Compliments of

JOHN M. CLARKE

Director State Museum and State Geologist

STATE HALL, ALBANY, N. Y.

New York State Education Department

Science Division, January 16, 1911

Hon. Andrew S. Draper LL.D.

Commissioner of Education

Sir: I have the honor to transmit herewith for publication as a bulletin of the State Museum, the annual report of the Director of the Science Division for the fiscal year ending September 30, 1910.

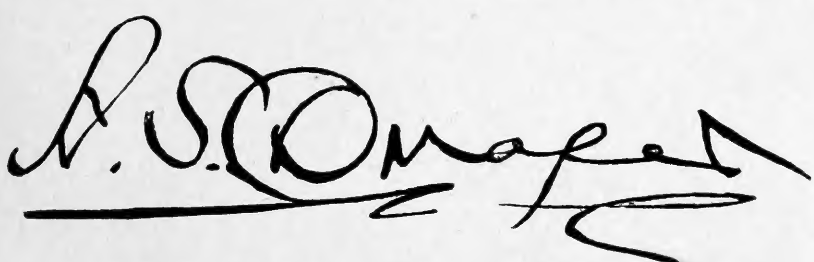
Very respectfully

John M. Clarke

Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 18th day of January 1911



Commissioner of Education

Education Department Bulletin

Published fortnightly by the University of the State of New York

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No. 493 | ALBANY, N. Y. | April 15, 1911

New York State Museum

John M. Clarke, Director

Museum Bulletin 149

SEVENTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

64TH REPORT OF THE STATE MUSEUM, THE 30TH REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1910

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INTRODUCTION

This report covers all divisions of the scientific work under the charge of the Education Department and concerns the progress made therein during the fiscal year 1909–10. It constitutes the 64th annual report of the State Museum and is introductory to all the scientific memoirs, bulletins and other publications issued from this office during the year mentioned.

Under the action of the Regents of the University (April 26, 1904) the work of the Science Division is "under the immediate supervision of the Commissioner of Education," and the advisory committee of the Board of Regents of the University having the affairs of this division in charge are the Honorables: T. Guilford Smith LL.D., Buffalo; Daniel Beach LL.D., Watkins; Lucian L. Shedden LL.D., Plattsburg.

The subjects to be presented in this report are considered under the following chapters:

I Condition of the State Museum
II Report on the Geological Survey
III Report of the State Botanist
IV Report of the State Entomologist

V Report on the Zoology section
VI Report on the Archeology section
VII Publications of the year
VIII Staff of the Science Division and State Museum
IX Accessions to the collections
X The New York State Museum Association
XI Appendixes (to be continued in subsequent volumes). All the scientific publications of the year

I

CONDITION OF THE SCIENTIFIC COLLECTIONS

Since my last report few changes have been necessitated in the location of the museum collections, except for continued progress in the transference of the scientific materials to the storage house and the general preparation of the collections for transfer to and exhibition in new quarters. This work has involved much careful and expert labor in all sections, the selection of choice exhibits, the preparation of groups, models and charts, and in reasonable measure the expenditure of money for expert assistance which the staff can not give. Much of the time which has before been given to the work of scientific research has of necessity been directed into the channels mentioned.

In my report of last year I stated the location of the collections in eight different places in the city of Albany, in addition to some valuable material in storage in the city of Rochester. These locations remain unchanged. Considerable valuable accessions to all departments of the museum have been made during the year. Their character is given under chapter IX of this report.

II

REPORT ON THE GEOLOGICAL SURVEY

AREAL GEOLOGY

In the progress of the survey directed toward the execution of the geological map of the State on the topographic scale of 1 mile to 1 inch, a considerable number of topographic quadrangles have been completed and published, with full explanatory details of geological structure. In addition to the completed quadrangles a variety of special maps have been issued in connection with particular geological problems, some of the older of these maps being on such geographic base of approximate accuracy as was best available, but all special maps of later years, whether they have covered limited areas, completed county areas or a series of counties, have been based on the topographic unit.

A list of all geologic maps of the State, of every description, issued officially or privately, was published in my report for 1908, and the number was there shown to be large, 329 entries being recorded. At least ten items may be added to this number at the present date. I append here a list designed to indicate only the complete quadrangle maps which have been made with special reference to the systematic execution of the State map. In this list the terms starred indicate maps now in press:

Alexandria Bay (Cushing)
Amsterdam (Prosser & Cumings)
Auburn (Luther)
Buffalo (Luther)
Canandaigua (Clarke & Luther)
Cape Vincent (Ruedemann)
Clayton (Cushing & Ruedemann)
Elizabethtown (Kemp)
Elmira (Clarke & Luther)
Genoa (Luther)
Grindstone Island (Cushing & Smyth)
Hammondsport (Luther)
Hempstead (Woodworth)
*Honeoye (Luther)
Little Falls (Cushing)
Long Lake (Cushing)
Mooers (Woodworth)
Naples (Clarke & Luther)
Nunda (Clarke & Luther)
Olean (Glenn)
Ontario Beach (Hartnagel)
Ovid (Luther)
Oyster Bay (Woodworth)
Penn Yan (Luther)
Portage (Clarke & Luther)
Port Henry (Kemp & Ruedemann)
Port Leyden (Miller)
*Poughkeepsie (Gordon)
Remsen (Miller)
Rochester (Hartnagel)
Salamanca (Glenn)
Theresa (Cushing & Ruedemann)
Tully (Luther)
Watkins (Clarke & Luther)
*Wayland (Luther)

In addition to these, reports have been rendered to the Director on the quadrangles listed below, which are awaiting publication chiefly for completion in certain details:

Batavia
Caledonia
Cazenovia
Chittenango
Morrisville
Phelps
Syracuse

On the following quadrangles of the topographic map, areal work is now in progress, as indicated by special reference in subsequent pages.

Albion	Lockport	Saratoga
Attica	Medina	Schuylerville
Broadalbin	Mt Marcy	Stamford
Depew	North Creek	Tarrytown
		Utica

Central and western New York. In western New York Mr Luther has been engaged in the resurvey of the Erie and Chautauqua county quadrangles, viz, Eden, Angola, Cherry Creek, Dunkirk and Westfield, to bring the detailed subdivision of the various formations into correspondence with that of the maps already published. The field work on these areas is regarded as practically complete and the maps are now being prepared for publication. As noted last year, work has also been in progress on the *Batavia, Attica, Depew, Albion* and *Medina* quadrangles.

On the Utica quadrangle the work was a completion of that begun the previous summer; the mapping of those parts of the quadrangle then left uncompleted, elaborating the details of those parts covered during the former season, and in carefully collecting the fauna of the region, especially that of the Lowville, Black River and Trenton limestones along the West Canada creek. Within the quadrangle there outcrop representatives of all formations of the Lower and Upper Siluric systems with the exception of the Chazy. Thus the Little Falls, Lowville, Black River, Trenton, Utica, Lorraine, Oneida-Medina, Clinton, Salina and Manlius are represented. As the dip is southwest the lower formations outcrop only in the northeastern corner of the area, while the uppermost formations are found only in the southwestern portion of the region. In many sections the glacial deposits are heavy and interfere greatly in working out the contacts.

The extreme northeastern section, being all that part on the quadrangle northeast of the West Canada creek, is covered with sand terraces of sufficient thickness to conceal all the bedrock of the region, except for outcrops of the Little Falls dolomite along Cold brook south of the village of the same name, and a few other outcrops on Buck hill, directly north. The upper 300 feet of this hill is Trenton limestone with the Black River and Lowville limestones occurring between it and the Little Falls dolomite. A mile and a half below the village of Poland, the Little Falls dolomite occurs, but a short distance farther south West Canada creek is underlain by the Lowville limestone, which continues nearly to Newport where the Little Falls again appears at the surface, due to the unconformity existing between these two formations. The region south of Cold brook and east of West Canada creek seems distinctly different from the rest of the region, and extends over as far as White creek on the Little Falls quadrangle, where the only outcrop in the whole region is a Lowville limestone quarry. The Trenton and Dolgeville members are not seen and there seems to be little evidence to indicate their presence except for a possible indefinite small thickness of Trenton.

The southwestern bank of the West Canada creek is markedly different from the other bank. It is steep and from a point about a mile and a half below Poland gives a continuous outcrop nearly to Newport. North of this point the steep bank is made up of glacial material until a point about two miles above Poland is reached, where the Trenton outcrops by the bridge.

Below Poland there are about 31 feet of Lowville in the bank and in the hills immediately bordering the creek. Above this occur from 7 to 9 feet of Black River limestone, which in general forms the top of the lowest terrace. Upon this rests the Trenton limestone with a thickness of about 200 feet forming the bordering hills. These are covered with sand, an underlying boulder clay appearing in places and commonly covering contacts. Where the country flattens out on the top of the hills the Utica shale appears and covers all the region to the west and south as far as the Mohawk river and some distance beyond. To the west along Nine Mile creek at a point just west of South Trenton a low fold brings the Trenton up about a foot above the surface of the creek and shows the Trenton-Utica contact. The Trenton also shows at two other points farther downstream, the region between being shales.

Southwest of Newport is a ridge of high hills which continues to the west, becoming lower and broader. This ridge is capped with the sandy Lorraine shales, having a thickness of 340 feet at the eastern end. Since there are but 440 feet of these shales occurring south of the Mohawk between the Utica below and the Oneida conglomerate above, it might seem probable that there existed at one time on the top of these hills an extra hundred feet or more of the Lorraine shales with a cap of the resistant Oneida conglomerate, thereby explaining the presence of this very prominent and dominant ridge, which seems to have been an important factor in determining the preglacial physiography of the region.

The thickness of the Utica shale is about 600 feet. This would seem to indicate that the rock floor of the Mohawk valley in this section might be Trenton limestone.

To the south of the Mohawk a narrow belt of Utica shale occurs up to an elevation of about 550 feet. Above this the black Utica shale changes into the gray Lorraine shale having a thickness of about 440 feet, and forming the northern slope of the southern escarpment. At an elevation of about 1000 feet come the northern outcropping edges of the Oneida conglomerate. This contains also shale and gray sandstone layers, often cross-bedded with intervening layers of fissile gray shales. In all there are about 100 feet of this formation.

Above the Oneida are 110 feet of Clinton shales, limestones, sandstones, and red hematite ore. The shales, limestones, and ore form the lower part and change upward into sandstone.

The Clinton is covered with 200 feet or more of red Salina shales The lower contact was found in the central southern part of the quadrangle and the upper contact in the southwestern portion. These are the only two outcrops, the region between being covered with thick drift. Above the red Salina, in the extreme southwestern portion only, were found 10 feet of green Salina shales and these were overlain in turn by gray, fissile, shaly limestone and greenish shales aggregating over 70 feet in thickness. The upper limit was covered. One of the bottom layers contained abundant crystal cavities in a black shaly limestone or calcareous shale. The middle portion in one place was a mass of sun cracks, indicating the conditions of formation.

The top of the Salina is covered with two different boulder clays and in the ridge beginning south of Norwich Corners is found the Manlius. Just beyond the southern edge of the map are the well-known Litchfield waterlime quarries.

Eastern New York. *Saratoga and Schuylerville quadrangles.* The areal survey of the Saratoga region has been carried well toward completion by Messrs Cushing, Miller and Ruedemann. In my last report, on referring to this subject and this region, I indicated the importance of a survey which, in view of the public interest in acquiring the mineral water rights of Saratoga Springs by the State, would take the form not merely of a surface study of the rock outcrops and dislocations but involve a subterranean exploration directed to ascertain the relations of the rock strata to the origin and accumulations of the saline waters and the relation of both to the stores of carbon dioxid. This subterranean investigation would involve an expenditure greater than our appropriations for areal geology will allow. The proposed plan has therefore been submitted to the Commissioners of the State Reservation at Saratoga, has met their approbation and, if the means are provided, it may be hoped that the project will be carried into execution.

The Precambric rocks of the Saratoga and Schuylerville region have received special attention. These consist chiefly of two types, syenites and rather uniform Grenville gneisses. There is but little Grenville limestone. A comparatively thin band of quartzite which locally is strongly graphitic, is worked for graphite at two localities; but the Grenville is mainly a white, or whitish, quartz-feldspar gneiss, with pinkish garnets quite like the rock at Sprakers and on the Little Falls quadrangle, and a very common rock in the Grenville of the southern Adirondack border. The syenite cuts through it in a series of comparatively small intrusions. In character and in variations much of the syenite is very like the rock at Little Falls. It becomes a coarse augen gneiss at its margins.

There are a few diabase dikes which make up in size what they lack in number. The great dike quarried just north of Saratoga for road metal was followed northward for 12 miles to the edge of the quadrangle, and is capable of furnishing an enormous amount of road material.

The Northumberland volcanic plug on the Schuylerville sheet was visited and carefully studied. Quarrying has rendered it much easier of study than was the case ten years ago when Doctor Woodworth first described it. It has been faulted and a tremendous shear zone cleaves it diagonally from base to summit. The nature of this shear zone leads to the belief that the rock must have been under considerable load when the shearing took place, and that the load has since been worn away. Hence a considerable antiquity for the plug is suggested.

It was found necessary for the correlation of the "Hudson River" shales of the Saratoga sheet to investigate first the Frankfort and Utica beds of the Mohawk valley. This work indicates that both the Utica and Frankfort stages consist of two different divisions. The lower one of the Utica shale agrees in its fauna with the lower third of the Martinsburg shale of the Appalachian basin and is undoubtedly of upper Trenton age. It is therefore separated from the typical Utica stage as *Canajoharie shale*. This formation, to which much of the shale along the Hudson and in Albany and Saratoga counties belongs, rapidly thins out westward and does not reach the meridian of Utica. In the lower Mohawk valley the remaining upper division of the Utica shale also differs somewhat in its faunal aspect from the beds in the neighborhood of Utica, but retains about the same thickness and lithological character.

The Frankfort shale which, from 300 feet at Frankfort swells to 1500 or 1800 feet in the lower Mohawk valley, has very unexpectedly furnished faunules at many horizons, although it had hitherto been considered as practically barren. Altogether about seventy species have been obtained, among them an entirely new eurypterid faunule, the first Lower Siluric eurypterid fauna known, except for the two fragments each of Echinognathus and Megalograptus. This eurypterid fauna was found to range through the entire thickness of the Frankfort shale with the exception of several hundred feet at the top exposed at the foot of the Indian Ladder in the Helderbergs, which carry a different fauna. The latter, which will be distinguished as *Indian Ladder beds,* are also characterized by the rapid alternation of shales and thin sandstone with argillaceous limestone beds.

The distribution of the eurypterid fauna in the Frankfort shale is peculiar in that this fauna rapidly disappears westward while the greater proportion of the other fossils continues, but the eurypterids continue westward into the Schoharie reentrant of the Helderberg escarpment. Since the eurypterids are associated with immense masses of seaweeds (Sphenothallus latifolium Hall, et al., which have been obtained in very complete specimens, and lend themselves to close study) which also fail in the finer shales to the west, it is inferred that the Eurypterid-Sphenothallus association was restricted to a sinking and rapidly filling "vorland" of the rising Appalachian land to the east, or to the littoral region, while the other Frankfort fauna was spreading farther offshore. The graptolite, brachiopod, trilobite and mollusk elements of the Frankfort fauna prove that the latter is to be regarded as a direct continuation of the Utica beds as has been generally done. The Lorraine beds have not been found in the Mohawk valley.

During the investigation of the Frankfort shale in the Cobleskill region, evidence was also obtained showing that the Brayman shale, which formerly was referred to the Clinton and later correlated with the Salina, is most probably of Lower Siluric age.

Adirondacks. Field work has been carried on by Professor Miller in the *North Creek* quadrangle where the territory, though fairly rugged, is well supplied with roads and outcrops are generally numerous so that very detailed observation has been possible.

About three-fourths of the quadrangle has been covered and, thus far, the rocks are all of Precambric age. A well-defined and heretofore unnoted outlier of Paleozoic rock (Potsdam sandstone and Little Falls dolomite) has been found just south of the sheet and one mile west of High Street village.

The Grenville formation is present to an unusual extent, making up nearly 50 per cent of the area so far studied. Limestone occurs in abundance and with it is associated an extensive mass of hornblende gneiss. Other common Grenville rocks are: quartzites, gray garnet gneisses, white feldspar gneisses, and graphitic schists. Almost without exception the Grenville occupies the valleys.

No less than four ages of igneous rocks — all younger than the Grenville — have been observed. Of these the syenites and associated rocks are by far most prominent. The greenish gray rather quartzose syenite often grades into a pink medium-grained biotite granite on one hand and into a gray coarse-grained, very porphyritic granite on the other. These syenites and granites have broken through the Grenville in a very irregular manner so that the geologic map will present a decided "patchwork" effect.

Large dikes or small bosses of gabbro cut both the Grenville and the syenite-granite series. No less than forty of these dikes have already been mapped and the rocks show but little sign of metamorphism. Pegmatite dikes are common and they have been found cutting the gabbros in many places.

The youngest rocks of the district are in the form of diabase dikes which are known to cut all the other formations, even the pegmatites. The rocks are generally much finer grained and the dikes are fewer in number and usually smaller than the gabbro.

The region has been subjected to rather extensive normal faulting and a number of these faults have been mapped. The strike of the faults varies from northeast-southwest to northwest-southeast.

The topography is almost wholly dependent upon rock character and structure. Because of several favoring conditions, exfoliation domes (syenite or granite) form a striking feature of the landscape.

The glacial phenomena are also of interest. Many glacial striae have been observed and in no case do they vary more than twenty degrees from due north and south. A fine example of a glacial lake (Lake Warrensburg) formerly covered all the lowland area around Warrensburg and had arms which extended for several miles up both the Hudson and the Schroon rivers. Another considerable lake existed in the vicinity of Johnsburg. It has also been quite definitely proved that, before the glacial epoch, the Hudson river did not flow southward across the Luzerne region, but that its course was past Warrensburg and the south end of Lake George and thence toward Glens Falls.

Work on the *Mt Marcy* quadrangle has been inaugurated by Professor Kemp who with Doctor Ruedemann recently issued a report on the Elizabethtown sheet. Mt Marcy lies next west and is a region of complicated and rough topography. So far as this field has been investigated there appears to be at the north a complicated mixture of the anorthosites and Grenville strata, especially the limestones of the latter. The region has afforded interesting contact zones with the characteristic lime silicates, wollastonite, garnet, pyroxene and the like.

Professor Hudson, who has been working as opportunity afforded on the special survey of *Valcour island,* reports progress in the execution of a topographic map with 1 meter contours and in the solution of many problems which have arisen most unexpectedly from the study of the latter unit — problems bearing on the greater history of Lake Champlain and its origin, on the special effectiveness of minor physical forces and on the life history of the fossil-bearing formations of which the island is constituted.

Southeastern New York. The survey of the *Poughkeepsie* quadrangle has been carried to completion by Professor Gordon and his report and map are now on the press.

In the *Highlands* district Doctor Berkey has studied three typical areas with special care and with laboratory aids in an effort to establish satisfactory subdivisions of the older crystalline series. It has been found possible to determine the sedimentary origin of an occasional rock and the igneous origin of certain others beyond reasonable doubt. Many of the strongly foliated gneisses are, however, practically indeterminable. It seems desirable to make these distinctions in the areal work of the Highlands wherever the types are developed on large enough scale. Chemical and microscopic studies have been made in connection with this work, and a special study is being made of the Cortlandt series in still greater detail.

Portions of the *Tarrytown* quadrangle and its geology have been reviewed with the intention of securing conformity with the later interpretations of formational relationships. The original field work on that quadrangle was done before some of these relations had been worked out. The matter referring to the Tarrytown district is being put into form for publication.

In previous reports reference has been made to a cooperative undertaking with the New York City Board of Water Supply in the elucidation of geological problems encountered in explorations along the line of the Catskill Aqueduct. Our representative in this work has been Doctor Berkey, whose report on studies from the earlier exploratory work *On the Geology of the New York City (Catskill) Aqueduct* is now printing. During the past year great progress has been made in actual construction in this important engineering work. Many shafts and tunnels penetrate portions of formations that have never before been exposed to observation. The opportunities for collecting data of much value in a study of this region have been exceptional, but immediate advantage must be taken of them.

A four-mile tunnel is almost completed beneath the Rondout valley, and similar ones, penetrating the Shawangunk mountains and beneath the Wallkill valley, have reached about the same stage. Smaller parts are finished at several other points farther south. Interpretations that had been made from the evidence of surface outcrops and drill borings are now being exposed to direct comparison with the facts revealed in the underground workings. These later and final results will be made available in some suitable form upon the completion of the work.

Exploration is still in progress on the Hudson river between Storm King and Breakneck mountains. The deepest boring in the middle of the river has penetrated river silts and drift filling to a depth of 751 feet below the river level without reaching bedrock. Inclined borings have been made from shafts at either side of the river and have advanced far enough to cross beneath the center of the channel. Each boring is about 1500 feet long and a survey of the holes indicates that they cross at a depth of approximately 950 feet below river level. It is certain therefore that the preglacial or glacial channel bottom lies somewhere between –751 and –950 feet. The drill cores indicate sound rock throughout.

The depths to which water circulation has accomplished extensive solution or decay is a related matter of special interest at several other points. In the Rondout valley the pressure tunnel has encountered several large clay seams, several feet wide, at a depth of 150 feet below present sea level. These seams are clearly fillings of former solution channels in the Helderberg limestones. They indicate ready circulation with tendency to cave development at a depth much below present action of this kind, and appear to give additional support to the belief in former continental elevation of considerable amount. In New York city exploratory borings have shown that decayed rock occurs in zones or streaks to depths reaching in rare instances to more than 500 feet. In the immediate vicinity fairly sound rock may be found. A study of the distribution of these decayed portions leads to the conclusion that they always follow structural weaknesses of the rock, either a contact, or a fault, or a crust zone, and that the decay to such extreme depth has been caused by a ready circulation of surface waters along those lines at a time when the continent stood at an elevation more favorable for such movements than the present. Incidentally their frequent occurrence throws some light on the question of prevalence of faulting within the New York city area.

A fundamental problem of the geology of southeastern New York has to do with the character and history of the basal gneiss, or the Fordham gneiss series, and the relation of overlying beds to it. The tunnels now in process of construction will penetrate some of those portions seldom reached and will add materially to the data bearing upon this question. Exploratory borings have already given indisputable proof of the existence of many thin interbedded limestone layers within the banded Fordham gneiss series proper. Nearly all of those discovered in this way lie beneath a heavy cover of drift and could not have been found except by drilling. This relation of certain limestone beds has been pointed out in former reports, but until recently the abundance of these interbeds has not been appreciated. Surface weathering tends to obscure them on the outcrops and this accounts in part for the difficulty of finding many satisfactory cases in field work.

Further study of the rock floor of Manhattan and Brooklyn indicates that the heavy drift cover has materially altered the outlines of Manhattan island and has displaced some of its streams and connecting channels. The East river, shifted out of its former course by the drift, is one of these. A drift-filled valley through the lower east side in southern Manhattan is more than 100 feet deeper than the present East river channel.

Doctor Berkey's investigations of the problems which have been brought into the foreground by these various engineering operations have been supplemented by the work of other geologists in the city of New York upon problems of immediate local concern. To

Professor Kemp, Doctor Berkey and Doctor Hollick has been assigned the acquisition of such data as will make a satisfactory report on the geology of Greater New York — a work which ought to be of large practical usefulness to architects, engineers and municipal betterments generally in the city of New York.

During the season Doctor Hollick has given his attention especially to the geological structure of *Staten island* both from surface exposures and from the records of underground structure.

Classification of the New York formations. The growth of our knowledge and the refinement of our work has made desirable a published restatement of the classification of the geological formations of the State. It is seven years since the last summary statement of this kind was issued. There are now about 125 names which have been applied to these formations — a bewildering number, but each has a value which requires exact definition for the intelligent appreciation of our geology.

SURFICIAL GEOLOGY

In the northern part of the State, Professors Fairchild and Chadwick have studied the special features of Lake Iroquois and Gilbert gulf.

The Lake Iroquois altitudes and limits in the region are now approximately determined. In the valleys of the large rivers, as the Grass, Raquette, St Regis and Chateaugay, the Lake Iroquois level is indicated by delta sand plains of vast extent which agree in their summit altitudes. The actual head of the easternmost of these deltas, that on the Chateaugay, was examined. Here the boulder and cobble deposits cover considerable area, and with the correlating lake features show a fairly definite altitude for the Iroquois water at 980 feet, taking the railroad tracks at Chateaugay station as 945.

About 3 miles southeast of Russell, on the meridian of Canton, is a series of heavy cobble and gravel bars which have a summit altitude of about 835 feet. The Iroquois plane between Watertown and Chateaugay has a rise of about 2.27 feet per mile, in direction northeast, and reaches Covey gulf, the point of escape, with an altitude of about 1016 feet, or about 36 feet over the head of the present channel. The fall of the lake level from the full-height or Rome level to the Covey gulf level was probably not over 15 or 20 feet. This fall might have been by removal of drift or rock, or down-cutting of the channel.

A recent Canadian survey has marked altitudes about the region of Covey hill and westward beyond Franklin, which helps to give precise figures for the height of the marine waters. The highest well-developed bar about Covey hill is 523 feet, which is 65 feet over the former aneroid figures.

The physical character of shoreline phenomena is alone conclusive argument for the marine origin. Going east from Covey Hill post office, eighteen good bars are noted in the descent of 130 feet, the widest interval being 12 feet. Such uniformity in strength and spacing could not be produced in the fall of glacial lake waters, but it is to be expected in the lifting of the land out of sea-level waters.

The remarkable series of close-set bars were followed westward about Covey hill promontory into New York, having a slow fall in summit altitude. This altitude of the unquestioned marine shore lines along the international boundary brings them into the same plane as the Gilbert gulf beaches in Jefferson and St Lawrence counties and removes any doubt as to the sea-level origin of the latter. The rise of the marine plane from Lafargeville to Franklin, Ont., is a little under 1 foot to the mile.

Professor Chadwick has directed attention to the several heavy delta sand plains lying in height between the Iroquois and the marine levels. These seem to indicate a stand of water too long to represent merely a pause in the rapid down-draining of Iroquois water across the steep face of Covey hill. They suggest some undiscovered complexity in the glacial lake history which requires further study.

In the Mohawk-Hudson region Professor Brigham has directed his observations to the southern limit of the Mohawk glacial lobe and to its relation to the Hudson valley lobe. The designation, Mohawk lobe, is of somewhat indefinite application, because the lobe was a part of the waning ice sheet and there is no boundary so marked by topographic features, glacial or otherwise, as to create a sharply definable stage deserving this name. Certain features, nevertheless, point to a reasonable differentiation of a glacier within the Mohawk valley and overlapping to some distance upon the headwaters region of the Susquehanna.

On the south the place of bifurcation between the Hudson and Mohawk lobes may be confidently placed at the northern end of the bolder development of the Helderberg escarpment, in the Berne quadrangle west and southwest of Altamont. This was inferred from an inspection of the contours of the map and is abundantly borne out in the field. In the southeastern parts of the quadrangle the movement was south. In the northwestern section the direction was nearly west, and in the central and southeastern parts around the village of Berne and toward the hamlet of Connersville, the direction of striae is intermediate. There is a sharp alignment of drumloidal forms in the east and north which does not prevail in the intermediate or southwest direction, pointing to the more prolonged and heavy scorings of the Mohawk and Hudson lobes.

About one and one-half miles west of Altamont the exposed slopes which were subject either to Hudson or Mohawk movements, show interesting striae ranging from s. 10° e. to west. On one surface are striae s. 5° e. crossed by another set having directions s. 30° to 35° w. Another surface has two sets, one s. 5° to 10° w. the other west. These records point to an alternating or conflicting control by the two movements at the very point of differentiation, as determined by the strong northward end of the Helderberg front.

To the westward detailed study is needed. There is, however, a significant development of moraines which may in a general way mark the southwest border of the lobe, and may probably be contemporaneous with the Gloversville moraine. These moraines occur near the headwaters of Cobleskill creek near West Richmondville; along Schenevus creek from its head to its junction with the Susquehanna; along the lower sections of Elk creek valley and Cherry Valley, and along the Susquehanna from Cooperstown to Portlandville. It is significant that a day's drive among the strong hills between Cooperstown and Westford led to the finding of but one locality of striae, showing a remarkably continuous sheeting of thick ground moraine for such topography. As noted by Chamberlain in his early work in central New York, the westward limit of Mohawk movements seems to have been in southern Herkimer county not far from West Winfield and Cedarville. The drumlins and drumlinoids with east by west axes are conspicuous between Richfield Springs and Herkimer.

INDUSTRIAL GEOLOGY

Report on gypsum. As mentioned in my last report, an investigation of the gypsum deposits of the State was undertaken in 1909 with the view of a comprehensive description of these resources which are widely distributed and of growing economic importance.

The investigation has now been brought to completion and its results made available in a bulletin recently issued.

The commercial utilization of the local deposits began about a century ago, but the present mining and manufacturing enterprises which they support may be said to be a development of the last decade. In this brief period the annual outturn of crude gypsum has grown from 50,000 tons to nearly 400,000 tons and, whereas the product was formerly marketed in unmanufactured condition, or at most simply reduced to powder at the mines, it is now mainly converted into calcined plasters that require refined mechanical treatment and correspondingly extensive plants. With the expansion of the trade many changes have taken place in the mining field, particularly the opening of very productive territory in the western part of the State where the gypsum is better adapted for calcination and the adoption of improved methods of extraction. The whole industry, thus, has taken on a new phase which has not heretofore received adequate attention.

Review of mines and quarries. The statistical canvass of the mines and quarries of the State conducted by this office, showed that a general improvement in the industries was manifest during the past year. The aggregate output of the mineral materials reached a value of $34,914,034, a gain of more than $5,000,000 over the total value reported for 1908. Though it fell somewhat short of the record for the industries, it evidenced their strong position after a period of very great depression, and their capacity for further growth. About thirty-five different products were represented in the total. The largest items, naturally, were clay and stone materials, though iron ores, cement, salt, natural gas, petroleum, gypsum and talc were produced in important quantities. It may be noted that the products are valued for the purposes of the statistical report in their crude form, so that the totals are not to be regarded as a full measure of the contributions made by the mineral industries as a whole.

Field work. Though no extended field work has been in progress within the past year, occasional trips were made, as opportunity offered, to observe new developments or discoveries in certain districts, of which there was need for definite information.

In southeastern New York some of the old iron mines of Columbia and Dutchess counties were visited and it is hoped in the near future to give the deposits of this section further study. The district is of great historical interest, having supplied the first ores used for iron manufacture in the State and long holding a prominent place among the mining regions of the country. There has been practically no production for the last twenty years; but with the recent improvements in the conditions surrounding the iron industry of the East, a revival of mining in this section seems not unlikely. No detailed study of the geology and ore occurrences is available at present; the literature is limited to the brief reports by Putnam and Smock which are mainly descriptive of the individual mining operations as conducted at the time of their visits (more than twenty years ago) and to one or two brief articles since contributed to the scientific press.

Recent exploratory work in the Adirondacks has added to our knowledge of the magnetic ores of that region, in particular those of Mineville and the vicinity of Arnold Hill. In the latter district some apparently extensive bodies of magnetite that had escaped the attention of mining companies formerly active there, have been uncovered. The explorations are to be continued until the importance of the deposits may be accurately measured.

SEISMOLOGICAL STATION

The Bosch-Omori pendulums which are installed in the basement of the State Museum have been maintained in good working order throughout the year. Such interruptions as occurred were necessary to the proper care of the instruments. In their present surroundings where the air becomes very moist during the summer months they are very liable to injury from rust and consequently require frequent attention.

The equipment has been improved by the addition of a large clock which is regulated every hour by standard time received over the Western Union wire. Hitherto the connection of the instrumental time clock could be made only by indirect comparison with the local service so that there was always an element of error in the records, amounting perhaps to as much as a minute. With the present arrangement the error can not exceed a few seconds at most, which is well within the limits of accuracy for registration in machines of this design.

The number of earthquakes recorded at Albany for the year ending September 30, 1910, was 23, as compared with 19 in the preceding year. A total of 77 disturbances has been observed since the instruments were installed in March 1906. Despite the fact that the records indicated a relatively high frequency for the year, in excess of that hitherto noted at this station, there were very few macroseisms and only a small number which afforded well-defined records with the phases so differentiated as to be of service for purposes of calculation. For the most part the shocks showed weak movements and were of uncertain origin. In agreement with these observations attention may be called to the comparatively few destructive earthquakes that have been reported by the press, whereas the few preceding years were memorable for the number and violence of such disturbances in various parts of the world.

An exchange of records has been maintained with other stations which are so situated as to make a comparison of the data mutually desirable. Brief notes on the observations have also been communicated to the press from time to time.

Particulars of the year's records are here given. For their interpretation it may be said that the Albany station is equipped with two Bosch-Omori horizontal pendulums, one set along the meridian and the other east-west. The weight of each pendulum, including arm, is 11.283 kilograms and the distance of center of gravity from rotating axis is 84.6 centimeters. Their period is maintained between the limits of 25 and 30 seconds. A multiplying ratio of 10 is used. There is no artificial damping. Albany is situated in latitude n. 42° 39′ 6″, longitude w. 73° 45′ 18″. The base of the instruments lies 21 meters above sea level.

RECORD OF EARTHQUAKES AT ALBANY STATION, OCTOBER 1, 1909 TO SEPTEMBER 30, 1910

Standard time

DATE	Beginning preliminaries	Beginning principal part	Maximum	End	Maximum amplitude
1909	h. m.	h. m.	h. m.	h. m.	mm.
October 20........	7 06 P. M.	7 32 P. M.	7 41 P. M.	8 30 P. M.	2
October 31........	5 30 A. M.	5 45 A. M.	5 45 A. M.	6 55 A. M.	3
November 10......	1 38 A. M.	....	1 48 A. M.	2 40 A. M.	2
December 9......	....	11 46 A. M.	....	1 + A. M.	1
1910					
January 1.........	6 08 A. M.	6 16 A. M.	6 17 A. M.	8 00 A. M.	20
January 22........	3 57⅓ A. M.	4 08 A. M.	4 10 A. M.	5 + A. M.	30
January 23........	2 02 P. M.	....	....	3 + P. M.	2
February 28.......	4 16½ P. M.	4 29 P. M.	4 31 P. M.	5 30 P. M.	1½
March 30.........	12 39 P. M.	1 01½ P. M.	1 04 P. M.	1 45 P. M.	1
March 31.........	2 07 P. M.	2 18 P. M.	2 20 P. M.	......	½
May 4............	7 40 P. M.	7 48⅓ P. M.	7 53 P. M.	8 + P. M.	1
May 13...........	3 15½ A. M.	3 34¾ A. M.	3 35 A. M.	5 00 A. M.	3
May 20...........	7 16¾ A. M.	7 24 A. M.	....	8 + A. M.	1½
May 31...........	12 02 A. M.	12 16½ A. M.	12 18 A. M.	12 50 A. M.	1½
June 16...........	1 50 A. M.	....	2 09 A. M.	4 + A. M.	6
June 17...........	12 14 P. M.	....	12 29 P. M.	1 20 P. M.	½
June 29...........	3 49 A. M.	....	3 55 A. M.	4 25 A. M.	¼
June 29...........	6 38½ A. M.	6 46 A. M.	6 49 A. M.	7 30 A. M	1
July 3............	4 28 A. M.	....	....	4 40 A. M	¼
July 6............	11 52½ P. M.	11 59½ P. M.	12 00½ P. M.	12 45 P. M.	3
August 4..........	8 39 P. M.	8 51¼ P. M.	8 52½ P. M.	9 40 P. M.	20
August 11.........	11 36½ A. M.	11 45 A. M.	11 46 A. M.	12 27 P. M.	2
September 23......	10 38½ P. M.	10 53 P. M.	10 54 P. M.	11 30 P. M.	1

October 20. The record of a distant earthquake, probably originating 5000 miles or more away, but not identified with any known disturbance on land.

October 31. Tremors showing fairly defined phases, with an indicated source 3000 miles distant. North-south component slightly larger than the other. Possibly a Mexican disturbance.

November 10. The time of beginning uncertain and perhaps earlier than indicated, as the first motion develops insensibly from the unbroken line. No tracing on the north-south instrument. Epicenter not known.

December 9. Phases of record undecipherable. The wave motion is preceded by tremulous lines which continue for a long time.

January 1. A fairly strong earthquake, apparently originating about 2000 miles from Albany, perhaps in the Caribbean region. Press dispatches later reported a disturbance in Yucatan on the same day but without information as to the exact time.

January 22. The heaviest quake of the year indicated on the machines, with a maximum amplitude of 30 mm and continuing for more than an hour. It originated in or near Iceland where severe shakings were reported at 7.45 a. m. local time, which is close agreement with the Albany record after allowance for longitude and period of transmission.

January 23. A wavy line, giving doubtful readings.

February 28. Very faint at first, with no decided wave motion for a considerable interval.

March 30. Tracing of a very distant quake.

May 4. The beginning was probably earlier than indicated. This appears to have been the shock which destroyed Cartago, Costa Rica, the only notable earthquake disaster of the year. The record does not give a true measure of the disturbance, which was extremely damaging and violent.

May 13. A characteristic tracing with moderate wave motion. Origin from 4000 to 5000 miles distant.

May 20. This seems to have originated within a relatively short distance, perhaps near Iceland.

June 16. A shock of moderate size, without any clear indications of its source. Slight tremors were reported in certain parts of Spain at about the same time. The north-south component much smaller than the east-west. The different phases are poorly distinguished.

June 29. Two microseisms of which the beginnings are uncertain. The records of June 17 and July 3 are likewise of this class.

July 6. The time indicated for the beginning may really belong to the second preliminaries. North-south component the stronger.

August 4. An earthquake of considerable intensity, showing only a slight movement in east-west direction. It had the appearance of a West Indian disturbance, but may have been submarine. The origin was about 2000 miles away.

August 11. Smaller but otherwise very similar to the shock of August 4.

September 23. Slight oscillations gradually increasing to a maximum and traveling along the meridian.

MINERALOGY

The work of the section of mineralogy has progressed along several lines.

In addition to short papers published during the year the work of investigating the recent mineral occurrences of New York city and vicinity has been inaugurated.

The card catalog of new crystal forms of minerals, mentioned in the last report, has now been published under the title "A List of New Crystal Forms of Minerals."[1]

This list, which includes 364 forms, recorded since the publication of Goldschmidt's "Index der Krystallformen der Mineralien," divided among 251 mineral species, is now rendered available to investigators in mineral crystallography.

There have been added to the collections several suites of mineral specimens, of which the most important are:

1 A series representing the more recent Canadian occurrences. This was acquired by exchange with the University of Torónto and contains notably a well-crystallized specimen of barite from Two Islands, Nòva Scotia; a large and handsome specimen of kermesite, in well-defined crystalline aggregates on stibnite, from West Gore, Nova Scotia; fine representative specimens of native silver, niccolite, erythrite and smaltite from Cobalt, Ontario; and a small but characteristic specimen of the recently described occurrence of pyromorphite from Moyie, British Columbia.

2 Among the rare mineral specimens from Norway and Sweden, presented to the museum by the Assistant State Geologist,

[1] School of Mines Quarterly, 1910. 31:320.

the following species were not previously represented in the collections:

Native lead from Langban, Sweden; the larger of the two specimens is exceptionally fine, presenting a surface of metallic lead 10 cm by 7 cm in extent.

Melanotekite from Langban, Sweden; a characteristic specimen of this rare mineral.

Pinakiolite from Langban, Sweden; a large characteristic specimen of this rare manganese borate.

Bröggerite from Satersdalen, Norway; a rare crystallized variety of uraninite represented by a well-formed crystal 9 mm in diameter.

Aeschynite from Iveland, Norway; a massive specimen of this rare niobate.

3 A representative series of minerals from the pegmatite exposed at Kinkel's quarry, Bedford, Westchester co., was collected during the past summer. This accession contains a fine microcline crystal, 19 x 8 x 7 cm, which shows with clearness twinning according to the Baveno law. Many smaller crystals, some of them developed with almost diagrammatic regularity, form part of this suite. Several specimens of cyrtolite, which has been described from this locality by Luquer,[1] add value to this series, some of them being coated with distinct crystals of the relatively rare mineral autunite. From a specimen of clear rose quartz two perfect spheres, 13 mm in diameter, have been cut, showing the asterism noted in connection with this occurrence by Manchester.

Calcites of New York, by Mr Whitlock, the monograph on this subject which has been mentioned in two preceding reports, has been published as Museum memoir 13. The aim of this work is to discuss the problem of the influence of genetic conditions upon the crystal habit of calcite by means of a close and detailed comparison of the habit of a number of calcite occurrences within the limits of New York State with special reference to the genetic conditions governing the formation of the crystals comprised in these occurrences. The summary of the results of this study indicate a consistent recurrence of closely related crystal forms in three groups of occurrences, in each group of which the governing genetic conditions are similar, notwithstanding the fact that the occurrences of the group are in most instances widely separated geographically.

[1] Luquer, L. McI. Am. Geol. 1904. 33:17.

With a view to rendering a work on so specialized a subject more intelligible to the general scientific reader and to gather together for reference the data available for the general study of the problem, the opening section of the monograph, consisting of 54 pages, is devoted to a theoretical discussion and explanation of terms. This comprises a brief account of the previous crystallographic work done in connection with New York calcite occurrences; a general bibliography of 176 titles covering the crystallographic literature of calcite; and a short discussion of the mathematical relations and formulas fundamental to the study. Under this latter head appears a list of the 313 well-established crystal forms of calcite, including those recorded for the first time in the body of the text, and a list of 115 doubtful or uncertain forms. A gnomonic projection of the above 313 crystal forms constructed on a spherical radius of 7 cm and measuring 100 cm by 90 cm is inclosed in a pocket. This has already proved of considerable service in working out the problems connected with the identification and depiction of calcite crystal forms. In this portion of the work is also included a diagram by the use of which the face outline of any crystal form of calcite may be readily drawn and by this means a model of it constructed in paper or cardboard.

The main body of the work is devoted to a detailed description of the calcite crystals comprised in the twenty occurrences discussed. These occurrences are as follows: Rossie, Antwerp, Sommerville, Sterlingbush, Lyon Mountain, Arnold Hill, Mineville, Chilson Lake, Crown Point, Smith's Basin, Glens Falls, Saratoga, Fayetteville, Union Springs, Howes Cave, South Bethlehem, New Baltimore, Catskill, Hudson and Rondout.

In all about 500 crystals were studied and about one-third of that number were measured. Types, based on crystallographic and genetic differences, are distinguished in the case of most of the occurrences, in one instance (Rondout) as many as nine types being recorded from a single occurrence. Throughout this portion of the work the genetic conditions governing the formation of the various types are discussed and the genetic relations of the types included in each occurrence are studied in some detail.

The crystallographic combinations discussed in the text are shown in 25 plates and include 136 figures.

A synoptic table of distribution of forms shows 100 forms recorded on New York calcite, of which 11 are new to calcite. The 11 new forms do not include those previously recorded by the writer in his published preliminary work on the Lyon Mountain and Union Springs occurrences.

PALEONTOLOGY

Monograph of the Eurypterida. This work, referred to in previous reports as in preparation, is now on the press. To indicate the general purport and scope of the work the preface to the volume is here appended:

While the senior author of this work was engaged in the preparation of the monograph of the American Devonic Crustacea, which constituted volume 7 of the *Palaeontology of New York* (1888), the forms of the Eurypterida there presented for consideration led to the impression that it would be a service to paleontology to restate in detail the structure of this unique group of extinct creatures. The Siluric rocks of New York had long been so profuse in these remains that the material was not wanting for such analysis and the late Professor James Hall, who in 1859 had given the most intimate account of the eurypterids known up to that time, concurred in the belief that the thirty years which had then passed would, with the aid of accumulated data and in the light of the contributions made by other writers, afford new facts worth recording. Not long after this Gerhard Holm published his very remarkable analysis of the structure of Eurypterus based on specimens from the Baltic Siluric and on the appearance of this exhaustive memoir it seemed that the anatomy of the group could hardly be supplemented except by the estimation of specific and generic differences, and the study of the habitudes of these animals. Notwithstanding, as early as 1895 I began the assemblage of materials looking specially to a revision of the New York and American eurypterid faunas. The collections of the State Museum were already pretty well supplied with representatives from the well-known localities at Buffalo and in Herkimer county and now these collections have been vastly amplified, first by repeated acquisitions from the Herkimer county localities during the past fifteen years, again by the close study of all outcrops of the Eurypterus beds along the line between Herkimer county and Buffalo which has progressed in connection with the field work in areal geology, then by the courtesy of the trustees of the Buffalo Society of Natural Sciences who in 1898, by special vote, placed at my disposal the extraordinary assemblage of specimens from the Buffalo cement quarries which is known, from the name of its principal contributor, as the Lewis J. Bennett collection. Soon thereafter followed the discovery of the Eurypterus-bearing black shales at Pittsford, Monroe county, which were brought to light by the work of enlargement of the Erie canal in 1895, the species of which were described by Mr Clifton J. Sarle in our reports, from material now in possession of the State Museum. To this notable addition to our knowledge has been added in years still more recent the new fauna in the dark shales of the Shawangunk grit at Otisville, Orange county, an assemblage of eurypterids remarkable for its profusion of immature growth stages. This fauna, lying far to the east of all previously known occurrences of these creatures, was described in a preliminary way by the writer. Still more recently, indeed since the preparation of this book was believed to be completed, the field investigations of Doctor Ruedemann have brought to light a large and new fauna in the Lower Siluric (Frankfort) shale rather widely disseminated in the lower Mohawk valley; this constitutes the very earliest assemblage of these merostomes in conditions which indicate that they formed a colony of long local duration.

