formed the fiords vallies, now occupied by the numerous rivers of Wisconsin.

Subsequently in the vicinity or same direction of these fiord vallies, glacial vallies were formed at frequent intervals for long lines of granitic boulders, of the Archean age are found, some measuring many tons, in size and weight; they no doubt had an agency in producing the grooves, scratches and polished surface, exhibited on the tops and sides of the ledges of the compact and fine grained limestone. The compressed condition of the fossils appears to be due to an upward pressure from an upheaval at the era of Silurian eruption, from which the same cause may have changed portions of the sedimentary dolomitic strata, either by igneous action or by solution into metamorphic beautiful calcite, or strontianite. Such a theory would account for the extraordinary compressed condition of fossil Cephalopoda, and other genera, and calcite crystals in the Waukesha limestone, and at the quarries in Wauwatosa, Racine and elsewhere in the state. An equally plausible theory is, that by a gradual submergence, or subsidence; and also from erosion, by the waves and currents of the ancient sea upon portions of the foundation or base of the coral reefs, certain parts were undermined, causing the superior portion of the rocks to tilt over and slide down in huge blocks, which give the appearance, upon exposure by quarrying, of an upheaval of the strata. Such causes, explain somewhat, the deep vertical fissures and seams, which permeate every portion of the Wauwatosa reefs, and this situation is taken
advantage of by workmen, in the process of quarrying, by blasting and excavating.

In certain parts of the reefs are coves, or pockets, which contain remains of distinct colonies of paleozoic life. For in one cove, you will chiefly find Foraminifera and Zoophyta. In another cove, the Brachiopoda; in another the Crustacea, and so on with each class and species of fossils. A similar state exists in other of the coral reefs; for the trilobites of Wauwatosa are not found at Waukesha. The magnificent and peculiar Echinoderms of Racine, are not found in other reef formations; and the trilobite species, *Illeínum imperator*, *Illeínum armatus*, are found in the southerly reefs of Burlington, Bridgeport and Algonquin.

From the foregoing considerations, aided by geological axioms and other published opinions of accepted paleontological authority, we offer these suggestions, as an effort to supply the “missing links” in our research, as to the age, period and epoch, wherein once lived, moved and had a being, “the fauna of Niagara and Upper Silurian rocks, as exhibited in Milwaukee, county, Wisconsin, and in counties contiguous thereto.”