The collections which have thus been brought together from the productive localities mentioned for the preparation of the present treatise have been really great; indeed they represent some thousands of specimens and it is quite within reason to say that no series of the Eurypterida of equal size and variety has ever before been assembled. It is quite as true that no equal area in the world has proved as fruitful in the quantity and diversity of these organisms as the State of New York. Through the courtesy of many correspondents and museums much material from outside of New York has been placed at the demands of this work: the species of the Kokomo waterlimes of Indiana; of the Cambric Strabops of Missouri; the Siluric Megalograptus of Ohio and the Carbonic Hastimima of Brazil and New Brunswick; in all, I believe, an unexampled array of these extinct arachnids.

The work of elaborating these earlier studies and expanding them into this fuller form has very largely depended on the aid of Dr Rudolf Ruedemann who has brought to the work keen analytical powers, a broad grasp of its problems and an enthusiastic assiduity. I fully realize and gladly express my obligation to this assistance and desire that the interested reader accord to my coworker adequate acknowledgment of his efficient part of this work.

The treatise itself seems to carry its own justification; aside from the close analysis of structural details, there are chapters on ontogeny, phylogeny, on life habits and conditions as well as on organization which, though possibly not beyond criticism, are at least informing and constitute an advance of knowledge.

To the following individuals and institutions the authors have been indebted for aid:

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Dr E. M. Kindle, Washington

Prof. Stuart Weller, Chicago

Dr Mark E. Reed, Buffalo

Mr Irving P. Bishop, Buffalo

Dr August F. Foerste, Dayton

Mr Fred Braun, Brooklyn

The illustrations in the work are from drawings skilfully rendered by George S. Barkentin; many of them, especially the restorations and stages of immature growth, are based on Doctor Ruedemann's sketches and camera drawings.

The eurypterid colonies of the New York Siluric are very distinctly localized and of them we know two at the bottom of the Salina series or beneath the salt beds and two at the top of the series. These colonies were doubtless partly breeding pools in brackish waters, partly more open basins, restricted in extent by the limitations of favorable physical conditions.

Colony O, or the Otisville basin, lying far eastward of the rest and on the borders of the Appalachian region, is embedded in an almost unlimited repetition of thin black shale between layers of heavy sandstone of the Shawangunk formation (Salina stage). In the construction of railroad improvements the rock wall here was broken down for ballast and while this work was in progress the eurypterid remains were detected by Doctor Ruedemann. From this time until the completion of the construction work referred to Mr H. C. Wardell was almost continuously engaged in acquiring these fossils and when the work was done the rock exposure was left with a vertical face, so that no further product is now available. In this eastern region of New York State the Salina formation is without salt deposits, but the Otisville basin doubtless antedated these deposits in central New York and is assignable to an early part of the Salina stage.

Colony P, or the Pittsford pool, is embedded in a black shale formation which has never been exposed in any natural outcrops. As we have observed, the rock was first brought to light by excavations made in the deepening of the Erie canal in 1895 and the outcrops were soon after covered by the riprap construction of the canal lining and so remain. Extensive collections of material were made by Mr Clifton J. Sarle; these were subsequently increased by the work of Messrs D. D. Luther, H. C. Wardell and Fred Braun. The opportunity of further acquisitions from this fauna rests with the future and depends on possible new excavations in the progress of public improvements.

Colony H, or the Herkimer pool, has been long exploited. It lies above the horizon of the salt and its localities are in the vicinity of Jerusalem Hill, Clayville, Sauquoit and Waterville. The most productive parts of the region have been the Wheelock and Schooley farms near Jerusalem Hill, though here as elsewhere actual outcrops of the waterlime are few. Experience has shown that the exploitation of the fresh rock does not afford eurypterids in satisfactory preservation, because of its blue-gray character. Exposure not only reduces this to a light gray but aids the fissility of the rock and the broad, flat surfaces of the fossils also help to induce cleavage planes in the matrix. Exposure of a few years to the weather aids but little. The experiment was made of taking from the outcrop a good many cords of fresh rock which were left exposed for a period of five years, but the result in the particulars referred to was wholly unsatisfactory. Therefore the supply of these fossils has come from weathered slabs distributed over this region. Miles of stone fences have been inspected and many rods of them taken down and rebuilt. Some of the most productive material has been found in the foundations and cellar walls of buildings and in one instance the foundation wall of a large barn has been removed without disturbing the building, the abstracted rock being replaced with concrete as the work proceeded. Many hands have helped in the acquisition of this material: Messrs D. D. Luther, R. Ruedemann, C. A. Hartnagel, Jacob Van Deloo, H. C. Wardell, Fred Braun and the writer, and while it may be difficult at present greatly to enlarge these extensive collections, still they are only an index of the profusion of these forms of life in this pool.

Colony B, or the Buffalo pool, appears to have been quite closely confined to the quarry beds of the Buffalo Cement Company in the northern part of the city of Buffalo. It is from these quarries that has come the majority of the specimens now widespread through the museums of the world. Formerly such specimens were available to any collector, but a few years ago the president of the company determined to place all specimens uncovered in the progress of quarry work in the possession of the Buffalo Society of Natural Sciences and by virtue of this laudable act that society possesses in the "Bennett Collection" a very remarkable array of these remains, which are specially noteworthy for the prevailing large size attained by the individuals. At the present time few Eurypterida are obtained from this historic locality and there is reason to believe that the boundaries of the pool have been approached, though remains of these creatures are found scattered at this geological horizon as far west as Bertie, in Ontario, the locality from which this waterlime formation takes its name. Like the Herkimer pool, that at Buffalo lies in the Bertie waterlime above the salt.

Colony S, or the Schenectady basin. This recent discovery (1910) of eurypterids in the Frankfort shale (Lower Siluric) is comparable to their occurrence at Otisville. These remains, usually in fragmentary condition, abound most freely in fine-grained black shale intercalated between thick calcareous sandstone beds locally known as "Schenectady bluestone," but they also occur in the sandy passage beds between the two. These sandy shales are full of organic remains, partly of the supposed seaweed Sphenothallus latifolium Hall and partly of what appear to be large undefined patches of eurypterid integument. In the black shales the eurypterid remains are rarer but their surface sculpture is excellently retained, and here their organic associates are Climacograptus typicalis and Triarthrus becki. As a result of imperfect retention of these eurypterids in the rocks where they most abound and their sparseness in the shales which have best preserved them, we are still left in ignorance of the full composition of this assemblage, but it is safe to say genera, species and individuals were abundant at this early period and the evolution of distinctive characters which we have heretofore recognized only in a later period had progressed to so sharp a differentiation, that we are compelled to carry back farther in history, some of the commoner generic designations. These remains in the Frankfort shale are distributed through fully 1500 feet of strata off a northeast-southwest coast line in an area of maximum deposition and it is difficult to conceive that the physical conditions of the habitat of these merostomes were those of an inshore pool; they were rather those of a purely marine basin where sedimentation went on rapidly in an appalachian depression. Hence among our assemblages of these creatures this occurrence is without parallel in respect to long endurance, while in the nature of the habitat it is comparable to that at Otisville.

All other occurrences of Siluric eurypterids in New York have been desultory and indicate no intercommunication between the pools or colonies mentioned.

Monograph of the Devonic Crinoidea. This work is progressing and the addition of new material has somewhat broadened its scope and usefulness. Its advancement is necessarily slow because of the inability of its author, Mr Kirk, to give his consecutive attention to it, but the field is being gradually covered fully and the work should result in a useful addition to the paleontology of New York.

Collections. Considerable collections of fossils have been made in the field, particularly from the Clinton formation of Oneida county, for the purpose of determining the rational position of this formation and fauna in the rock series. Excavations in the Agoniatite limestone of the Marcellus division have resulted in procuring a ton or so of material illustrating the large goniatites and other cephalopods of that horizon, of which the museum collections stood in need. This work has been done by Mr Hartnagel. Doctor Ruedemann has carried on investigations into the nature and relations of the shale formations of the lower Mohawk and upper Hudson valleys by extensive collecting throughout this region.

III

REPORT OF THE STATE BOTANIST

The following is a summary statement of the progress and results of the work of the State Botanist for the past year.

Specimens of plants for the herbarium have been collected in the eastern, northern and western part of the State. They are from the counties of Albany, Chemung, Columbia, Essex, Greene, Livingston, Rensselaer, Saratoga, St Lawrence, Steuben, Ulster and Warren. The number of species of which specimens have been added to the herbarium, including those collected and those contributed by correspondents, is 269. Of these, 79 species are new to the herbarium and 23 are considered new to science. The new species are all fungi.

One hundred and seventy-six persons have contributed specimens. This number also includes those who sent specimens for identification only, if the specimens were collected in this State and were desirable additions to the herbarium. There were made 2419 identifications of specimens sent by correspondents or brought to the office by inquirers. Both the number of persons for whom identifications were made and the number of identifications are decidedly larger than in any previous year. For 1909 the corresponding numbers are 152 and 1717. This indicates a gratifying increase in the general desire for botanical knowledge.

Specimens of five species of Crataegus have been added to the very large number already represented in the herbarium. Four of these are new to our flora.

Specimens of five species of mushrooms have been collected, tried for their edible qualities, and approved. These make the number of our New York edible species and varieties now known 205. Life-size colored figures and full plain descriptions of the five added species have been prepared. One species has been found to be remarkable for its sudorific qualities. If eaten freely it causes profuse perspiration, but no other inconvenience. Its flavor, texture and digestibility are faultless, but it should be considered medicinal rather than edible.

In pursuance of a previous plan, a monograph of the New York species of Hypholoma has been prepared. The genus includes several sections which, while agreeing in the common character of having a marginal veil, are in no other respects quite unlike each other. This, coupled with the fact that in any one group closely related species are found, makes a revision and collation of the New York species of the genus especially desirable.

Having been informed that the raspberry patches of the fruit growers in the vicinity of Marlboro, Ulster county, were suffering from a disease, a visit was made to that place in July and some of the diseased plants examined. They were found to be principally affected by a parasitic fungus, Sphaerella rubina Pk. The fruiting canes put forth their leaves and blossoms as usual and commence to develop their fruit, but before it ripens it withers and dries on the branches. The dryness of the season doubtless aided the destructive tendencies of the fungus and the loss was severe. The diseased canes bore patches of the fungus but it had already distributed its spores, which, according to previous observations made on the type specimens, mature early in the season, even in April and May. In consequence, the young canes showed brown or blackish patches on the lower part, in some cases near the ground, thereby showing that they had already been infected and in their turn would probably bear a crop of spores next spring. It would seem to be possible to check this disease by spraying the young shoots with fungicides, but the spraying should evidently begin as soon as the young shoots are three or four inches high, and be repeated once a week till the blossoms begin to open.

While at Marlboro, the attention of the Botanist was called to a diseased chestnut tree. It was a young tree with sickly looking foliage and a few dead branches. It was suffering from the chestnut bark disease about which much that is sensational and needlessly alarming and pessimistic has recently been published. This is the only instance recorded of its occurrence in Ulster county and, with one exception, the most northern station for it in this State. It has been reported from as far north and west as Cooperstown but no specimens from that locality have been examined and it probably does not yet occur west of the Hudson river valley, unless possibly in a few widely separated and limited, isolated stations. The most northern station for this disease is Vischer's Ferry, Saratoga county. It is an apparently outlying station, no intervening one between it and Marlboro being known.

In 1899 a census of the species of plants found in Bonaparte swamp, Lewis county, was taken and a list of the names of the species was published in the report for that year. The number of flowering plants and ferns found there is 128. The swamps and marshes of the State are a part of its natural resources. They are the result of a long, slow process by which shallow lakes are transformed into plant-producing areas, or, in other words, in which water surface is changed to land surface. In this process plants play an important and very large part. In the beginning, aquatic plants and aquatic and sphagnous mosses occupy the more shallow parts of the lake. By the annual growth and decay of these a mass of sedimentary material, which is largely vegetable in its composition, accumulates. This gradually spreads till in many cases it occupies nearly or quite all of the lake surface. In due time it becomes sufficiently dense and firm to sustain amphibious and marsh-loving plants. These gradually take possession and carry on the work till the consistency of the surface is sufficient to give support to marsh grasses and sedges, which give us what is locally known as "beaver meadows."

In some cases, instead of a grassy marsh there is formed a shrubby marsh in which small shrubs have taken possession instead of or in connection with the grasses and sedges. By their intermingling roots and the annual falling of leaves the surface becomes denser. The next stage is ushered in when swamp-loving trees can maintain an existence. These gradually become numerous enough to overpower and suppress much of the herbaceous vegetation and many of the smaller shrubs, and the wooded swamp results. The borders of a marsh may be and often are simply a wooded swamp which itself is only an older part of the marsh. The grassy marsh appears to be less inviting to the advent of trees than the sphagnous and bushy marshes and, prairielike, it often remains open an indefinite time. Cleared swamps and open grassy marshes may, by proper drainage and treatment, be turned into productive land. The products of the marshes are sometimes utilized. The fruit of the various species of Vaccinium is gathered for food. The grasses and sedges of the "beaver meadows" are sometimes cut for hay, but this is rarely done except in cases of scarcity or very high prices of hay of better quality. The partly decayed remains of the vegetation of the marshes constitute peat. The less fibrous peat is used for heating purposes, fertilizers, and as an absorbent or bedding material in stables. The more fibrous kinds which come especially from shrubby or grassy marshes are used for purposes demanding a more fibrous material. That we might have a more definite knowledge of the species of plants most active in the transformation of our marshes into a more useful condition, a list of the plants at present found growing in Cranberry marsh, Sand lake, Rensselaer county, and in Averyville marsh, North Elba, Essex county, has been made. Two visits were made to the Cranberry marsh, one in July and one in September. A few plants were found on the second visit that were not seen on the first, presumably because they had not yet developed sufficiently to attract attention. The whole number of species found in this marsh is 72.

One visit was made to Averyville marsh. It was in September, and though the marsh covers a larger area than the Cranberry marsh, only 58 species were found there. This is probably due in part, at least, to the lateness of the visit. The number of species common to the two marshes is 33. More than half the number of species found in Averyville marsh occur also in Cranberry marsh. Of the species common to the two marshes, 15, or nearly half, are trees and shrubs. If we compare the list of species in Bonaparte swamp with those of the two marshes we find only 19 species common to the three localities. The flora of the wooded swamp is seen to be quite unlike that of the open marsh, as might be expected.

PLANTS ADDED TO THE HERBARIUM

New to the herbarium

Amanita bisporigera *Atk.*
A. floccocephala *Atk.*
A. velatipes *Atk.*
Ascochyta menyanthis *Oud.*
Aulographum ledi *Pk.*
Biatora coarctata (*Sm.*) *Nyl.*
Calvatia craniiformis (*Schw.*)
Camelina sativa (*L.*) *Crantz.*
Cercospora phlogina *Pk.*
Cladosporium paeoniae *Pass.*
Climacium kindbergii (*R. & C.*)
Clitocybe biformis *Pk.*
C. maxima *G. & M.*
Cortinarius croceofolius *Pk.*
C. glaucopus (*Schaeff.*)
C napus *Fr.*
C. triumphans *Fr.*
Crataegus aristata *S.*
C. brainerdi *S.*
C. calvini *S.*
C. longipedunculata *S.*
C. nemorosa *S.*
Crepis setosa *Hall. f.*
Cryptosporium macrospermum *Pk.*
Cycloloma atriplicifolium (*Spreng.*)
Cytospora microspora (*Cd.*) *Rabenh.*
Diplodia linderae *E. & E.*
Eccilia mordax *Atk.*
Eurotium subgriseum *Pk.*
Gloeosporium caryae *E. & D.*
G. divergens *Pk.*
Grindelia squarrosa (*Pursh.*) *Dunal*
Helianthus petiolaris *Nutt.*
Heterothecium pezizoideum (*Ach.*)
Hygrophorus caprinus (*Scop.*) *Fr.*
Hypericum prolificum *L.*
Hypochnus tristis *Karst.*
Hypoloma delineatum *Pk.*
Inocybe rimosoides *Pk.*
Lactarius boughtoni *Pk.*
Lentinus piceinus *Pk.*
Lychnis coronaria (*L.*) *Desr.*
Machaeranthera pulverulenta (*Nutt.*)
Macrosporium heteronemum (*Desm.*)
Marasmius contrarius *Pk.*
Myxosporium carpini *Pk.*
Naemospora croceola *Sacc.*
Naucoria sororia *Pk.*

Oidium asteris-punicei *Pk.*
Oxybaphus floribundus *Chois.*
Pertusaria leioplaca (*Ach.*)
Pholiota terrigena *Fr.*
Phoma piceina *Pk.*
P. simillima *Pk.*
P. stictica *B. & Br.*
Phyllosticta betae *Oud.*
P. subtilis *Pk.*
Physcia hispida (*Schreb.*)
Picris hieracioides *L.*
Pilocratera abnormis *Pk.*
Placodium ferrug. discolor *Willey*
Plasmodiophora elaeagni *Schroet.*
Pleurotus approximans *Pk.*
Ramalina rigida (*Pers.*) *Tuck.*
Rhabdospora physostegiae *Pk.*
Scirpus occidentalis (*Wats.*) *Chase*
Sideranthus gracilis (*Nutt.*) *Rydb.*
Sphaeropsis smilacis latispora *Pk.*
Sporotrichum grisellum *Sacc.*
Theloschistes flavicans *Wallr.*
Thlaspi perfoliatum *L.*
Trichothecium subgriseum *Pk.*
Triosteum perfoliatum *L.*
Usnea trichodea *Ach.*
Vermicularia beneficiens *Pk.*
V. pomicola *Pk.*
Verticillium agaricinum (*Lk.*) *Cd.*
Viburnum venosum *Britton*
Vicia villosa *Roth*

IV

REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports that the past season has been remarkably quiet so far as unusual outbreaks of injurious insects are concerned. The Entomologist was exceptionally fortunate in discovering a colony of pedogenetic larvae, presumably those of Miastor americana. These extremely peculiar forms were previously unknown in this country and have been studied by only a few Europeans.

Fruit tree pests. The experimental work with the *codling moth* was continued during the present season under more diverse conditions and data secured which will be of great value in the practical control of this species. The experiments were conducted in the orchards of W. H. Hart, Poughkeepsie; C. R. Shons, Washingtonville, and William Hotaling, Kinderhook. Great care was taken to secure an ample number of trees likely to produce a nearly uniform amount of fruit. As last year each plot, except in the case of Mr Hotaling's orchard, consisted of 42 trees, the fruit from the central six alone being counted. Comparisons were made to ascertain the relative efficacy of one spray given just after the blossoms dropped, with this treatment supplemented by a second application about three weeks later. The unusual abundance of the codling moth during the past season renders the data secured of exceptional value because they show the possibilities under very adverse conditions.

The *San José scale* is still very destructive, especially to peach trees, though our progressive orchardists have comparatively little difficulty in controlling it. A lime-sulfur wash, particularly that known as the concentrated wash, either homemade or commercial, has proved very satisfactory, as a rule, in checking this pest. In the Hudson valley there was complaint of injury by the *cherry maggot* and an investigation of the pest and methods of controlling it was inaugurated. The *cherry and pear slug* was exceptionally abundant in this region and also in the western part of the State. The *pear psylla* was somewhat abundant in the lower Hudson valley and reports of serious injuries were received from certain sections in the western part of the State.

The work of a new apple pest which may be known as the *lined red bug* (Lygidea mendax Reut.) was observed in the Hudson valley. This insect occurs in early spring, lives upon the more tender terminal leaves and, under favorable conditions, may inflict considerable injury.

Shade tree pests. The injurious work of various species has been brought to our notice. The more important of the shade tree pests is the *elm leaf beetle,* a well-known form which has been exceedingly abundant on Long island, throughout the Hudson valley and in certain cities in the western part of the State. The *sugar maple borer* has been unusually numerous on the trees of Fulton, Oswego county, destroying or practically ruining a number of magnificent trees. The *cottony maple scale* has been somewhat abundant in the lower Hudson valley, while the injurious work of the *false maple scale* was observed in several localities in the vicinity of New York city.

Forest insects. The *snow-white linden moth,* a pest which has been very destructive in the Catskills for the past three years, was abundant in limited localities last season and its flight in small numbers was observed in various places. A series of outbreaks by another leaf feeder was reported from several localities. They were due to the operations of a green, white-striped caterpillar (Xylina antennata) frequently designated as the *green fruit worm.* The destructive work of the *hickory bark beetle,* noted in a preceding report, has been continued. An unusual outbreak was that of *Abbott's sawfly,* a false caterpillar which stripped or nearly defoliated many white pines in the foothills of the Adirondacks. The *spruce gall aphid* has continued to be abundant and injurious on Norway spruce, in particular. It is interesting to record the discovery of another species of gall aphid, new to the

State, occurring upon the Colorado blue spruce. The above noted insects have been the subject of correspondence and, in some instances, of field investigations during the past season.

Gipsy and brown tail moths. Much interest was aroused early in 1909 by the finding of thousands of winter nests of the brown tail moth on many shipments of French seedlings. A number of such nests occurred on shipments received in 1910, though the pests were not so abundant as during the preceding year. The careful inspection of the stock appears to have prevented this insect from becoming established in the State. There is much more danger of this moth being brought into New York State on shipments of full-grown nursery stock originating in infested American territory than there is of its being introduced with imported seedlings. It has been found necessary to give considerable time to the determination of remains of caterpillars, cocoons and egg masses in order to be certain that none of these fragments on nursery stock indicated the presence of either the gipsy or brown tail moth.

A personal investigation of conditions in eastern Massachusetts shows that no pains are being spared to prevent the dissemination of either the gipsy or the brown tail moth. Particular attention has been given to keeping the property abutting on the principal highways free from the pests so as to eliminate in large measure the danger of their being carried by vehicles of any kind. There has been, however, some extension of the territory occupied by these two pests. The gradual spread of these insects appears to be inevitable, though the utmost care is taken in the treatment of the outlying colonies. It is gratifying to state that the serious infestation recently discovered at Wallingford, Conn., has been handled in such a satisfactory manner that only a very few specimens rewarded a week's careful search by a gang of fifteen men. An examination of the work with parasites showed that no stone was being left unturned in an effort to find, rear and liberate a large number of efficient enemies of these pests. The Entomologist would emphasize once more the grave danger of bringing either one or both of these pests into the State on nursery stock originating in the infested area, and would call attention to the great desirability of promptly exterminating any isolated colonies which might be found in the near future.

House fly. The popular interest in the control of this pest has continued and bids fair to result in important and far-reaching sanitary changes. The demand for information exhausted the edition of Museum Bulletin 129 on the *Control of Household Insects* and necessitated its republication in an extended and revised form as Museum Bulletin 136 entitled *The Control of Flies and Other Household Insects.* The Entomologist has been called upon to give a number of popular lectures upon this insect and has made personal examinations of conditions in several localities, giving special attention to situations favorable for the production of flies in cities and villages.

Gall midges. Studies of this extensive and interesting group have been continued and the results are now in manuscript. This publication will describe fully some 800 species, 441 having been reared. The tabulation of plant galls, made with the assistance of Miss Hartman, shows that we know some 538 species representing 44 genera and living at the expense of some 177 plant genera referable to 66 plant families. In addition to the above, there are some 5 species reared from unknown plants and 11 species belonging to 3 genera known to be zoophagous.

A number of new species have been reared during the year. Miss Cora H. Clarke of Boston, Mass., has continued to collect and forward to us excellent series of galls from which we have been able to rear several previously unknown species. The care of this material has devolved largely upon D. B. Young and Miss Hartman. The latter has also made a large number of microscopic mounts of these fragile forms.

Miscellaneous. The Entomologist spent nearly six weeks in Europe, giving special attention to museum methods, shade and forest tree insects and the gall midges. Collections were studied in the following institutions: British Museum of Natural History, London; the Universities of Oxford and Cambridge; the Tropical School of Medicine, Liverpool; the zoological gardens at Antwerp; the Royal Museum of Natural History at Brussels; the botanical gardens of Ghent; Museum of Natural History and the entomological station at Paris; the University at Zurich; the exceptionally valuable collection of forest insects in the Forestry School at Munich; the natural history collections in the Senckenberg Museum at Frankfurt; the Winnertz collections in the University of Bonn; the Museum of Natural History, Berlin, and the Museum of Natural History at Hamburg. In addition, the Entomologist spent several days with Prof. J. J. Kieffer of Bitsch, Germany, studying his exceptionally valuable collection of Cecidomyiidae, and with Prof. E. H. Rübsaamen at Remagen, Germany, a day devoted largely to examining his numerous excellent drawings and a discussion of the classification of this group. A portion of a day was spent with Oberförster H. Strohmeyer of Münster, Germany, studying his excellent collection of Scolytidae, while another day was passed with Oberförster Karl Philip at Sulzberg obtaining first-hand information of forestry methods as practised in Germany.

Publications. Numerous brief, popular accounts dealing with injurious insects have been prepared by the Entomologist for the agricultural and local press, besides a few more technical papers for scientific publications. A revision of Museum Bulletin 129, as noted above, was issued during the year, while the report for 1909 appeared last July. A tabulation of the midge galls known to occur upon several plants was published in August under the title of *Gall Midges of Aster, Carya, Quercus and Salix*.

Collections. A valuable addition to the collections was secured through the generosity of Prof. J. J. Kieffer, of Bitsch, Germany, who kindly donated to the museum a number of his generic types of European gall midges. These have been carefully mounted and are accessible to students of the group. A fine series of Italian midge galls was secured by exchange with Dr Mario Bezzi. These were carefully arranged and labeled by Miss Hartman. Miss Cora H. Clarke, as already noted, has contributed some valuable biological material, mostly insect galls.

The arrangement and classification of the collection has been forwarded as rapidly as possible, though with the limited office staff it is practically impossible to keep the collections properly classified, while the securing of desirable additional material must of necessity proceed slowly. The restrictions due to a small staff will become more apparent with the occupancy of quarters in the new building, accompanied by the obligation of maintaining a larger exhibit. The school teachers of Albany, Troy and presumably other near-by localities are making extensive use of our exhibit collections in connection with the regular school work. It is the aim of the Department to have a representative collection of the species occurring in the State, though the assembling of such means the work of years.

The nearly completed monograph on the gall midges shows that the State collections in this family will far exceed anything that can be assembled elsewhere for some years to come. It will always be valuable because of its very large series of generic types or cotypes. Mr Young has identified and arranged the Conopidae, besides doing much miscellaneous work in classifying insects collected during the year and identifying species sent in for name. A number of Hemiptera have been very kindly determined by a well-known authority in this group, Mr E. P. Van Duzee of Buffalo. Miss Hartman has also assisted in the arrangement of the collection and has reared and spread a number of specimens.

The value of the exhibit collections will be greatly enhanced when the series of plant groups designed for the exhibition of insects in their natural environment in the new Education Building has been completed. The wax work for four of these groups has been delivered and it is planned to complete the remainder next year. Several excellent models representing injurious insects are now on exhibition and more should be secured, preferably made to order, since only a few can be purchased in the market, while no one has attempted to prepare models of many forms which could be exhibited in this manner to very great advantage.

Nursery inspection. There has been close cooperation with this phase of the work conducted by the State Department of Agriculture. Numerous specimens of both native and foreign insects have been submitted to this office for name, and the Entomologist has been frequently consulted in regard to various problems. This work, while consuming much time and often necessitating identifications of minute forms, like scale insects or the recognition of species by fragments or the comparatively unknown early stages, is very important, since the treatment of large shipments must depend in great measure upon our findings.

Office matters. The general work of the office has progressed in a satisfactory manner, the Assistant State Entomologist being in charge of the office and responsible for the correspondence and other matters during the absence of the Entomologist in Europe and while away on vacation. Miss Hartman, in addition to matters noted above, has rendered material assistance in bibliographic work and in translating from German, French and Italian works. Numerous specimens have been received during the year for identification and many inquiries made concerning injurious forms.

V

REPORT ON THE ZOOLOGY SECTION

During the year the Zoologist, Frank H. Ward, and the Taxidermist, Alfred J. Klein, both tendered their resignations and left the service of the Department. Up to his departure, Mr Ward devoted most of his time to the arrangement and labeling of the shell collections and to plans for the exhibits, and especially for the cases, for the hall of zoology in the Education Building. As a result of his work, Mr Ward left a plan covering the different types of cases that will be required, the dimensions and number necessary for each type, and their arrangement in the hall. In its main features this plan seems entirely satisfactory, providing the necessary space and a logical arrangement of the material, as well as allowing for growth along the lines on which it is proposed to develop the museum.

The necessity of this and other work looking toward the coming change of quarters, as well as the lack of space in Geological Hall, not only for the exhibition, but also for the storage of more specimens, prevented the staff from undertaking any field work, so that the accessions along some lines are less than usual, yet the total number of specimens added was raised to a figure far beyond that reached for many years by the purchase of the Ingalls collection of shells, comprising, according to an estimate by Mr Ward, a total of about 24,000 specimens from all parts of the world. While its purchase must be regarded as a departure from the plan of confining the collections of this museum to the natural history of New York State, yet the rank long held by this institution among collections of Mollusca is so high as to deserve to be maintained, in so far at least as can be done without materially interfering with the development of the collections along the lines which have been determined on as most important.

The cases for the fish and mink groups mentioned in the last report were received and set up in Geological Hall, but further additions to the exhibits in this building are out of the question for lack of space, and this same difficulty has seriously delayed the preparation of the large mammal groups which are contemplated, or for which specimens have already been acquired. A group of four porcupines with accessories was completed by Mr Klein, who held the position of Taxidermist until September 1, 1910, but it awaits not only a case, but room for setting it up.

A number of casts of native reptiles and amphibians was also purchased, as these casts show the natural color and appearance of the animals better than either stuffed or alcoholic specimens. A consistent effort has been made to get together the materials for more bird and mammal groups, even though all attempts to set them up must be deferred until more room is available. With this end in view the Zoologist made a trip to Silver Bay to examine the collections of Mr Silas H. Paine who had an extensive private collection that was being broken up and sold. Many of the best specimens had been bought by others before this museum was notified that they were for sale, but several good bird groups and much material useful in setting up other groups remained and negotiations for its purchase were in progress at the end of the fiscal year.

Birds of New York. The first volume of this work covering the water and game birds has been issued, under authorship of Prof. E. Howard Eaton, with forty-two plates in color by Louis Agassiz Fuertes. The public demand for this publication has been very large and it has, on this account and in view of the limited edition, been necessary to restrict the distribution very largely to sales. A larger edition is required in order to meet the reasonable requirements of the citizens and it is believed this will be provided. The second volume of the work, which will embrace the land birds, is practically completed and its publication within a year is confidently hoped for.

VI

REPORT ON THE ARCHEOLOGY SECTION

The work of this section of the museum embraces a number of coordinate sciences which cover nearly all divisions of anthropology. Among the special branches to which attention is devoted may be mentioned ethnology, folklore, archeology and human osteology. Most of these subjects require research in the field. Other special work is the securing of Indian models for casts, the supervision of the work of the sculptors and artists and directing the collection and production of the various accessories necessary for the series of ethnological groups. This is referred to in greater detail hereinafter.

It will be noted that the term archeology as applied to this section of the museum's activity is descriptive of only one of the important branches of its researches and that the term anthropology conveys a more accurate impression of the scope of work pursued.

The field of research. The special line of investigation to which the attention of the Archeologist is directed is that of studying the culture of the aborigines of New York, both that of the past and of the present. This is done in order to bring to light data for correlation. Many of the fundamental facts of anthropology have been gleaned from the study of the American Indians. In our State there lived, and now live, representatives of a very important and highly developed Indian stock. Much has been written of the New York aborigines, but much of their culture remains unrecorded and various facts they present are very significant.

Our work is limited primarily by the lines of the State. Within these bounds we make systematic surveys and excavations of the various sites of aboriginal occupation, and instal the various artifacts and other materials bearing on the culture-history of our Indians in the archeological collections of the State Museum. The State is our field and wherever suitable sites can be found these are examined or excavated. This, with the collection of the relics and specimens of Indian art, constitutes the work in archeology.

Various tribes and stocks have inhabited this area during remote times and even now remnants of some exist. Each tribe or stock, except perhaps the earliest, has left traces by which it may be differentiated from the rest. To sift out the problem of the different successive or contemporary occupations, to discover lines and times of migrations and to determine the cultural facts, form a field of research for constant activity.

The Indians that yet remain in this State are the various tribes or nations of the Iroquois, viz: the St Regis Mohawk in Franklin and St Lawrence counties; the Oneida in Madison county; the Onondaga in Onondaga county; the Seneca in Cattaraugus, Erie and Chautauqua counties; the Tuscarora in Niagara county; and the Cayuga who live mostly with the Cattaraugus Seneca. A few Abenaki, survivors of the Canadian Algonquin, live in the Adirondacks in the vicinity of Lake George, while others are scattered throughout the State.

Few tribes of North American Indians have occupied so prominent a place in history and literature as the Iroquois. Their conquests, their government, their endurance as a people, and their keen intellect, wonderful sagacity and political capacity as individuals have excited the admiration of even their enemies. Thousands of pages have been written on the Iroquois and yet so full of interest is their history that as a subject for the historian, the romancer or the anthropologist, they furnish a never failing topic for discussion.

An examination of the pages of the works on the Iroquois reveals that but little has been added to the sum total of knowledge about them since the time of Colden and later the time of Morgan. Many writers, it is true, such as Schoolcraft, Hale, Clark, Boyle and Beauchamp, have contributed much of importance, but the fact remains that no thorough ethnological study has ever been made. A vast reservoir of data remains untapped, and in stating this the truth is not overdrawn. So much about the Iroquois remains to be learned that all that has been recorded seems but a pittance. To grasp this work and rescue from oblivion the knowledge which is now within our grasp is the work of a lifetime, but within a lifetime a great part of it will be beyond the reach of human effort. The minds that know and hold the old-time lore will have passed into the great silence. In this state of conditions the ephemeral things of museum routine ought not to be permitted to interfere with the opportunity that lies before us.

Among the ethnological subjects which have been matters of study may be mentioned Iroquois mythology, folk cults, dreams and dream influence, gesture and emotional language, names and the doctrine of names, costumes and personal ornament, sign language, symbols, decorative art, periodic ceremonies, wampum records, the code of Dekanowideh and the code of Handsome Lake. Notes on many other subjects are awaiting elaboration.

Information on many of these subjects is totally lacking and is not to be had outside of our notes, which are as yet, in most cases, only outlines.

Several large collections of archeological material have been offered us, but without funds it is not possible to acquire them. Most of these collections are invaluable and can never be duplicated. In many instances they represent the greater part of the relics collected in a given region and are the result of years of investigation.

There is no legitimate reason why funds should not be appropriated for the purchase of this material, which by every reason should become the property of the State. The interest of other institutions both here and abroad in these collections has led to the purchase of some and their removal beyond our control. The State of New York can hardly afford to permit the loss of this vast historical and archeological wealth, and yet mistaken policy has permitted it in the past.

No attempt has been made to rearrange the archeological collections, since there is no means of displaying any collections, however well arranged. It is likewise difficult to remove the numerous objects that crowd upon one another because our storage room is limited and the short time when proper facilities will be provided would make the work a waste of important time.

During the year the Archeologist examined several of the old collections that had long been in storage and endeavored to check the specimens found, against the catalogs. Many specimens were missing, having disappeared through the years. Several boxes taken from storage in the malt house contained only dust and shreds of cloth, the result of destruction by mice. Even some of the more recent specimens had been almost destroyed by moths. This destruction of important objects is largely the result of improper and limited exhibition space and the previous lack of permanent curators.

Public interest. The interest of the public in the work of this section is steadily increasing as is attested by the call for its publications, the visits of interested collectors and the hundreds of letters from persons desiring information about anthropological subjects. Visitors and letters come not only from our own State, but from many parts of this continent and from Europe. The plans for the large ethnological exhibit have awakened the interest of museum officials from many institutions who have either written or called in person.

The range of inquiries directed to us is wide and covers the entire field of anthropology and Indian history.

It is the aim of the archeological section to arrange its exhibits in the new Education Building so as to especially appeal to the public interested in Indian relics and lore. In preparing these exhibits the fact is borne in mind that the State Museum is the people's museum and that its function as a division of the Education Department is to educate and not to confuse those who view its collections. Such a plan will in no wise impair the scientific value, but rather increase it and at the same time add much to popular interest and education.

ETHNOLOGY

The work of this division of our researches has been especially productive of results both in the acquisition of important specimens of Iroquois and Algonquin handiwork and in the important notes recorded.

The Archeologist during his various field trips for Indian models has used his spare moments on the Iroquois reservations in New

Plate I

Symbolic and ornamental decorations embroidered on buckskin with moose hair and porcupine quills

York and Ontario in seeking information regarding ceremonial rites, folk cults, myths etc., and in collecting such ethnological material as could be acquired by purchase. In this latter matter, although much of great historic and scientific value was found, it was impossible to acquire everything because of limited funds at hand.

During the year 160 ethnological specimens have been acquired.

Fig. 1

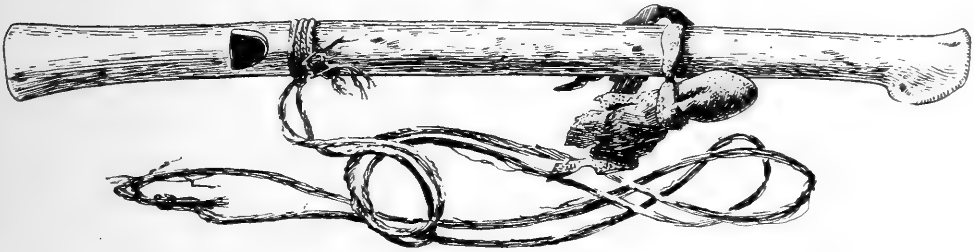
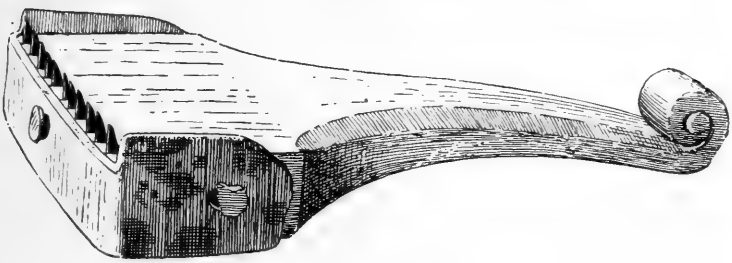


Fig. 2

Fig. 3



Ethnological specimens

Fig. 1 Little water flute made of a turkey bone
Fig. 2 Crooked knife with an antler handle
Fig. 3 Splint gauge

All about one-half natural size

Special subjects of inquiry and study during the year have been the art and symbolism of the New York aborigines, costumes and personal adornment, and Iroquois uses of maize and other food plants. The notes on the last mentioned subject, the result of some ten years research, were revised, annotated and presented for publication as a bulletin.

Much attention has been given to the study of the decorative art and symbolism of the New York Indians, which resulted in revising and enlarging a manuscript monograph on the subject and holding it as the nucleus for further study. With the Iroquois, the

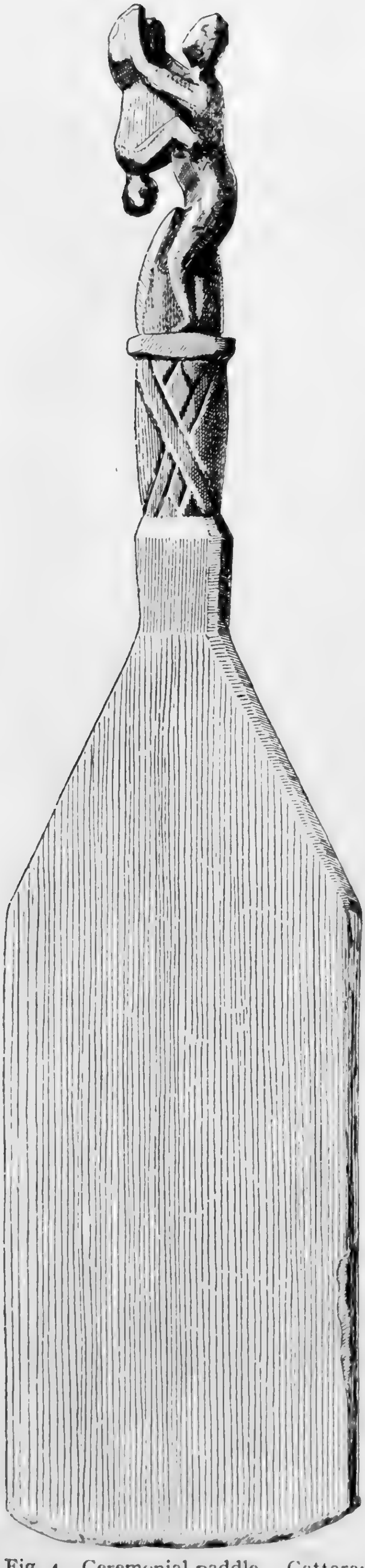


Fig. 4 Ceremonial paddle. Cattaraugus Seneca

world tree, the *scroll* or *helix,* the *sun,* the *circle,* the *horn* and the *serpent* symbols were predominant. In connection with this research has been the study of pictographs and decorative motifs.

At the commencement of our plans for the Governor Myron H. Clark Hall of Iroquois Ethnology, when the costuming of some forty casts of Indians became a problem for consideration, it was found that no description of the Iroquois costume through the various periods existed. It became necessary to make a special study of the subject not only from books but from the Indians themselves. By good fortune many valuable notes were obtained and we may now represent with a degree of accuracy the various costumes of the Iroquois. Some of the existing pictures of Iroquois costumes are erroneous, the peace garments and war costume being represented together.

The dressing of the hair, the face painting and tattooing are other important details that have been studied with enlightening results.

Manuscripts and codes. Among much interesting matter one important manuscript has come into the possession of the division. This is the Dekanawideh code of the Iroquois by Seth Newhouse, a Canadian Mohawk. Mr Newhouse has for twenty years been compiling the manuscript, which treats of the Hiawatha legend and the Iroquois constitution. Horatio Hale, in his "Book of Rites," mentions the constitution but it is believed that it has not heretofore

Plate 2

Group of Six Nations chiefs in their council hall at Ohsweken, Ontario. In governmental policy the Canadian Iroquois still adhere to the old Hiawatha law.

been available in manuscript form. The essential accuracy of the document is attested by a similar manuscript compiled by the chiefs of the Six Nations of Canada, the two being written independently. The codes have been transmitted by word of mouth for generations. The Newhouse version is written in Indian-English and affords a quaint example of the transcription of Indian thought and concept into English, a most difficult thing to do at best as translators agree.

Some additional notes on the Handsome Lake religion were made and also on the various folk cults. The study of signs, omens and charms has been continued.

ARCHEOLOGY

Owing to the pressure of other work it was not possible for the Archeologist to visit the field for archeological work until late in July, when about ten days were spent in examining certain sites in

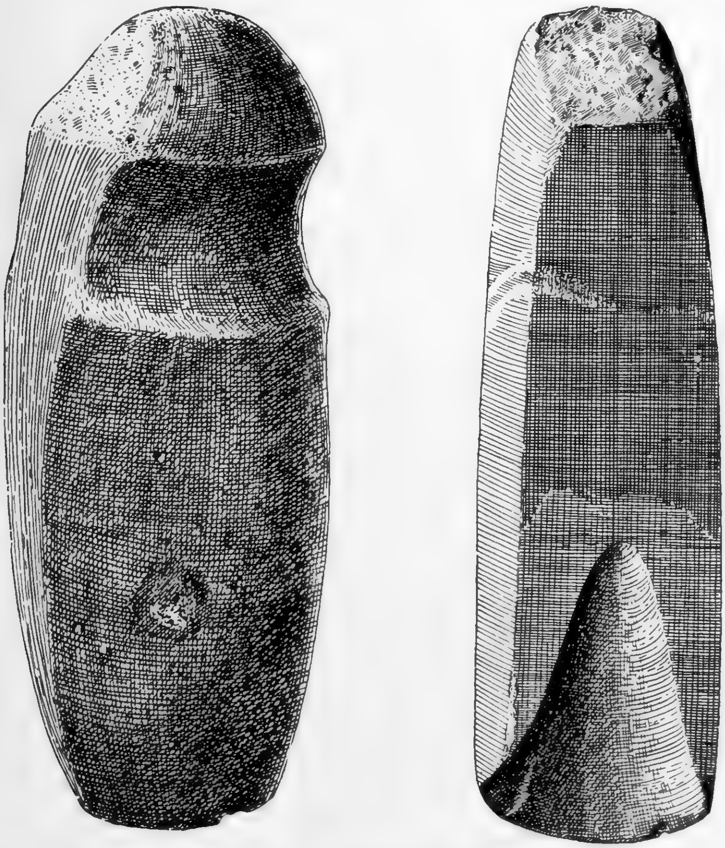


Fig. 5, 6 Grooved axe and gouge from Silver Lake. Three-fifths natural size. Collected by N. T. Clarke

Jefferson and St Lawrence counties. Here ten or more places were visited. Most, if not all, of the described sites known to literature have been destroyed and in some it was not even possible to obtain a potsherd or flint chip. Nearly a week was spent in the vicinity of Black lake, where a thorough survey was made. Two pipes of probably Algonquin origin were obtained here and a wooden spoon from the bottom of the lake near The Cedars. The special assistant in archeology, Mr E. R. Burmaster, made an examination of all the islands in the lake but was unable to find traces of any large camp sites.

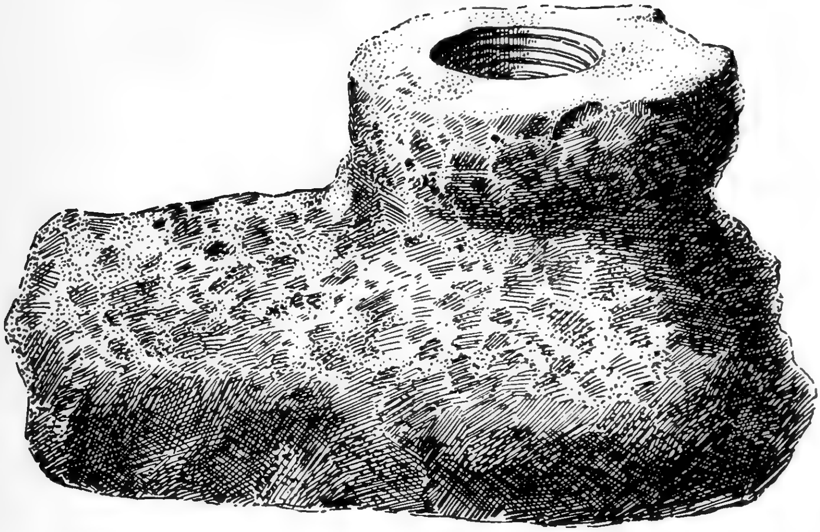
Some of the islands in the St Lawrence were visited, especially several in the vicinity of Hammond. Several sites were there found and a number of articles secured.

No other field work was undertaken until late in August when it was decided to make a reconnaissance of certain portions of the field with the idea of obtaining a better knowledge of localities. Sites near Binghamton, Union, Windsor and Elmira were visited first. Later certain sites near Hammondsport were examined. Most of the time up to October 1st was spent in the Genesee valley.

Fig. 7, 8 Clay pipes from Erie county. One-half size

Several important and productive sites were found and listed for future exploitation. Some of these sites have never been excavated, but preliminary examination revealed skeletons and extensive ash and refuse beds. A site in Erie county with which the Archeologist has been familiar for some time yielded several crushed pots that may easily be restored, several pipes and other material of interest.

Plate 3



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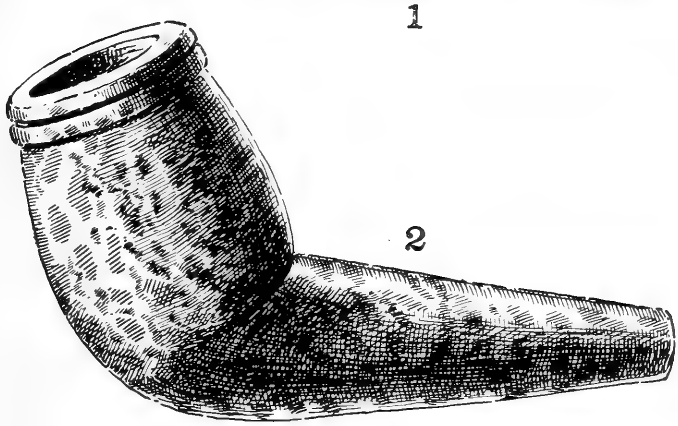

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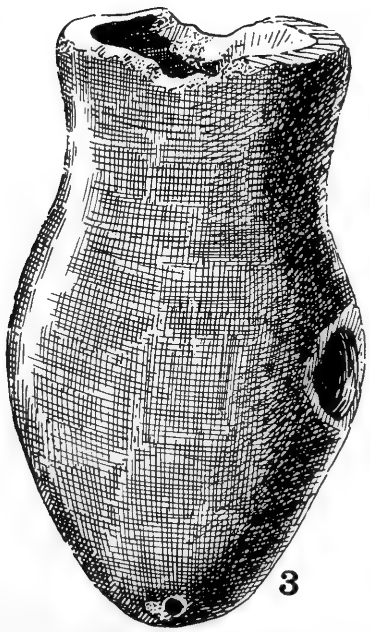

3

Stone pipes collected during 1910. 1 Steatite pipe from Black Lake; 2 Polished steatite pipe from Edwardsville; 3 Flattened vase pipe from Pompey

Plate 4

Early Onondaga site near St Lawrence, Jefferson county. The State Museum has a large number of specimens from this site.

Several small collections of interest have been secured by gift and purchase. Among these is a collection of objects from village sites and graves in the vicinity of Pompey, obtained through Mr D. D. Luther of Naples; a collection of interesting flints, a fine gouge and a grooved axe from Silver Lake and Warsaw, obtained through Mr Noah T. Clarke; and a splendid series of smaller material and fragments from Nichols pond and Cazenovia, collected by Mr E. R. Bradley. These objects are from the ancient Oneida territory, the Nichols pond site being identified by General Clark as the fort stormed unsuccessfully by Champlain in 1615. One French axe was found there by Mr Bradley.

Fig. 9–12 Typical specimens from Nichols pond, Oneida site. This site is very probably the one which Champlain stormed unsuccessfully in 1615. Cuts full size

Archeologic frauds. The awakened interest in the relics of our aborigines and the great scarcity of fine material has led many persons to believe that the manufacture of counterfeit relics will pay. For several years the Archeologist has warned collectors and institutions through this report; to the list of localities where frauds have been discovered he wishes to add that there are pipes from Briar Hill, St Lawrence county, and pipes and inscribed stones from Chautauqua county which are fraudulent.

A curious coincidence has led to the sending to this office of brass medals a little larger than a silver quarter, each counterparts of the other, but from different localities. One was sent from Illinois, one from Schuylerville and one from Lake George. The medals have on one side the head of an Indian and before him a war club, while the reverse has the head of an Indian woman and before her a cradle board. The workmanship of these objects is very modern, perhaps less than fifteen years, but in every case the objects have been excavated from depths and associated with Indian remains. The Lake George specimen, which was the third to come to this office, was sent by courtesy of Mr James A. Holden, treasurer of the New York State Historical Association. It had been sent to him by the finder. The specimen was attached to a brass fob and revealed the character of the specimen. The object is not Indian of course and probably no Indian ever saw one until very recently. The designs and attempts to reproduce Indian objects show a lack of familiarity with such things. The workmanship, however, is not bad and the object used as a watch fob is rather effective. Any information as to the origin of this object will be welcomed by the Archeologist.

Ethnological groups. The attention of the Archeologist has been taken up largely with plans for the ethnological groups which constitute the special feature of the Governor Myron H. Clark Hall of Iroquois Ethnology. The task of securing proper models, especially Indian females who are among the most modest of women, is no light one and calls for a great deal of tact and patience. Since the close of the fiscal year ending September 30, 1909, the Archeologist has secured models from the various Seneca and Canadian reservations and casts have been made in Buffalo and in New York. To secure Cayuga models for the Ceremonial group, the Archeologist visited the Grand River reservation and cast a series of ten typical heads. Mr D. C. Lithgow, an artist, also accompanied him and made color sketches of skin texture and color, besides paintings of heads. He also made drawings and notes on the old Iroquois architecture.

During June and July life casts of six Cayuga Indians and three Oneida Indians were made in New York by Casper Mayer, sculptor. For several models the museum is indebted to Mr. F. E. Moore of Middletown, who permitted the Archeologist to engage them during the interim of the morning and evening productions of his Hiawatha play. This did much to expedite the work and special thanks is due Mr Moore for his kindness.

The Cayuga Ceremony group represents a group of members of the False Face Company and a Cayuga family within a log lodge. The period represented is late in the 18th century. Masks and the mask ceremonies are among the most striking and well-known of Iroquois ceremonies, and the abundance of material in our collections illustrating the mask rituals led to the choice of this specific subject. The Cayugas are and have been noted for their love of ceremony and ritual.

The group of casts which has been made represents a false face doctor blowing ashes through the hair of a woman as a charm against disease. One woman is seated at the rear of the lodge and holds a basket of incense. Another masked figure is seen plunging his hands in the fire for a handful of hot embers which the magic of his mask makes impotent to burn. One masked dancing figure is in the act of asking his fee of tobacco from a boy who stands frightened at one side. A large old Cayuga sits astride the singer's bench and with his turtle shell rattle beats time as he chants the ritual of his cult.

The group will be installed within an actual cabin from one of the reservations.

Of the Oneida industrial group, three figures have been secured. One is of a sleeping child, one of a woman making baskets and one of a man carving a bowl.

The painting of the backgrounds for the groups of Agriculture and Food Preparation and of the Return of the Mohawk Warriors has practically been completed. As described in my report last year, the artist, Mr D. C. Lithgow, accompanied the Archeologist into the field and made oil paintings of the scenes chosen as data for the large cycloramas. These scenes are: first, at the opening of the Genesee river as it emerges from its high banks at Mount Morris and flows northward into the broad valley, with a patch of cultivated corn land in the foreground; and second, a scene overlooking the site of the Mohawk village of Tionontogen near Sprakers in the Mohawk valley. The artist, under the direction of the Archeologist, has reproduced the village and stockade on the canvas in a manner that critics say is most commendable. The backgrounds are not to be regarded, however, as paintings since they are to serve another purpose altogether. The foreground of the groups in which the figures will be placed will be built up to the scenic background so that the picture will really commence with the foreground and present a continuous scene. By employing a special paint which has no gloss whatever and by carefully managing the lights above, it is hoped that the illusion will be as perfect as paint and plaster can make it.

THE MARY JEMISON MONUMENT

On September 19th the Archeologist in an official capacity attended the exercises of the American Scenic and Historic Preservation Society in the unveiling of the Mary Jemison statue at Letchworth Park.

The statue, which is the gift of the lamented William Pryor Letchworth LL.D., to the State of New York, was modeled by Mr Henry K. Bush-Brown of Newburgh and represents Mary Jemison and her baby in Indian costume as they appeared after the 500 mile journey from the Ohio country to the Genesee.

Mary Jemison is known to popular history as "The White Woman of the Genesee" from her long association with the valley of that name. In 1755 when she was a mere child she was captured by a band of Seneca Indians and French adventurers, who, to prevent pursuit, killed the other members of the family except two brothers, Thomas and John, who escaped. Mary was adopted into a Seneca family and upon arriving at a marriageable age was married to She-nin-jee, a Delaware Indian who lived under the jurisdiction of the Senecas. It is the first child of this marriage who is represented on the statue in the cradle board.

Mary Jemison was called by the Seneca, Degiwenes, meaning Two Falling Voices. Most histories copy Seaver's error in orthography, calling her Deh-he-wa-mis. There is no "m" sound in the Seneca tongue.

Mary Jemison lived among the Seneca 78 years and died September 19, 1833, at the advanced age of 91 on the Buffalo creek reservation, where she was buried in the Seneca burying ground. The interesting story of this heroic woman as written by James E. Seaver from dictation by Mary Jemison herself has passed through seven editions and several of these have been issued by Mr. Letchworth.

The encroachments of civilization threatened the destruction of the old burying ground and in order to preserve her remains William

Pryor Letchworth had them removed, on March 7, 1874, at his own expense to his estate, Glen Iris, at the falls of the Genesee. Here he erected a marble monument and surrounded the new resting place with the headstones from a Seneca graveyard which had been used as a culvert by a road contractor. Doctor Letchworth removed the stones, built a new culvert and set these old markers deep in the soil about the grave of Mary Jemison so that the tops project a few inches above the ground.

A lifelong study of Mary Jemison led to Doctor Letchworth's conception of a bronze memorial statue. In its preparation by the sculptor the Archeologist was able to assist by furnishing notes and suggestions as to the costume and other accessories. The artist, however, preferred the long flowing plain type of dress not only as a more graceful garment but as a symbol of the west from which Mary journeyed in her travel to the Genesee.

The statue was unveiled on the 67th anniversary of Mary Jemison's death. A number of prominent people from all parts of the State were present and many representatives of local historical societies attended.

At the appointed hour the meeting was called to order by Hon. Charles M. Dow, chairman of the Letchworth Park committee of the American Scenic and Historic Society. Prayer was offered by Rev. L. A. Pierson of Castile. Mr Dow gave an address in which he gave a history of the park and its gift to the State by Doctor Letchworth.

George F. Kunz Ph.D. D. Sc., president of the Society, in a masterful address, spoke of the duty of preserving the picturesque places of our country. He mentioned the State's work at Watkins Glen, Niagara Falls, Stony Point and the Hudson River palisades. Glen Iris or Letchworth Park, he said, was one of the most beautiful spots in New York State. He expressed the appreciation of the people for its gift to them, and assured Doctor Letchworth that the society which he represented would prove faithful to its trust.

Doctor Letchworth responded in a short address, in which he expressed his satisfaction for the hearty interest of all concerned. He handed to Secretary E. Hagaman Hall a letter, in which he conveyed the statue to the State.

The Archeologist, who had been invited by Doctor Letchworth and the American Scenic and Historical Preservation Society to assist in the unveiling, was introduced by Secretary E. H. Hall and asked to give a short address, which follows:

Ladies and Gentlemen: In considering the position of an Indian woman in her tribe, most of us are, no doubt, influenced by the conventional schoolbook description which, I assure you, is most misleading as applied to the Iroquois. Lest you pity her too much and pity the condition of a captive white woman, permit me first to say that embodied in the constitution of the Confederacy of the Five Nations we find recorded in most emphatic language a recognition of the nobility of womanhood. Those sterling qualities that under stress bring out the wonderful moral courage of woman never received greater appreciation than that given by the Iroquois Indian.

Though as a cosharer in the burdens of life, woman labored in lodge and in field, through her council speaker her voice rang out with authority in the Confederate senate, and no warrior, no chief, no sachem, ever rose to so high a position that he could disregard it with impunity. Man might be the hunter, the forester, the warrior, the statesman, but woman was the bulwark and foundation of Iroquois society and government. As the court of the last resort in all important matters she was man's political superior.

Such was the position of woman in the aboriginal Empire State.

During the tragic events of a border conflict in which the Iroquois found himself plunged, face to face, he struggled with a powerful invader whose unfamiliar agencies of offence he could only match with his own desperate devices; snatched from her parents, there came to the Seneca-Iroquois a little captive white girl. Startled and crushed at first, she splendidly rallied. Among them she grew to maidenhood and, as the wife of an Indian, to motherhood. Singularly tried by circumstances she remained ever a woman whose pure impulses, never sullied, were ever directed to justice and charity. Her life was a leavening influence to the people of her adoption and its nobility excited their admiration and reverence.

Worthy of marble and bronze is the White Woman of the Genesee! Worthy is she because of the fortitude, the patience, the tender sympathy, the motherly devotion which she ever exhibited even in the most trying circumstances. Her wonderful moral courage, her modesty, her heroism and her gentle heart compel our appreciation and reverence.

It is with such emotions that Mrs Kennedy (Gawennois), a descendant of Mary Jemison of the fourth generation, and Miss Carolina Bennet (Gaoyowas), of the sixth generation, and I, a descendant of the people among whom she dwelt, unveil to you this bronze statue of Mary Jemison, known to the Seneca Indians as Degiwenes of the Heron clan.

Amidst these scenes so near those of her life, her sorrows and her smiles, she gazes forth into the beautiful valley.

A legend of old tells that the Sun God in passing over this spot always paused to view these wondrous falls, to watch the play of the rainbow and to inspect the mighty seam in the rock. Who knows but that, as the ancient story tells, the Sun Spirit lingers again with us in this rare spot to look upon this fitting tribute of an appreciative heart to a noble woman, Mary Jemison, the White Captive of the Genesee!

The monument was then unveiled.

Assisting with the Archeologist in the unveiling was Mrs Thomas Kennedy, daughter of "Buffalo" Tom Jemison, the grandson of the child represented on the back of the statue, and Miss Carolina Bennet, a descendant of Mary Jemison of the sixth generation and granddaughter of the celebrated runner, Deerfoot.

The statue was draped with the American flag, which entirely concealed it. The cords were arranged at each side so that when lifted the flag rose like a butterfly above the beautiful bronze image. The people arose to their feet amidst great applause. The wonderful majesty of the girlish figure arrayed in Indian garb, her sweet Scotch-Irish face showing in every line a story of her struggle to carry her babe and herself on foot through the narrow forest paths, impressed every one. The sculptor had interpreted his subject in a sympathetic, masterful way. The figure is about nine feet high.

Charles D. Vail LL.D., of Geneva, a trustee of the Scenic Society, spoke of the value of art in preserving the great traditions of history and expressed his appreciation of Doctor Letchworth's work. Professor Vail read a letter from the sculptor, Mr Bush-Brown, describing the ideal which he had endeavored to embody in the statue.

Prof. Liberty H. Bailey of Cornell University and a trustee of the Society spoke on the outdoor ideal and paid a tribute to Doctor Letchworth's love of the beautiful in nature.

Mr James N. Johnson, the "dean poet" of Buffalo, made a few extemporaneous remarks in which he said that more poetry had been written of Glen Iris than any other spot in America, "but then," he said, "it is easy to write poetry about Glen Iris."

Rev. H. A. Dudley of Warsaw, who had once seen Mary Jemison as she passed through the Genesee valley in 1831, said that it was as a school boy that he saw her. He had a bundle of books under his arm and was passing down the road when he saw a wagon, driven by Indians, halt. Peering over the back he saw within an aged woman lying on a mattress. The woman who was

Mary Jemison looked up and greeted him pleasantly. "Where are you going?" she asked in English; "To school," he answered lifting up his books. "That is right," she answered, "learn all you can and be a good boy." Mary Jemison was at that time 89 years of age.

In the Albany *Knickerbocker-Press* of September 25th, the following description of the closing ceremonies appeared:

Perhaps the most interesting part of the unveiling was that which only a dozen persons saw.

When the crowd had dispersed Mr Parker called a chosen few together to participate in the Indian dedicatory rite. Mr J. N. Johnson, the Irish poet and an Irishman from Mary Jemison's parents' country; Miss Bishop, the secretary to Mr Letchworth, with Miss Howland, his niece; Mrs Kennedy and Miss Bennet, the two Indian descendants of Mary Jemison, and Mr Parker, gathered about the grave, which lies at the foot of the statue. Miss Bennet shelled from the cob four handfuls of native-grown Indian corn, scattering each handful as she shelled it upon the grave as a symbol of immortality. Mrs Kennedy, as an older descendant, gave a short address in the Seneca tongue. She then asked Mr Parker to light the grave fire and give the Ha-yaut-wat-gus offering. Mr Parker did so, lighting the fire from four sides, and repeating the ancient graveside rite of the Senecas. As the smoke arose to the sunny sky, Mrs Kennedy led away the company, whom she asked to look back once to see the still ascending smoke.

Mr Parker has promised to explain the symbolism of this strange old ceremony in a report to the Letchworth Park committee. It was indeed a most impressive rite, and one not seen for many years, now being known only to the Canadian Iroquois.

The monument was dedicated on September 19th, just sixty-seven years after Mary Jemison's death.

Letchworth Park lies on both sides of the Genesee river, fifty miles south of Rochester, and embraces the three falls of the Genesee. As a spot of great natural beauty, it rivals Watkins Glen and is visited by hundreds of excursionists each month.

In order to preserve this region from the ravages of commercial interests and conserve the park, Mr Letchworth in 1906 deeded it to the State. It is still his property, but nominally under the jurisdiction of the American Scenic and Historic Preservation Society.

A crude scar, as despoiled by lumbermen, Mr Letchworth has spent a lifetime in beautifying it.

The statue of Mary Jemison is his latest effort to beautify and add interest to it. The old Caneadea Indian council house stands on one side, her daughter's log cabin on the other, and Mary Jemison in bronze gazes forth into the future which none of us may know.

VII

PUBLICATIONS

A list of the scientific publications issued during the year 1909–10, with those now in press and treatises ready for printing, is attached hereto. The publications issued cover the whole range of our scientific activities. They embrace 2051 pages of text, 286 plates and 17 maps.

The labor of preparing this matter, verifying, editing and correcting is onerous and exacting. Taken altogether, it excellently indicates the activity and diligence of the staff of this division.

ANNUAL REPORT

1 Sixth Report of the Director, State Geologist and Paleontologist for the fiscal year ending September 30, 1909. 230p. 41pl. 2 maps. 4 charts.

Contents:

MEMOIRS

2 No. 12 Birds of New York, volume 1. By E. Howard Eaton. Introductory chapters: local lists, water birds and game birds. 501p. 42 colored plates.

Contents:

3 No. 13 Calcites of New York. By H. P. Whitlock. 190p. 27pl.

Contents:

BULLETINS

Geology

4 No. 135 Geology of the Port Leyden Quadrangle, Lewis County, N. Y. By W. J. Miller. 62p. 11pl. map.

Contents:

5 No. 137 Geology of the Auburn-Genoa Quadrangles. By D. D. Luther. 36p. map.

Contents:

6 No. 138 Geology of the Elizabethtown and Port Henry Quadrangles. By J. F. Kemp and Rudolf Ruedemann. 176p. 20pl. 3 maps.

Contents:

7 No. 142 The Mining and Quarry Industry of New York State. By D. H. Newland. 98p.

Contents:

8 No. 143 Gypsum Deposits of New York. By D. H. Newland and Henry Leighton. 94p. 20pl. 4 maps.

Contents:

9 No. 145 Geology of the Thousand Islands Region. By H. P. Cushing, H. L. Fairchild, Rudolf Ruedemann and C. H. Smyth, Jr. 1949. 62p. 6 (5 colored) maps.

Contents:

Entomology

10 No. 136 Control of Flies and Other Household Insects. By Ephraim Porter Felt D.Sc. 56p.

Contents:

11 No. 141 Report of the State Entomologist for the fiscal year ending September 30, 1909. 116p. 10pl.

Contents:

Botany

12 No. 139 Report of the State Botanist for the fiscal year ending September 30, 1909. 116p. 10pl.

Contents:

Archeology

13 No. 144 Iroquois Uses of Maize and Other Food Plants. By Arthur C. Parker. 120p. 31pl.

Contents:

GEOLOGIC MAPS

14 Port Leyden Quadrangle
15 Auburn-Genoa Quadrangles
16 Elizabethtown-Port Henry Quadrangles

In press

MEMOIRS

17 Birds of New York, volume 2
18 Eurypterida of New York

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Geology

19 Geology of New York City (Catskill) Aqueduct
20 Geology of the Poughkeepsie Quadrangle
21 Geology of the Honeoye-Wayland Quadrangles

Entomology

22 Report of the State Entomologist for the fiscal year ending September 30, 1910

Botany

23 Report of the State Botanist for the fiscal year ending September 30, 1910

VIII

STAFF OF THE SCIENCE DIVISION AND STATE MUSEUM

The members of the staff, permanent and temporary, of this division as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
Jacob Van Deloo, Director's clerk

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
David H. Newland, Assistant State Geologist
Rudolf Ruedemann, Assistant State Paleontologist
C. A. Hartnagel, Assistant in geology
Robert W. Jones, Assistant in economic geology
D. Dana Luther, Field Geologist
Herbert P. Whitlock C. E., Mineralogist
George S. Barkentin, Draftsman
Joseph Morje, First clerk
H. C. Wardell, Preparator
Dudley B. Mattice, Stenographer
Martin Sheehy, Machinist
Joseph Bylancik, Page

TEMPORARY ASSISTANTS

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. J. F. Kemp, Columbia University
Dr C. P. Berkey, Columbia University
Dr Arthur Hollick, Bronx Garden
G. H. Hudson, Plattsburg State Normal School
Prof. W. J. Miller, Hamilton College
Burton W. Clark, Washington, D. C.

Geographic geology

Prof. Herman L. Fairchild, Rochester University
Prof. Albert P. Brigham, Colgate University

Paleontology

Edwin Kirk, Washington, D. C.

BOTANY

Charles H. Peck, M. A., State Botanist
Stewart H. Burnham, Assistant, Glens Falls

ENTOMOLOGY

Ephraim P. Felt, B. S. D.Sc., State Entomologist
D. B. Young, Assistant State Entomologist
Fanny T. Hartman, Assistant
Anna M. Tolhurst, Stenographer
J. Shafer Bartlett, Clerk

ZOOLOGY

Willard G. Van Name, Ph.D., Zoologist
Arthur Paladin, Taxidermist

Temporary assistants

Prof. E. Howard Eaton, Canandaigua
Dr H. A. Pilsbry, Philadelphia

ARCHEOLOGY

Arthur C. Parker, Archeologist

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Limonite ore, Ancram 5
Slabs of brecciated limestone, Hudson 2

Block of augen-gneiss, Bedford........ 1
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Iron carbonate, Greendale 4

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Crinoids from Portage formation near Laona and Griswolds 23
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Frankfort shale fossils from gully two miles east of Rotterdam Junction 40
Frankfort shale fossils from near Delanson 50

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MINERALOGY

Donation

D. H. Newland, Albany
- Native lead, Langban, Sweden 2
- Melanotekite, Langban, Sweden 1
- Gadolinite, Iveland, Norway 1
- Rutile and albite, Gjorestad, Norway 1
- Rutile, Gjorestad, Norway 5
- Pinakiolite, Langban, Sweden 1
- Uraninite (Bröggerite), Sätersdalen, Norway 1
- Manganophyllite, Langban, Sweden 1
- Thorite, Arendal, Norway 1
- Aeschynite, Iveland, Norway 1
- Apatite, Gellivare, Sweden 4
- Euxenite, Iveland, Norway 1
- Columbite, Iveland, Norway 1
- Monazite, Risör, Norway 1

R. W. Jones, Albany
- Copper and malachite, Elco co., Nevada 1
- Pyrite, Boulder co., Colorado 1

H. P. Whitlock, Albany
- Microcline, Niantic, R. I. 5
- Albite, Niantic, R. I. 4
- Muscovite in microcline, Niantic, R. I. 3

Beers, Charles H. New York city
- Calamine (cut), Chihuahua, Mexico 1

Manchester, J. G. New York city
- Autunite on cyrtolite, Bedford 1

Kelly, F. W. Albany
- Calcite (stalactite), Howes Cave 1

Blumenthall, M. Lockport
- Sphalerite, Lockport 1
- Celestite, Lockport 1
- Calcite and dolomite, Lockport 1
- Gypsum, Lockport 2

Hulett, W. H. East Greenbush
- Pyrite crystals, Bloomingrove, Rensselaer co. 17

Wallace, J. J. Gouverneur
- Pyrite in talc, Fowler 2

Exchange

University of Toronto Museum, Toronto, Canada
- Sodalite, Sodalite Creek, B. C. 1
- Wernerite, Cardiff Township, Ont. 1
- Pentlandite, Vermillion Mine, Sudbury, Ont. 1
- Niccolite, Cobalt, Ontario 1
- Smaltite, Cobalt, Ontario 1
- Native silver, Cobalt, Ontario 1

Native bismuth, Cobalt, Ontario 1
Ulexite on gypsum, Wentworth, N. S. 1
Howlite, Wentworth, N. S. 2
Chalcocite, Tatamagauche, N. S. 3
Corundum, Salem, India 4
Pyromorphite, Moyie, B. C. 1
Erythrite, Creston, B. C. 1
Native gold, Larder Lake, Ont. 1
Analcite, Two Islands, N. S. 1
Chabazite, Two Islands, N. S. 1
Barite, Five Islands, N. S. 1
Kermesite and stibnite, West Gore, N. S. 1
Native antimony, West Gore, N. S. 1

Purchase

Beers, Charles H. New York city
Calamine, Chihuahua, Mexico 10
Calamine (cut), Chihuahua, Mexico 6
Malachite and chrysocolla, Chihuahua, Mexico 5
Malachite and chrysocolla (cut), Chihuahua, Mexico 2
Malachite, Chihuahua, Mexico 5
Quartz (cut), Chihuahua, Mexico 3
Obsidian, Chihuahua, Mexico 1
Obsidian (cut), Chihuahua, Mexico 1

Jones, Ch. H. New York city
Calcite, Kelly Island, Ohio 18
Calcite (loose crystals), Kelly Island, Ohio 23
Calcite, Tiffin, Ohio 1
Calcite, Genoa, Ohio 1

Krantz, F. Bonn, Germany
Model of Cullinan diamond (glass) 1
Models of Cullinan diamond cuttings (glass) 9

Schmidt, A. A. Albany
Sphalerite (polished), loc.? 1
Quartz (agate), (polished), loc.? 2

Collection

Whitlock, H. P. Albany
Tourmalin in quartz, New York city 2
Pyrite in dolomite, New York city 2
Muscovite in pegmatite, New York city 9
Pyrolusite (dendrite) on microcline, Bedford 3
Autunite on cyrtolite, Bedford 3
Cyrtolite, Bedford 2
Quartz (rose), Bedford 8
Quartz (rose), cut 2
Microcline (crystals), Bedford 18
Microcline crystals in quartz, Bedford 10
Beryl, Bedford 16
Quartz in microcline, Bedford 1
Tourmalin in quartz, Bedford 1

Calcite, Becraft Mt.	6
Calcite, Greendale	15
Luther, D. D.	
Barite (concretions), Silver Creek	81
	356

ENTOMOLOGY

Donation

Hymenoptera

Stillwell, S. W. Charlotteville. Thalessa atrata Fabr., black long sting, adult on maple, June 13

Kampfer, A. L. Albany. Thalessa lunator Fabr., lunate long sting, adult, July 23

Latham, Roy. Orient Point. Aulacidea tumidus Bass., gall on Lactuca, August 30

Dodge, J. H. Rochester. Through State Department of Agriculture. Neuroterus batatus Fitch, galls on white oak, July 8

Lackey, Andrew. Johnsburg. Lophyrus abbotii Leach, Abbott's sawfly, larvae on pine, August 3

Wilson, J. W. Olmstedville. Same as preceding

Cox, Townsend, Jr. Setauket. Lophyrus ? lecontei Fitch, Leconte's pine sawfly, larvae on pine, October 20

Post, H. S. Albany. Trichiocampus viminalis Fall., poplar sawfly on poplar, August 29

Rose, L. A. Rensselaer. Eriocampoides limacina Retz., cherry and pear slug, larvae on cherry, August 22

Dodge, J. H. Rochester. Through State Department of Agriculture. Harpiphorus tarsatus Say, sawfly, larvae on Cornus mascula, September 15

Rinkle, L. F. Boonville. Harpiphorus versicolor Nort., sawfly, larvae on Cornus alternifolium, September 18

Coleoptera

Lohrmann, Richard. Herkimer. Entimus imperialis Först., diamond beetle, adult, May 7

Schaefer, P. A. Allentown, Pa. Calandra granaria Linn., granary weevil, adults in grain bins, December 27

Frey, S. L. Palatine Bridge. Magdalis? barbita Say, black elm snout beetle, grubs on elm, March 18

Dorrance, Benjamin. Dorranceton, Pa. Through Hermann Von Schrenk. Pissodes strobi Peck, white pine weevil, larvae on pine, July 13

Von Schrenk, Hermann. Southern California. Phloeodes diabolicus Lec., adult on Polyporus growing on Eucalyptus, March 20

Fitch, F. A. Randolph. Bruchus obtectus Say, bean weevil, adults, March 21

Clarke, Miss L. E. Canandaigua, Haltica ignita Ill., strawberry flea beetle, adults on Virginia creeper, August 3

Clark, F. T. Ticonderoga. Galerucella luteola Müll., elm leaf beetle, larvae and pupae on elm, July 19

Foulk, Theodore, Flushing. Through State Department of Agriculture. Melasoma scripta Fabr., cottonwood leaf beetle on poplar, September 7

Lynch, Mrs J. DeP. Barneveld. Centrodera decolorata Harr., adults on locust, October 18

Brown, H. T. Rochester. Desmocerus palliatus Forst., cloaked knotty horn, adults on elder, June 6

Payne, W. A. Bronxville. Elaphidion villosum Fabr., maple and oak twig pruner, work on oak, July 31

Ellison, Burton. Poughkeepsie. Prionus laticollis Dru., broad-necked Prionus, adult, July 18

Marshall, D. T. Hollis. Xyloryctes satyrus Fabr., rhinoceros beetle, August 1

Keating, J. D. Fort Edward. Euphoria inda Linn., bumble flower beetle, adult, September 6

Gillett, J. R. Kingston. Cotalpa lanigera Linn., goldsmith beetle, adult, April 15

Joutel, L. H. Europe. Thanasimus rufipes Brahm., adult, July 29

Filer, H. B. Buffalo. Podabrus rugosulus Lec., adults, June 16

Minturn, Purley. Locke. Agriotes mancus Say, wheat wireworm, larvae injuring oats, May 20

Diptera

Reist, Mrs H. G. Schenectady. Calliphora viridescens Desv., larvae, July 30

Dick, H. E. A. Rochester. Bombyliomyia abrupta Wied., adult, July 26

Hodges, G. C. New Hartford. Rhyphus fenestralis Scop., adults, April 24

Lohrmann, Richard. Herkimer. Bibio xanthopus Wied., adult May 18

Johnson, Fred. North East, Pa. Contarinia johnsoni Sling., grape blossom midge, adult, May 28

Stene, A. E. Kingston, R. I. Monarthropalpus buxi Lab., pupa on box, May 19

Kieffer, J. J. Bitsch, Germany. Joanissia aurantiaca Kieff., Aprionus miki Kieff., A. pinicola Kieff. MS., Monardia stirpium Kieff., Bryomyia bergrothi Kieff., Miastor cerasi Kieff. MS., Brachyneura squamigera Winn., Winnertzia fusca Kieff. MS., W. pinicola Kieff. MS., Colomyia clavata Kieff., Colpodia anomala Kieff., Dicerura scirpicola Kieff., Porricondyla venustus Winn., Camptomyia ? binotata Kieff., C. nigricornis Kieff., Holoneurus pilosus Kieff. MS., Lasioptera rubi Heeg., Baldratia salicorniae Kieff., Stefaniella atriplicis Kieff., Trotteria sarothamni Kieff., Rhizomyia silvicola Kieff., Cystiphora taraxaci Kieff., Macrolabis stellariae Kieff., Arnoldia castanea Kieff. MS., A. sambuci Kieff., A. cerris Koll, Lasiopteryx (Ledomyia) divisa Kieff., L. (Ledomyia) lugens Kieff., Dasyneura sisymbrii Schrnk., D. urticae Perris, Rhabdophaga karschii Kieff., R. pierrei Kieff., Mikiola fagi Hart., Psectrosema tamaricis Stef., Schizomyia galiorum Kieff., Zeuxidiplosis giardiana Kieff., Stenodiplosis geniculati Reut., Thecodiplosis brachyntera Schw., Bremia longipes Kieff., B. ramosa Kieff., Aphidoletes urticariae Kieff., Massalongia rubra Kieff., Hormomyia cornifex Kieff., Monarthropalpus buxi Lab., Pseudhormomyia granifex Kieff., Xylodiplosis aestivalis Kieff., X. nigritarsis Zett., Putoniella marsupialis F. Lw., Endaphis perfidus Kieff., Macrodiplosis volvens Kieff., Clinodiplosis galliperda F. Lw. Especially valuable because a number are cotypes

Lepidoptera

Carriere, Mrs. Albany. Sphecodina abbotii Sm. & Abb., Abbott's sphinx, larva on woodbine, July 13

State Department of Agriculture. Rochester. Saturnia pavonia Linn., Emperor moth, cocoon on French nursery stock, January 31

Griffith, L. C. Through State Department of Agriculture. Anisota senatoria Sm. & Abb., larvae on oak, September 9

Lackey, Andrew. Johnsburg. Basilona imperialis Dru. Imperial moth, larvae on pine, August 18

Adams, L. H. Johnstown. Through State Department of Agriculture. Ctenucha virginica Charp., larvae on pine and gooseberry

Griffith, L. C. Lynbrook. Through State Department of Agriculture. Halisidota caryae Harr., hickory tussock moth, larvae on maple, July 11

Hotaling, William. Kinderhook. Arsilonche albovenosa Goeze, larva, September 27

Anderson, Alex. Stonyford. Xylina antennata Walk., green fruit worm, larvae on maple, June 16

State Department of Agriculture. Geneva. Same as preceding, larvae on apple, June 28

Gordinier, H. W. Troy. Notolophus antiqua Linn., rusty tussock moth, eggs, March 9

Vaughan, H. E. Ogdensburg. Same as preceding, caterpillars on elm, June 18

Griffith, L. C. Lynbrook. Through State Department of Agriculture. Datana integerrima? G. & R., larvae, July 11

Perry, C. C. Eagle Bridge. Schizura concinna Sm. & Abb., red-humped apple caterpillar, larvae on apple, September 10

Capron, Louis. Menands. Synchlora viridipallens Hulst., adult, August 4

Griffith, L. C. Sag Harbor. Through State Department of Agriculture. Cingilia catenaria Dru., chain-spotted geometer, larvae on sweet fern, bayberry, August 2

Thomson, Edward. Frost Valley, Denning. Ennomos subsignarius Hübn., snow-white linden moth, eggs on maple, March 28

Ayer, J. C. Glen Cove. Same as preceding, adult, July 22

Bullis, W. A. West Sand Lake. Phobetron pithecium. Sm. & Abb., hag moth caterpillar, larva, September 13

Newell, H. I. Richmond Hill. Zeuzera pyrina Linn., leopard moth, pupae, July 1

Beam, T. J. Port Chester. Through State Department of Agriculture. Same as preceding, exuviae on maple, July 5

Serins, E. G. South River, N. J. Through Country Gentleman. Same as preceding, larvae on apple, September 17

Dodge, J. D. Rochester. Hyponomeuta malinella Zell., ermine moth, larvae on imported French apple stock, June 24

Barden, J. J. Orleans. Same as preceding, larvae on apple, June 27

Ham, R. H. Niverville. Ancylis nubeculana Clem., larvae on apple, September 1

Harris, S. G. Tarrytown. Dichomeris marginellus Fabr., Juniper webworm, larvae on juniper, February 28

Rhind, L. D. Plandome. Through State Department of Agriculture. Same as preceding, larvae on Irish juniper, April 26

Hammond, Benjamin. Fishkill. Aspidisca splendoriferella Clem., resplendent shield bearer, winter cases, March 24

Hemiptera

Collins, J. D. Utica. Belostoma americanum Leidy, giant waterbug or electric light bug, adult attached to a fish, May 4

Cook, D. H. Altamont. Brochymena quadripustulata Fabr., adult, July 15

Thorne, W. P. Lagrangeville. Same as preceding, nymphs, August 26

Wheeler, Fred. Mongaup Valley. Through State Department of Agriculture. Blissus leucopterus Say, chinch bug, nymphs on corn, August 5

Lee, V. P. D. Altamont. Haematopinus piliferus Burm., sucking dog louse, adult on dog, January 8

Webber, Mrs C. F. Athens. Ormenis pruinosa Say, lightning leaf hopper on matrimony vine, August 26. Also Aleyrodes vaporariorum Westw., white fly on coleus, August 26

Briggs, F. F. Pocantico Hills. Chermes abietis Linn., spruce gall aphis, galls on spruce, June 23

Harris, S. G. Tarrytown. Same as preceding, adults on spruce, June 26

Foulk, Theodore. Flushing. Same as preceding, galls on spruce, October 12

State Department of Agriculture. White Plains. Chermes cooleyi Gill., galls on Colorado blue spruce, August 4

Richardson, M. Y. New York city. Chermes pinicorticis Fitch, pine bark aphid, adults on pine, May 12

Goldenmark, Miss Pauline. New York city. Same as preceding, eggs, February 12

State Department of Agriculture. Rochester. Chermes piceae Ratz., adults and eggs on Nordmann's fir, May 17

Patch, Miss Edith M. Orono, Me. Chermes pinifoliae Fitch, pine leaf aphid, adult on black spruce, January 29. Also C. consolidatus Patch, adults on larch; C. floccus Patch, adult on black spruce; C. lariciatus Patch, adults on white spruce, January 29

Wood, G. C. Barneveld. Pemphigus imbricator Fitch, beech blight, nymph on beech, August 31

Knapp A. P. Hillsdale, N. J. Through *Country Gentleman.* Pemphigus tessellata Fitch, woolly maple leaf aphid, adults on maple, June 16

Seymour, Miss May. Lake Placid. Same as preceding, eggs, June 20

Boren, R. M. Ballston Lake. Schizoneura americana Riley, woolly elm leaf aphid, adults on elm, June 5

Judson, W. P. Broadalbin. Same as preceding, adults and young on elm, June 10

Vaughan, H. E. Ogdensburg. Same as preceding, adults on elm, June 18

Ashley, C. S. Old Chatham. Schizoneura lanigera Hausm., woolly apple aphis, nymph on apple, November 9

Niles, Mrs S. H. Coeymans. Same as preceding

Rose, J. F. South Byron. Same as preceding, November 10

Bell & Smith. Castleton. Same as preceding, November 13

Woolworth, C. C. Castleton. Same as preceding

Peck, C. H. Lake Placid. Lachnus abietis Fitch, on balsam, September 8

Dunbar, John. Rochester. Psylla pyricola Forst., pear psylla, adults on pear, September 20

Smith, H. B. Nashville, Tenn. Through *Garden Magazine,* Doubleday, Page & Co., Pachypsylla celtidis-gemma Riley, hackberry nodule gall, galls on hackberry, February 16

Peterson, O. W. Fairfield county, Conn. Through *Country Gentleman.* Eulecanium tulipiferae Cook, tulip tree scale on tulip, August 31

State Department of Agriculture. Asterolecanium pustulans Ckll., golden oak scale, adults on oak, May 16

Foulk, Theodore. Flushing. Through State Department of Agriculture. Asterolecanium variolosum Ratz., on oak, September 7

Beresford, Archibald. Mt Vernon. Phenacoccus acericola King, false cottony maple scale, young, January 21

Fisher, Mrs Alice G. Batavia. Same as preceding, eggs on maple, July 18

Dudley, Miss Fanny. Newburgh. Same as preceding, females and young on maple, October 4

Olsen, C. E. Winfield. Pseudococcus longispinus Targ., mealy bug, February 24

Country Gentleman. Albany. Same as preceding, larvae on coleus, August 30

Morley, G. W. Haverstraw. Through State Department of Agriculture. Pulvinaria vitis Linn., cottony maple scale, females and young on maple, July 26

Cockerell, T. D. A. Boulder, Col. Pulvinaria occidentalis subalpina Ckll., immature, August 31

Bard, R. H. C. Syracuse. Through State Department of Agriculture. Gossyparia spuria Mod., elm bark louse on elm, July 9

State Department of Agriculture. Brooklyn. Eriococcus azaliae Comst., on azalea, November

Huested, P. L. Kingston. Aulacaspis pentagona Targ., West Indian peach scale, adult on Japanese flowering cherry, January

State Department of Agriculture. Same as preceding, adult on Japanese cherries, February 3

Woolworth, C. C. Castleton. Aulacaspis rosae Bouché, rose scale on rose, November 13

Woodford, L. L. Pompey. Same as preceding, adults on rose, April 29

Landreth, W. B. Schenectady. Chionaspis americana John., elm scurfy scale, crawling young, May 10

Hechler, C. H. Roslyn. Chionaspis euonymi Comst., euonymus scale, eggs on ? Euonymus, May 19

State Department of Agriculture. Long Island. Fiorinia fioriniae var. japonica Kuw., adults on Japanese hemlock, June 9

Orthoptera

Ashley, N. Old Chatham. Chortophaga viridifasciata DeG., green-striped grasshopper, nymphs, March 26

Exchange

Bezzi, Mario. Torino, Italy. Galls of Cystiphorasonchi F. Lw., Dryomyia circinans Gir., D. lichtensteinii F. Lw., Dasyneura sisymbrii Schrnk., Perrisia[1] sp., P. alpina F. Lw., P. capitigena Br., P. crataegi Winn., P. ericina F. Lw., P. fraxini Kieff., P. oenophila Haimh., P. pustulans Rubs., P. rosarum Hdy., P. salicariae Kieff., P. ulmariae Br., Rhabdophaga rosaria H. Lw., Mikiola fagi Hart., Rhopalomyia artemisiae Bouché, Oligotrophus sp., O. capreae Winn., O. corni Gir., O. reaumurianus F. Lw., O. solmsii Kieff., O. taxi Inchb., Mayetiola poae Bosc., Asphondylia sp., A. sarothamni H. Lw., Schizomyia pimpinellae F. Lw., Harmandia petioli Kieff., H. tremulae Winn., Clinodiplosis vaccinii Kieff.

ZOOLOGY

Donation

Mammals

Corbin, Austin, President. Blue Mountain Forest Association. Buffalo, calf, Bison bison (Linnaeus), skin.................... 1

Klein, A. J. Albany. New York weasel, Plutorius noveboracensis (Emmons) skins 2

[1] A synonym for Dasyneura.

Latimer, G. S. Masonville. Black squirrel, Sciurus carolinensis leucotis (Gapper) skin 1
Peck, Dr Chas. H. Albany. Little brown bat, Myotis lucifugus (Le Conte) skin 1

Birds

McKinley, J. D. Loudonville. Holboell grebe, Colymbus holboelli (Reinhardt) skin 1

Reptiles

Burmaster, E. R. Irving. Puffing adder, Heterodon platyrhinos Latreille, spec. 1

Amphibians

McCann, Mrs. Albany. Tiger salamander, Ambystoma tigrinum (Green), spec. 1

Fishes

Bean, Dr T. H. Albany. Steelhead trout, Salmo gairdneri Richardson, spec. 1

Purchase

Mammals

Paladin, Arthur. Albany. Gray fox, Urocyon cinereoargentatus (Schreber), spec. 2
Prest, F. L. Grosse Isle, Magdalen Islands.
Harbor seal, Phoca vitulina (Linnaeus), skin 1

Birds

Gowie, Mr. Albany. Screech owl, Otus asio (Linnaeus), skins. 5

Casts of reptiles

Ward's Natural Science Establishment. Rochester.
Brown snake, Storeria occipitomaculata (Storer) .. 1
Garter snake, Thamnophis sirtalis sirtalis (Linnaeus). 1
Blue-tailed lizard, Eumeces fasciatus (Linnaeus) 1
Leather turtle, Amyda mutica (Le Sueur) 1
Soft-shelled turtle, Aspidonectes spinifer (Le Sueur) .. 1

Casts of amphibians

Mud puppy, Necturus maculosus Rafinesque 1
Hellbender, Cryptobranchus alleganiensis (Daudin) .. 1
Spadefoot toad, Scaphiopus holbrooki, Harlan 1

Mollusks

Marvin, Dwight. Greenwich. The Ingalls collection of shells. These have not been fully sorted or cataloged; an estimate of their number left by Mr Ward is as follows:

Gastropoda	3500	
Pelecypoda	5000	
Pulmonata	15500	
Total	24000	24000
		24025

ARCHEOLOGY

Excavation

By **A. C. Parker and E. R. Burmaster**

Golah, Monroe county	
Arrowheads	51
Flint drills	2
Pipe bowl fragment	1
Bone awl	1
Brant, Erie county	
Hammer stones	5
Arrowheads	81
Stone metate	1
Pipe, terra cotta	1
Clay pots, crushed	2
Clay pots, nearly entire	2
Stone celts	7
Flint knives	2
Serrated slate arrowhead	1
Brass arrowheads	8
Brass kettle bail	1
Bone tubes	40
Bone tubes (human leg bones)	6
Potsherds	50
Celts	7
Celts in process	2
Shell beads	5
Wampum beads	40
Iron trade axes	2
Bark cloth fragment	1
Ripley, Chautauqua county	
Pottery vessel, entire	1
Edwardsville, St Lawrence county	
Pipes, stone	2
Gorget, pendant	1
Potsherds	20
Lima, Ontario county	
Wolf's tooth, perforated	1
Gorget	1
Chenango Forks, Broome county	
Soapstone bowl fragments	3

Stone hoes	2
Pottery fragments	10
St Lawrence, Jefferson county	
Potsherds	32
Spear head	1
Animal bones, box	1
Flint knife	1
Hammondsport, Yates county	
Stone bar	1
Net sinkers	25
Hammer stones	6
Celts, crude	2
Arrowheads	5
Clarke, Noah T. Albany	
From Silver Lake	
Arrowheads	3
Gouge	1
Grooved axe	1
Celts	2
Spear head	1
Worked stone	1
Dann, John. Honeoye Falls	
Hawk bells	3
Fragment of beaver skin	1
Fragment of shell gorget	1
Pipe stems	3

Purchase

Bradley, E. R. Cazenovia	
Atwell site, Cazenovia	
Pipe stem fragments	19
Pipe bowl fragments	14
Flints	3
Potsherds, undecorated	2
Potsherds, decorated	17
Antler fragments, worked	3
Antler dagger handle	1
Potsherd, salamander decoration in relief	1
Potsherd, broken	1
Potsherd, human face effigy	1
Pottery disks	2
Stone disk	1
Triangular arrowheads	4
Bone awl	1
Bone bead	1
Pot rim fragments	3
Fragment of pipe	1
Worked trilobite fossil	1
Fragment of worked antler	2

Potsherds	3
Worked shell	1
Nichols Pond, Oneida site, Fenner, Madison county	
Bone awls	2
Bone awl, polished and notched	1
Worked bones	2
Bone awls, short	8
Bone bead	1
Brass bead	1
Miscellaneous flints	8
Phalanx bones	3
Shuttle or needle, bone	1
"French" iron axe	1
Atwell site, Cazenovia	
Decorated potsherd	1
Pottery face	1
Pottery pipe fragment, showing many faces	1
Potsherd (handle or ear)	1
Dog teeth	3
Antler cone	1
Broken awls	3
Pipe stem fragments	2
Rude flint spear	1
Antler pitching tools	2
Notched net sinker	1
Antler tips, worked	3
Triangular flint points	2
Bear teeth	3
Pottery face	1
Bone awls, small	5
Bone spear, broken	1
Chisel, bone	1
Fragments, animal bone	2
Onondaga county, Pompey sites	
Trade beads, strings on card	8
Wells, Miss Lucy S. Naples	
Flat vase pipe, stone bowl	1
Pottery pipe bowl	1
Shell cylindrical bead	1
Runtee shell beads	2
Celt	1
Owl head effigy, clay	1
Jesuit rings	2
Catlinite ornaments	3
Catlinite face effigy	1
Shell, heron (?) effigy	1
Small celts	2
Arrowheads	6
Iron tomahawk blade	1
Sioux brush	1

Donation

Hine, Dr J. W. Albany

Copper spear (should have been acknowledged last year) 1

Clarke, John M., from Peter Barlow

Mic-Mac relics, Bonaventure county, Province of Quebec

Celt 1

Quartz arrowheads.. 2

Quartz knife.. 1

Wren, Christopher. Plymouth, Pa.

From the Susquehanna river valley, between Pittston at the upper end of Wyoming valley and Sunbury (Shamokin) at the junction of the north and west branches

Argillite arrow point found at Retreat (material from Delaware valley near Trenton) 1

Rhyolite arrow point, Hunlocks creek (material from quarry near Gettysburg, Pa.) 1

Ordinary arrow points, Hunlocks creek.. 5

Arrow points, Sunbury, Pa. (formerly Shamokin and the home of Shekillemy) 10

Piece soapstone pot, Hicks Ferry.. 1

Fine argillite celt, Beach Haven 1

Green rubbing stone, Dundee farm, Wyoming valley 1

Sinew or bow string dresser, Nanticoke, Pa. 1

Sinew or bow string, Buttonwood Flats 1

Sinew or bow string, Shawnee Flats 1

End notched net sinkers.. 3

Side notched net sinkers 4

4 notched net sinkers.. 1

Large chipped net sinkers, notched disks 2

Small chipped net sinkers, notched disks 2

Piece of red paint, Plymouth, Pa. 1

Small common pitted stone.. 1

Large double flat ended hammer stone, not grooved, West Nanticoke 1

Large pitted and notched hammer stone, flat ends, Shawnee Flats 1

Net sinker, grooved, thick.. 1

Common hammer stone, Nanticoke 1

Crude argillite hatchet, Wapwallopen 1

Common hammer stone, Shawnee Flats 1

Argillite axe not grooved, Dundee farm 1

Extra pitted stone, Shawnee Flats.. 2

Common chipped hatchet, Nanticoke 1

Small muller, Buttonwood Flats.. 1

Fine muller, Dundee farm 1

Metate, Shawnee Flats 1

Soapstone pot handle, Northumberland, Pa. 1

ETHNOLOGY

Purchase and collection in the field

Parker, A. C.

Carving of wolf head totem	1
Basket sieve	1
Corn meal sieve (basket)	1
Bow and 2 arrows	3
Husking pin of bone	1
Turtle shell rattles	2
Baby board	1
Bowl, carved of wood	1
Bone whistle	1
Water drum	1
Snow snake	1
Dolls	2
Woman's cincture	1
Calabash rattle	1
Husk moccasins	4
Tortoise rattle	1
Bark rattle	1
Husks for weaving, bundle	1
Peach stone dice	8
Husk tray	1
Husk salt jugs	2
Husk masks	3
Death feast paddles	2
Ceremonial doll	1
Powder charger, bone	1
Crooked knife, antler handle	1
Medals, small	2
Corn hulling basket, low	1
Wooden bowl for holding bread	1
Wooden eating bowl	1
Child's eating bowl	1
Wooden spoons	2
Beaded skirt	1
Head band, Abenaki	1
Pack strap, fragment, Abenaki	1
Rolls of colored splints, Abenaki	3
Paddles carved	1
Leggins, women's, pair	1
Woodchuck skin for drum head	1

Burmaster, E. R.

Wooden spoon from bottom of Black lake	1
Buffalo horn spoon	1
Abenaki quilled robe	1
Abenaki ceremonial mats	3
Seneca woman's leggins, pair	1
Workbasket	1
Deer bone buttons, game	8

Peach stone dice, game	6
Tump line	1
Dried corn scoop	1
Salt jug of husk	1
Moccasins, pair	1
Bead workers outfit	1
String purple wampum	1
Neck bands	2
Evaporating tray	1
Sifting baskets	2
Spoons	2
Wooden bowl	1
Hominy ladle	1

Loan

Bush-Brown, Henry K. Newburgh

Brooch and scalp lock	1
Turtle shell amulet	1
Moccasins, pair	1
Mountain goat quiver and bow	1

Donation

Bush-Brown, Henry K. Newburgh

Set of old carpenters reamers	12

Purchase

Harrington, Prof. M. R.

Iroquois specimens	
Baby board	1
Silver brooches	10
Melon baskets	2
Cherokee specimens	
Baskets	11
Ball player's sticks	2
Pottery vessels	2
Pottery effigy	1
Potters paddle	1
Potters stone smoother	1
Miniature (woman's) pipe	1
Moccasins, pair	1
Ceremonial scratcher	1

Schmidt, A. A.

Decorated birch bark boxes	2

MISCELLANEOUS

Donation

Putnam, William R. Wayville

Fork and hoe plowed up near Saratoga lake	2
	836

X

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In order to bring into more intimate touch with the State Museum the citizens who are disposed to appreciate its intentions and purposes, the Director has invited a considerable body of representative men from all parts of the State to participate in the organization of an association, which shall have for its purpose the intelligent support of this organization. The members of this association are entirely voluntary adherents from whom nothing is asked but a reasonable expenditure of public spirit and moral support. The work of the State Museum is very widely known in the scientific world, but in spite of its more than half century of existence, it is not so widely known among the citizens of the State as it ought to be. In consequence it suffers in educational effectiveness and in a general widespread touch with the scientific and intellectual interests of the public. The New York State Museum Association is designed to increase the usefulness of the institution by bringing its work nearer home to the citizens of the State. Invitations to enroll in the membership of this organization have been extended, not miscellaneously but to members of the community selected on the basis of demonstrated public spirit and civic usefulness in other directions. It is however greatly desired not to exclude from this enrolment the name of anyone to whom the activities of the State Museum make a direct appeal. Such names, even though not reached by the invitations sent out by the Director, will be welcome additions to the enrolment. All have been asked to remember that this museum is the only institution of the kind which the State has undertaken to maintain and should therefore in every respect be made creditable to the commonwealth and commensurable in influence and interest with similar institutions supported by private beneficence.

In undertaking this organization the Director invited several men of distinction to act with him and thereby to give the weight of their indorsement to this association. All thus invited cordially assented to act with the Director as a provisional executive committee, composed as follows:

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COMPARATIVE SKETCH OF THE PRECAMBRIC GEOLOGY OF SWEDEN AND NEW YORK

BY J. F. KEMP

The eleventh International Geological Congress, which was held in Stockholm, August 17 to 25, 1910, afforded visitors from elsewhere exceptional opportunities to become familiar with the Scandinavian Precambric exposures and problems. One excursion of three weeks' duration, before the sessions of the Congress, was planned for northern Sweden; while a second covering ten days was devoted to southern Sweden. Besides these two, and both before and after the sessions, two others were tendered the visitors specially interested in the iron ore deposits. The mining trip before the Congress in part coincided with the one planned for the Archean geologists but the two that came afterward were essentially different. Since in each group was a member of the New York State Survey, Mr Newland accompanying the mining sections and the writer the Archean, it has been thought by these two observers that a sketch of the geology of the Swedish magnetites as compared with those in New York, and an outline of the Swedish Precambric as compared with the home exposures would present elements of interest. The latter sketch may be best given first since all the iron ores are in the very ancient strata.

A few figures of relative areas will be of interest in establishing a point of view. New York contains 49,170 square miles, of which 1550, or about 3 per cent, are lakes. Sweden covers 172,876 square miles or approximately three and one-half times as much as New York; one-twelfth of its area consists of lakes. Norway has 124,445 square miles, so that Scandinavia proper is nearly six times as great as the Empire State. Were we to take together with New York the New England States, Pennsylvania and Maryland, the total would be very nearly that of Sweden. Sweden, however, is so much narrower that if we lay it off from the northern point of Maine, it would reach a little beyond the extreme southern point of North Carolina. In population of the date 1900, Sweden had 5,136,000, and Norway, 2,240,000. The total of the two was a little more than New York's 7,268,894. In 1910 New York had grown to 9,113,279, but the two Scandinavian countries have probably not changed so much. The Precambric rocks in New York cover about 11,800 square miles, or about one-fourth of the dry land. In Sweden the proportion is far larger, perhaps nearly nine-tenths. Since one-twelfth of Sweden is covered by lakes the areas compared are therefore nearly in the ratio of 4 to 50.

The older Paleozoic section in Sweden is not so thick as in New York, yet its exposures are very widespread. The relicts left by erosion and spread as they are in scattered areas throughout the kingdom, indicate the very general presence of these strata at one time over all of its extent. The island of Gothland in the Baltic and the many glacial boulders of the older Paleozoic rocks, which are found in the drift in the Åland Islands, Finland, lead to the belief that other areas are beneath the waters of this inland sea. The lower members of the Paleozoic are grouped under the name Siluric which is then subdivided in descending order into Gothlandic, Ordovicic, and Cambric. The Swedish geologists thus follow the lead of Murchison. We are here chiefly concerned with the contact of the Cambric upon the ancient crystallines. This is of such a character as to prove the old bedrock upon which the first Cambric strata were deposited to have been in general very even. Such relief as can be detected in most of the areas is slight and the old land surface seems to have been worn nearly to a level.

These observations coincide with the greater part of the observations around the Adirondacks. Professor Cushing has demonstrated the very even sub-Potsdam floor along the north and northwest sides (1)[1] and has recently discovered in the southeastern edge much the same relief, although hummocks as high as 100 feet seem recognizable. Doctor Ruedemann has described in some detail the small inliers of gneiss amid the encircling Potsdam at Port Henry. (2) In the quadrangles mapped by Prof. W. J. Miller along the southwestern edge, the same condition is indicated but, as is well known, sedimentary overlap brings several of the Ordovicic members in contact with the Archean. The escarpment of the Medina sandstone in the Little Falls quadrangle led Professor Cushing to strongly suspect that it, too, had once extended over the ancient gneisses (3).

The writer has suggested the original extension of the Ordovicic and Cambric sea up valleys in the Archean along the eastern side

[1] The figures in parentheses refer to the bibliography at the close of this paper.

of the Adirondacks at the time of deposition. There is some ground for this inference. Similarly in the actual highlands of Sweden, land areas, already carved into hills and deep valleys, are believed to have existed in Cambric time (4, p. 6).

The nature of the surface on which the Poughquag sandstone north of the Highlands of the Hudson was deposited is so little exposed that we can cite it for comparison.

Professor Högbom states (4, p. 4) that at most of the contacts between the Cambric and older rocks in Sweden, one finds the bottom layers of the former resting on a weathered breccia of the subjacent Archean. The breccia turns into kaolinized gneiss which continues to a depth of one or two meters. These relations are paralleled at the " Noses " along the Mohawk where the Beekmantown limestone rests on decomposed gneiss (5) but the general experience in New York is to find rather fresh Precambric rocks beneath the Cambric, as if the advancing waves had swept the old bedrock clean of the products of weathering. In Sweden one curious feature of these contacts remains far away from present exposures of the Cambric strata. A few little, so-called " sandstone dikes " have been found in crevices of the ancient gneisses. In them Cambric brachiopods which serve to establish the age have been detected. One of these on a high hill of gneiss, on an island off the east coast of southern Sweden, not far from Västervik, was shown to us and excited much interest. It reminded the Americans of the similar explanation suggested by Prof. J. E. Wolff for the narrow Cambric quartzite in the crystalline limestone at Franklin Furnace, N. J., (6) discovered by Mr F. L. Nason and believed by him to be interbedded (7).

The most recent scheme of classification of the Precambric which has found favor in Sweden is in part the one suggested by Professor Sederholm, the Director of the Geological Survey of Finland, where, over a vast area, scarcely any other than Precambric rocks appear, and where careful studies have been carried on in later years. In part also it has been suggested by Professor Högbom of Upsala. Beneath the Cambric strata we find the following (4, p. 2):

Upper or Jotnian	Epijotnian dislocations
	Jotnian
	Subjotnian land surface denudation and igneous rocks

Middle or Jatulian		Epijatulian folding
		Jatulian
		Subjatulian land surface and denudation
Lower or Archean		Serarchean granites
		Archean
		No chronological subdivision. Differences due to varying metamorphism

Along the more northerly border of Sweden and Norway there is a great development of moderately metamorphosed sediments and of less evident gneisses which have been called the Seve series. Professor Törnebohm has shown that they rest upon the typical Jotnian sandstones and considers them a later formation. Professor Högbom is inclined to place them in the Jotnian as an upper division. Their great point of interest lies in the fact that they have been thrust-faulted upon the Cambric and Ordovicic fossiliferous beds and thus appear above strata which are later. They have ridden in from Norway, and when one looks for the parent exposures the latter are now 100 to 150 kilometers distant. The thrusts, therefore, if existent are greater than any yet described elsewhere. On the other hand some Swedish geologists oppose the explanation by thrust faults, and insist that there is a regular stratified series. They are then confronted with the difficult problem of higher lying and strongly metamorphosed and rather flat strata resting upon others scarcely if at all metamorphosed and at times richly fossiliferous.

We visited several crucial localities in Jämtland where we could locate the fault plane within narrow limits although it was not itself visible, but on Mt Luopahta in Lapland we saw it clearly beneath a small waterfall. Black and greatly crushed Lower Paleozoic slates supported a heavy stratum of so extremely crushed and disguised a member of the Seve series that an earlier Swedish geologist had given the rock the special name "kakirite," from Lake Kakir in Lapland. In Jämtland the rocks are collectively called "sparagmite" from the Greek word meaning to crush.

With the typical or lower Jotnian we have no equivalent in New York. It is a series of sandstones and diabases much like the Torridonian of Scotland and the Keweenawan of the Lake Superior region and Canada. In Sweden it appears in scattered areas much as do the Cambro-Siluric strata. The largest area is in middle Sweden along the boundary with Norway. The Jotnian sandstones exhibit perfectly preserved suncracks and ripplemarks and may display but little in the way of metamorphism.

The sandstones and diabases along the beautiful coast of eastern central Sweden in the district of Nordingra were shown to the visiting geologists. The sedimentary characters were as well preserved as in our Siluric Medina sandstone, as for instance at Lockport, and the grade of metamorphism was scarcely greater. This recent aspect led earlier observers to correlate the sandstones with Paleozoic formations, notably the Old Red Sandstone, but the Precambric age is now very well established (4, p. 10–11).

The floor of older rocks beneath the Jotnian is very even so far as visible and reminds one of the floor beneath the Cambric. The foundation rocks are, however, devoid of products of weathering and seem to have been swept clean by the oncoming waters. The Jotnian sandstones, sometimes many hundred meters thick, far surpass the Swedish Cambric, and since the quartz grains in them were probably freed by the weathering of older rocks the sub-Jotnian time interval is believed to be far greater than the sub-Cambric.

One extraordinary feature of the eruptives is the curious "Pebble diabases" near Brevik, in central southern Sweden. Dikes of diabase are so fully charged with rounded boulders, that the observer can only interpret them as follows: it appears that a loosely compacted conglomerate, or even a boulder bed, has been penetrated and suffused with a basaltic magma as with so much water; on chilling, the result was a rock almost like a conglomerate, with a basalt bond or cement. We have few parallels for these rocks in America, but one is reminded of a dike at Nash's Point, Vermont, where a trachytic magma is surcharged with boulders derived from lower lying formations, although it now cuts Ordovicic slates (8).

In the table of formations given above, under Jotnian is mentioned a group of sub-Jotnian igneous rocks. A brief outline of these will serve also to explain the methods of correlation developed by the Swedish and Finnish geologists when dealing with igneous and metamorphic rocks in disconnected areas. The Jatulian period closed with strong folding, as will be later brought out. Subsequent to the folding there appeared in Finland extensive intrusive masses of a peculiar granite, of coarse porphyritic texture. The porphyritic crystals may be one to two inches in diameter. They have a core of reddish orthoclase and a rim of green oligoclase and are very characteristic. The granite weathers badly and for this reason has received the Finnish name rapakivi or rotten stone. Wherever these porphyritic granites or even finer-grained porphyritic rocks are found with the zonal phenocrysts, they are called throughout Scandinavia rapakivi.

Now, the Finnish rapakivi is later than the post-Jatulian folding. The rapakivi can be traced across the Åland group of islands which separate the Baltic sea from the Gulf of Bothnia and themselves have rapakivi rocks. It finds parallels or representatives farther north along the east coast of middle Sweden near Sundsvall, and inland about 60 miles at Ragunda. In this latter region the granitic rocks of coarse texture lie beneath the Jotnian; but their texture shows that they crystallized beneath a load which was eroded before the Jotnian sandstone was deposited. Thus we have a long time interval between the close of the Jatulian period and the beginning of Jotnian sedimentation. If now we establish the geological date of the Swedish rapakivi, near Sundsvall, we also fix the time of various other types of igneous rocks, such as diabases, gabbros and granites, which cut the rapakivi but precede the Jotnian sandstone. Extremely interesting exposures of all these were shown to the visiting geologists at and near Ragunda, Sundsvall and north along the coast in Nordingra, and are described in the guidebooks to Excursion A 2. The visitors viewed with growing enthusiasm the impressive phenomena of interrelated igneous types which Professor Högbom spread before us, nor will we ever forget the deep impression made by them.

The most extensive of the Jotnian exposures, as stated above, lies in western middle Sweden along the Norwegian boundary. The underlying rock consists largely of the famous Dala-porphyries, which are a subject of much difference of opinion. Some think them Archean; others are not convinced that this is true and urge a later age.

Near Sundsvall, which is a city in eastern central Sweden, and the most important lumber center of the country, there is the island of Alnö, with its famous nephelite rocks, whose age is uncertain. In many places throughout Sweden there are diabase dikes whose age is also indefinite. It is conceivable that they may belong in this interval between the Jotnian and Jatulian.

New York can not furnish parallels for all the formations just reviewed. As earlier stated, the Jotnian seems nearest akin to the

Keweenawan of the Lake Superior region; but if, with Professor Högbom, the Seve group is considered upper Jotnian it might furnish a parallel with the Manhattan schist and Inwood limestone of southeastern New York. At all events the Seve group as represented by the Åre schists is lithologically very similar to the latter. The Grenville on the other hand is much more like the sedimentary rocks in the Archean, than like the Jatulian.

As a parallel with the Dala-porphyries we have the Precambric volcanic rocks which are so generally distributed along the Atlantic seaboard (9); which have been well described in Wisconsin (10); and which are of special interest in southeastern Missouri (11). We can only say that porphyritic and felsitic rocks were also developed on this side of the ocean.

The Jatulian (pronounced Yatulian) series was named originally by Professor Sederholm of Finland. The exposures which primarily suggested its establishment are found in the latter country. They consist of quartzites, schists, dolomitic limestones and, strange to tell, of beds of anthracitic carbon, which may attain a thickness of two meters (12, p. 10). Strata referable to the Jatulian are less abundant in Sweden and are in fact practically limited to one area, the west side of Lake Wenern in the southwestern portion of the country. They constitute a series of folded and metamorphosed sediments, long known as the Dal-formation.

The sub-Jatulian surface, or the one beneath the Dal-formation, is believed by Professor Törnebohm to have been a mountainous one, with valleys cut quite deeply, but Professor Högbom considers it to have been at most hilly. There is thus a time-gap represented by erosion, but not of so great length as either the sub-Jotnian or sub-Cambric.

Back of the Jatulian lies the vast complex of extremely difficult rocks forming the Archean of the later Swedish geologists. The term is not used by them exactly in either the original sense of Precambric as given by Professor Dana, nor the later modification to which it has been subjected by the Lake Superior group of geologists, as embracing only those rocks which were older than recognizable sediments; but it applies to the great complex of ancient rocks, consisting either of deep-seated intrusives or of sediments always heavily metamorphosed. On the bases of the characters shown by the foundation rocks on which the Jatulian rests, Professor Högbom infers an erosion of some thousands of meters and therefore the greatest time-break in the history of the earth.

Undoubtedly the obscurity which always surrounds the products of deep-seated processes has in large part served to make the interpretation of these rocks difficult. The tendency of earlier geologists to see in the gneissoid structure evidence of sedimentary bedding has also stood in the way of conceptions characteristic of later workers.

In outlining the Swedish Archean we may establish therefore at the outset that,

1 It closed with a vast period of denudation.

2 Back of this there was a very important development of granites which may be classed under four types.

3 Back of the granites just referred to there is a great complex of minor sediments and major deep-seated intrusives.

To the time interval of erosion, reference has already been made. The granites are widespread and of great interest. They are characteristically massive. While Professor Högbom makes four types, Professor Törnebohm, on the map of the Swedish Geological Survey, distinguishes three groups, each with several subdivisions. The four types of Professor Högbom embrace (*a*) a coarse-grained gray or reddish porphyritic granite, one of whose occurrences is called the "Refsund" and was seen by the foreign visitors. It is difficult to mention any familiar American occurrence that is closely similar. (*b*) A fine to medium-grained gray or light reddish biotite granite which is prominent in the city of Stockholm itself where it was shown to the members of the Congress. The quarries in Stockholm remind a visitor of Dix Island, Maine; Barre, Vt.; and Westerly, R. I. (*c*) A true muscovite-granite in Ångermanland which was not in the routes of the excursions. (*d*) Coarse pegmatitic granite which we saw on the island of Utö. All of these types are grouped by Professor Högbom under the name Serarchean or late Archean, a rather bad word etymologically, as it has a Latin prefix (serus, late) to a Greek derivative, Archean.

The members of the great complex, older than the granites just mentioned, present an extremely difficult subject to set forth intelligibly in a short space or even for a Swedish geologist of a lifetime's experience to make comprehensible. We may select, however, certain main features.

Sedimentary rocks are represented by the usual types. There are greatly compressed conglomerates, one of which was shown to us near Malmbäck in southern Sweden. The pebbles of finely crystalline rocks were pinched out to lenses and, while easily recognizable, were well on their way toward gneisses. The rolling out and flattening produced by the great pressure were very impressive. We have no parallels in New York but in the Lake Superior region similar phenomena may be seen.

Quartzites are at times well preserved, and while hard and dense and obviously the results of extreme metamorphism, they are typical cases of the rock. In the city of Västervik they were shown to the visitors in excellent exposures.

Crystalline limestones and dolomites are important members. They appear in the mining districts of southern Sweden and are at times the wall rocks of important ore-bodies, as at Sala. The excursionists saw them in a number of localities.

Mica schists are also frequent rocks. They are associated with the group of leptites.

Leptite is a comprehensive name now largely used for the fine-grained and banded or stratified rocks which are of great areal extent in middle and southern Sweden and which, with the associated sediments just cited, contain the ore bodies. Leptite, derived from the Greek word for fine-grained, is not a name of a special rock but of a group whose grain or texture is very small. The varieties cover a wide range and have doubtless resulted from several different original rocks. The hälleflintes of the early writers are included. They are flinty-looking rocks which consist of minute quartzes and feldspars and are well known in the iron-mining regions. Many more coarsely crystalline varieties than the excessively fine hälleflintes are also included under the term leptite, although their grain is always minute. Generally speaking, the leptites remind one of the Saxon granulites more than anything elsewhere. They may be sheared and crushed effusives. They may be consolidated and metamorphosed tuffs. They may be sediments recrystallized to rocks of minute grain. Somewhat similar types can be recalled in a few cases in America, but they are not common. We have none in New York.

Gneisses with garnet, cordierite, sillimanite and graphite are not unimportant members of the great complex. They are believed to be of sedimentary origin. They remind one strongly of some of the gneisses of the Grenville series in the Adirondacks. Exposures of the so-called "garnet-gneiss" a few miles east of Stockholm at Fagersjö, which were reminiscent of some of the Adirondack rocks, were shown to us. Though long regarded as sedimentary by the Swedish geologists, there is now a decided disposition to consider the "garnet-gneiss" as a complex mixture of igneous intrusives and partly digested sediments. It contains remarkable angular masses of amphibolite which seem to be torn off rather by a deep-seated igneous mass than by mechanical flowage.

A very important member of the complex is the time-honored "iron-gneiss," a rock of granitic composition with grains of magnetite distributed through it, but never segregated in amount rich enough to be of economic value. It is prominent in southern Sweden and is believed to represent a granite magma whose differentiation was so diffuse as never to have yielded an ore-body. The particles of magnetite are rather more prominent than in any of our ancient granitic gneisses other than such as the lean ores at Lyon Mountain and at the Benson mines. Geologically, however, the parallel is close.

Breaking through the sediments and the leptites are, furthermore, great intrusive masses of granite with gneissoid foliation, concentric with the borders of the batholiths and with massive textures at the center. When mapped in some of the areas, the sediments and leptites look like relatively narrow channels amid an archipelago of large islands of the intrusives. In these channellike belts are found the iron ores of southern Sweden.

Along the southwestern border with Norway, very coarse granitic gneisses appear, strongly banded and sometimes with streaks of amphibolite. They have "eyes" of feldspar an inch or more in diameter, and very strongly remind the American visitor of some of our old Laurentian gneisses. They were shown to us near Trollhätten.

Another feature of the Swedish Archean that is of especial interest to the visitor familiar with Adirondack geology is found in a series of basic intrusive masses which run north and south through southern central Sweden and which swing westward as they pass north and reach the Norwegian boundary. They are called hyperites and are later than certain quartzites of the region. The rocks are practically the same as the basic gabbros of the Adirondacks and, like them, contain bodies of titaniferous ore. The most famous of the latter, Taberg, was shown to the visitors. Its geology is practically the same as the many bodies known to us in Westport and Elizabethtown, but Taberg is much larger than any of ours.

Anorthosites appear in Sweden just as they do in the Adirondacks and in the province of Quebec, but not on so extensive a scale as in America. Exposures were shown to us on the northeastern coast in the district of Nordingra that reminded the writer very strongly of the American rocks. In Norway both the anorthosites and basic gabbros appear and with them are the syenitic series of the New York geologists (mangerites of the Norwegian observers) as Professor Cushing made clear some years ago (13).

Along the southeastern coast of Sweden between Stockholm and Västervik the visitors were shown phenomena that were new to the greater number of us. Innumerable islands dot the coast; they have been smoothed and polished by the great ice sheet until over widths of 10 to 20 yards along the shore the ledges appear as if prepared by a lapidary. Two rock magmas, a gabbro and a granite, are intermingled in the most intimate way. In the ledges visited by us, the granite had habitually pierced the gabbro, but in less accessible localities we were told that the relations are reversed. The granite at times seemed fairly to impregnate the gabbro with its red orthoclase crystals and to half digest it, until the observer hardly knew which rock name would apply. In another locality, Trollholmen, we saw contacts of gabbro on quartzite with similar absorption phenomena, leading at times to quartz-bearing gabbros.

When the interpenetration of two deep-seated magmas becomes very intimate and pressure phenomena or marked flowage later produce gneissoid structure, peculiar "veined" or "injected" gneisses may result. Finland also furnishes very instructive exhibitions of these phenomena which were described to us by Professor Sederholm. In fact the members of the Congress who saw the exposures and took part in the discussions based thereon, became deeply impressed with the importance of always keeping in mind the possible deep-seated conditions which have produced the phenomena and of adjusting explanations in accordance with them.

One extremely striking case of what is considered differentiation was the object of a day's study on the island of Ornö, just off the coast, east of Stockholm. A central, coarsely crystalline mass of diorite is surrounded by a border of finely but persistently banded, differentiation products. The latter appear as light and dark bands, respectively feldspathic (salic) and amphibolic, pyroxenic or biotitic.

The bands vary from a fraction of an inch to several inches in width and with slight variation may run for hundreds of feet. They are concentric with the diorite. They remind one of some cases of persistent foliation in our old gneisses, such as the Fordham, but the writer had never seen anything of equal perfection. Our ancient gneisses are more coarsely crystalline. Ornö is well illustrated in reference (14).

In the far north at the two iron-mining districts of Gellivare and Kiruna we saw geological sections in some respects different from anything mentioned above. At Gellivare, syenitic rocks are the ones associated with the ore bodies and strongly remind one of the walls at Mineville, and elsewhere in the Adirondacks. At Kiruna we find an extended section from syenites below on the west, through two thick sheets of porphyry, with the ore-sheet between them, to a series of sediments and schists of various sorts which constitute the eastern section and which remind one both of the Huronian and the Keewatin strata of the Lake Superior region.

With the above general review of the component rocks in mind, we may grasp some of the larger features of the Swedish Archean. The sedimentary rocks and the leptites appear in separated localities. It is necessary therefore to treat them individually, just as our New York geologists have of necessity first studied the Adirondacks and the Highlands of the Hudson as distinct areas, and the Lake Superior geologists have taken up one by one the several iron ranges. Parallels may then be later drawn and correlations may be established. The correlations are, however, necessarily based on lithologic characters and on the parallelism of great unconformities or periods of faulting. The igneous masses must in time be matched by their lithologic characters and mutual relations. It would lead to too long and involved a discussion were we to attempt in this paper to follow out the several areas. They must be studied in the Swedish monographs and with maps in hand. In this way, however, the correlations have been elaborated. All Scandinavian geologists are not agreed upon the parallels which have been suggested. It is easy to see, however, that in the nature of the case these equivalents are largely matters of opinion rather than the results of demonstration.

The ordinary metamorphosed sediments of Sweden have many close parallels in our Grenville strata, but the leptites are not known with us. The granites, syenites, hyperites and anorthosites are much the same on both sides of the ocean, but the peculiar rapakivi type fails here. In New York and in the East in general, the writer knows of no such remarkable interpenetration phenomena as those seen in Sweden, but the Lake Superior region may contain them. Notwithstanding the contrasts, there remained in our minds a profound impression of similarity and resemblance, so much so, that while in the field the Americans in the end became embarrassed at their constant and almost irrepressible tendency to remark upon it to their Swedish hosts. The visitors were fearful lest they prove wearisome.

In conclusion the writer may express his indebtedness to Professors Högbom, Holmquist and Bäckström and to Doctors Quensel and Gavelin for the personal guidance and explanations which made the excursions so exceptionally instructive.

As an appendix to the remarks on Swedish geology, a brief statement of the scheme of classification adopted by Professor Sederholm in Finland may be given. As will appear, the older rocks have been more extensively subdivided in Finland than in Sweden. The American equivalents suggested by Professor Sederholm are added.

Jotnian		Diabases, labradorites and clastics, rapakivi granites	Keweenawan
		Unconformity	
Jatulian	Upper	Eruptives, clastics, anthracite, dolomite	Upper Huronian
	Lower	Greenstones, clastics, dolomites	
		Unconformity. Post-Kalevian granites	
Kalevian	Upper	Greenstones, clastics	Lower Huronian
		Unconformity	
	Lower	Greenstones, schists, clastics, dolomites	
		Unconformity. Post-Bottnian granites	
Bottnian		Eruptives, clastics, leptites	
		Unconformity. Post-Ladogian granites	
Ladogian		Greenstones, phyllites, schists, clastics, limestones, hälleflintes	
Katarchean		Granitic gneisses, greenstones etc.	

In the above table I have condensed the rock types under collective names, like clastics, and have called by the name greenstone, rocks described by Professor Sederholm as metabasites. The full table, printed in English, will be found on page 93, Bulletin 23, of the Geological Commission of Finland, 1907.

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The paper gives excellent views of these wonderful exposures.

In addition to the references to the Swedish literature specifically referred to above, the writer has also used a pamphlet by Prof. A. E. Törnebohm, Explanatory Remarks, to accompany the Geological General Map of Sweden. This map, on a scale of 1 : 1,500,000, or about 25 miles to the inch, has also been used. A much larger one has been issued by the Swedish Survey. The members of the excursions in connection with the Congress were furnished with excellent guidebooks. The writer has especially drawn upon nos. 1–6, 15 and 18.

NOTES ON THE GEOLOGY OF THE SWEDISH MAGNETITES

BY D. H. NEWLAND

The general features of the Precambric geology of Sweden are outlined in the paper by Prof. J. F. Kemp which should be consulted in connection with the following notes on some of the Swedish districts notable for their magnetite deposits. Inasmuch as these ores have likewise an important place in the mining activity of our own State and much uncertainty surrounds the relationships and origin of the local deposits, it is thought that a brief discussion comparing the two series of occurrences, though so far removed from each other, may well be presented here. The notes are based on observations of the writer while a participant in the excursions of the International Geological Congress during the months of August and September 1910. The excellent guides to the different mines, prepared by the Swedish geologists for the use of the visiting members, have been freely consulted for details, as have also some of the reports and monographs from other sources.

The iron industry of Sweden, as is well known, derives its raw material from magnetite deposits in the Precambric rocks. In this respect the country stands practically by itself among the more important iron producers of Europe; for elsewhere the ores chiefly represented are hematite and limonite, or occasionally carbonate, associated with rocks of much later age. The magnetites are contained in crystalline schists and certain igneous rocks of acid composition that are all assigned to the Precambric, though they may belong to widely variant horizons of the series. It is upon these ores and their features of occurrence, suggestive in some instances of the magnetites found within the Adirondack and Hudson River gneisses, that attention will be fixed.

Sweden also possesses deposits of titaniferous magnetites, quite analogous to those occurring in the Adirondack gabbro-anorthosite areas. One occurrence at Taberg, in southern Sweden, is of large size and has been mined to some extent in the past, but it is low grade, resembling in composition rather the magnetite-silicate mixtures of the smaller gabbro intrusions than the larger Adirondack deposits like those of Lake Sanford. There are many occurrences of titaniferous ores among the igneous areas of southern Norway, and one of considerable magnitude at Routivara in Swedish Lapland.

A third group of ores which may be mentioned to complete the list, consists of the lake and bog limonites so frequently cited in the literature of ore deposits as instructive examples of present-day processes in ore formation. They are said to have furnished the first material for iron manufacture in Sweden. With the improvement of methods for working and treating the magnetites, the lake deposits have lost their importance and are no longer employed in the furnace.

While it is purposed to give particular attention to the geological features of the magnetites, some information on the industrial side will be useful perhaps for comparison with the present situation of iron mining in this country.

Of the two main districts in which the magnetites are distributed, central Sweden has long been and still is the support of the Swedish metallurgical industry. The deposits of that district are characteristically low in phosphorus and sulfur and the mine output is consumed locally in the manufacture of charcoal iron for which a wide demand still exists in spite of the development of methods for refining the ordinary product of coke furnaces. Mining there may be said to enjoy certain advantages that are not apparent in this country. The greater value of the ores as compared with those of usual composition admits their profitable extraction from small deposits and the expenditure of more labor in their preparation for the furnace than is economically practicable elsewhere. In the work " The Iron Resources of the World," recently issued by a committee of the Stockholm Congress, F. R. Tegengren places the number of active mines in central Sweden in 1908 at 277 and the total production of ore for the same year at 1,884,451 metric tons. In the total are included 262,620 tons of concentrates from 23 plants. When it is considered that about one-half of the product consisted really of high phosphorus ore, contributed by the Grängesberg and one or two other mines which are exceptional to the district, it is seen that the individual workings are very small. Such operations recall to mind the days of the forge iron industry in this State, when the numerous small deposits of the Adirondacks were actively worked with an individual output perhaps of a few hundreds or thousands of tons a year.

Some of the mines of central Sweden have been worked almost continuously for the last four or five centuries. It is not to be inferred, however, that the methods and equipment at the smaller properties are, as a rule, crude or antiquated; on the other hand, they are often very efficient and the cost of production is surprisingly low on the basis of output.

The low phosphorus magnetites have no counterpart with us. They carry generally but a few thousandths or at most hundredths of a per cent of phosphorus and usually correspondingly low amounts of sulfur.

The deposits with moderate to high phosphorus content, which furnish the closest parallels to our own from a commercial viewpoint, have become prominent producers only in recent years when the export demand began to develop. The output of Grängesberg and the Lapland mines goes almost entirely to other countries, owing to the fact that Sweden has no coal suitable for blast furnace use. Since the completion of the Luleå-Narvik Railroad in 1902, by which the Lapland mines secured outlets to both the Baltic and the Atlantic coasts of Scandinavia, the shipments have grown very rapidly. This district now produces much more than central Sweden, the output for 1908 amounting to 2,724,886 metric tons, with a probable total around 3,500,000 tons for the current year. The shipments go to Germany, France, England and even to the United States, competing here with our own magnetic ores of the East.

The facilities for extraction and handling the product in the mines of Lapland are on the largest scale, as perforce they must be to permit exportation of a low-priced material like iron ore. Open quarry work is generally practised, though at Gellivare, where the pits have already attained considerable depths, underground mining is being introduced. The aspect of enterprise and permanency which the mines and their surroundings reflect is most pleasing, as it is rare enough in mining settlements under more propitious climates. Kiruna and Gellivare are flourishing towns of 6000 or 7000 inhabitants each, with attractive buildings and all the conveniences of modern communities, though both lie within the Arctic Circle.

The exploitation of the high phosphorous magnetites will probably not proceed as rapidly in the future as the mining situation might admit, owing to the strong position taken by the government in favor of their conservation in the hope that ultimately they will be used at home. A definite limitation has been put upon the amount that can be exported; in the case of the Kiruna mines this is fixed substantially at 3,000,000 tons and for the Gellivare mines at about 800,000 tons annually during a period of 25 years. It is believed, however, that these amounts will be increased before long, as the magnitude of the resources becomes better appreciated. The possibility that the ores may be needed for iron manufacture in Sweden arises from the large water powers of the country and their future application to electro-metallurgy.

Turning now to the geological features of the magnetites, the Lapland deposits will be first considered for the reason that they have been on the whole less influenced by metamorphism, therefore are more readily interpreted, and their associations perhaps more nearly approach those found in some localities of our own State. Attention can be given only to the Kiruna and Gellivare mines since the limited time of the excursion did not permit any visits to the localities remote from the railroad.

Rocks of syenitic composition are the prevailing ones associated with the magnetites of Lapland. They range from massive, even-textured or porphyritic, clearly igneous types to gneissoid and finely granular phases that have entirely lost their igneous structures. Quartz is a variable component. Magnetite, diopside, hornblende and biotite are the chief dark constituents. Areas of granite and gabbro interrupt the syenites, and the latter are penetrated by dike intrusions of pegmatite, granite and more basic rocks.

At Gellivare we saw the syenite in its varied development from massive to extremely granulated and gneissoid types. With the exception of local granite intrusions and certain small belts of a basic schistose rock that are considered by Professor Högbom to represent igneous dikes, the syenite prevails throughout the ore-bearing districts. No sedimentary gneisses are recognized in the vicinity. The general impression gained from the cursory field study and later comparison of the country rocks indicates close resemblance to the ore-bearing syenitic gneisses in the northern Adirondacks, particularly Lyon mountain, Palmer hill and Arnold. The main element of difference that can be readily pointed out is that in the Adirondacks the gneiss belts are seldom without some interfolded remnants of the Grenville sedimentary rocks. Mineralogically and chemically the two series are very similar. Both are characterized by high soda percentages, which place them in the soda-syenite class, the prevalence of perthitic and acid plagioclase feldspars, and by relatively large amounts of free iron oxid in the form of magnetite, which has, however, a very unequal distribution due to its tendency to aggregate in bands and schlieren surrounded by rock containing less than the average proportion of magnetite.

The Gellivare iron ores occur in the form of lenses, bands and chimneylike bodies with a linear arrangement that conforms more or less closely to the secondary structures of the wall rocks. Three or four parallel series of deposits can be recognized, the individual members of which vary in magnitude and shape and also in their characters. There is the same tendency toward overlapping which is so pronounced in most of the Adirondack mines. Horses of pegmatite and of the country rock are not infrequently encountered in the midst of the ore, reminding one of the occurrences in the "Old Bed" mines at Mineville and in the Lyon mountain deposits. The similarity of the two districts has been noted by Professor Sjögren who visited Mineville in 1891.[1]

The ores themselves present some striking contrasts. The high phosphorus ores are the same granular mixtures of magnetite and apatite as are represented by the product of certain Adirondack mines, but on the other hand the mixed magnetite and hematite ores and the purer bodies of the latter in contact with, or independent of, the magnetite are foreign to our State. This feature we found to be repeated at Kiruna and in many of the central Sweden localities. The hematite is specular and not pseudomorphic after magnetite as is the case with the few occurrences of this mineral in the Adirondacks. Here it is undoubtedly a result of catamorphic processes in very limited areas in which the magnetites have been intruded, faulted or otherwise exposed to accentuated weathering. Professor Högbom[2] refers to the possible secondary origin of the hematite at Gellivare, stating that this derivation is suggested at times by decomposition of the adjacent wall rocks; but he also points out that the contacts cannot be distinguished in other cases from the magnetite contacts. The relation of the two ores in this district is thus open to question. With reference to Kiruna, Dr Per Geijer[3] expresses the view that the hematite, except where its presence can be attributed to surface alteration, is an original constituent of the ore bodies, though in that section it appears to occur

[1] The Geological Relations of the Scandinavian Iron Ores. Am. Inst. Min. Eng. Trans. 1908, 38:794–95.

[2] The Gellivare Iron Mountain. Guide to Excursions of the International Geological Congress.

[3] Geology of the Kiruna District. Stockholm, 1910, p. 257.

more commonly as veins which are regarded as having a somewhat different origin than the magnetites.

Kiruna with its three great ore zones, Kiirunavaara, Luossovaara and Tuolluvaara, easily ranks first among the Swedish magnetite districts. To Kiirunavaara must be conceded the credit also of being the largest accumulation of this ore of which we have any certain knowledge. The single deposit is estimated to contain more than one-half of the total available ore in Sweden, which is figured at 1158 millions of tons and recent magnetometric surveys indicate a greater extension of the mass than had been previously taken into account.

The three ore zones referred to outcrop on the summits of as many ridges which rise rather prominently above the Lapland plateau. The Kiirunavaara deposit is a continuous tabular or sheetlike mass forming practically the whole ridge of that name, which extends 3.5 kilometers north and south, and running under the lower ground at each end so as to give a total length of more than 5 kilometers. Its thickness ranges from a maximum of 164 meters to 50 meters or somewhat less, the higher points of the ridge showing the greatest width of ore. It inclines at a rather high angle to the east, disappearing under a mass of quartz porphyry.

The ore occurrence at first sight seems in strong contrast with the Gellivare type. The wall rocks are massive, porphyritic, and show little or no effects of metamorphic influences. Their structures are rather those of dikes or volcanic rocks than of intrusives which have crystallized by slow cooling at great depths. But the more striking features relate to the ore itself, which has a dense steely appearance, revealing no granularity or crystalline texture to the unaided eye and breaking with smooth surfaces like basalt; the ore furthermore is practically pure magnetite, the whole mass averaging about 96 or 98 per cent of that mineral, with apatite as the only nonmetallic ingredient of importance. Analyses sometimes run over 70 per cent in iron. The distribution of the apatite is very irregular, so that it has been found possible to extract in a large way several different commercial grades of ore from the one deposit. The interesting structures which develop out of the variable relations between the magnetite and apatite have been described by Dr. O. Stutzer[1] and more fully by Doctor Geijer[2].

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[1] The Geology and Origin of the Lapland Iron Ores. Jour. Iron & Steel Inst. II. 1907.

[2] Geology of the Kiruna District. p. 88 et seq.

The Kiruna deposits were undoubtedly the most instructive in regard to considerations of ore-genesis that we saw in Sweden. There were few members of the excursion, apparently, who were not impressed by the evidences in favor of the igneous derivation of the magnetites, however much individual opinion may have varied in regard to the exact process by which the ore came to occupy its present position. The undoubtedly igneous character of the wall rocks, the structures exhibited by the ore itself, the dikes of apatite connected with the same and found in the porphyry, and the apophyses of ore in the footwall of Kiirunavaara and more notably in the surrounding porphyry of Tuolluvaara, seemed conclusive on that score. These features have been admirably set forth in the monograph by Doctor Geijer already quoted, and further discussion of them here may be spared.

As to the precise construction to be placed upon the evidences, for a theoretical explanation of the ore genesis, the views of the Swedish geologists and others who have studied the district are somewhat at variance, though many accord on the more essential points. Högbom, Sjögren, Stutzer and Geijer agree that the magnetites have been derived from the porphyries and that their concentration primarily has been due to magnetic differentiation. But these authorities take issue on the problems connected with the subsequent history of the ores for which it is possible to give several versions: the magnetites may have cooled in place along with the wall rocks; again, they may have been forced up through the partially or completely cooled rocks in the form of dikes like those of pegmatite; or they may have flowed out on the surface as lava sheets in an interval between the eruption of the foot-wall and hanging-wall porphyries. Of course the different views do not conflict with the validity of the general principle, and it is not improbable that the sequence of events with respect to the several deposits may be explainable in more than one way.

The relations of the Kiirunavaara-Luossovaara ores seem exceptional in that the two walls have a somewhat different composition— the hanging being classed as a quartz porphyry and the foot as a syenite porphyry — though the variation is not large. For these deposits Bäckström and later De Launay would assign a pneumatolytic-aqueous origin, according to which the iron was brought up in the form of vapors and precipitated at the surface in the presence of water during the interval of the two porphyry eruptions which are believed to have been submarine. This explanation involves the activity of some metamorphic agency sufficient to change the original hematite or pyrite to magnetite. Its application could hardly be extended to the other occurrences, which are inclosed by a single rock mass, a condition that is quite general in the magnetites of the Archean.

The visit to Kiruna and Gellivare was interesting furthermore for the insight it afforded in regard to the changes wrought by regional metamorphism. There can be no doubt of the fundamental similarity between the two localities as has been emphasized by Lundbohm.[1] At Kiruna, however, the ores and wall rocks have remained undisturbed since their formation; while at Gellivare the rocks have been so compressed and crushed that they have lost largely their original structures, and the magnetites with their included minerals have assumed a coarsely crystallized phase. To extend the comparison even further it may be said that our Adirondack magnetites illustrate the extreme effects of metamorphism, a more advanced stage than is evidenced by the conditions at Gellivare. Here, the rocks only seldom show anything in the way of structures that can be taken as original, they are interfolded in the most intricate manner, and the ore bodies are of the most varied and complex shape. Yet in these features they appear not more removed from the Gellivare occurrences than the latter are from the Kiruna deposits.

The excursion through central Sweden, which followed the close of the sessions in Stockholm, afforded opportunity for a brief visit to the Dannemora, Norberg, Flogberget, Grängesberg and Långban iron mines. The writer did not continue with the party to Persberg and Taberg, but instead made a trip to the mines at Striberg and vicinity which were off the route of the regular excursion.

The magnetites of this district present a great variety of characters and modes of occurrence, and it is impracticable in this place to do more than call attention to some features that have a comparative interest. Their investigation is attended with extraordinary difficulties, as will be appreciated by anyone familiar with the occurrences or with the painstaking work that has been done by the Swedish geologists in this field.

The Precambric complex that contains the magnetites is an intricately involved assemblage of gneissoid and massive igneous

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[1] Sketch of the Geology of the Kiruna District. Guide to the Excursions of the International Geological Congress. Stockholm, 1910.

rocks, various uncertain gneisses, and an apparently sedimentary series represented by quartzites, schists and crystalline limestones, besides many rocks of merely local importance. The undoubtedly igneous types, which are generally later than the ore-bearing formations proper, include granites, diorites, feldspar porphyries and diabases, the last two occurring commonly in dikes that intersect the magnetite bodies. Of the gneisses a varied assortment exists: the prevailing members in vicinity of the ores are alkali feldspar-quartz rocks of strongly cataclastic textures and belong to the leptite group under the Swedish terminology. The use of the word "leptite" in Sweden is explained in the foregoing article by Professor Kemp. The term comprehends both granulite and the extremely dense hälleflinta-gneiss. They range from granites to diorites in composition, but prevailingly carry some free silica. The nearest approach to this series in the Adirondacks is perhaps the gneiss surrounding the Hammondville magnetites which has been described by the writer.[1] The rocks of more or less sedimentary aspect seem to be relatively subordinate to those already mentioned, yet they inclose some large ore bodies. Their field appearance recalls the Grenville series of the Adirondacks. Of local prominence are amphibolites, usually feldspathic and with biotite or pyroxene and "skarn." (This very useful word is employed in Scandinavia for the aggregates of dark minerals—chiefly hornblende, pyroxene, biotite and garnet and their weathering products — that mark the borders of the ore bodies or occur as a gangue to the metallic minerals). As to the general method of distribution of the crystalline rocks in central Sweden, it may be said that the true granites constitute great masses which appear on the map as more or less rounded areas. The ore-bearing leptite and sedimentary rocks form belts squeezed in between or winding about the granite areas.

Grängesberg with its large bodies of apatitic magnetite stands apart from the other mines of central Sweden which we visited. It is rather allied, if any comparison be justifiable, to Gellivare and to our own apatitic magnetite occurrences as exemplified by Mineville. The resemblance lies not only in the mineral association peculiar to the ores, but is reflected as well in the larger features of the occurrence — the general uniformity of the surrounding gneisses, their predominantly sodic character, and the presence of granitic rocks, especially the pegmatites which border or interweave the ore

[1] Geology of the Adirondack Magnetic Iron Ores. N. Y. State Mus. Bul. 119, 1908, p. 45–49.

bodies. The Great Export pit with its broad lens of ore, rolling walls, pegmatite dikes and horses of country rock seems almost a physical counterpart of some of the Gellivare mines.

In an illuminative chemical and petrographical study of the Grängesberg area Dr H. Johansson[1] has found much to support the view of a magmatic origin for the ores. By reconstructing from chemical analyses a theoretical magma representing the average composition of the ore-bearing formation, he shows that it corresponds to a fairly acidic alkali granite with a predominance of soda over the potash element. The complex is characterized by rather strongly contrasting rock types from a chemical standpoint which correspond to the cleavage products of such a magma under a discontinuous process of differentiation. As extremes of the series we have on the one hand the granulite and gneiss group with 68 per cent or more of silica, and on the other hand the amphibolites with 50 per cent silica, with only few intermediate types. The ores that separated out during the differentiation show consistent relations to their inclosing rocks. The skarn ores are peculiar to the soda granulites; the apatite ores come in the plagioclase gneisses and granulites of more basic composition; and the quartzose ores are found with the potash granulites.

The ores of Grängesberg, as illustrated in the Export mines, which are much the largest of the group, are granular mixtures of magnetite and apatite. The latter amounts perhaps to rather more than 5 per cent of the whole. In some smaller mines of the vicinity hematite is the chief ore, and it occurs in one part of the Export mines, constituting the western half of the large northern deposit. It usually carries some magnetite and apparently grades into the latter. An explanation for its presence, which has been noted also in connection with the Gellivare deposits, is not easily found. The hematite is not a produce of later weathering, at least that derivation does not appear probable. The occurrence of hematite as a primary constituent of igneous rocks may be conceded, but its accumulation in quantity in the deep-seated zone by magmatic differentiation would hardly be expected.

The included bands of country rock are a curious feature of the larger ore bodies. They trend generally in the direction of the strike but may send off branches and coalesce with the foot or hanging wall so as to form a network separating the ore into

[1] Die eisenerzführende Formation in der Gegend von Grängesberg. Geol. För. För. Stockholm, 1910.

innumerable small lenses. The division of the ore and wall rocks is, however, quite sharp.

At Dannemora, Norberg and Långban we saw some typical deposits of such low-phosphorus ores as have been the mainstay of the Swedish iron industry since the middle ages. The association of magnetites with limestones, observed in some occurrences, has few parallels apparently outside of Sweden, and there are no similar deposits, of any importance at least, within our own State.

The Dannemora deposits have the form of vertical shoots, or stocks as they are referred to by Professor Sjögren in the guide to the district, and occur within a small belt of dolomitic limestone that is in turn surrounded by gneiss. The limestone belt is scarcely two miles long and a quarter of a mile wide. The gneiss belongs to the hälleflinta variety, with a dense ground mass, and is believed to be a crushed quartz-porphyry. Of later age than either of these rocks are granite in large intrusions and dikes of several kinds, the latter only coming in contact with the ore. The magnetite is mixed with silicates, chiefly amphibole and pyroxene, and much of it is too low grade to be used directly in the furnace. Like many of the low-phosphorous ores which we saw, it has a very fine texture.

A somewhat related occurrence of magnetite is represented by the southern mine group (called Klackbergsfältet) at Norberg. Lenses of dolomite are included in a fine-grained gneiss (leptite) and together are arranged in a discontinuous belt that follows the general country strike. Smaller lenses of magnetite are found here and there either wholly within the dolomite or along its contact with the gneiss.

The ores are high in lime and contain several per cent of manganese in the form of carbonate. An unusual ingredient of magnetites, noted in this place, is graphite which coats the natural joint surfaces so that the ore when seen in mass looks like so much coal. The phosphorus content is remarkably low, on the average about .002 or .003 per cent. The iron runs from 40 to 50 per cent, but as there is an excess of fluxing constituents the grade is really better than the iron percentages indicate.

Another series of magnetites at Norberg is represented by the skarn ores which are directly bounded by leptite or else form pockets and irregular bodies within lenticular masses of the same skarn minerals that compose the gangue. These minerals are chiefly amphibole, pyroxene and garnet. The association and the presence of considerable calcite at times suggest that the deposits are genetically related to the former group, but that in this case a more complete alteration has been effected, leaving little trace of the original limestone walls. The occurrence has some analogy to the magnetites in the western Adirondack region, notably the Fine and Clifton ore bodies, which have been described by the writer[1] as a separate type from the magnetites of the eastern and northern Adirondacks. Professor Sjögren has called attention to the Tilly Foster mine of Putnam county as an illustration of the skarn magnetites, finding a complete agreement in the mineral association with the Nordmarken occurrence in Wermland. The Cranberry deposits of North Carolina, described by Keith, are also placed by him in the same class.

The quartz-banded specular hematites at Norberg, also seen by the writer in their typical development at Striberg, are remotely, if at all, comparable as to physical features with any deposits in this State. They consist of finely-divided hematite, subordinate magnetite, and quartz, with a lamellar and oftentimes banded structure due to the alternate arrangement of ore and gangue minerals. This structure may have all the regularity of bedding and has been frequently cited in support of a sedimentary derivation of the ores. The wall rock is leptite, with more or less mica in addition to the usual quartz-feldspar aggregate which characterizes that rock.

At Långban we found iron and manganese ores forming lenses and shoots in dolomite surrounded by granitic gneiss, leptite and diorite. The iron and manganese are not intermixed, as in the similar occurrence at Norberg, but are distributed in separate though often contiguous bodies. The shoot shape is most characteristic. A series of altered trap dikes (called sköls, a name applied also to zones of shearing or jointing accompanied by decomposition) seems to be related to the ore deposition, a very interesting feature to which Mr H. V. Tiberg, the manager of the mines, directed our attention. On the upper side of horizontal dikes the shoot may flatten out into a sheet to diminish or disappear below them, suggesting that the mineralization has been due to underground circulations after the intrusions took place.

This brief survey of a few of the central Sweden mines will serve to show the complexity of geological and mineral features which characterize the ore occurrences in that district. As a whole the deposits are fairly distinct from those found in the Pre-

[1] Geology of the Adirondack Magnetic Iron Ores. N. Y. State Mus. Bul. 119, 1908, p. 37-42.

cambric of New York, or the adjacent areas, though between individual mines of the two regions certain similarities may be apparent or genetic relationships indicated.

The origin of the central Sweden ores is a question still under debate by the geologists of that country. The sedimentary view, which seems to have been the first to gain prominence in the Swedish reports, as is instanced also in the literature of our own Precambric magnetites, apparently has lost favor among the recent workers in the field. Of these, Doctor Johansson, whose paper on the Grängesberg mines has already been quoted, and Professor Sjögren, in his recent contributions, have emphasized the inadequacy of the sedimentary theory as applied to most of the deposits. The present tendency, judging from the later researches, is to consider the deposits as magmatic segregations — an explanation more suited perhaps to the high-phosphorus ores which are included within the granulitic gneisses — or as the result of metasomatic processes that may have accompanied the neighboring igneous intrusions. The latter explanation applies with special force to the skarn ores and those found in limestone; while the silicious banded hematites are possibly to be excepted as a separate class with sedimentary affinities. The subject, however, is too intricate to be given further attention in this summary.

The writer wishes here to express his obligations for the guidance and many courtesies that he received during the excursions. It is needless, perhaps, to say that the visits both in Lapland and in central Sweden were crowded with interesting features, scientific and technical, which have found no place in the foregoing notes. To the leaders of the excursions, Doctor Lundbohm for Lapland and Professors Sjögren and Petersson and Doctor Johansson for central Sweden, and to Mr Per Larsson, manager of the Striberg mines, an especial acknowledgment is due.

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NOTES ON THE GEOLOGY OF THE GULF OF ST LAWRENCE

BY JOHN M. CLARKE

As opportunity has afforded during the summer months the writer has continued his observations on the geology, principally of the Paleozoic formations, lying about and within the Gulf of St Lawrence. Not all the notes and records made are yet properly digested and fitted into their sequence in the geological history of this region, but there are some which extend and fortify my earlier researches and others which illuminate the investigations of earlier workers in these fields. The more tangible of these records are here brought together as an expression of progressing knowledge which it may be hoped will eventually give us a clearer conception of the development of this interesting region and of the causes producing the gulf itself.

I

THE RELATIONS OF THE PALEOZOIC TERRANES IN THE VICINITY OF PERCÉ

Percé is a region of boundless geological variety and interest. The writer feels that he has, in previous publications, only intimated its history, the details of much of which must be left to future students of the region, particularly that part of it lying back of the coast mountains. But in order to portray in panorama the relations of the Paleozoics here represented in a way that may help to clarify the situation, in the accompanying sketch a liberty has been taken with this irregular coast line by stretching out all its angles, headlands and bays into a straight line, so that, regardless of the unavoidable distortion involved, the eye may grasp not only the attitude of the rocks but their relative history. This section, which will be taken as only an approximation to accuracy of expression and whose discrepancies are freely avowed because of stretching a right angle into a straight line, is about six miles in length, unequally foreshortened at the north end, and extends from near Cannes des Roches at the north to the vicinity of l'Anse au Beaufils at the south. The point of view is out to sea east of Bonaventure Island, from the edge of the 50-fathom line which along this stretch of coast makes a deep bay inward toward this island (see Hydrographic map, p. 14, N. Y. State Mus. Mem. 9.

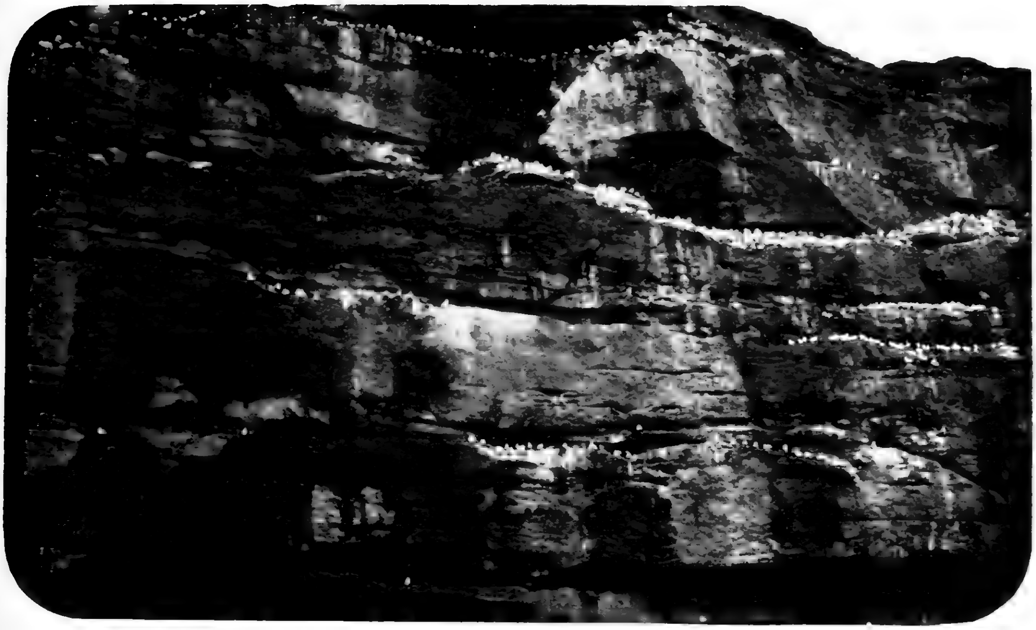
PANORAMA SKETCH OF THE SEA FRONT AT PERCÉ

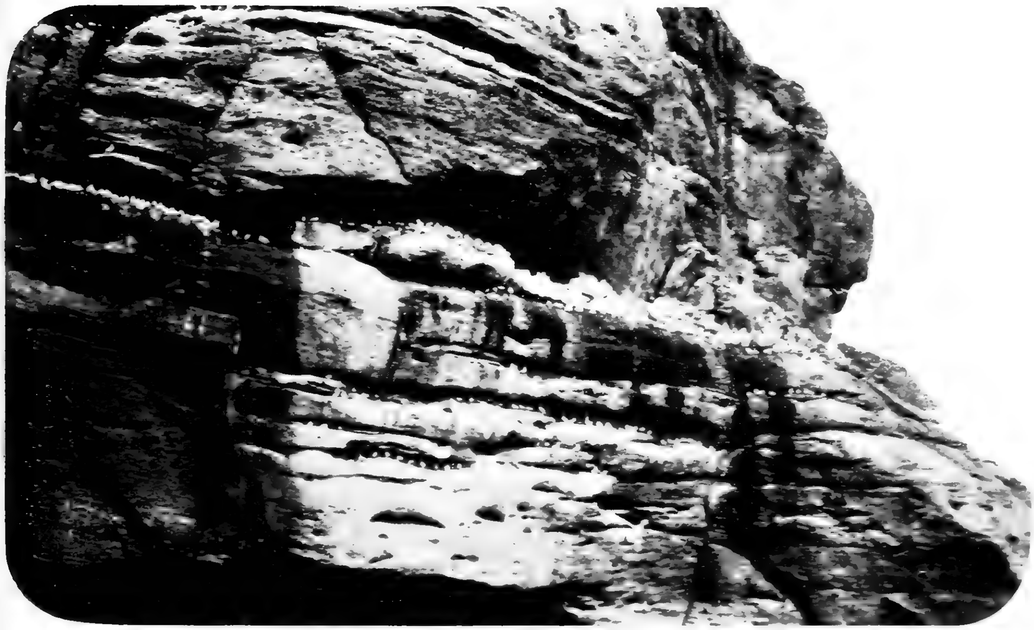
v. 1 Early Devonic of Eastern North America, 1908). This 50-fathom line is a submarine terrace at this point, one of the steps leading down to the great cut in the Bonaventure rock plateau made by the channel of the St Lawrence river. What is actually exhibited in this sketch is the present stage of the attack of the gulf waters on the folded and unfolded rocks of Percé, supplemented by the outstanding fault faces of the mountain cliffs and by the general effect of weathering denudation.

A contrast of fundamental moment lies in the attitude of the younger and older rock beds; the former horizontal or gently undulating, the latter simply inclined and, on the south front, vertical. A fact of similar moment is that the latter, consisting of Lower and Upper Siluric and Lower Devonic, are exposed in jutting cliffs by the removal of the mantle of softer beds from over them.

Bonaventure sands and conglomerates. These beds lie today much as they were originally laid down in the shallow waters of a rough coast which must have been not greatly unlike, in its broken rugged cliffs, the coast of Percé as it is now. I believe the Bonaventure series of beds, at least so far as we can distinguish it from the Gaspé sandstone series, or so far as it can be defined from its original section on Bonaventure Island, represents in time the latest stage of the Devonic and possibly the earliest of the Carbonic. We can not prove the latter affiliation from any evidence around Percé, nor indeed is this age demonstrable from intrinsic evidence at any point throughout its distribution from Gaspé bay to the head of the Bay of Chaleur. We have been in the way of deferring to current opinion in this matter, but can now go no further than to recognize an interval between this deposit and the earlier Devonic of the country, often intensified by down-faulting, the absence of any marine later Devonic and the continuity of this mass of sands and conglomerates as an accumulation of landwash along a bold upturned Precambric and early Paleozoic coast. I have had occasion before to refer to the fossil-bearing pebbles of this conglomerate,—Cambric, Siluric and Devonic; heads of Halysites often of large size (that here figured is from the cliff face on Bonaventure Island); fragments of the Gaspé sandstone and of the Percé Rock massive with their characteristic species. There is some order in the assortment of these pebbles, for there are as a rule few jaspers and other crystallines mixed with the limestones and few fossil-bearing blocks where the crystalline pebbles abound. Logan records a block in this conglomerate weighing upward of eight tons, but while such large ones are not familiar to my observation there is plenty of

Plate 1





Bonaventure conglomerate; Gannet cliffs of Bonaventure island

similar evidence that large, usually angular, masses were thrown down by seasonal freezing and thawing in the sea cliffs of those old days.

While these red Bonaventure rocks have undergone but slight deformation, it is their noteworthy down-faulting that has given to Mt Ste. Anne and its outlying cliffs their peculiar impressiveness. Ste. Anne rises, back of the sea cliffs and terrace of Percé, in a vertical east face from which has parted and, as I take it, slid down to lower level, that portion of the original mantle represented now by Bonaventure island and by the Robin reefs which the waters of the " Channel " have not yet washed away. Ste. Anne was once the " Table-a-rolante," and its gently rolling surface slopes downward to the north; but passing this, the observer is abruptly confronted by a second majestic fault scarp, the Grande Coupe, over whose smoothed face the water falls in vertical wavering lines to a level as low as the road, thence following to the sea a second fault plane which traverses the older rocks in a line at right angles to the Grande Coupe. This scarp faces north. Again at the back of Ste. Anne facing the south and west is an even more impressive fault cliff, the " Amphitheatre." Cut off thus by three bold fault faces, this mass of Bonaventure conglomerate is peculiarly isolated. The mountains roll up to greater heights westward of these undulating surfaces of Ste. Anne, but except for the first range, known as White mountain, their composition is as yet little understood. There is no area of these Bonaventure rocks known to me along the coast from there up the Bay of Chaleur, where this mode of bold faulting has been repeated, nor is there any very satisfactory evidence that the down-breaking of Mt Ste. Anne on at least three sides has involved the lower rocks on which it rests. These lower and older rocks constitute the very heart of appalachian upfolding and made a most irregular and unstable floor for the conglomerates, which may account for the manner in which the mantle has broken asunder without great distortion. Remnants of the down-thrown blocks still lie on the land; one constitutes the shore front in a strip reaching from the Robin beach south to Birmingham's hill; another lies beyond the vertical limestone of Cape Blanc, where there is a sharp fault against the latter, with evidence that the edges of the conglomerates have been dragged downward; again, way at the north end of the section at Cannes des Roches, is a tipped block lying at fault with the Siluric, while the very top of Red peak, the highest point overhanging the Malbay, seems to be an outlier of the Bonaventure limestone-conglomerate resting on the upturned angles of the Percé Rock Devonic; this too has presumably been separated from the parent mass of Ste. Anne by a fault.

One additional fact is here worthy of record. Overlying the slopes of Mt Joli, particularly the south flank, is a very thin mantle of a gray unfossiliferous shale, whose attitude is apparently at right angles to those vertical beds. What is present is a mere residuum reduced to little more than a film but it seems to be a remnant of some gray shale that pertained to the Bonaventure series and has been broken up by weather. I would make this intimation with reserve, as it is possible that this thin accumulation has some later origin.

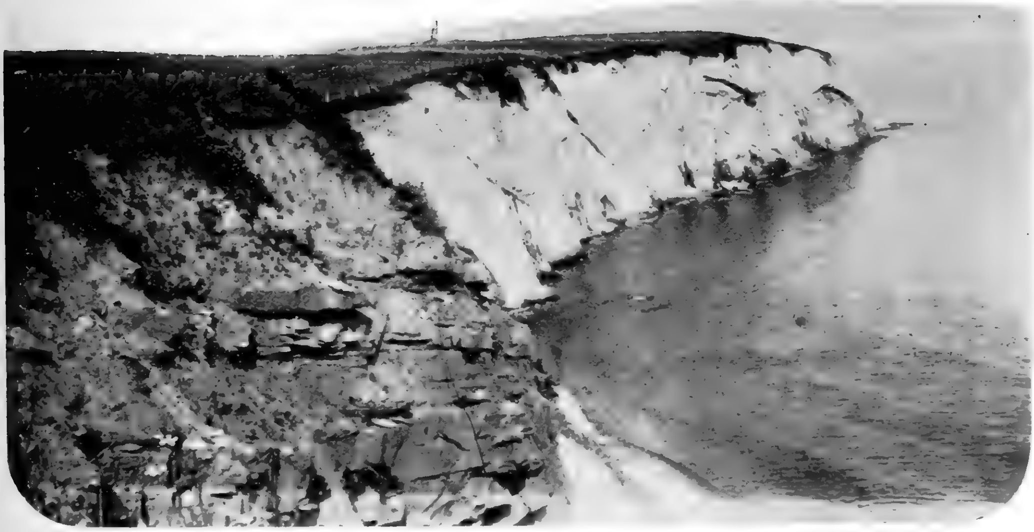
The vertical rocks. It is in the matter of attitude that the great contrasts of this coastal geology lie. On all the southward stretch from the angle of Mt Joli, the old rocks are but very little out of the perpendicular, standing with an inclination of 80°–85° s. This is true of all the Siluric shales and thin limestones of Mt Joli and Mt Canon, of the highly colored Devonic of Percé Rock and of the red and white limestones of Cape Blanc. On the north limb of the coast angle these older strata are less uniform in attitude and more faulted against each other but all steeply inclined. Throughout the complete series, however, there is a multitude of displacements, to which I have previously given some attention. Denuding these earlier rocks of their overburden, one finds the basis on which to restore the pre-Bonaventure appalachian upfolding, which has received its essential shove from the south, as the arm of the great mountain system here curved itself toward the east. All the capes and promontories of the coast lie where the more durable vertical rocks have stood against the sea, while the softer Bonaventure mantle was destroyed. These various Paleozoic rocks and their contents have been already pretty freely discussed by the writer and on this occasion it is desired only to consider somewhat more fully the character of the *cliffs at Cape Blanc and their extension into the White mountain.*

The overlap of the red Bonaventure sands and conglomerates on these vertical limestones is beautifully seen on this sea front. Unfortunately these cliffs are very difficult of access except in a calm sea, for they run sheer to the water with only a little beach here and there north of the cape. From above they are quite out of reach. The northernmost part of the vertical series, especially where covered by the red Bonaventure, is deeply stained red and green, but the color has not been derived from the rocks above.

Plate 2

Colony of Halysites — a boulder from the Bonaventure conglomerate, Bonaventure island.
Length of original 10 inches.

Plate 3



Cliffs of Cape Blanc or Whitehead, Percé, viewed from the south. In the foreground horizontal red Bonaventure sandstone; the cape is composed of vertical gray-white Siluric-Devonic beds

The basal mass of the Bonaventure here is wholly of deep red, soft sands, the conglomerates not appearing for a distance of some 30 to 50 feet higher. The vertical beds below, beginning at the north, are alternating shales and thin sands with thin limestones, the shales dark, the limestone bands red, green or blue. Southward the color is lessened and the beds become a gray white as they approach the point of the cape where the lighthouse stands. Beyond the cape the white beds and the entire series is terminated by down-faulting against the red Bonaventure rocks beyond them. The thickness of this vertical series of limestones is from 1500 to 2000 feet without much evidence of loss from internal faulting; and in attitude the beds fully conform to those of the Percé Rock and the Mt Joli series. I have before shown that the fossils of these beds are distinctively Siluric and the lists I have given indicate now a Lower Siluric age for the southernmost or whiter layers and a later stage for the northern, more highly-colored series. This condition, if correctly inferred, seems to imply an overturn of the strata, but much still remains to be learned from the fauna. The fossils are not especially abundant, not often clearly preserved and rather difficult to acquire, but the acquisition and subdivision of the fauna of the series remains an interesting problem. This limestone massive inshore affords exposures along Birmingham's brook and thence on toward Irishtown, rising gradually into the ribs of White mountain, skirts the rear of the Ste. Anne plateau in higher elevations, shows itself at Corner of the Beach and comes out to the Malbay shore in that vicinity (shown on the section here at the north end). It thus encircles the entire series of Siluric, Devonic and Bonaventure rocks about Percé, and forms the outstanding wall of an ancient basin within which the Bonaventure rocks were here laid down. We have as yet no reliable evidence that these Bonaventure deposits extended westward beyond this rock wall.

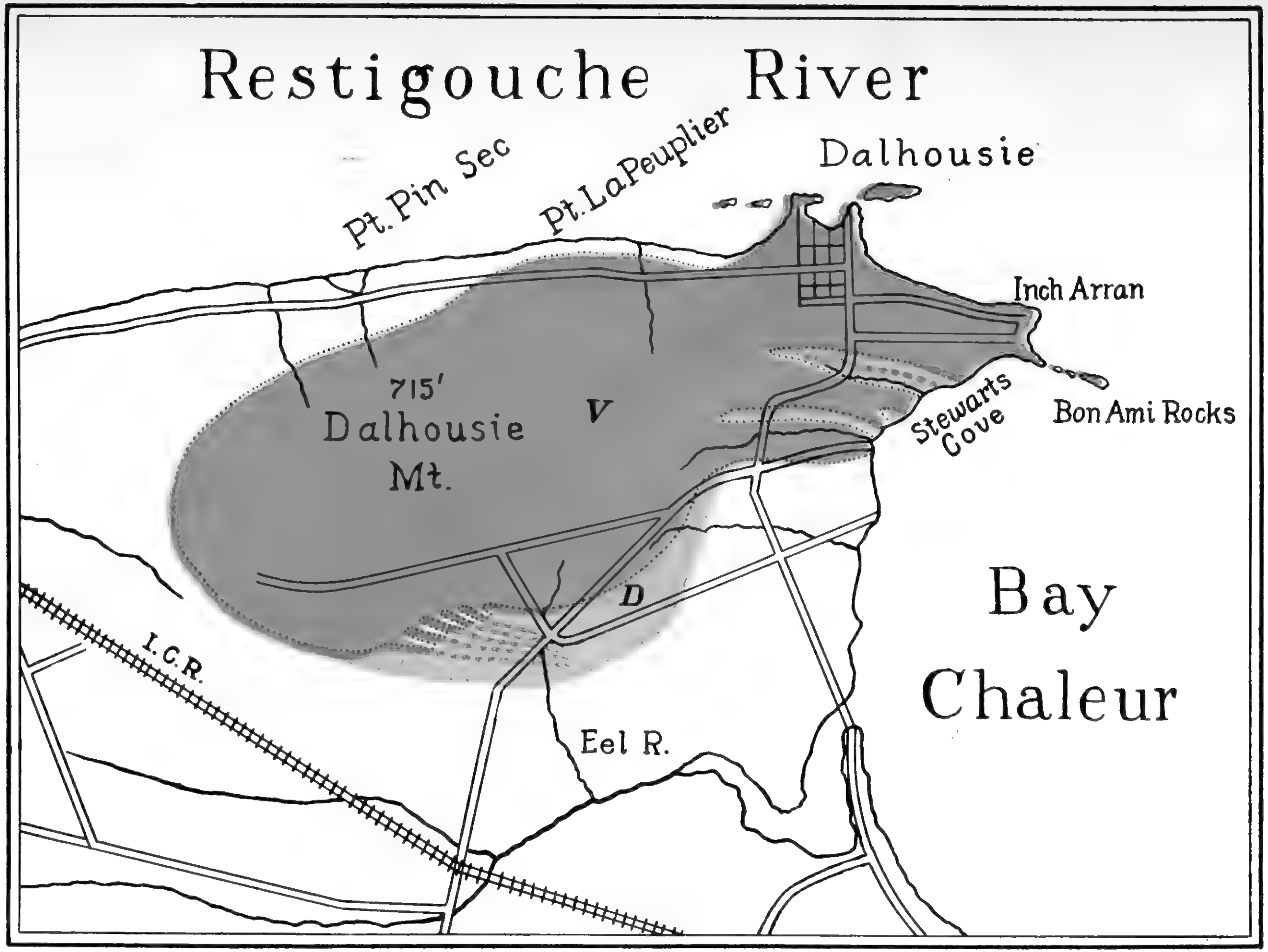
II

ERUPTIVE CONTACTS IN THE MARINE DEVONIC DALHOUSIE BEDS AT DALHOUSIE, NEW BRUNSWICK

This mass of soft and highly fossiliferous shale has been described at length and its fossils fully discussed in the second volume of my memoir on the Early Devonic of Eastern North America (1909). I have more recently had opportunity to examine the extension of these beds from the shore exposure at Stewart's cove, inward or westward toward Dalhousie mountain. It is necessary here to restate briefly the interesting geological relations in order to bring out the pertinence of my present remarks. Dalhousie mountain lies a mile or so back from the shore of the Bay of Chaleur at Dalhousie and appears to be a large boss of eruptives from which apophyses extend eastward into the sea, a large arm reaching down through the village and projecting as two points at the waterfront, thence extending continuously to the lighthouse at Inch Arran, covering the Inch Arran beach, including the islets known as the Bon Ami rocks, and therefrom reaching to the opening of Stewart's cove. This heavy lava mass is interesting for its great inclusions of crystalline blocks which are finely displayed in the bluff below the Inch Arran light. These inclusions are of various composition, pink and gray syenites prevailing, and in this much weathered rock face where the decomposition of the lava has spread radially from their surfaces, the cliff looks as though it had been shot full with great missiles whose impact had fractured the matrix.

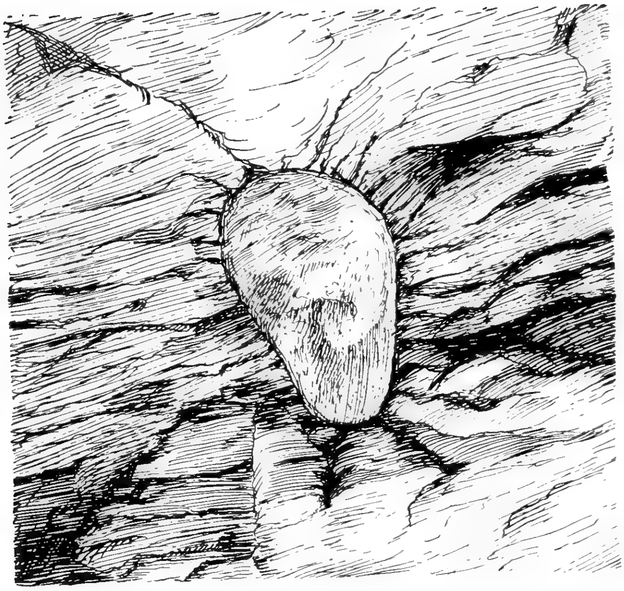
At the south end or bottom of this mass begins an exposure of the upper inclined fossil-bearing Dalhousie shales, the contact being buried under the beach sand and the highest beds, which are coral limestones, being exposed only at extremely low water. Continuing several hundred feet along the shore cliff wherein are one or two thin ash beds, the shale series is cut by a second volcanic mass at the mouth of Stewart's brook where the contact is sharply defined and its effects manifest. The front of this second volcanic mass is a fifth of a mile long and near its midlength lies a large but quite clearly embedded mass of the shale, whose precise position in the series is not entirely certain. At the bottom or south end of this lava mass the lower section of the shale series appears and continues for several hundred feet more. Its base (beds with Gypidula pseudogaleata) lies on a floor of volcanics which, on the shore section, terminates the sedimentaries. The entire section of Devonic sediments here is measured at about 450 feet, without evidence of repetition in its parts, and it is actually cut but once by the volcanics. These extrusives were contemporary with the deposition of the sediments, and it seems probable that they are actually connected as apophyses with the mass of Dalhousie mountain as represented on the original map of this region by Dr R. W. Ells (1884). Here on the shore front the volcanic masses are very heavy and their contact effects are shown by the induration of the shales, the whitening of the calcareous fos-

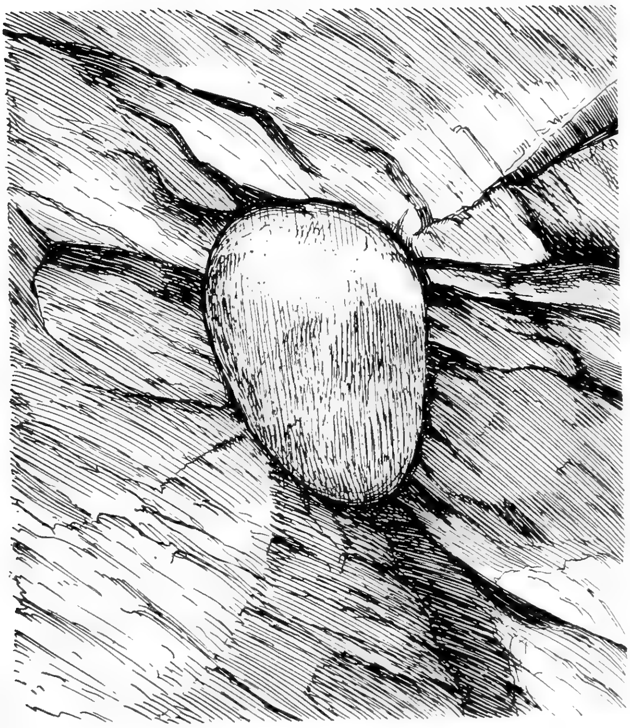
Plate 4



Sketch map of Dalhousie showing the relation of the eruptive mass (V) and its apophyses to the Devonic marine sediments (D)

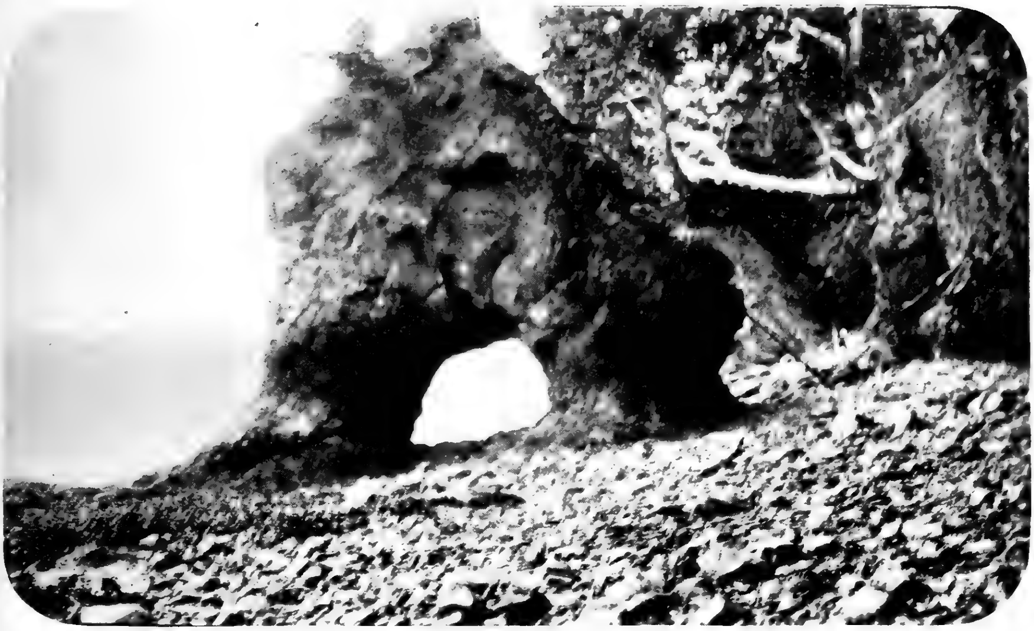
Plate 5





Inclusions of syenite in the diabase at Inch Arran light, Dalhousie

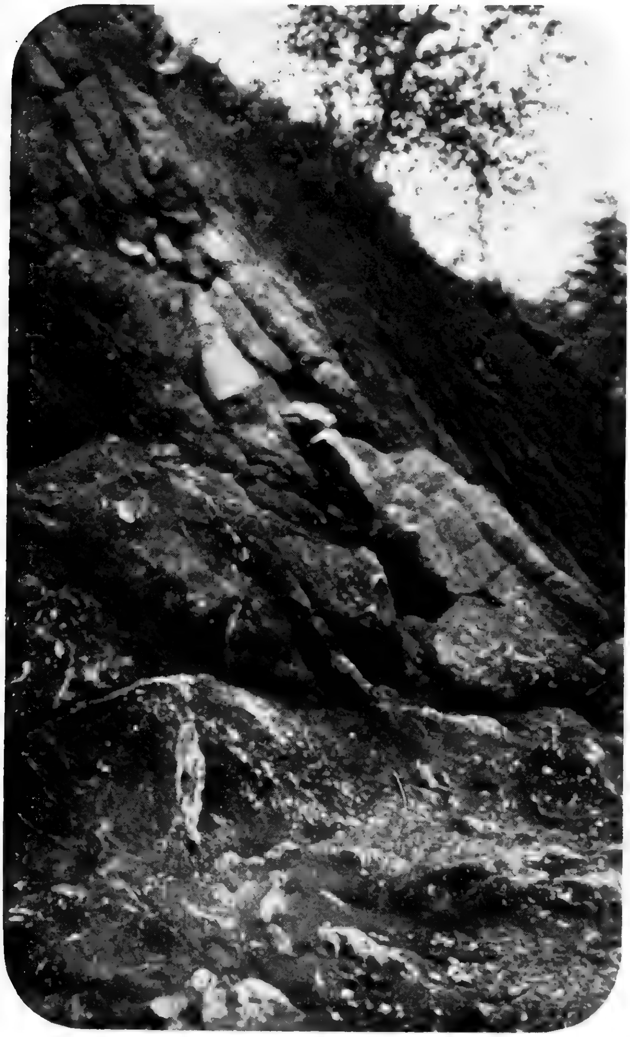
Plate 6



Dalhousie—Gateway to Fossil cove—an arch of eruptive rock

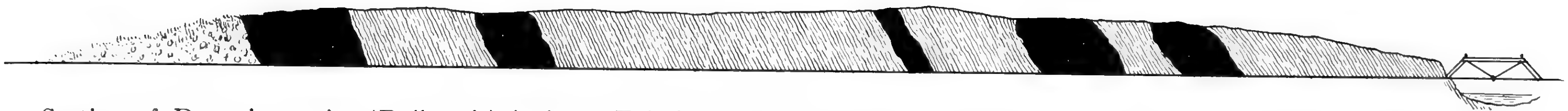
Dalhousie—Fossil cove at very low tide exposing about 25 feet of strata at the top of the series, largely coral beds not before recorded. The pick is resting on the uppermost layer.

Plate 7



Contact of fossil-bearing beds (above) with the eruptives (below). The soft calcareous shales are baked into limestones. Fossil cove, Dalhousie.

Plate 8



Section of Devonic marine (Dalhousie) beds on Eel river road, 202 feet in length, showing five interbedded masses of volcanic tuffs and ashes. The dip of the unaltered fossiliferous beds is indicated and is to the north.

sils and the deposition of secondary calcite. There is no breccia formed as the sediments were not sufficiently hardened at the time of the outpours to produce a breakage of this character.

Back on the heavily wooded mountain there are no traces of any other rock than the eruptive and the only clues that I have obtained as to the inward extension of these almost ruined masses of Devonic rocks are located along the road southward to Eel river, which runs with some deviation parallel to the coast but at a distance of three-fourths to one mile back. The rock cuts along this road complete without simplifying the relations of the sedimentaries and eruptives.

Sediments and eruptives in the Eel river road section. On consulting the adjoining sketch map there will be seen an east and west crossroad reaching from the shore to the Eel river road and passing along the main eruptive mass. Turning south on the Eel river road the remaining width of the volcanic is soon passed and the road cuts a series of red sandstones, followed by dark reddish shale and yellow decomposed limestone. The shale has produced a peculiar fishplate which competent authority has thought may be Pteraspis or an ally, and the decomposed limestone is profuse in Ostracodes, of which there is abundance in similar position on the shore section. The shore, however, has produced no red sandstone, no reddish shale and no fish remains. The outcrop of the sedimentaries is here not more than 50 feet in entire length; then follows the eruptive which is not interrupted until the road crosses the bridge over Stewart's brook and in a west curve takes the next rise. In a position which corresponds to the lower or south section on the shore there is shown in this road a slight extent of similar Devonic shale. From this point on, all correspondence in the shore and road section is lost, for on the shore the sediments have ended. One continues on the highway, however, over the hill, crossing the second bridge beyond the house of James Stewart and here begins the section which is seen in diagram on the following plate. Here the outcrop face is 202 feet long; its sediments are all normally and steeply inclined to the north as on the shore and are crossed by *five* distinct beds of contemporaneous lavas, tuffs and ashes. The contacts of the sedimentaries with these thin ejections are absolutely unaltered; indeed here, as on the shore section, there are ash beds in which the fossils lie unaffected. Evidently the thin volcanic masses carried too little heat to effect any change in the sediments lying in cool waters, only the heavier outpours seen on the shore section radiating enough heat to produce any contact changes.

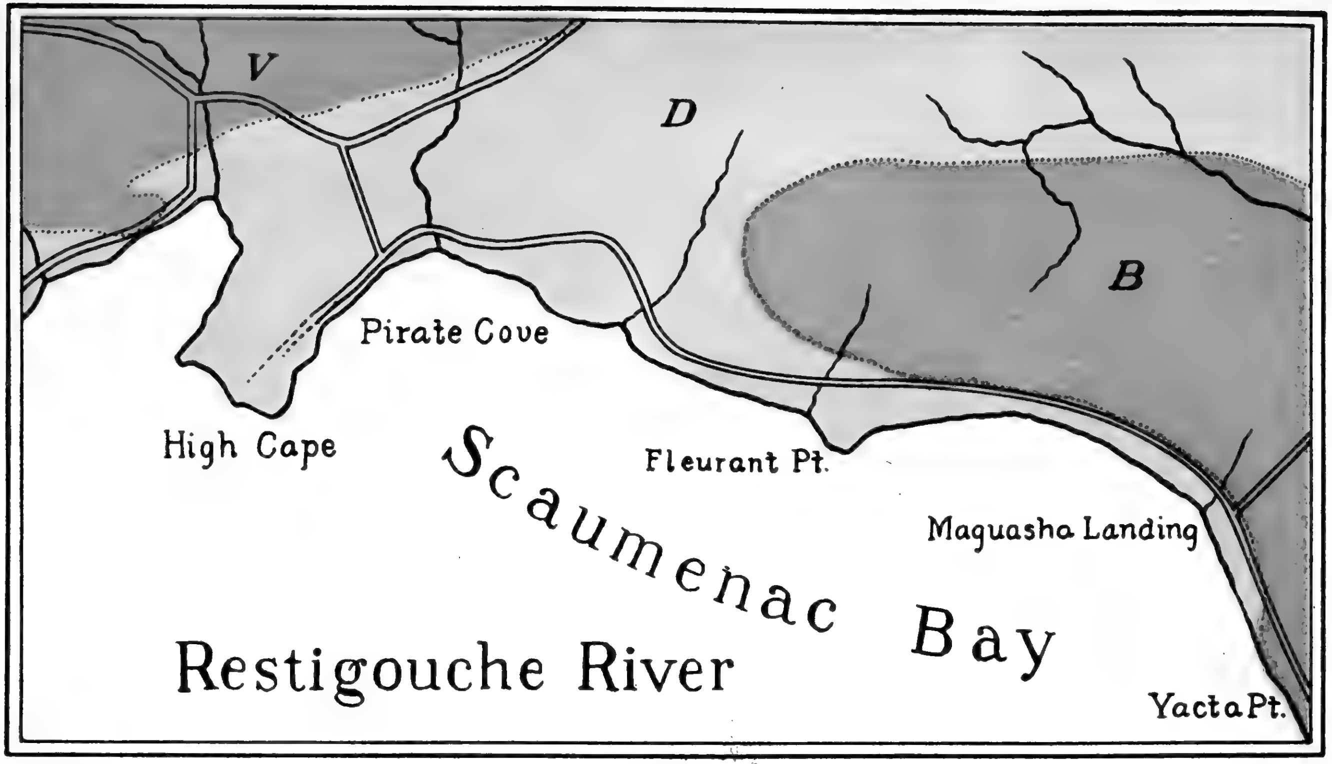
On the accompanying sketch map the distribution of the sedimentaries and their accompanying volcanics are indicated as now known. It presents an occurrence of singular and unusual interest.

III

STRATIGRAPHY OF THE DEVONIC FISH BEDS AT MIGOUASHA, PROVINCE OF QUEBEC

The fish-bearing beds of this region are probably the most remarkable of any Devonic deposits known in respect to the abundance and excellent preservation of their fish remains. These have entered into the literature of paleontology extensively and generally under the name of the fishes or beds of Scaumenac bay, Escuminac, Fleurant point or Yacta point. In view of the polynomial character of the region it is well to be explicit. These beds lie on the north shore of the Restigouche river where it broadens into the headwaters of the Bay of Chaleur. Their location is straight across the water from Dalhousie, N. B., whence a ferry runs to what is known as Migouasha landing, where the rock wall of the bay is degraded to the water. At a quarter of a mile east of Migouasha landing the red rocks of the "Bonaventure" formation come down to the water in an eastward dip, and at about three-quarters of a mile westward of the landing is the projection of Fleurant point. The high-colored "Bonaventure" beds rising from the water line at the east, present a contact with the underlying gray fish-bearing beds for a distance but on passing Migouasha they retreat into the hills of the background and all the rock beds exposed thence westward to Fleurant point are the gray sands and shales with fish. In the voluminous literature relating to the contents of these rocks little has been recorded as to their stratigraphy and the essential evidence which has led to their general acceptance as Upper Devonic has been brought out by Doctor Ells's account of the locality given thirty years ago. These gray Devonic sands with their nodules of various sizes, carrying Bothriolepis, Scaumenacia and several other fishes in extraordinary preservation and the blocky masses filled here and there with their remains, attain a considerable thickness at the highest point along the stretch of coast, perhaps a clean exposure of 100 feet and, in view of their dip eastward, a total thickness of not far

Plate 9

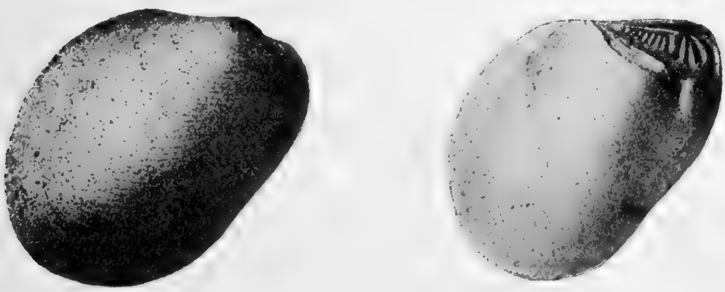


Sketch map of the Devonic fish locality at Migouasha. V=Eruptives; D=Devonic; B=Bonaventure

from 200 feet. This region is the Scaumenac bay of the reports. I have no fault to find with the determination of the age of these beds as Upper Devonic; not only geological relations indicate this but Doctor Eastman states that the composition of the fish fauna itself substantiates this reference. There is something to be said both for and against the assumption that the " Bonaventure " conglomerate of this part of the coast is wholly Carbonic; in fact in its typical development where it fronts the gulf at Percé, it certainly seems to complete the late Devonic interval.

My attention has been attracted to a layer of loose rounded boulders which underlies the fish beds along the shore not far west of Migouasha landing. It is a rather striking accumulation lying together like a mass of till with the boulders rolling out into the landwash. These boulders, which are largely limestone, contain a variety of invertebrate fossils. Some blocks consist only of colonies of Halysites; another single boulder contains Dalmanites micrurus Green (head and pygidium), Camarotechia cf. dryope Billings, a small Leptostrophia, Chonetes and Pholidops and a rather striking species of Cyrtodonta,[1] which indicate a normal marine early Devonic fauna. The boulders and their contents are comparable to the limestone pebbles and boulders of the red conglomerates (Bonaventure) of Percé, though the gray color and comparatively slight thickness

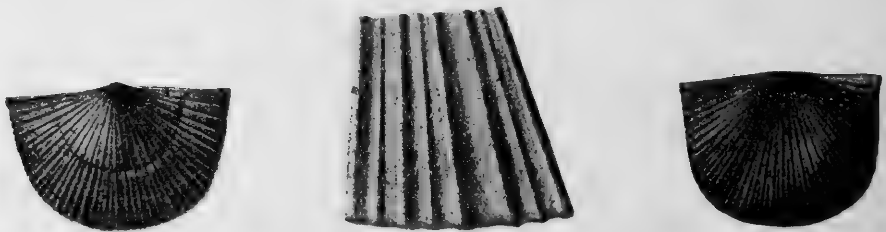
[1] Cyrtodonta gratia — an oblique shell with very low convex valves, not expanding behind, very slight forward extension, giving thus an outline quite usual in the genus though perhaps somewhat less orbicular than in the few species now known in the Devonic of the Atlantic province. The



Cyrtodonta gratia nov. Exterior of right valve and internal cast showing the character of teeth

exterior is closely lined concentrically. The anterior muscle scar is deep and the umbonal teeth strongly developed into a comblike arrangement in which the first and third anterior teeth curve toward each other, enfolding the second; behind these six lesser teeth diminishing in size to the umbo.

of the mass forms a strong contrast. Of course the age of the fish beds depends on the age of the youngest fossil to be found in the boulders of these underlying beds and as yet I have seen nothing later than the Helderbergian. It is therefore possible that the sedimentation of the fish beds began before the opening of the stage we should elsewhere characterize as Upper Devonic. An additional supplementary fact is worthy of record. A large angular block of highly argillaceous black limestone, with a weight of several tons lying on the Migouasha beach above the reach of high tide, has every appearance of having been derived from the rocks of these near-by escarpments. This block contains in some abundance a brachiopod of the genus Schuchertella, and though I have not been able to identify it with species known to me, it is evidently of early Devonic type. Figures of this species are here introduced and the distinctive characters may be



Schuchertella sp. Ventral and dorsal valves with enlargement of the surface. From the shore at Migouasha

given as the coarse, wide apart, rounded ribs, with flat interspaces divided in later growth by intercalary ribs, all the interspaces being traversed by fine longitudinal lines.

IV

HISTORICAL NOTE ON THE LEAD MINES OF GASPÉ BASIN

In my writings on the geology of Gaspé, reference has been made to recent and present attempts on the peninsula of the Forillon to exploit for galena and silver the little calcite seams which fill the joint crevices of the Lower Devonic Grande Grève limestone beds. These efforts began far back in the history of New France and the most serious of them, as well as the most productive, was at Little Gaspé close to the contact line of the limestones with the overlying Gaspé sandstone. It is a singular illustration of the undying persistence of legend in the face of well-established fact that a forlorn hope early dismantled should have revived and been persistently pursued for well nigh 250 years.

Plate 10

Boulder bed with interstratified sands lying beneath the fish-bearing beds at Migouasha. These boulders abound in Devonic and Siluric fossils.

Some years ago there was found among the departmental archives of the Seine-Inférieure at Rouen the manuscript journal of Jean Doublet. This was edited and published by Charles Brèard in 1883 under the title "Journal du Corsaire Jean Doublet de Honfleur, Lieutenant de Frègate sous Louis XIV." Doublet was a freebooter whose stirring life has put a thrill into every page of this remarkable book. He was the son of François Doublet who in 1663, under concession from the Company of New France, attempted to settle the Magdalen islands and disastrously failed in every respect save that of giving to these islands the name of his wife Madeleine. When this expedition to the Magdalens took place Jean Doublet was seven years old and the little fellow stowed himself away on his father's ship as it left the roadstead of Honfleur, only allowing himself to be discovered when a boatswain into whose bunk he had crawled threw himself down on top of the sleeping boy. The vessel was then well out to sea and the angry father had to take the boy along with him to the Magdalens, fortunately indeed, for it is to him we owe practically all we know of this attempt to colonize those islands. Returning to France at the end of the season, full of promise of success in the fisheries there, the elder Doublet came back to the islands in the spring to find his colony broken up, his stores pillaged and the place wholly abandoned. So this attempt ended in disaster. In 1665 François Doublet, the father, was commissioned by the Compagnie des Indes Occidentales to go for them to the coasts of Gaspé to examine a lead mine about which reports had come to France through the Intendant Talon. M. Brèard says in a note quoted from the Archives de la Marine, Canada (1665), that Talon, judging that the discovery of precious or even base metals was a matter of importance to the king, obtained the right to send to Canada forty workmen. The company recruited these in Normandy and the command of them was given to François Doublet. In addition to the lead, the ingenieur-fondeur believed he had discovered silver on the coast of Gaspé. "The belief seems well founded," wrote Talon.

In "Sketches of Gaspé" (1908) I quoted Nicholas Denys's remarks on this Gaspé mine (1672) in which he says he had known of the place for twenty years, that is as early as 1652, doubtless from reports communicated by the Indians to the missionaries. Indeed as early as 1663 Father Balloquet was sent to look up the place and, according to the Jesuit Relations, returned not finding his mine "good."

Jean Doublet gives this account of the mining in Gaspé:

In the year 1665, my father was asked by the Company of Canada[1] if he would go to Quebec on one of our vessels which would fit out at Havre, in the capacity of a commissioner to mine for lead along the shores of the river St Lawrence where discoveries had recently been reported. They promised to furnish him seventy men for this purpose and also a German mining engineer and an interpreter, all at the expense of the company, and to provide in general all tools and provisions as well as the necessary ships. My father was to have 3000 francs a year and 4 per cent of the profits on the lead; the engineer to have 4000 francs; the interpreter 600; the workmen in proportion. My father accepted the position which he would not have done had it not been for his previous losses. When the ship was in the roadstead at Havre ready to sail, a boat came to carry my father to it, as he was all ready; and I plead so well that I prevailed on both him and my mother to let me go with him; so we were taken aboard the ship which was commanded by the celebrated Captain Poulet of Dieppe. We found the vessel extremely crowded by eighteen horses and two stallions from the King's stables. The hay for the sustenance of these filled up the whole place. Then between decks there were eighty respectable young women who were to be married on our arrival at Quebec; all these together with our seventy workmen made a veritable Noah's ark.

Our passage was pretty fair, although it took us three months and ten days to arrive at Quebec. M. de Tracy was viceroy, M. de Courcelles was governor, M. Talon was intendant, M. de la Chesnèe-Auber was commissary general of the company. When my father had issued his orders a vessel of 70 or 80 tons was equipped to carry us with all our necessary things to the mines. On the 13th of August we arrived and disembarked at Gaspé and set to work on our lodges and furnaces. On the 28th we began to pierce into the rock on the south side where was the first discovery the native savages had made. These savages in making a fire for their kettles had used one of these rocks for a handiron (de chenet) and lead came out of it. This they found after their fire was extinguished and they took it to M. de la Chesnée who sent it to France. This it was that had occasioned our enterprise as it was thought that considerable of this metal might be found here as it is in England. On the 6th of September the said mine, after having been excavated 32 feet deep, was fired and we had two men killed and one named Doguet, of Rouen, had both his legs blown off, while three others were slightly wounded. This was their fault as they did not retire as far from the mine as they

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[1] What is here meant is the "Compagnie de la Terre Ferme d' Amerique," reorganized by an edict of May 28, 1664, under the name "Compagnie des Indes Occidentales" (Brèard).

Plate 11

Colony of Halysites, from the boulder bed at Migouasha. Length of original 10 inches

were ordered to. At a depth of two feet this mine promised well as we found there eight inches and four lines of face. But after we had reached a depth of 32 feet, it ended in nothing. This discouraged the Sieur Vreiznic, our engineer, who said that in all the mines he had excavated even of two or three lines at the surface, he had found at a depth of 20 feet more than a foot of face without counting the veins scattered in various places.

From the 15th to the 24th of September we worked on the north side. After having removed the earth from the rock we found at the surface five inches, one line; and after the mine was opened there were found only two inches. From the 27th of September to the 4th of October we worked on the east side without losses or wounds to our men. We had some hopes of succeeding better here, since we had found on the surface nine inches and three lines, but at a depth there was nothing at all. And that we might have nothing wherewith to reproach ourselves, on October 28th we tried the west side, where on the surface were only two and a half inches, and at 20 feet depth nothing.

The season obliged us to return to Quebec as we had neither provisions nor lodging fitted to resist the great cold and snows; so we were forced to abandon our work which had yielded us no more than eight to nine thousand weight of lead. We took our departure on St Martin's day and on the same vessel that had brought us, and the mine had only made a hole in the purses of the miners.[1]

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[1] A play on words: "La minne mina la bource des mineurs."

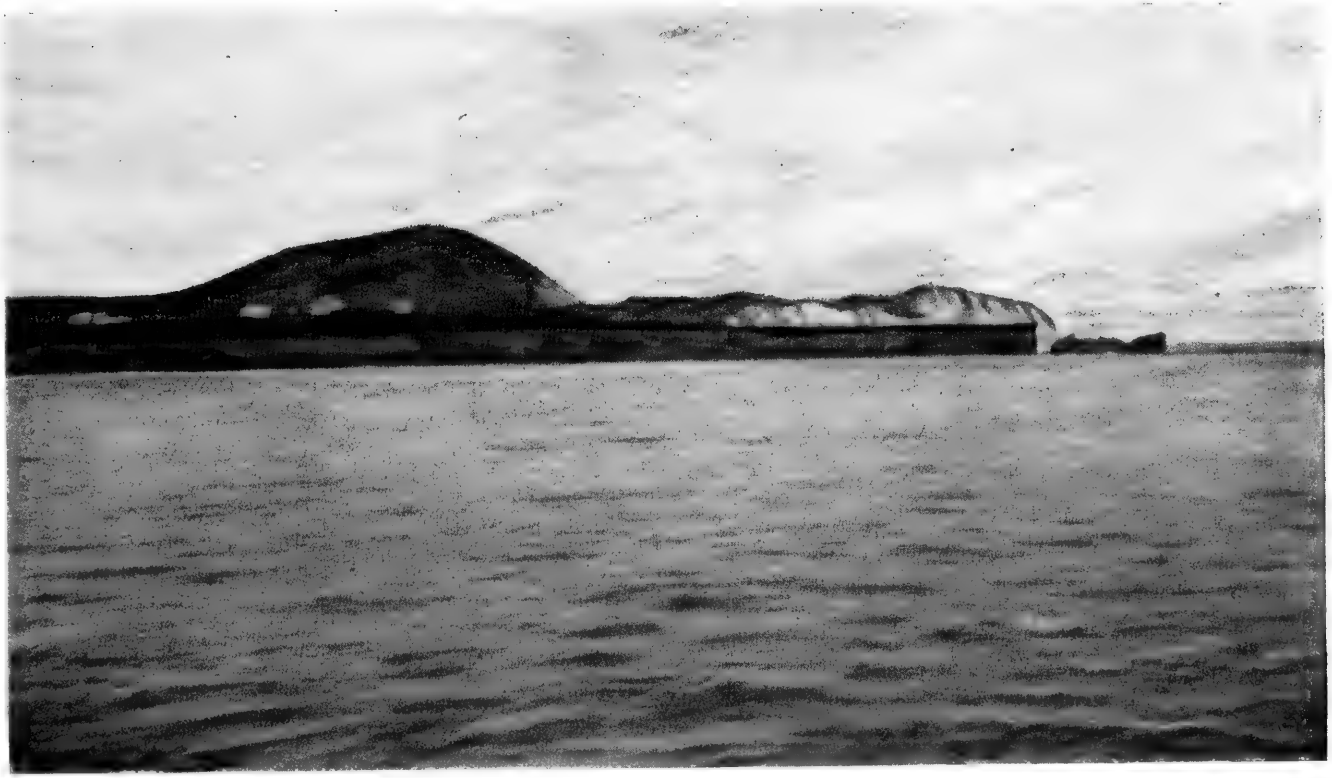
OBSERVATIONS ON THE MAGDALEN ISLANDS

The Magdalen islands, lying in the very heart of the Gulf of St Lawrence, are a chain of disjected and sea-wracked remnants of continental land, standing today as they have stood since the beginning of navigation in these turbulent waters, a fearful menace to the sailor and his craft. The chart shows them stretched out like a long key lying crosswise of the waters in a direction which corresponds to the general northeast-southwest course of the basal rock folds and depressions which govern the fundamental contour of all the lands of the lower gulf. If the eye will follow the 20-fathom line on the chart, it will be seen what a tremendous platform has been carried away by the waves in the gradual wasting of the land to this slight depth and what slender, broken remnants of it now remain above the water line. A 20-fathom elevation to the water line would throw all the chain of islands into one land mass and leave them as slight elevations along the rib of a broad plateau which, altogether, would present many hundred times the area of the land now remaining. Even the 10-fathom line sweeps about all the islands, tying them into one, and reaches out to take in Brion island at the north and the Great and Little Bird rocks further east; so that if the water might stand now at this 10-fathom line, or in the days when it did so stand, the broader Magdalen island would stretch its key out into a long, slender and gracefully curved handle.

Today these islands differ only from the isolated rocks of Brion and the Birds by being fringed with sand spits and dunes and tied to one another by tremendous sand bars, which the seas at the east and the west have piled up into a double chain, leaving between the great interior lagoons, Basque harbor, House harbor, the Great Lagoon and its branch at the extreme north behind the dunes of Grosse Isle and East point. Thus the sea has tried to bury the remnants of its own destruction, tossing back to these feeble fragments of the land its very ruins.

Compared to the area of the Magdalen group as it appears on the chart, the actual area of rock land is small and resolved into little insular units of soil and of population. *Entry island* stands at the eastern terminus of the chain and faces the entrance to Pleasant bay, sometimes the least, and sometimes the most dangerous harbor on all the coast. Westward and separated from Entry by the tremendous spit of Sandy Hook is *Amherst island,* whose harbor and

Plate I



Magdalen islands. Shore cliffs on Alright island; showing the contrasting colors of the soft and hard sandstones and the "demoiselle" topography.

landing at the little triangle of Mt Gridley the eye will barely catch except by close inspection of the chart. This little spot of rock is really cut entirely away from the island proper, but a sand bar leads across to Demoiselle hill and beyond this narrow neck of actual land the island widens out, extending east and west for nearly ten miles across, broken by demoiselle hills which have a trend parallel to the northeast course of the island chain. The two great bars which run north from Amherst and inclose the Basque harbor are cut across by tickles or gullies too narrow to make a passage except for the smallest craft at high water; but the inhabitants drive along these bars from island to island fording the tickles as best they can — always a perilous passage if the sea outside is heavy. Reaching out with these two arms Amherst clutches *Grindstone island*, an almost circular land mass with high shore cliffs on nearly every side, and again an interior of rounded demoiselle elevations, the nature of which we shall presently refer to. Then from Grindstone two arms again extend north and eastward.

At the west is the immense bar reaching 27 miles from Hospital cape to *Grosse Isle* inclosing midway of its course the little rock fragment, *Wolf island*. At the east Grindstone is separated from the land next north, *Alright island*, by the tickle which leads into House harbor, the best of the land-locked roadsteads of the island, and ferriage is necessary to reach the south end of the crescent-shaped film of land which makes Alright. This island is little else than a row of beautifully rounded demoiselle hills whose grassy green summits and gray sides form a brilliant contrast with the low-lying platform of red rocks at the water's edge. Perhaps two-thirds of the area represented on the map as constituting Alright island is rock land; the rest is sand and the great eastern bar here runs its course, passing the little rock called *Shag island*, on to the northeast until it is broken across by the Grand Entry, the broad tickle leading into the northern expansion of the Great Lagoon. This, too, is good harborage but the vessels in heavy sea or low tide rarely take the risk of running it. I have waited eight hours on the sands of Grand Entry for the coast steamer standing in the offing with an east wind and a falling tide, to muster courage to run the passage. From Grand Entry to Old Harry point is another sickle-shaped bit of land, cut into and perhaps in two or three by sand-covered passages. This is *Coffin island*, and on the sea front from here around to East point, the farthest tip of the islands, and back again to Grosse Isle, there is no rock land — all is a vast stretch of high duned sands. Behind these sands and facing the lagoon is the bit of land called

East island, with its high half-ruined North East cape which peers out far over the sands and is the first point of the islands that confronts the traveler from the north. There remains in this chain of sand, Grosse Isle, a divided island, one single hill standing out on the west coast as North cape, the rest a headland, Grosse Isle head, facing in a long escarpment the interior lagoon.

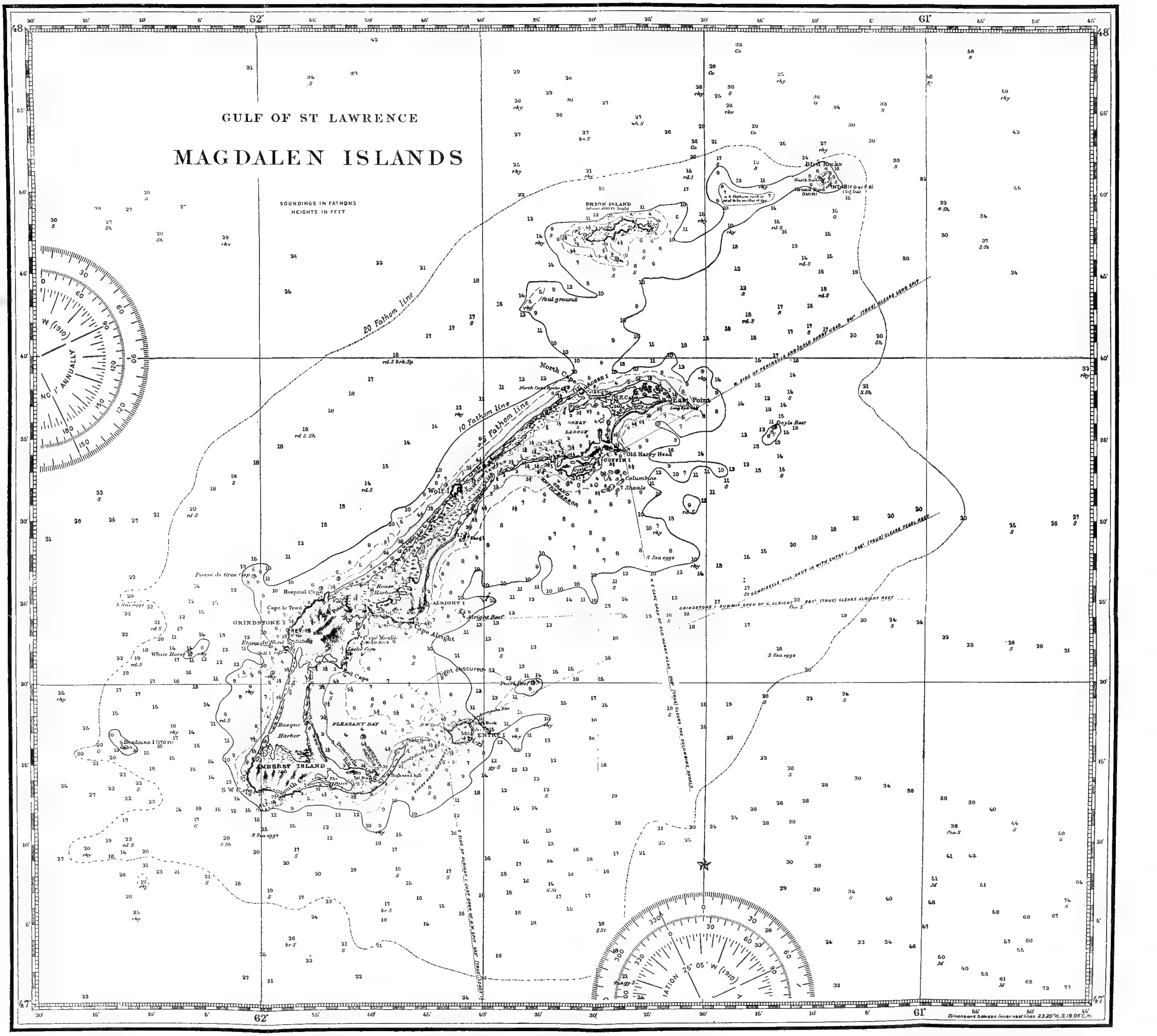
It is an instructive feature in the structure of these islands that the northern lagoon both south and north abuts against so many steep bare cliffs. The waters of this great lagoon are shallow and navigation in them is closely restricted to a narrow sinuous channel through whose course the navigator is guided by a staked way. These waters could not in their present condition have contributed to the downfall of the rock cliffs; the interior cliffs were made in days before the lagoon existed or its sands were heaped up to cut off the outer sea.

These bits of land which constitute the Magdalens have been saved from total destruction by the slow elevation from the sea in later stages of their history which has given birth to the sands, and extended them over the wasted plateau which the waters themselves have created. I should not say that this was a recent effect, for these great sand bars are often a mile or more across from water to water and the dunes which cap them may be 100 to 150 feet in height, while their mobility is restrained in part by caps of bunch grass and stunted spruce. The islands and their sands are the ruin wrought by the sea; so they in their turn have wrought terrific ruin to sailors and sail from the time the Europeans began to throng the gulf. Their long, low, dark coasts and treacherous bars have lain like a trap for the unwary navigator; and when beating out of his course for the channels at the north or the south, or in times of stress when the northeast or northwest seas were driving against the rocks and sands, hundreds of craft have gone ashore on these unlighted cliffs; the bleaching ribs of dead ships are seen on all the coasts, and tales of shipwreck make up much of the history of the islands.[1]

Of the islets that lie off the chain only one — *Deadman's island,* a sarcophagus of rock a few miles west of Amherst — is noteworthy and that for its history and associations. It was gruesomely

[1] Many of the inhabitants are castaways and M. Brassette, the venerable postmaster at Amherst, has told me that within his time there have been, he thinks, not less than five hundred ships, great and small, cast upon these islands.

Plate 2



Extensive corrections, Oct. 1908

Washington, D.C. published, July, 1888, at the Hydrographic Office, under the authority of the SECRETARY OF THE NAVY.

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sung by Thomas Moore, was the Isle d'Alezay of Cartier's first voyage (1534) and is the Corps Mort of the French. Of the larger islands at the north *Brion* lies ten miles away from Grosse Isle, a block of rock three miles long with sheer walls on nearly all sides, and the *Bird rocks,* famed for centuries for their myriads of waterfowl, lie twenty miles from Grosse Isle. These and their feathered dwellers, the gannets, murres and puffins, kittiwakes and razor-billed auks, have been the subject of many romantic bird tales, the object of numerous marvelous camera sketches, but the geology of these little rocks is simple and of a piece with that of the other fragments of the plateau. The tragedies of human life on this isolated crag of the Great Bird, where reason has often given away to madness and living has fallen foul of death in the keeping of the light, have not been told to the world.

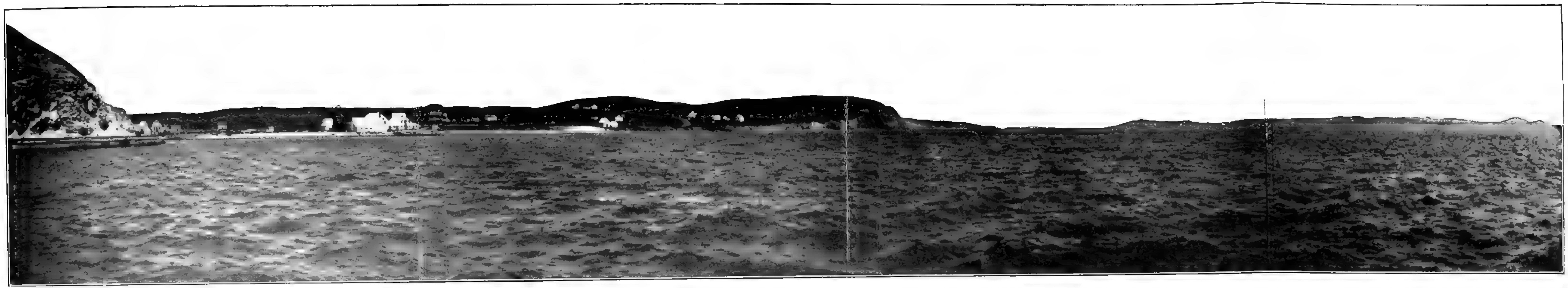
HISTORY OF THE ISLANDS

It is not to be supposed that such tattered fragments of the earth as these islands could have played any large part in the caravan of human events in the western world. Yet each place has been a factor in the progress of discovery at least, and in this these islands have their share. Their intimate history has never been written and perhaps there is no good reason why it should be. Certainly this is not the place in which to set forth even so much as the writer has been able to bring together from the records of explorations and the journals of the early navigators. So much only as is appropriate to the occasion is here put down.

Jacques Cartier was the first European to see these islands, so far as we know. In his first voyage, that of 1534, his course lay southward from the straits of Belle Isle and he made these rock lands in succession from the north; first the Bird rocks, which he named the *Isles aux Margaulx,* then Brion island, to which he gave the name of the first Admiral of France, Philipe Chabot, Sieur de Brion. Here he went ashore and of it he wrote such a glorious description as to make the reader feel he had found a paradise on earth. Some of the later voyagers applied this name, Brion, to the entire group of islands, but Cartier in his second voyage speaks of crossing over from Brion island, which he revisited, to *Les Araynes* — the sands of Grosse Isle and East point. By this name and its variants the group was set down on many of the earlier charts. The charts of the gulf which date from soon after Cartier's voyages, those of Desliens, 1541, Desceliers, 1546, 1550; Champlain, 1609; Mason, 1626, and others, are not altogether reliable historical records but are of interest in showing the growth of ideas concerning the form of the islands, and their changes in name, their years of confusion with the Isle St Jean (Prince Edward Island) and their gradual distinction from it. Indeed few if any of the charts to Champlain's time and later made out the Isle St Jean, 50 miles to the west of the Magdalens. We do not know how soon after Cartier's discovery the Normandy and Breton men got in among these islands, but by the latter part of the 17th century the stories they brought home of the tremendous number of seals and walruses to be had, reached England, and started English expeditions into this quarter. There was a voyage made in 1591, by a skipper unknown, on behalf of M. de la Court, Pré Ravillon and Grand Pré, for the purpose of killing "Morses" for "traine oyl" (see Hakluyt's Voyages, v. 8, p. 150), which of itself indicates previous attempts by the French for the same purpose. Then the English attempts upon the islands began, and George Drake made a passage in 1593, finding the harbors occupied by "Britons of S. Malo and Basques of S. John de Luz." Drake found that "by coming a day after the Fayre" his efforts were put to naught; just as Charles Leigh and Sylvester Wyet, who with Drake were the first Englishmen to sail so far within the gulf, are said on their arrival to have been confronted by two hundred French, who had planted three pieces of ordnance on the beach, and three hundred savages — an opposition which led to a sharp sea fight and seems to have effectually dissuaded further attempts on the part of the English to fasten their hold on this business.

These islands were granted in 1653 by the Company of New France to Nicolas Denys as a part with the vast region stretching from Cape Canso at the south to Cape des Rosiers at the north, and the next year Denys received from the king letters patent as governor and lieutenant general to all this great territory. Even today the Magdalen islands belong to Gaspé county and the Province of Quebec. In those early days land patents in the world of New France were given easily and conflicting claims to the same territory issued from the same source often resulted. So it happened that in 1663 the Company of New France conceded these islands to François Doublet of Honfleur, who was commissioned to establish a colony on the "illes de Brion" for the cod and seal fishery. Doublet was also given per-

Plate 3



N. T. Clarke phot.

Cape aux Meules, Grindstone island — Volcanic gypsum cliffs — House harbor — Alright island — Pointe Basse

Panorama view of the east shore of a part of Grindstone and Alright islands

mission to change the name of the islands from Brion to *Madeleine,* which was the name of his wife. So this name has come down to the present, a memorial of conjugal devotion, though Doublet's attempts at settlement failed totally and have been almost forgotten.[1]

Like Doublet, Denys failed in his efforts to induce colonization and in 1720 the islands with S. Jean and Miscou, were conceded by letters patent to the Count de Saint-Pierre, Equerry to the Duchess of Orleans. He was commissioned not alone to carry on the fisheries but to cultivate the soil and cut the timber. So far as we know the attempted colonization under this patent effected little and the islands were lost sight of until after the fall of Louisburg and the evacuation by the Acadians of Grand Pré and other settlements when many of the homeless families came here and here their descendants today constitute the majority of the population. In 1763, after the fall of New France, the English government annexed the island to Newfoundland, but by the Quebec Act they were soon after attached to that province where they now belong.

A new era in their history, however, began in 1798, when they were granted by George III under letters patent to Admiral Isaac Coffin, in recognition of his service during the American war and the new proprietor established there a feudal system of land tenure which has remained close to the present day as the last flickering expression of medievalism in the English lands of the western world. Sir Isaac Coffin required the occupants of the islands to take titles in the nature of perpetual leases at an irredeemable rent or emphyteutic leases. The islands cover nearly 100,000 acres and at the usual return of 20 cents per acre per year this would have produced a considerable ground rent

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[1] They probably would be entirely forgotten if it were not for a short, sharp passage in Denys's Description Gèographique et Historique des Costes d l'Amérique Septentrionale, 1672, and had not the departmental archives at Rouen afforded in recent years the manuscript journal of Doublet's son, which was edited and printed in 1883 by Brèard, under the title *Journal du Corsaire Jean Doublet de Honfleur.* This is a remarkable story of a freebooter's life in every quarter of the watery globe, beginning with his successful attempt, at the age of seven, to stow himself away aboard his father's ship which came out to the Madeleines in 1663, the experience of the colony there, the return next year to find the colony demoralized, the place abandoned and the venture wholly lost. Only the name of the islands has remained to record in the geography of the place the first attempt at permanent settlement.

but it never proved collectable, and the system resulted in continued contentions between agent and tenant and at times in considerable migrations from the islands.

In later years the attitude of the seignieur has been more lenient, property may now, under specific law, be acquired in fee and the population has grown to nearly 7000 people, chiefly French who occupy the larger islands, Amherst, Grindstone and Alright, while the English communities are on Entry, Coffin and Grosse Isle. A few years ago the seignieurial rights of the Coffin heirs were acquired by the Magdalen Island Development Company, and the feudal land tenure seemed to have at last become extinguished. In their efforts to develop the islands this company erected extensive fish houses and equipped the islands with gasolene boats for the fishing, but these efforts do not seem to have aided the people or the productiveness of the islands and it is understood that the property has never entirely left the possession of the Coffin heirs.[1]

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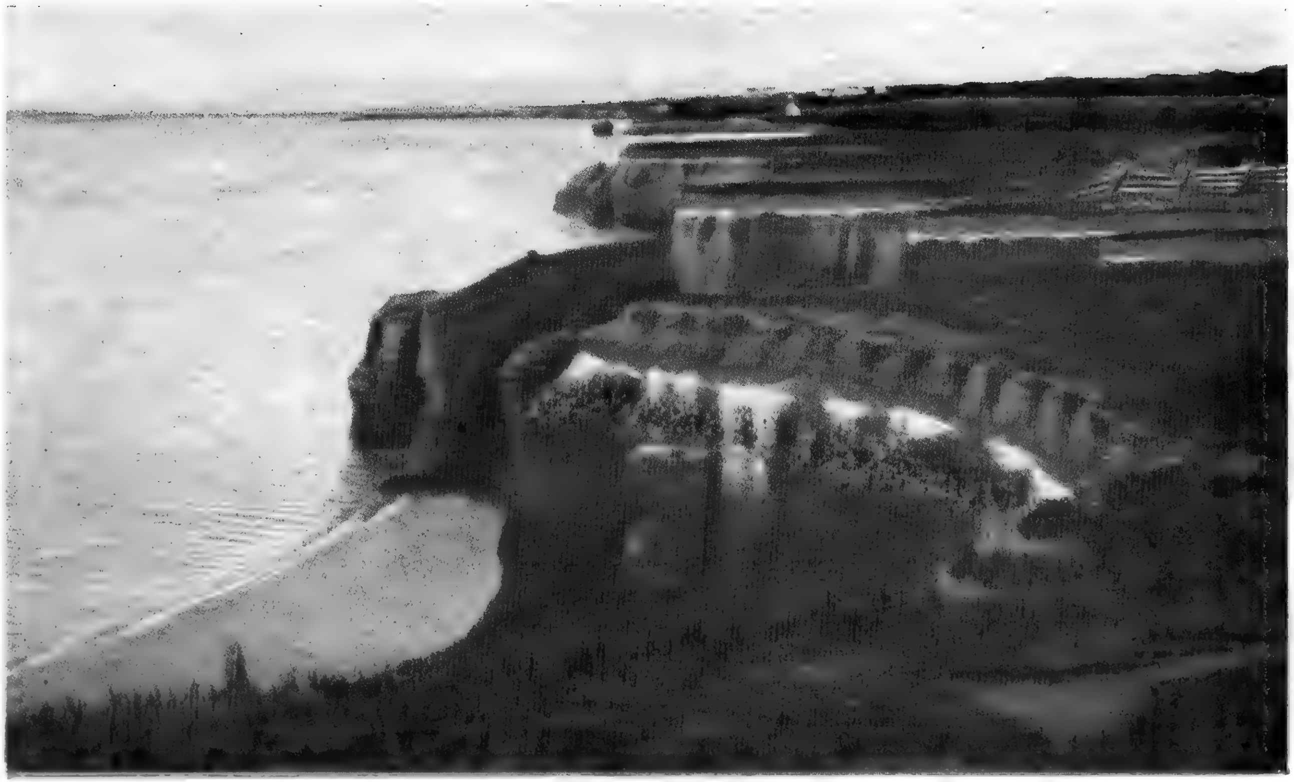
[1] A very interesting account of the land tenure on the islands forty years ago was given by Faucher de Saint-Maurice in his *Promenades dans le Golfe Saint-Laurent* (1874, p. 167). This account is not fully pertinent to the existing conditions and must be regarded as slightly colored by the author's sympathetic interest in the Acadians; but it is out of such feudal tenure as is here pictured that the present state of land and freehold has evolved:

> With little regard to the right of the first settlers the English Government committed an act of irreparable injustice. It struck a death blow at the development and future of this charming archipelago, which the sailor has picturesquely called *le Royaume du Poisson*. And so ever since that fatal date, August 24, 1798, the inhabitants of the Madeleines, knowing that they could never own their land, have exerted themselves only so much as necessary to make a living and they know only by hearsay the enjoyment of proprietorship and the love of the soil.
>
> So sad a condition of affairs finally aroused the Provincial Government of Quebec. Sixty-six years after the concession of the islands a commission was charged by Parliament with an inquiry into the land tenure of the archipelago. Fifty-two inhabitants of the Madeleines hastened to answer a series of printed questions which were distributed among the people. Some had lived on the islands for twenty-five, thirty-five and forty-five years; others fifty, fifty-five and sixty years. Only one of these, Jean Nelson Arseneau, was born there, and the dean of the residents was Bruno Terriau, who had lived in the group sixty-six years. All declared that they held their lots as tenants by virtue of long leases and their replies made some curious revelations to the Government.
>
> Thus some of the settlers had billets of simple location which gave them the right to take a lease from the proprietor, while others had a lease for ninety-nine years. Those who had held a lease for fifty-two years had the right to make it continue, and holders of a lease during ten years, to exact a permanent lease from the proprietor. The last procedure did not seem very pleasing to the agents of Admiral Coffin and all agreed that it was gradually

Plate 4



Magdalen islands. Shore cliffs on Grindstone island in the low lying platform of red Permic sandstone. The line of decolored white sand is everywhere conspicuous and in the foreground a layer of angular diabase pebbles is visible beneath the white sand.

Convincing clues to the history of a country are embalmed in its place names. I have here given the principal names on these islands with suggestions as to their origin.

Madeleine Magdalen Magdalene	English (Magdalen, Magdalene)	Named for Madeleine Doublet, wife of François Doublet, 1663.

Maudlin — broad French and vulgar English.

Brion Bryon Byron	on most English maps (Bryon, Byron)	This name, applied by Cartier, 1534, to the island now bearing it, was often used by early explorers for the whole group. It was given in honor of Philipe Chabot, Sieur de Brion.

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disappearing, for whenever the opportunity presented, the agents changed these leases about.

Generally these leases contained clauses which permitted the seignieur of the islands to take over the lands, to take advantage of their improvements and to possess himself, without reimbursement, of the house and buildings if by some ill-luck the tenant could not fulfil the terms of his lease. It was thus that two of the descendants of the oldest settlers of the Madeleines, Louis Baudraut and François Lapierre, were compelled, after many years of hard work and privations, to abandon to Admiral Coffin the land where their ancestors had lived and which their children had improved to the best of their ability.

This is the way in which Fabien Lapierre was not quite stripped of all his possessions. This man having decided in 1863 to explore the north coast of Labrador, left the land he had occupied for twenty-five years to the care of two of his compatriots, Basile Cormier and Emile Morin. They were to hold it on condition of keeping it up, paying the rent and turning it back to him on his return. For the first year everything went well. The agent consented to take the rental from Lapierre's proxies; but after the beginning of the second year he refused their money, took possession of the land, cut the hay, forced open the house and stored it with the crops for winter use, and afterward sold the whole, land and dependencies, to Desiré Giasson. The following year Lapierre returned and claimed his property. In reply Coffin's agent threatened him not to obstruct the cutting of wood and told him if he continued to make trouble, he would chase him off the islands. But finally by his own pleas and the help of his priest, the Abbé Boudreault, the poor man succeeded in recovering a part of his land on the condition of consenting to a new lease which obliged him to pay annually a shilling an acre. The rest of his property remained and is yet in possession of the purchaser Giasson who has claimed legal title to it by the payment of five pounds. It is not difficult to understand the evils which such a régime imposes on the archipelago and some of the inhabitants, shaking off their torpor, have undertaken to test before the Circuit Court of the Madeleines the titles of Admiral Coffin. Some plead the law of limitations, others allege the illegality of the leases and their burdensome tenure, as contrary to the colonization and progress of the islands. The more philosophical state that for nearly a century their forefathers had cultivated these lands in full ownership, while their descendants and legal heirs can occupy them only as tenants; and the more equivocal say that their ancestors never consented to the title of Admiral Coffin. All these complaints accomplished nothing. The court decided in favor of the proprietor and as most always happens the complainants who perhaps had a chance on appeal from this decision were not able, for lack of

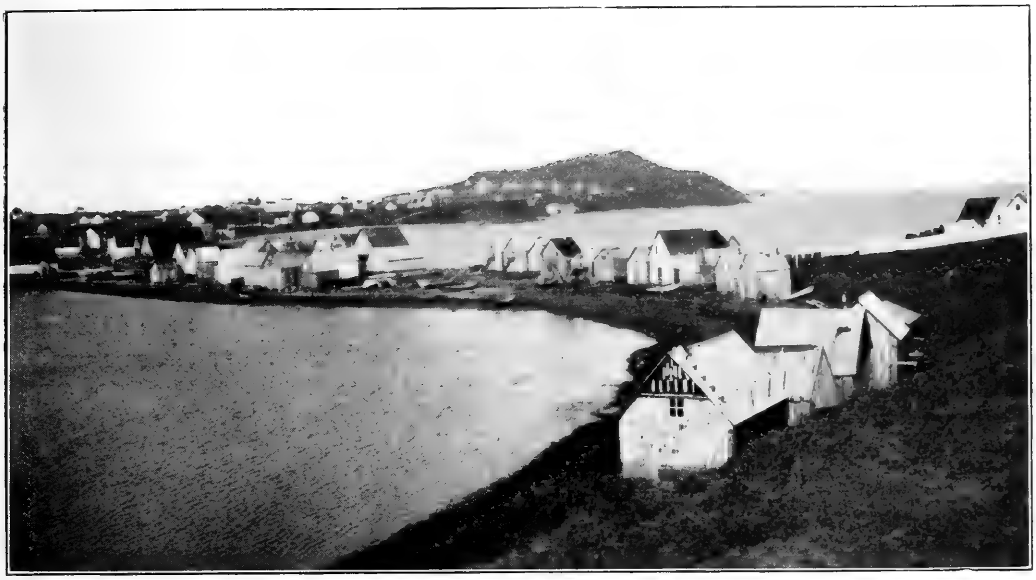
Ramèes Ramea Ramies	Champlain applied the name *Ramèe-Brion* to the entire group, Ramèe having reference to the way in which the islands are strung together by bars. The name was in use before Champlain's time as it appears in Fisher's narrative of 1591 and Drake's, 1593: "Called by thè Britons of S. Malo the Isle of Ramea."
Les Araynes I. des Arenos I. des Arenes I. aux Sablons I. aux Sabloens I. Duoron	Cartier, in his second voyage, speaks of crossing over from Brion to the sands, "les araynes," meaning the sands of Grosse Isle and southward. The name appears on early charts in the alternative forms given and applied to all the group except Brion and Alezay.
Entry I. I. de l'Entrèe	A very early name, though evidently not Cartier's. It guards the southeastern portal of the group.

money, to go to a higher court. So matters take their course. Apathy and discouragement reign supreme in the islands which only await the coming of a new régime to become a storehouse of abundance. The tenants continue to pay local and school taxes while their lord and master rigorously exacts the annual rental of the lands — rents which are exorbitant compared with those elsewhere. Nevertheless in the midst of this secret discontent, some of the old settlers find a way to be satisfied with their position. Many of them have a hundred acres under cultivation for which they pay annually only five shillings or a quintal of cod. These are the kings of the isles and they are the envy of those about them; for a young settler who wishes to rent the same amount of land uncultivated and unwooded would be obliged to pay twenty cents a year per acre. Fulfilling this condition he becomes a tenant. For a while youth, ambition and love of work let loose their forces. Under his plow the desert becomes fertile fields. The fish help to make good his deficit. He will be able to live comfortably and be happy though only a tenant. But bad times come, the rent is behind; then come the threats of the agents. The demon of expropriation hovers over his little property; nothing remains to the unhappy man but exile or servitude.

It is not surprising that nearly all this population which otherwise might be enterprising and rich live here, half asleep and in poverty. Strangers flee from this nest of feudalism. These vexatious conditions have resulted in a large migration from the islands to Labrador. More than three hundred heads of families have left the islands and established themselves at Kekaska, Natashqouan and Esquimaux Point. These departures have weakened the population of the islands. Every year large numbers go to join those that have already left and it looks as though in the near future the islands may become entirely deserted.

The remedy for the condition pictured here has been found in legislation by the Quebec Parliament which enacted a law in 1895 (Statutes of Quebec, 58 Victoria, Cap. XLV) regulating the form of the land tenure, declaring outstanding occupants to be proprietors subject to payment of rentals and insuring the right of redemption of capital. This law seems to have brought a much desired confidence and sense of security to the islanders without detracting from the income of the seignieur, who now being an heir and substitute of the original proprietor, had, it seems, no legal right to alter the form of the first leases. The province has still further alleviated the condition of the islanders by assuring in amendments to the law cited (59

Plate 5



Havre Aubert, Amherst island. Mt Gridley in foreground, "Fishtown" (sandbar) in center and Demoiselle hill in distance; Pleasant bay at the right (east) and the "Basin" at the left.

Amherst island. Mt Gridley from the face of Demoiselle hill; English church on the sky line and Entry island in the distance.

Amherst I. I. Aubert Hâvre Aubert	Gen. William Amherst — a name given by the Coffin patentees. The old French name is Hâvre Aubert and this is the post office name today. Aubert was commissioner for the islands at an early day and the " Hâvre " has reference to the interior lagoon which has been at various times open for small vessels.
Pleasant bay Baie au Plaisance	The broad bay on the east coast of Amherst, a deadly anchorage in an easterly gale.
Cabin cove L'anse aux Cabanes	On the south shore of Amherst. Has reference to Micmac lodges there at an early day.
West point Sou'west point Sou'west cape	On Amherst.
Mt Gridley	The little triangle of land at Amherst wharf. Gridley was an American who established the first lobster fishing here about 1763.
Demoiselle hill	On Amherst. Takes its name from its symmetrical shape which the French thought resembled a maiden's breast, in which respect it is like all the volcanic-gypsum hills on Grindstone, Alright and Entry.
Basque harbor Harbor Basque Hâvre aux Basques	A name dating to the 1600's when the Basques were in possession.
Grindstone I. Pierre Meulière Isle aux Meules Isle Blanche	The English name translates the French; all are due to the coarse white sandstone which forms the principal headland, Cape Meule.
Leslie cove	Named for William Leslie, early pioneer of the lobster business, and still there after 40 years' residence. This is the post office name of the eastern part of Grindstone I.
Red cape,	Grindstone I. Its blood-red sandstones.
Cape le Trou	Grindstone I. Stands on the hydrographic chart but does not seem to be known to the residents.

Vic. Cap. XXXVIII, 1895, and 60 Vic. Cap. XIV, 1897) a repayment to the tenant of one-third the amount necessary to effect the freehold.

While writing this note, I am informed of a new organization, the Eastern Canada Fisheries, Limited, which is reported to have taken over all the assets of the insolvent Magdalen Islands Development Company and which proposes to take full advantage of the great natural wealth of the sea in those islands.

Hospital cape Cap au hopital	Grindstone I. The origin is lost both to the French and English, but the name naturally suggests a wreck and rescue.
Etang du Nord	Grindstone I. Pronounced by the English, *Tantanour*. The *pond* is the north pond of Basque Harbor.
Alright I.	Sailor's term. Not older than the Coffin patent. Either this or Grindstone I. was called Saunders I., by Bayfield or the Coffins.
House harbor Harbor Maison Hâvre aux Maisons	The harbor between Grindstone and Alright. An ancient term referring to early settlement, probably the first on the islands.

Shag I. This is a bird roost and a shag is a cormorant.

Grand Entry	This passage between Alright and Coffin island seems to have been in use from the days of the Basques and Bretons. It was, I believe, the harbor called by Leigh, 1591, Halobolina, and was mentioned by Cartier.
Pointe Basse	The steamer landing at Alright — not on chart. (Pointe Basque?)

Coffin I. Named for the proprietor, Sir Isaac Coffin.

Old Harry head, Coffin I. Probably of like date.

Grosse Isle	The Great Island of the Magdalens or the Great Magdalen of a few English writers. One of the smallest of the group but connected by vast sands with all the other land at the north.
North cape	This is the Cap au Dauphin of Cartier, a name still in use among the French.
Bird rocks Isle aux Margots Isle aux Margaulx Isle aux Oiseaux	The last two are Cartier's names, 1534. The Rocks are separated into North or Great Bird (140 acres) and the Little Birds, two in number.
Deadman's I. Corps Mort Alezay Alezai	Seven miles west of Amherst. Alezay is Cartier's name.

TOPOGRAPHY AND GEOLOGY

Surface modeling. Though the islands are not commanding in bold contrasts of contour, their scenery is inviting and unusual. Rock platforms of dark purple-red bound the lower levels of the coast, broken by higher cliffs of volcanics or of gray sandstone where the sea has cut into the rounded hills. The division in the topography is, in respect to cause, threefold: the sands,

Plate 6

Demoiselle hill, Amherst island

Red sandstones carrying in the upper part, just under the soil and embedded within the sand, an irregular layer of angular diabase pebbles. The sandstones are horizontal, the apparent cross bedding being a secondary structure. Grindstone island

the rock platforms and the volcanic-gypsum hills. To the first is due, of course, the present outline and extent of the charted islands and in them are to be found brilliant illustrations of the process of deflation — dune building and anchoring, rock etching — and, further, evidence of the slow upward lift of the islands save perhaps at the southeast. By the rock platforms are meant the low flat-topped rock lands which skirt the rounded hills and reach the coast line in level surfaces and low red fronts of 50 feet or so. The hills are all of one type and I propose to speak of them as *demoiselle hills;* rounded, symmetrical, beehive-shaped elevations with grassy surfaces and separated by shallow or deep cauldronlike depressions. They are the ribs of the islands presenting not only higher but much more resistant fronts to the attack of the sea than the soft crumbling platforms of red sandstone. Their height varies from 580 feet, St Lawrence hill on Entry, down to the knolls and knobs on Grindstone and Grosse Isle, some of which are no higher than the dunes upon the beaches.

These many breasted islands proclaim their neglected fertility and trumpet their virgin claims in the unheeding ears of their fisher folks, whose thoughts are only of the sea. It has perhaps still to be demonstrated that the demoiselle hills have all a like origin. The Demoiselle on the shore of Pleasant bay at Amherst is a volcanic-gypsum knob (and by this term, which I shall endeavor to explain more fully, is meant an association of gypsum with volcanic effusions and debris), those on Grindstone are mostly of the same order, but Cape aux Meules on Grindstone and Pointe Basse on Alright are gray sandstone knobs in which the presence of either volcanics or gypsum has not made itself evident at the surface, whether or not those may lie at the root of them. The general landscape effect of the islands is well shown in the accompanying panorama view, extending from Cape aux Meules on Grindstone (left) northward to the outermost tip of Alright. The tickle into House Harbor enters the middle distance, the rock front at the left is gray sandstone, the hills next north the volcanic-gypsum series traversing Grindstone, and the rounded tops of Alright beyond lie scattered among the half-disclosed gypsum masses.

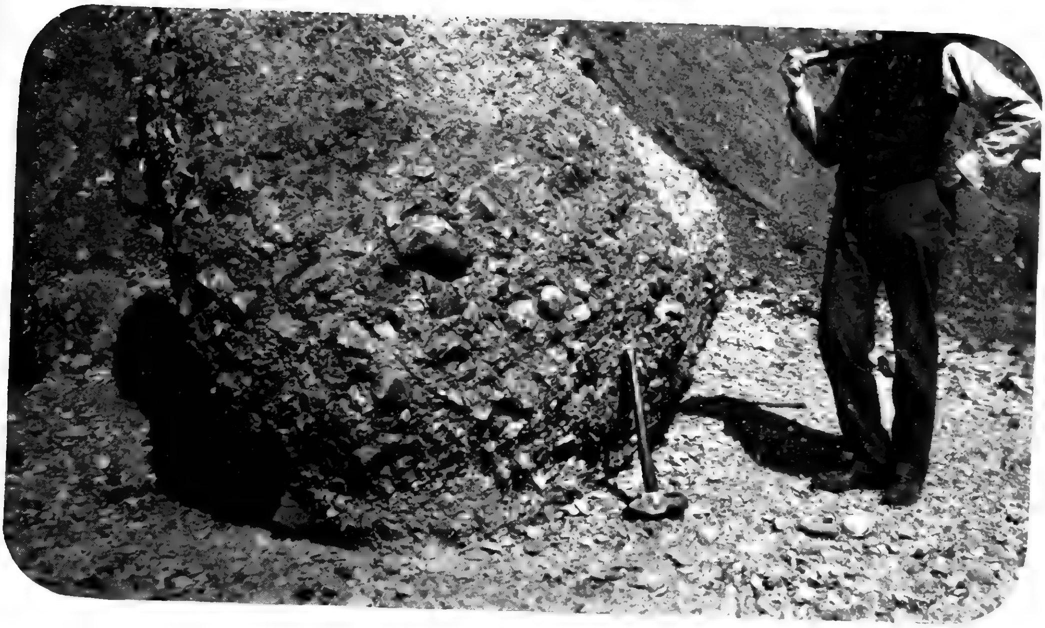
Rocks. In a broad sense the rocks of the islands are gray, hard, schistose sandstones, sometimes slightly mottled; brilliant purple-red or blood-red soft sandstones; volcanic masses in the form of diabase sheets, accompanied by agglomerations of tuffs, permeated by thin seams and sheets of gypsum and followed along their faces by enormous gypsum deposits. The rock geology of the islands has received attention only once and then in a careful though brief report made by Mr James Richardson for the Dominion Survey during the summer of 1880, just 30 years ago, and published in the Geological Survey of Canada, report for 1881.[1] Mr Richardson's keen insight into the relations of these rock masses is a noteworthy characteristic of his work, even though he frankly left many questions to be illuminated.

Stratigraphy. The only detailed section of these rocks given by Richardson is taken from the sea front of Amherst island on Pleasant bay and extending along the escarpment of Demoiselle hill. This section of 856 feet (measured) shows that the hard gray and mottled sandstones lie at the bottom and the soft deep-colored red sandstones above. Yet a change of dip between the lower and upper masses suggests a disconformity and necessarily qualifies the assumption of vertical succession. At the base of this whole sedimentary series lies a mass of partly compact but for the most part badly broken volcanics with an extensive deposit of gypseous clay and an agglomeration of both together. This seems to make the base of the section and produces the curves of Demoiselle hill.

This section of the sedimentaries is typical for the islands Grindstone and Alright, where there is opportunity for adequate exposure. Probably the east shore of Grindstone affords a more favorable and longer section than any other as here is a clean coast line from House Harbor at the north to and beyond Red cape at the south. Here it is seen that the red sandstones which cover all the shore section from just south of Cape aux Meules to Red cape, are, as everywhere else, quite horizontal, and they make a broad flat fringe about the rather distant elevated interior. The sea has cut into them like a mouse into a cheese, carving their frontage into marvelous and bewildering zigzags, aisles and obelisks. Following these red beds north to the cape, they pass without evident loss of conformity or continuity into the gray hard sandstones which make the "Meules." This apparent continuity of the soft red and hard gray series is often seen and I am disposed to believe an approximate explanation of it is to be found in the almost invariable presence with the gray sandstones, when elevated into demoiselle hills, of the vol-

[1] Report of a Geological Exploration of the Magdalen Islands, p. 1-11 G.

Plate 7



A mass of gypsum filled with angular blocks of diabase. Grindstone island.

Block of diabase entirely surrounded by massive gypsum. Grindstone island.

Plate 8

Red sandstone cliffs at Leslie cove, Grindstone island

canic-gypsum masses. I fancy there is little to militate against the conception that these volcanic lavas with their sulfur and other gases have not only indurated the sands and thus made them more resistant to meteoric downwear, but have decolored them by rendering the iron oxid soluble. On Grosse Isle Head like conditions are exhibited on a small scale, but more effectively on Alright island where all the demoiselles display the hardened gray sandstones.

Shales and limestones are of the rarest occurrence, but where they have been observed the shales, when calcareous, carry fossils. Where the great gypsum deposit of Grindstone, stretching nearly east and west across the island from north of Cape aux Meules, reaches the vicinity of Cape le Trou, there are fossil-bearing brown bituminous limestones with goniatites and pelecypods, lying close against the white outstanding gypsum cliffs. A few fossils have also been found near House Harbor along the gypsum masses exposed on the property of the Widow Arseneau. At Grand Entry I observed lying among the piles of " killicks " on the beach many blocks of gray calcareous shale with fossils in them and inquiry of the fishermen brought me to the outcrop of this rock at Oyster basin on Coffin island. Mr Richardson reported but one locality of fossils, that on the sea face between Cape aux Meules and House Harbor. Those I have obtained at the three localities mentioned, amounting in all to a very considerable quantity of material (10 barrels were brought away from the Oyster basin locality) I have placed in the hands of Dr J. W. Beede, who has very kindly undertaken to examine and report upon them. Their evidence is, of course, ultimately essential to the determination of the geological age of these formations.

Doctor Beede's conclusions indicate that the marine fauna is of early Carbonic age, to be paralleled in horizon with the Mississippic of the interior basin yet with palpable evidence of development in an Atlantic basin isolated from the interior by the appalachian uplift. All the outcrops which have produced this marine fauna lie very clearly at the base of the sedimentary rock series of the islands, beneath the gray and red sandstones. As to the red sandstones there is no reason to assume any lack of continuity with the similar beds of Prince Edward Island. These have commonly passed as " Triassic " rocks and Leidy, Dawson and Dana believed that this age was effectively determined by the discovery in that island of the reptilian remains which were determined as the lower jaw of a dinosaur.

I am informed by Doctors Lull and von Huene that recent study of this fossil shows it to be the lower jaw of the pelycosaur and hence indicative of Permian age.[1]

Volcanics. Mr Richardson believed that the volcanic deposits, on Amherst island particularly, lay at the base of the sedimentary series. It may be quite true that the evidence of their transection of the strata is obscure and even such obscure evidence may give way to proof of interbedding. These volcanics are diabases which stand out in nearly vertical posture on the sea cliffs, are highly amygdaloidal, deeply weathered, and complicated with gypsum deposits. In fact the compact beds are accompanied by agglomerations of lava blocks, decomposed tuffs and gypseous clays in very instructive association; wherever they lie in contact with the sandstones the latter are gray and hard, their induration and decoloration extending for considerable distances away from the contact. The apparent alteration of the augite or allied minerals in the diabase to a chloritic condition gives it in many places a vivid green color and its amygdules are found to contain analcite, chabazite, etc., while the crevices and seams carry pyrite, specular hematite and manganite. Sometimes the manganite is in considerable quantity and excavations have been made for it on Grindstone, whence nodules of comparatively large size have been taken. Frank D. Adams made analysis of this manganite in 1881[2] and found it to contain MnO_2, 45.61 per cent; water hygroscopic, 0.10 per cent. The hematite also occurs in considerable rather impure masses.

The association of the gypsum with the diabase is most intimate and while the character of the former is discussed separately I shall here refer to the mode of association. In the greater volcanic exposures, as on Grindstone above Cape aux Meules and on the east face of Alright, these vertical dikes make the highest cliffs. Here the accompanying agglomerates of volcanic blocks, the great masses of volcanic debris in the form of tuffs and ashes, have been referred to. On Grindstone the volcanic masses (at least two distinct dikes are present) have a thickness of fully a thousand feet; with them

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[1] Doctor Lull has given me the following citations relating to these remains:

Leidy. On Bathygnathus borealis, an extinct saurian of the New Red sandstone of Prince Edward's Island; Journ. Acad. Nat. Sci. Phila., (2), ii, p. 327–30, pl. XXXIII, 1854.

Cope. Synopsis of the extinct Batrachia, Reptilia, and Aves of North America, 1869, p. 119.

Dana. Manual of Geology, 4th ed., 1896, p. 754, fig. 1180.

Dawson, J. W. Acadian Geology, 1868, p. 119, fig. 29.

Case. Revision of the Pelycosauria of North America, 1907, p. 63.

von Huene. Neues Jahrb. f. Min., etc., Beil.-Bd. 20, 1895, p. 343.

[2] Chemical Contributions. Rept. Geol. Survey Canada, 1881, p. 18.

Plate 9

Grosse Isle, from the dunes at the north; showing almost the entire island and fishing settlement, with the English church on the hill. The cape points northwest and the gulf lies to the right.

Grosse Isle. Partly overgrown sand dune; height about 150 feet

Plate 10

The beach at Grosse Isle; in the distance the long sand dunes stretching around North cape

are heavy deposits of tough gypseous clays and fine clear cliffs of crystallized gypsum. All through the volcanics are seams and crystallizations of gypsum, permeating the mass through a multitude of crevices so that large blocks of trap lie entirely surrounded by gypsum. Wherever the trap extends the gypsum follows. In the course of this trap dike westward across Grindstone island the surface is broken up into kettle holes and knobs where the gypsum has undergone secondary change, and where it comes out at the western side of the island near Cape le Trou the white gypsum cliffs stand up brilliantly, with diabase on one side and fossiliferous magnesian limestone on the other. Wherever the volcanics are well developed the gypsum appears and seems always to occur in the presence of the volcanics, except on Grosse Isle Head where a small area of gypsum lies in the gray hard sandstones, and the volcanics, if present, are concealed under an overgrown surface. Without attempting to solve the problem of these interesting occurrences it may be said that there is very little lime left in the exposed rocks of the islands — too little by far to indicate an adequate supply for the lime in these masses of gypsum[1] and if the sulfur in the combination has been supplied by the lavas (which seems, in view of the intimate association of the masses, an almost unavoidable inference) it must have found its lime in some deeper source of older rocks.

Gypsum. The open display of this mineral is brilliant. In the sea faces of Grindstone and of Alright and the weathered pinnacles near Cape le Trou, the rock varies in color through white, gray and pink-white into saffron, red and black; most of it is mottled black and white in laminated colors and all is compact and solid. In secondary deposits among the cavities of the lava are sheets of satin spar together with great crystallizations from a foot's length to the size of one's arm. Some desultory efforts were made years ago to find a market for this gypsum but the material was carelessly selected and taken as ballast to Quebec; the attempt was not really a serious one. The natural supplies lie at the water's edge, working would be free and open and transportation by water to Montreal would give a short haulage by rail to manufacturing centers; by water to Pictou, Boston or New York would grade the haulage according to the port. I have had a series of analyses of the gypsum rock made by Dr E. W. Morley which give some clue as to the ability of the material to meet present commercial demands. These

[1] A million tons of gypsum are easily available on the island of Grindstone alone.

samples were taken from the commonest expressions, not necessarily from the purest. Sample 1 is somewhat out of the ordinary and is not an average. Samples 2 and 3 are fair averages of the predominant rock and there remains a very substantial opportunity of acquiring a better grade by selection. These analyses are here appended.

ANALYSES OF GYPSUM FROM GRINDSTONE ISLAND

By E. W. Morley

Sample 1 Compact gray, with red and green mottles
2 Coarse crystalline, with alternating black and white bands
3 Darker, with more finely alternating black and white bands

(Each sample has been done in duplicate and the average given)

Sample 1	A	B	Average
Water	14.96	14.90	14.93
Silica	20.93	20.94	20.94
Alumina	5.14	5.07	5.10
Ferric oxid	2.20	2.21	2.21
Calcium carbonate	2.98	3.07	3.02
Magnesium carbonate	4.49	(4.49)	4.49
Calcium sulfate	49.50	49.25	49.37
Chlorine	Trace	Trace	Trace
	100.20	99.93	100.06

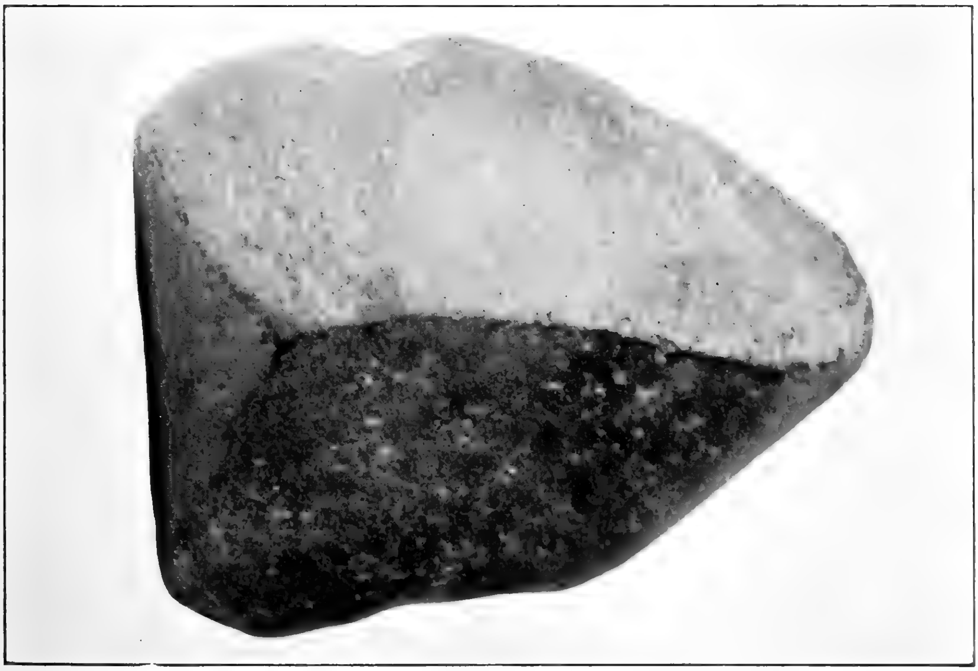
Sample 2	A	B	Average
Water	19.83	19.92	19.87
Silica	0.34	0.37	0.36
Alumina	0.00	0.01	0.01
Ferric oxid	0.36	0.38	0.37
Calcium carbonate	4.29	4.19	4.24
Magnesium carbonate	1.90	1.90	1.90
Calcium sulfate	73.34	73.44	73.39
	100.06	100.21	100.14

Sample 3	A	B	Average
Water	20.00	20.06	20.03
Silica	0.38	0.43	0.41
Alumina	0.29	0.27	0.28
Ferric oxid	0.32	0.32	0.32
Calcium carbonate	2.04	2.06	2.05
Magnesium carbonate	1.19	1.26	1.22
Calcium sulfate	75.74	75.82	75.78
	99.96	100.22	100.09

Plate 11

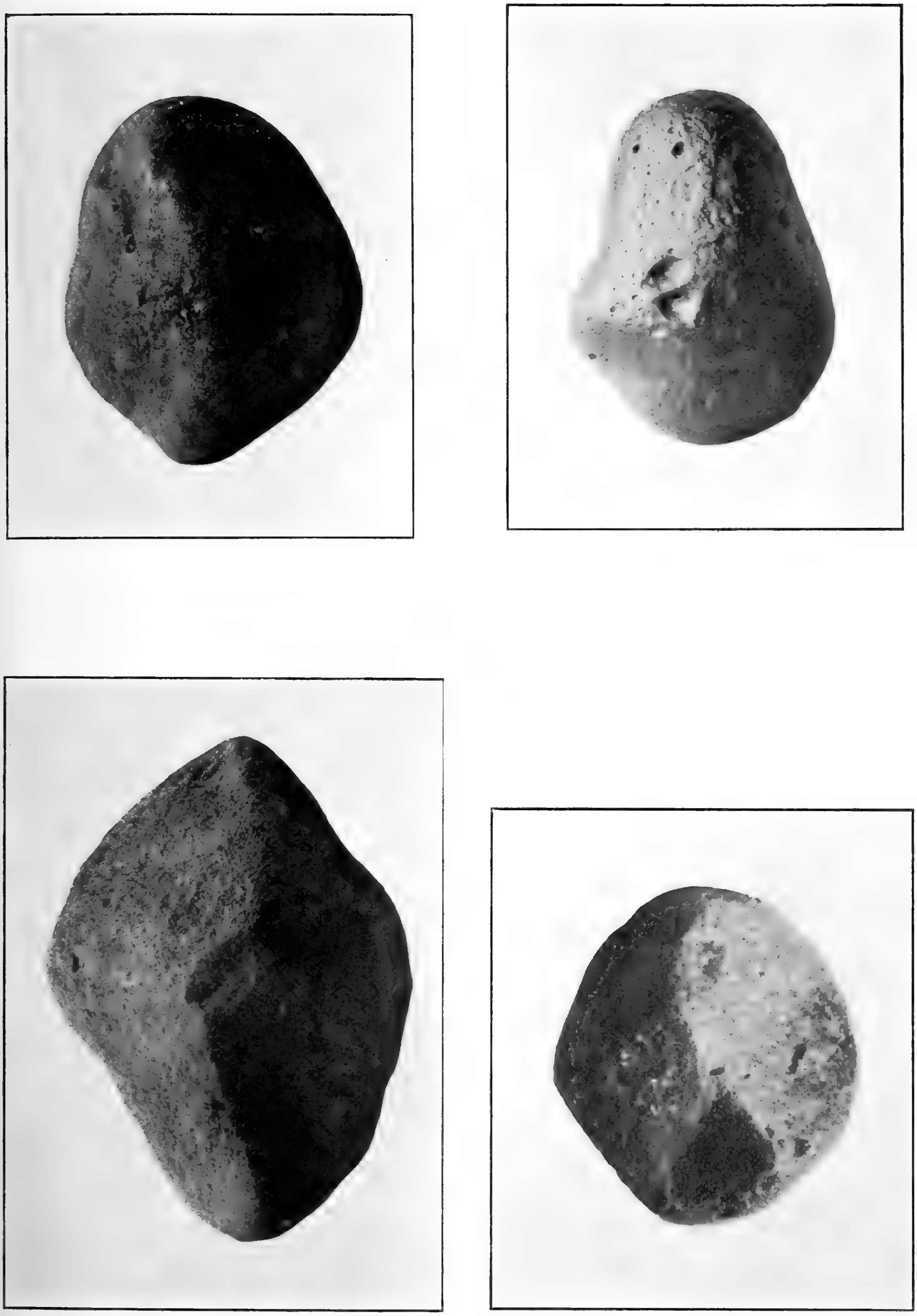
Etched boulder (dreikantner) of banded quartzite. Grosse Isle. Length 7 inches

Plate 12



Sand etched quartzite boulder from the dunes of Grosse Isle. Length six inches

Plate 13



Etched and glazed pebbles of quartzite and sandstone from the red sandstone beds on Grosse Isle head

I have asked Mr David H. Newland, Assistant State Geologist and an accepted expert on gypsum and its commercial values, to express his judgment of the usefulness of these deposits so far as indicated by the analyses given. Mr Newland says:

The sample no. 1, described as "compact gray, with red and green mottles," is an impure material, containing only about 62 per cent of hydrated calcium sulfate or gypsum itself. There seems to be a good deal of free silica or quartz in the sample, and also clay, the latter reaching 10 per cent or a little more. The percentages of iron oxid and carbonates are likewise high as compared with the amounts found in most of the gypsum used for calcined plasters. Rock of the grade indicated by this analysis would have little or no commercial value. Owing to the high iron content the calcined product would undoubtedly be discolored, as it would also be inferior in setting properties by reason of its low percentage of calcium sulfate.

Sample no. 2, coarse crystalline, with alternating black and white bands, according to the analyses contains about 93 per cent of gypsum substance. The chief impurities are lime and magnesia carbonates. These act, of course, as dilutents but would not be detrimental to the use of the material for most purposes. The iron content is fairly low and the burned product should be a good white. The material compares well with the average rock used for the manufacture of calcined plaster in this country, though somewhat inferior to the highest grade of gypsum as represented, for example, in some of the western deposits.

Sample no. 3, darker than no. 2, with finer bands, has about 96 per cent of the hydrated sulfate. It differs from no. 2, chiefly in the smaller percentage of lime carbonate, the difference being made up by the increase in gypsum. The small percentage of alumina, indicative of the presence of clay, is negligible. While the iron is somewhat less in amount than in the preceding sample, there would probably be no essential variance of color between the calcined product of the two grades. The main feature is the increased percentage of the gypsum, which adds by so much to the commercial value of the rock.

Soil. The soil of the islands is essentially residual. The islands have never been subjected to glacial action. One finds on the sand spits and on the lower rock platforms, especially of the northern islands, plenty of ice-borne boulders, for the most part dropped where they lie, and now glazed by the blown sand, but there has been no disturbance of the soil by ice erosion. Hence the softer red rocks, which are largely felspathic, have undergone deep decomposition in place and, under the vegetable mould at the top, the soil extends downward often for 5 or 6 feet carrying all the structure of the stratification and passing by evidences of less and less decay into the disintegrating layers of the sandstone and thence into the solid rock. A typical section of the soil is given in this sketch, taken from the excavation for Miss Shea's hotel which was being dug at the time of my visit, on Mt Gridley, Amherst island. This includes a section 7′ 4″ from the surface, there being, from above down:

(1) 6″ of dark brown plant mold

(2) 8″ pure white sand

(3) 8″ deep black mold

(4) 3′ deep red residual soil retaining stratification lines and pebbles (rotted) in place

(5) 2′ 6″ reddish passing into yellow soil, running downward into the rotting rock fragments and finally to the solid rock.

White sand. In nearly every soil section on the red rocks the eye is struck by the persistent thin layer of pure white glistening sand not far beneath the surface. It occurs on all the islands, so far as I have visited them. This sand is doubtless the original red sand decolored by the organic acids which run downward from the vegetable mold, have dissolved the iron oxid and perhaps by transference have given the dark color to the layers which immediately underlie. These highly pure quartz sands are so interesting in their association and in their relation to this residual decomposition that I present here analyses of them made by Dr E. W. Morley, who precedes his report upon them by a statement of his mode of treatment. He says:

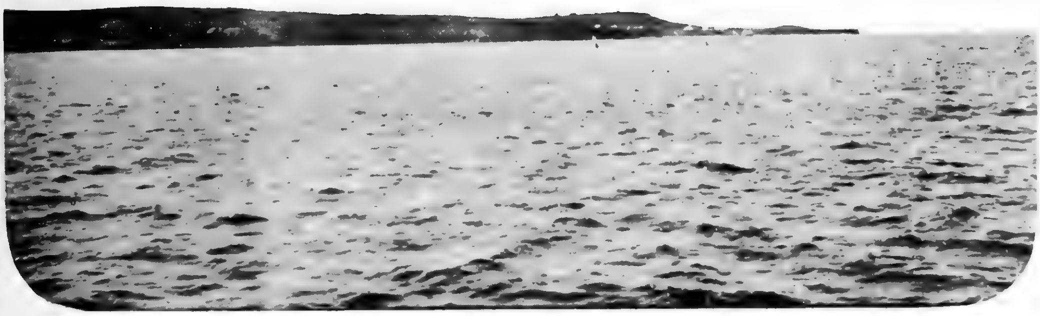
I first sifted the two samples, with as little friction as possible, through meshes of 20, 40, 60, 80 and 100 to the linear inch. The table inclosed shows the result. Then the two coarser educts from the white sand were gently pressed with the finger, and the sifting of this sample repeated, with the result shown. The coarser part of the red sand consisted of small fragments of sandstone but the fragments of the white sand were friable and fell into powder finer than 100 to the linear inch. This renders highly probable your suspicion as to the relation of the two sands.

On analyses, the composition was found as in the first and second columns of the table. It may be said that a trace of silica was not separated from the alumina, that potash and soda were not separated and that water was determined simply as loss. In other respects the analyses were as accurate as can be made.

In columns 3 and 4 the analyses have been recomputed as percentages of the weight found for silica. It is seen that every soluble constituent of the white sand is less than in the red sand. As the calcium oxid and sulfuric acid were in both cases equivalent within the errors of determination, they have been entered as calcium sulfate.

Plate 14

Northeast cape, northernmost land of the Magdalens, viewed from within the lagoon at Grosse Isle. This is the Cap au Dauphin of Cartier. 1534



West end of Brion island, seen from the north

Sands from Magdalen islands

	Analyses		Analyses recomputed			Mesh of sieve	Red %	White %	Pressed white %
	Red	White	Red	White	Difference				
SiO_2....	82.15	91.66	100.00	100.00	.....	Retained by 20	4.3	5.0	0.7
Fe_2O_3...	1.30	0.42	1.58	0.46	1.12	40	3.9	2.2	0.2
Fe O....	0.28	0.25	0.33	0.27	0.06	60	3.1	8.2	7.2
Al_2O_3...	8.84	4.16	10.76	4.54	6.22	80	1.4	5.4	6.6
Ca O....	0.46	0.18	......	......	.....	100	3.5	9.2	8.9
Mg O...	0.49	0.14	0.60	0.15	0.45	Passed by 100	83.7	69.9	76.3
K_2 O....	3.17	2.25	3.86	2.45	1.41	....	....	....	......
SO_3....	0.72	0.22	......	......	.....	....	....	....	......
Water...	2.51	0.65	......	......	.....	....	....	....	......
Ca So_4..	.....	.....	1.42	0.55	0.87	....	....	....	......
	99.92	99.93	118.55	108.42	10.13	....	....	....	......

In these analyses it is quite clear that the red sand differs from the white in the loss of nearly everything soluble by organic and meteoric acids and the inference is fair that the latter are the bleached residue of the former.

Depth of rock decomposition. So profound has been the decay of the red sandstones that it is sometimes difficult to tell where the altered rock ends and the unchanged rock begins. On nearly all sea front exposures, which have naturally not been of long duration, the finger can often penetrate the surface to a considerable depth. On Grosse Isle Head along a new road opened at the side of the lagoon, the red rock has been cut to a depth of several feet from the mold. The red rocks here are interspersed with boulders, some of which are sand-etched (dreikantner). These boulders, when crystaline, hold their substance well, but if of sandstone, as is often the case, they are rotted clear through like their matrix.

On Grindstone island, and particularly along the banks at Leslie cove, there lies between the deoxidized sand and the red sandstone an irregular layer of small angular diabase pebbles forming a gravel which lies with a conspicuous lack of uniformity and constitutes a component part of the sand rock. This layer may be traced all about the southwest cliffs of the island. The pebbles show no marked decay, and are in places accompanied by large boulders. While this layer of angular diabase pebbles lies directly beneath the soil, yet the parts which descend within the substance of the sand rock have no appearance of entering preexisting crevices but are a contemporaneous part of the sandstone itself.[1]

[1] On the cliffs of Red cape, Grindstone island, lying on this gravel layer and buried under 6 to 12 inches of plant mold and sod we uncovered the bones of

Deflation. In a region so given over to sands and so exposed to the winds evidences of the destructive power of moving sand are on every hand. The traveling of the dunes does not indeed extend far inland though they have piled up about the few spruce patches that remain on the shores. The most notable effect of sand etching is seen in the angled crystalline boulders. These boulders are ice borne, dropped where they lie by the bergs and floe ice of no recent date. It is very noticeable that these ice-carried blocks are much more abundant in the northern islands, Coffin and Grosse Isle, and that here nearly every example, whether on or in the soil, is a dreikantner, while on the southern islands such blocks are seldom angled by this etching. This fact is naturally explained by the much more exposed situation of the northern islands. Not only are these evidences of recent deflation very apparent, but the adjoining plate shows a group of sand-varnished, angular pebbles taken from several feet down in the decomposed red sandstone at Grosse Isle Head — a testimony that the moving sands were etching pebbles and boulders when these ancient sandstones were being formed, and rather conclusive proof of the continental origin of these rocks.

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several walruses, from the skull of one taking a great leaden slug weighing upward of an ounce. On the retreating sea cliffs these bones may be seen projecting here and there from beneath the uncertain soil. These are rather interesting occurrences as it is said that no walrus has been killed in the Magdalens since late in the 18th century. The hunting of the walrus is one of the romantic bits of the early history of the islands. Cartier's enthusiastic account of Brion island and its paradisiacal charms told stories of them which excited the lust of both Bretons and English and it was over the walrus hunting that blood was shed between these peoples. In this pursuit it was the practice to drive the great beasts from the waters or the floe ice up on to the low shore platforms and shoot them at leisure. The bones of the victims are occasionally found at Old Harry point and elsewhere, while the name Sea Cow (vache marine) point still records these resorts. Dr J. A. Allen quotes Professor Packard as stating that the last walrus seen in the gulf was in 1841, when one was killed at St Augustine on the Labrador, but I have heard the report that a few years ago one floated on an ice cake driven under a northeast gale, well up the St Lawrence to beyond Fox river.

The Rev. John Prout, Anglican minister in the islands, kindly put me in the way of securing a very large head taken from the drifted sands at Wolf island and I append here some comparative notes as to its dimensions:

Dr Allen in his measurements of skulls of the Atlantic walrus, Odobaenus rosmarus, cites from one old male: (1) Canines, length from plane of molars, 330 mm; (2) canines, circumference at base, 197 mm; (3) canines, distance apart at tips, 273 mm. A middle aged male gave the following: (1) 250, (2) 177, (3) 248.

The skull taken from the sands of Wolf island has these measurements thus: (1) 410 mm, (2) 190 mm, (3) 280 mm.

Plate 15

Great Bird rock, from the south; showing light house and accessory buildings

Little Bird rocks, seen from just off the Great Bird

Plate 16

Cliffs of Great Bird rock, from the north. The larger birds are gannets, the smaller murres and puffins.

Sea cliffs of Great Bird rock. Horizontal ledges of sandstone affording nesting places for the gannets and other sea fowl.

Fertility. The deep rich residual soil that overlies the plateaus of the lower land levels has an unbounded fertility and on the knobs and demoiselles where the red sandstone runs into the gray its fertility is carried with it. Today a mere scratching of the surface of the land produces an abundant return of grass, barley and oats and deep plowing is seldom done. Indeed, year after year gives the same fair return of hay without any cultivation. With the simplest mode of planting, potatoes produce enormously and are the common winter food for hogs and cattle. The natural situation of the islands has made them the home of fisherfolk. The lobster, cod, mackerel, herring and seal abound here as they do nowhere else in the gulf and it is these that absorb the energies of the people. Farming only tides over the intervals between the fishing to maintain the live stock and to afford a supply of vegetables. The fertility of the soil seems to have been entirely overlooked as a commercial factor but even recognizing the limitations of the season, it has tremendous possibilities and in the matter of potato cultivation would give large returns at a minimum of cost.

RECENT LITERATURE RELATING TO THE MAGDALEN ISLANDS

S. G. W. Benjamin. The Atlantic Islands as Resorts of Health and Pleasure. Chap. 4, 1878.

James Richardson. Report on the Geological Exploration of the Magdalen Islands. 1881.

S. G. W. Benjamin. The Cruise of the "Alice May." The Century Magazine, April 1884.

A. M. Pope. In and around the Magdalen Islands. Catholic World. 39:369. 1884.

George Patterson. The Magdalen Islands. Nova Scotian Institute of Science. Proc. and Trans. v. 1, pt 1, p. 31–57. 1891.

Anon. Among the Magdalen Islands. Chambers Journal. April 1893, p. 193–95.

Frank Yeigh. Among the Magdalen Islands. Canadian Magazine. October 1908, p. 505.

W. Lacey Amy. The Magdalen Islands. Canadian Magazine. February and March 1911.

For Cartier's route along these islands, 1534, 1535, *see* J. P. Baxter: Jacques Cartier. 1906.

THE CARBONIC FAUNA OF THE MAGDALEN ISLANDS

By J. W. Beede

The Carbonic (Mississippic) fauna of the Magdalen islands. collected by Doctor Clarke, was submitted to the writer for study. Like the earlier Paleozoic faunas of the Gulf of St Lawrence region, these Carbonic faunas are peculiarly interesting and exhibit characters which throw much light on the history and geography of the time and region in which they lived.

In preparing these notes the writer has been under obligation to the authorities of the Peter Redpath Museum, McGill University, for the loan of material from the Dawson collection for comparison with the fauna in hand, and to Dr Stuart Weller for similar aid from the Walker Museum.

History and correlation of the fauna

The only mention heretofore made of this Magdalen islands fauna is in Richardson's report of 1881, to the Canadian Survey. The very few fossils then collected were submitted to Sir William Dawson for identification and his letter in reply is quoted as follows: "I should think the fossils herewith returned indicate, so far as they go, a lower Carboniferous age. The most characteristic is a small specimen of Bakewellia antiqua, a very widely distributed species, of which I send one of my own specimens from Windsor for comparison. There is also a Modiola or Cypricardia, which may be the shell I have called avonia, from Windsor, in Nova Scotia; and a little Cardinia like C. mara, but not determinable. The most abundant species is a Serpulites which is very near S. annulites, from Nova Scotia, but the state of preservation is so peculiar that I can not be sure of it; the rock altogether resembles one of those black eroded limestones, which, in Nova Scotia, we find in close proximity to the beds of gypsum and which are usually very bare in fossils."

Sir William here drew no conclusion regarding correlation, but it is fair to infer that he supposed the fossils from the Magdalens and Nova Scotia to be intimately related. An inspection of the list of species recorded later in this discussion shows that the relation of these faunas is quite as intimate as Dawson suspected. Indeed it is so close that the outside correlation of the one may be regarded as equally affecting the other.

Correlation of the Nova Scotia faunas

In the light of these facts the history of the correlation of the Nova Scotia faunas is of peculiar interest here.

Dawson considered their position in the geologic column and their relationships abroad very thoroughly and discussed these points in some detail in his *Acadian Geology*,[1] from which the following summary is extracted:

"The earliest statement as to their age was that of Mr R. Brown, in Hamilton's 'Nova Scotia.' He correctly regarded the limestones of northern Cumberland as lower Carboniferous, on the evidence of their stratigraphical position as underlying the Cumberland coal-field."

In the central part of the province these rocks were referred to the "New Red Sandstone." In 1841 Sir William Logan took the beds below the Windsor limestones at Windsor, Nova Scotia, to be Coal Measures and referred the limestones to the Permic. In 1843 Lyell explored the Avon-Pictou region and doubted Logan's correlation. His views were subsequently confirmed by Dawson and Brown. Davidson found many of the brachiopods to be identical with those of the British "Carboniferous Limestone." De Koninck confirmed Davidson's view and correlated them directly with the Carbonic limestones of Visé, Belgium. Nevertheless the red sandstones, marls and pelecypod fauna recalled to their minds the rocks and fauna of the Permic system, the "Bakewellias" playing an important rôle in this respect, and it was also pointed out that they did not suggest the Carbonic of the United States, but the Permocarbonic, Newberry and Meek both remarking upon it.

In the last edition of *Acadian Geology,* Dawson clearly summarizes his views on the age of the rocks and the peculiarities of the fauna. In number 6 of these statements (p. 284) he says: "It is evident that the marine fauna of the Lower Carboniferous in Nova Scotia more nearly resembles that of Europe than that of the western states. This is no doubt connected with the fact that the Atlantic was probably an unobstructed sea basin as now, while the Appalachians already, in part, separated the deep sea faunas of the Carboniferous seas east and west of them . . . " and again:

"It is a matter of regret to me that I have not had the time fully

[1] Dawson, Acadian Geology, p. 278–85. 1878.

to investigate all the facts belonging to this curious question. I would commend it to those who follow me, to whom that which I have been able to do may at least be of use in guiding their researches."

Here we have a clear conception of the scope of the whole problem.

Passing over the intervening time to the present, Schuchert's summary of the correlation will suffice for our purposes. He states:

"The oldest fauna of this series at Windsor includes but few species, and these remind one of Kinderhookian time. In the higher dolomites at Windsor a rich fauna appears that is very different from that in any American Mississippic horizon, and as it is also unlike those of Europe it is difficult to correlate. Seemingly it is of Keokuk time, yet it may be somewhat younger, as Lithostrotion is reported at Pictou, which is not far from Windsor." [1]

Characteristics of the fauna

The faunas here discussed were collected from two islands, Grindstone and Coffin, and from five localities, as follows: On Grindstone island: (1) close against the gypsum bluffs not far from Cape le Trou on the west coast, where the rock is a very calcareous, rusty sandstone; (2) near the gypsum bluffs facing the great lagoon, on the property of N. Arseneau — gray calcareous shale as in the locality following. On Coffin island at Oyster basin in a calcareous shale; fragments of this shale have been obtained at Grand Entry landing and at Old Harry point, both on Coffin island, but the former were transported and the latter probably not in place.

In the Grindstone island fauna the most striking feature is the peculiarity of its makeup. The brachiopods are characterized by an abundance of Productus belonging to two limited groups, all other groups being absent. There is also a total absence of the Spirifers. A few Dielasmas are present, a Pugnax and an Orbiculoidea. The Pelecypoda are well represented. Among them are Liopteria, Parallelidon, Modiola and Aviculopecten which constitute the majority of the specimens. There are a few undeterminable gastropods, a Euomphalus and a few poorly preserved cephalopods.

The Productus fauna seems to have developed from two stocks, in an inclosed basin, and the species present fall into two groups, the members of each group being in many ways strikingly similar, but differing sufficiently to permit of careful distinction. This char-

[1] Schuchert. Paleogeography of North America. Geol. Soc. Amer. Bul. p. 551. 1910.

acter, together with the fact that the other groups common to the rocks of this age are absent, is indicative of the isolation of the basin at the time the rocks were deposited. The absence of the Spirifers and of Chonetes, Derbya, Orthothetes and the like all point to the same conclusion.

A general feature of the fauna, especially of the Grindstone island localities, is the extent to which it is dwarfed, the dwarfing being carried even farther than is the case with the Nova Scotian fossils.

Both the Grindstone and Coffin island faunas are related to the "carboniferous limestones" of Nova Scotia, the former the more intimately. The Oyster basin material has 8 species in common with the Nova Scotia rocks and the Cape le Trou material has 20 species. The Cape le Trou and Oyster basin rocks have 6 species in common as listed in this paper. Four species are common to both islands and to the Nova Scotia rocks.

Serpula infinitesima, Stenopora ? sp., Hemiptychina ? waageni, Lingula, Strophalosia, Aviculopinna, Nucula, Pleurophorus?, Schizodus denysi, Martinia glabra, Bucanopsis, Euphemus?, and the Ostracoda are confined to the Oyster basin locality and horizon. Five of these species are rather common, several specimens of each and more of some of them occurring in the collection.

The following rather important species, or genera, are represented only in the Cape le Trou collection, the most of them by a number of specimens: Spirorbis sp., Rhombopora exilis?, Dielasma sacculus, Productus auriculispinus, Pugnax, Aviculopecten lyelli, Liopteria, Modiola pooli, Parallelidon dawsoni, Euomphalus exortivus?, and most of the cephalopods. The striking feature of these comparisons is the fact that so many of the common species at each locality are restricted to that locality and bed. Though the beds are distinct and of somewhat different composition, yet they are hardly so different as to account for the difference in the faunas contained. There would seem to be a stratigraphic break or a considerable difference in the salinity of the water in which the two beds were laid down. The two localities are about 35 miles apart.

The species in common are: Beecheria davidsoni?, Orbiculoidea limata, Productus dawsoni, its variety acadicus, P. tenuicostiformis, and Orthoceras sp. A.

The peculiarities of the Oyster basin fauna, besides those already discussed, are relatively few, it being a better balanced one than that of Cape le Trou. As to which of these two is the older will probably have to be left to the stratigraphy. In the Windsor (Nova Scotia) section most of the Spiriferacea were confined to the base of the section or were more abundant there than anywhere else. We do not know the range of the species in that section. The fact that Martinia glabra occurs here and not at Cape le Trou could be interpreted as evidence for the greater age of the Oyster basin beds. The restricted Productus fauna of the latter beds and the absence of Aviculopecten lyelli would also point in the same direction. There can be little doubt that the Cape le Trou beds represent beds *d* or *e*, or both, in the Windsor section. From the description given by Dawson[1] it also seems probable that the Oyster basin rocks may represent the base, beds *a*, and *b*, of the Windsor section. The Nodosinella, worms etc., together with Martinia glabra, would seem to indicate it, but by no means certainly.

The Nodosinella from a pebble on the beach of Coffin island at Grand Entry is of peculiar interest in being closely allied to a British species. The Nuculas show a fairly close relationship to British species.

The Oyster basin fossils indicate quite as close alliance with the remaining American Mississippic faunas as does the Cape le Trou fauna. One species, Schizodus cuneus Hall, is almost certainly specifically identical. Girty records Martinia glabra? from the Moorefield shales of Arkansas, and two or three other shells are likely to prove identical on further evidence. None of the Magdalen islands species has been considered identical with the other American species unless the evidence was practically conclusive. This method is hardly practical in studying faunas of the same general basin and succession, but in treating isolated basins it is the only safe one. Aside from the evidence referred to, the affinities of the Oyster basin fauna seem to lie quite as strongly with the Kinderhook as do the affinities of Cape le Trou fossils.

I can not hope to have avoided all British and western European synonomy in describing these fossils, since neither the great mass of the literature nor the time to utilize it has been at my disposal.

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[1] Acadian Geology, p. 279, 280. 1878.

Correlation with Mississippi basin faunas

A very striking evidence of the isolation of the southern St Lawrence basin at this time is the want of relationship of the fauna of Nova Scotia and the Magdalen islands, with the faunas of similar age in the Mississippi basin. While the number of species common to the two regions is small, yet careful study reveals several species of very similar characters. This is especially true of species of the genera Edmondia, Liopteria, Productus, Schizodus etc. Indeed some of them are so similar that were one a little incautious in discriminating characters they might be considered as identical.

Productus tenuicostiformis is sufficiently like P. tenuicosta that were it larger and more produced anteriorly the two would readily pass as the same species. P. dawsoni is also closely related to P. laevicosta and P. ovata. Edmondia sp. is very closely related to E. nitida and to E. quadrata from the Kinderhook, but appears to have the beaks more nearly terminal, and is closely related to E. obliqua from the Devonic. Relationships nearly as close occur among the other groups and will be occasionally mentioned under the specific descriptions. The general affinities seem to lie with the lower Mississippic. At the same time their rather close relationship to the Devonic pelecypods also makes it apparent that the fauna can not be much farther removed from the Devonic than its relationships with the Mississippi valley faunas would indicate. There seems to be much evidence in the Magdalen islands material to confirm Schuchert's correlation of the beds with the Kinderhook and immediately overlying beds.

THE FAUNA OF CAPE LE TROU, GRINDSTONE ISLAND

These specimens are mostly preserved as casts in a ferruginous magnesian limestone having the appearance of a brownish sandstone.

Spirorbis sp.

Casts too poorly preserved for identification.

Rhombopora exilis Dawson?

Stenopora exilis Dawson. Acad. Geol. p. 287, fig. 85. 1878.

Molds of specimens have the size and form of this species and so far as can be determined, a similar topography.

Orbiculoidea limata nov. ?

(See page 177)

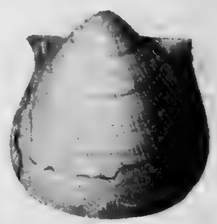
Productus dawsoni nov.

Specimen nearly subquadrate in outline, widest somewhat in front of the middle. The hinge is slightly shorter than the greatest width of the shell, the lateral margins are concave posteriorly and very gently rounded into the evenly curved anterior margin. The shell is quite depressed for a Productus and the beak barely projects beyond the hinge, not recurving around it. The ears are nearly flat, triangular, carrying many fine spines. The remaining characters are common to the rest of the surface. The surface of the pedicle valve is ornamented with very fine striae which are sharply rounded and narrower than the valleys separating them, somewhat inclined to be wavy, increasing by implantation. The spines of this form seem to be confined to the ears, or nearly so. Posteriorly, there are very slight concentric wrinkles.

Productus dawsoni nov. Pedicle valve. Cape le Trou, Grindstone I.

Dimensions. Length and width of shell 20 mm, length of hinge 15 mm. The specimen figured has a convexity of 4 mm, though it may be very slightly flattened. Fifteen or more striae in 5 mm.

Remarks. This species is very similar to specimens labeled Productus cora var. dawsoni Hartt, from the Carbonic limestone of Nova Scotia. It is also very closely related to the form figured by De Koninck from the limestone of Visé, Belgium, under the term P. striatus.



Productus dawsoni var. acadicus nov. Cape le Trou, Grindstone I.

Productus dawsoni acadicus nov.

This variety resembles P. dawsoni in many of its characters but is much more convex, relatively broader and perhaps has a somewhat more protruding beak.

Dimensions. Length, 19.5 mm; width, 21.5 mm; length of hinge, 17.5 mm; convexity, 7 mm, and slightly flattened.

Productus arseneaui nov.

Cast of small size, subquadrate, wider than long. Ears small, convex, with concentric wrinkles. Hinge-length and transverse diameter of the shell about equal. Lateral margins arcuate; anterior border broadly sinuate, the sinus occupying half its length. The sinus is present over half the length of the pedicle valve. On the surface are about 66 radiating striae, 11 or 12 in 5 mm. They increase in number by implantation and bifurcation, spines sometimes occurring on the latter points. Posterior part of shell with transverse wrinkles. Diductor muscles attached to 5 or 6 diverging ridges in the pedicle valve; adductor callosities elliptical, deeply depressed on cast.

Remarks. The sinus and the diductor scars and general form of the shell distinguish it from the other species.

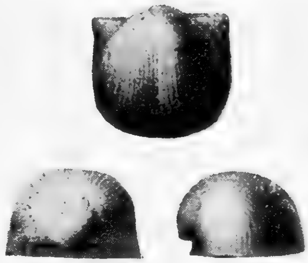
Productus laevicostus White?

Productus laevicostus White. Journ. Boston Soc. Nat. Hist. 7:220. 1860.

A specimen apparently identical with this species.

Productus prouti nov.

Shell small, very arcuate from beak to front, except in old specimens when the anterior is nearly straight. Hinge-length slightly exceeding the width of the shell which is narrow for its height. Surface poorly preserved, but one specimen is marked with 9 or 10 striae to 5 mm. On some of the specimens there is no sinus.



Productus prouti nov.
Cape le Trou, Grindstone I.

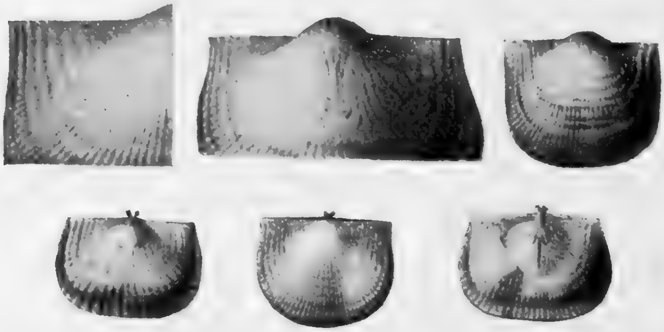
Dimensions. Length of shell 12 mm; width, 14 mm; length of hinge about 16 mm; convexity, 10 mm.

Remarks. This species differs from P. doubleti in being much more arcuate, more finely striated, and in having a much more highly inflated beak.

As is shown in the illustration, the shell appears to have had a considerable cardinal area and may possibly have possessed teeth. Better preserved material may show it to be a Productella.

Productus tenuicostiformis nov.

Shell subquadrate, gibbous; hinge as long or longer than the transverse diameter of the shell; lateral margins nearly straight from the hinge nearly to the front of the shell where they gently curve into the nearly straight anterior border; beak but slightly produced beyond the hinge, not recurved, very slightly and very broadly inflated. Pedicle valve very strongly arcuate longitudinally and a terrace is frequently traceable around the shell at the edge of the visceral chamber; surface sculptured with moderately fine radiating striae about equal in width to the intervening depression, increasing largely by interpolation in the older part of the shell and by splitting in the anterior portion. Ten or 12 spines are scattered over the surface of the shell and several crowded on the ears. Posterior part of the valve marked with concentric wrinkles becoming stronger near the ears. The interior of the valve has the muscular attachments well developed and sharply defined as is revealed in a cast; anterior adductors attached to low indistinct ridges; diductors attached to four or five low bilobate or looped ridges on either side of the adductors. Brachial valve more nearly subquadrate than the pedicle valve, the hinge being about equal to the anterior width of the shell. Valve nearly flat over the visceral region, somewhat depressed in the central region and elevated around it, geniculated at the margin (unless surrounded by a wall). Beginning at the ears a very narrow platform extends outward enlarging as it passes around the sides to the anterior of the valve where it has the width of a millimeter or more. Mesial septum reaching well toward anterior part of valve. Adductor attachments nearly round but showing a tendency to digitate lobation. Cardinal process bilobate at least below, as shown in cast.



Productus tenuicostiformis nov. Cape le Trou, Grindstone I.

Dimensions. Length of shell, 14 mm; width, 18 mm; length of hinge, 19 mm; 9 or 10 striae in 5 mm.

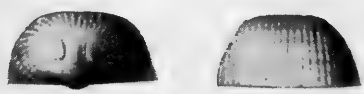
Remarks. The horizontal platform surrounding the visceral area of the brachial valve is of unusual interest since it occupies the position of the murication in Marginifera. No murication is, however, preserved in our specimens, though it could hardly be expected that it would be, and there is little to lead one to suspect that such murication did exist. The generic disposition of the shell is not quite clear. The cardinal process is bilobate, below at least, as in Productella, though there seem to be no crural plates to assist in forming sockets for the teeth of the opposite valve and the pedicle valve seems not to have had teeth. The well-defined muscular attachments go with other characters in suggesting its place in Productus. The platform, even though not supporting a murication, seems to forecast the subgenus Marginifera. Since the more important features are those of Productus, it seems advisable to leave it in that genus until better material is available. This material will be found upon careful search in the Carbonic limestone of Nova Scotia.

Externally, this species resembles Productus tenuicosta from the type locality, though it is much smaller and much less produced anteriorly. The full elucidation of the internal characters of both species may show them to be identical, but at present this seems unlikely.

Since this discussion was written a copy of Girty's paper,[1] in which he describes the new subgenus Diaphragmus, has come to notice. The character upon which this subgenus is based is exhibited in specimens from the Chesser Group and in a fragmentary specimen figured later from the Moorefield shales. The specimens from older rocks at Cape le Trou and Oyster basin have this feature well developed. Indeed there is some suspicion of its presence in what may be Strophalosias from the latter locality. This character seems to have originated as early as the lowest Kinderhook or later Devonic in such shells as Productus dissimilis Hall, and reached its fullest development in Marginifera muricata, M. splendens, and M. wabashensis. The presence of the " plate " or " diaphragm " is to be regarded as the inception of shell deposition in the peripheral region of the brachial valve together with its geniculation and later became more and more pronounced resulting in sharp murication of the Pennsylvanic species. Since somewhat similar characters occur in other shells of the Strophomenacea the structure is of doubtful systematic significance at best, and the splitting up of the subgenus Marginifera on the basis of the extent of the deposit seems hardly warranted.

Productus doubleti nov.

Cast small, gibbous, strongly arcuate longitudinally, most arcuate near the beak. Beak inflated, broad and full, extending but slightly beyond the hinge. No marked sinus present, central part of shell but slightly flattened in transverse profile; nearly equally arcuate when viewed from side or front. Hinge about equal in length to the greatest anterior width of the shell. Lateral margins slightly arcuate, rounding into the convex front of the shell. On the surface there are 36 coarse radiating striae, those in the central part of the shell being coarser than those on the sides. No



Productus doubleti nov. Anterior and posterior views of cast of pedicle valve. Cape le Trou, Grindstone I.

[1] Ann. N. Y. Acad. Sci., XX, 3, II, p. 217, 1910.

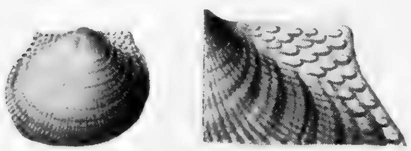
concentric wrinkles over visceral region except a trace of one near the left ear. Muscular impressions weak and not so elaborate as in the preceding species.

Dimensions. Length, 12 mm; width, 16 mm; hinge, probably 13 or 14 mm; 6 striae in 5 mm.

Remarks. This shell resembles to some extent P. arcuata Hall but is smaller, almost without reticulations over the visceral chamber and very much less produced anteriorly.

Productus auriculispinus nov.

Shell small, subquadrate in outline, somewhat broader than long. Beak but moderately inflated, the shell rather evenly convex. Hinge short, postlateral margins gently sinuate reaching the hinge nearly at right angles; lateral margins rounding into the evenly convex anterior border. Beak projecting but slightly beyond the hinge and not recurving around it. Fine spines are crowded in rows on the small, triangular, flat ears. Shell covered with fine radiating striae about equal in width to the furrows between them, increasing in number by interpolation or rarely by bifurcation. Crossing these are ill-defined concentric wrinkles, which are much better defined and stronger on the brachial valve.



Productus auriculispinus nov.
Cape le Trou, Grindstone I.

Dimensions. Length, 13 mm; width, 15 mm; length of hinge, 10 mm; 12 or 13 striae in 5 mm.

Remarks. This species differs from P. dawsoni in being relatively broader with shorter hinge and in greater general convexity of the pedicle valve. Specimens nearly related to or perhaps identical with this one were included by Dawson under Productus cora. They occur in the limestones at Windsor, Nova Scotia. There is little danger of confusing this species with any other American member of the genus.

Pugnax magdalena nov.
Dorsal and ventral sides.
Cape le Trou, Grindstone I.

Pugnax magdalena nov.

Specimens of moderate size, flattened upon fossilization, apparently rather gibbous and orbicular in outline in uncompressed specimens. Posterior third of shell smooth, anterior two-thirds with fold, sinus and costae; fold decidedly elevated and divided by a median sulcus into two strong, angular costae. There are two or three costae on the sides of the brachial valve. Pedicle valve gently convex posteriorly, deeply and broadly sinuate in front with single broad, low fold in the center and two or three on the sides of the valve. The cast, though excellently preserved, shows no indication of a mesial septum in the brachial valve.

Dimensions. Length, 8.5 mm; width, 9.5 mm; somewhat modified by flattening.

Remarks. Externally this species seems closely related to Camarophoria explanata McChesney, and to P. globulina Phillips. It is very doubtful if the shell was ever so globular as the latter, on the form figured by Dawson, and the former has been shown by Weller to be a true Camarophoria, possessing a strong mesial septum. Our specimen apparently is without this septum and consequently a true Pugnax, like those of the Mountain limestone of Ireland.

Dielasma sacculus Martin

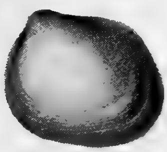
Dielasma sacculus (Martin). Cast of ventral valve. Cape le Trou, Grindstone I.

Beecheria davidsoni Hall & Clarke

A poor cast having a form very suggestive of this species.

Edmondia intermedia nov.

Cast small, obliquely subovate or quadrilateral, only moderately gibbous, beak very near the front of the shell; hinge straight with characteristic slit beneath it; posterior margin nearly straight and oblique above, rounding into the elliptical ventral border which passes with a still gentler curve upward to the hinge. Surface of cast striated on its younger portion with minute, evenly spaced lines parallel with the border; there are also larger growth varices.



Edmondia intermedia nov. Cast of left valve. Cape le Trou, Grindstone I.

Dimensions. Length, 17 mm; height, 15 mm; length of hinge, about 10 mm.

Remarks. It is not certain that this species may not be E. nitida Winchell, and it is also very closely related to E. quadrata Weller. It differs from them, apparently, in having its beak more nearly terminal. It is also closely related to E. obliqua Hall, but differs from it in the same respect as well as in the less angular termination of the umbonal ridge and in having the ventral and dorsal margins more nearly parallel.

Edmondia magdalena nov.

Shell small, oblique, very elongate for the genus, nearly twice as long as high. Umbones inflated, protruding above the hinge which is nearly straight and extending about six-tenths the length of the shell. Posterior margin subtruncate, rounding below into the elliptical ventral border which continues in an elliptical curve to the hinge. Beak 2 mm from the anterior end of the hinge. The details of ornamentation are not well shown on the cast, but there are fine, even concentric striae and the usual undulations of the genus.

Edmondia magdalena nov. x2 Cast of left valve. Cape le Trou Grindstone I.

Dimensions. Length, 9+mm; height, 5+mm; hinge, 6+mm.

Remarks. This species is similar to E. hartti Dawson, but is much smaller and the hinge slopes less steeply anteriorly, and it is slightly more truncated on the posterior end.

Parallelidon hardingi Dawson?

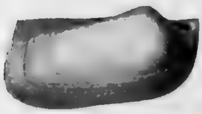
Macrodon hardingi Dawson. Acadian Geology, p. 302, fig. 102, 1878.

One small specimen probably belongs to this species. It is on a slab with Sanguinolites insecta Daw.

Parallelidon hardingi Dawson. Windsor, N. S.

Parallelidon dawsoni nov.

Shell small, subquadrangular, beaks very convex and arched over the cardinal area. Anterior end short, abruptly rounding downward and backward into the gently sinuate ventral margin. Posterior lateral edge evenly and abruptly rounded into the truncated posterior margin which reaches the hinge at a slightly obtuse angle, the anterior and posterior borders being nearly parallel. The length of the hinge is equal to the length of the shell and its direction nearly parallel to the ventral margin. The cast shows fine concentric lines and larger growth varices.



Parallelidon dawsoni nov. Cape le Trou, Grindstone I.

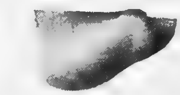
Dimensions. Length, 13.5 mm; height, 7 mm; beak, 4.5 mm from front.

Remarks. In illustrating his species, P. hardingi, Dawson used two specimens, one (fig. 102a) a very short, highly gibbous specimen, quite convex beneath the beaks and on the ventral margin also; and a much longer specimen (fig. 102b) which was less gibbous, with fairly strong depression beneath the beaks producing a corresponding sinuosity in the ventral border. In this genus it seems that these specimens must be regarded as being specifically distinct. The first is taken as the type of his species and the second (2820, in part, Peter Redpath Museum) is regarded as belonging to the species now under discussion. The casts from Grindstone island are smaller and show no trace of radiate markings, nor does the specimen (a cast) just referred to in the Dawson collection. They are regarded as belonging to the same species.

This species is very closely related to P. obsoletus Meek and Worthen, from the Coal Measures of the Mississippi valley, but is smaller, has the beak extending more sharply over the cardinal area, and the long teeth parallel to the hinge reach much farther back. It differs from P. cochlearis (Winchell) as figured by Weller in that the posterior margin joins the hinge much more nearly at right angles, making the shell less oblique. That shell is probably the nearest relative known of our species.

Leptodesma borealis nov.

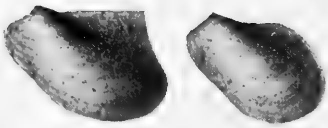
Cast of right valve small, aviculiform, with long projection in front of the beak. Hinge about as long as the shell; posterior margin sinuate above but soon becoming gently convex and gradually rounding into the ventral margin. Ventral margin quite sinuate beneath the beak on account of the strong depression in the shell, beyond which the border is convex to the tip of the hinge. The umbonal ridge nearly dies out posteriorly. Surface marked with varices of growth and smaller striae.


Leptodesma borealis nov. x 2. Cast of right valve. Cape le Trou, Grindstone I.

Dimensions. Length of hinge, 8 mm; length of umbonal ridge, 6 mm; beak, 2+mm from front of hinge; height of shell at posterior end of hinge, 4.75 mm; angle of umbonal ridge to hinge about 30°.

Liopteria dawsoni nov.

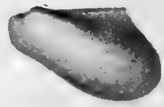
Cast of left valve small, moderately convex, hinge shorter than the length of the umbonal ridge. Posterior margin sinuate, rather evenly rounded at the termination of the umbonal ridge; ventral margin somewhat sinuate anteriorly but convex around the lobe projecting in front of the beak. The lobe is small and nearly tri-



Liopteria dawsoni nov. x 2. Cape le Trou, Grindstone I.

angular. The weak teeth parallel to the posterior end of the hinge are shown. Varices of growth more widely spaced along the umbonal ridge than elsewhere; the finer lines being about evenly spaced except near the beak.

Dimensions. Length of hinge (from back to posterior end, in this case), 7.5 mm; length of umbonal ridge, 8+mm; height at extremity of hinge, 6+mm; angle of umbonal ridge to hinge, 35°.

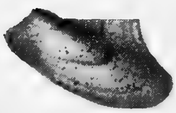


Bakewellia antiqua" Dawson. Gay's river, N. S.

Remarks. Though smaller, these specimens seem to be the same species as the "Bakewellia antiqua" of the Dawson collection from Gay's river, N. S. Neither our specimens nor the one examined from the Peter Redpath Museum, Dawson's collection, were seen to possess the vertical cartilage pits of Bakewellia though they may possess them. Until they are discovered I am inclined to refer the specimens to the genus Liopteria.

Liopteria acadica nov.

Cast of left valve small, aviculiform, well inflated for this genus, hinge shorter than the shell. Beak well elevated; umbonal ridge elevated and very oblique; posterior margin obliquely sinuate, rounding regularly and rapidly into the convex posterior ventral margin; ventral border sinuate beneath the beak; anterior end of shell lobate, the front sloping downward. Cast shows the usual varices and finer striae of growth common to these shells from this locality.



Liopteria acadica nov. x 1.5. Cape le Trou, Grindstone I.

Dimensions. Length of hinge, 7 mm; length of umbonal ridge, 11 mm; greatest length of shell, 12 mm; angle of umbonal ridge to hinge, 25°.

Pteronites cf. latus McCoy

Pteronites latus McCoy. Carb. Foss. Ireland, p. 81, pl. 13, fig. 7, 1844.

Pteronites latus Hind. Carb. Lam. p. 8, pl. 5, fig. 6, 7, 1901.

Shell small, subtriangular, posterior end probably slightly sinuous. Growth undulations are the only surface marks preserved on the cast. Beak removed from anterior margin. The angle between the hinge and ventral margin is about 35°, the length of the hinge, 11 mm; the height at extremity of hinge, about 7 mm; greatest length of the shell, 12 mm.

Remarks. The ends of our specimen are missing. The shell is very similar in form to Hind's figure of P. latus McCoy, and the dimensions are similar, relatively, though our specimen is much smaller. It also seems to be related to shells from the Waverly of Ohio.

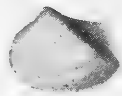
Cardinia subquadrata Dawson?

Cardinia subquadrata Dawson. Acadian Geology, p. 304, fig. 108, 1878.

A poor cast, the generic and specific determinations doubtful.

Schizodus richardsoni nov.

Cast of valve small, form oblique, characteristic of genus. Beak subtriangular, narrowly inflated; umbonal ridge elevated and gently angular; anterior end of shell short, rapidly curving downward into the elliptical ventral margin which terminates in the angular upward turn at the end of the umbonal ridge. Posterior truncated margin nearly straight and almost vertical, reaching the hinge at an angle of about 120° leaving a relatively large concave triangular area above the umbonal ridge and below the hinge.



Schizodus richardsoni nov. Cast of left valve. Cape le Trou, Grindstone I.

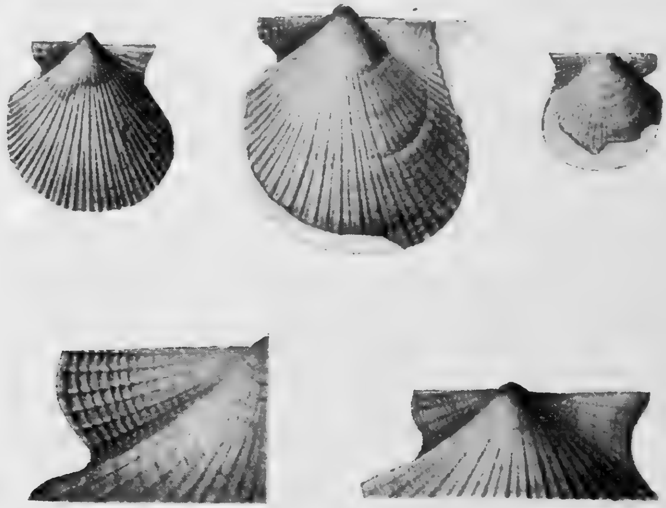
Dimensions. Height, 9 mm; length, 11 mm; length umbonal ridge, 10 mm.

Remarks. This species is much like S. ellipticus Hall, from the Hamilton. It seems to differ from it in the front of the shell being shorter and the posterior margin reaching the hinge at a larger angle. The beak is thus made a little more prominent. It differs from S. iowensis in having a relatively longer, straighter hinge while the area between the hinge and the umbonal ridge is proportionately larger and the posterior truncation more nearly vertical. Our specimens are closely related to both species.

Aviculopecten lyelli Dawson

Aviculopecten lyelli Dawson. Acadian Geology, p. 305, fig. 111a-c, 1878.

Cast of left valve subovate, beak pointed, protruding 1.5 mm beyond the hinge. Shell moderately convex; anterior ear triangular, separated from the shell by a sulcus, rounded at the extremity; margin separated from that of the shell by a deep sharp sinus. Posterior ear somewhat larger, triangular, less sharply separated from the body of the shell, extremity rather pointed, posterior margin sinuate in joining the shell. Both ears ornamented by radiating striae crossed by striae which, on the anterior ear, are sharp and high, giving it a cancellated appearance. The sculpturing of the shell is somewhat similar to that of the ear. The radiating costae two ranked, the smaller ones interpolated between the larger, 37 in all, crossed by concentric lamellae which are highly vaulted on crossing the ridges as shown in the molds. Ridges rather sharp and about as broad as the furrows except on posterior region where the latter are wider.



Aviculopecten lyelli Dawson. Above, two left valves and one right; below, enlargements of the hinge. Cape le Trou, Grindstone I.

Dimensions. Length of hinge, 12.75 mm; length of shell, 17 mm: height, 19 mm; 6 or 7 striae in 5 mm; angle of beak about 90°.

Remarks. The specimens figured and described here are somewhat undersized. They are closely related to a species from the Knobstone of Indiana but differ in the relative breadth of the ribs, size of the shell, etc. There is a cavity beneath the beaks of our casts, but it is difficult to determine its true character.

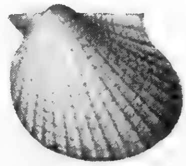
Aviculopecten acadicus Hartt?

Cf. Aviculopecten acadicus Hartt. Dawson's Acadian Geology, p. 307, fig. 114, 1878.

Shell small, convex; ears not well developed; beak sharply pointed. Anterior ear sharply separated from the shell, posterior ear not so distinct from it. About 25 radiating costae are shown, separated by wide interspaces and crossed by concentric lines or laminae which are raised on the costae making them appear nodose or the shell reticulated.

Dimensions. Length, 4 mm; height, 4 mm.

Remarks. The slight truncation prevents the shell from being circular as described by Hartt for his specimen from the base of the Windsor limestone. In other respects it agrees very closely with his description and the bit of surface detail figured by him, unless the lamellae are more highly vaulted on our specimen. The species is unrepresented in the Dawson collection in the Peter Redpath Museum and specimens have not been available for comparison.



Aviculopecten cf. acadicus Dawson. Cape le Trou, Grindstone I.

Modiola pooli Dawson?

Cf Modiola pooli Dawson. Acadian Geology, p. 301, fig. 100, 1878.

These specimens, while larger, may be identical with M. pooli Dawson. The Shubenacadie specimens seem slender, but if they were increased to the size of these might be identical. The specimen figured is a cast and has been compressed and distorted, producing the effect of a posteriorly placed beak and a depression beneath it which it did not possess.

Modiola pooli Dawson. Cape le Trou, Grindstone I.

Sanguinolites insectus Dawson?

Cf. Sanguinolites insecta Dawson. Acadian Geology, p. 303, fig. 196, 1878.

The specimen from Grindstone island differs from Dawson's figure in not contracting quite so rapidly toward the beak. Since the beak of Dawson's specimen and of ours are both missing it is impossible to say whether or not they are specifically identical.

Euomphalus exortivus Dawson?

Cf. Euomphalus exortivus Dawson. Acadian Geology, p. 309, fig. 118, 1878.

Mold of specimen only, except a flattened section of outer whorl. It is clearly related to the above species, but is much larger, being nearly twice the size.

It differs from E. sulcifer angulatus Girty, from the Guadalupian in being larger and having the sulcus more nearly in the center of the whorl.

Gastropoda, 2 species, all minute, too poorly preserved to identify.

Gastropod, a large Pleurotomaria-like species, too poorly preserved for identification.

Conularia planicostata Dawson

Conularia planicostata Dawson. Acadian Geology, p. 307, fig. 117, 1878.

Cast of specimen agreeing in all essential characters with Dawson's species.

Conularia sp.

Fragment of another species, too poorly preserved to identify. It is quite slender with about 18 or more ribs in 5 mm. Though poorly preserved, the ribs appear to have been crenulated. Striae coarser and more distant than C. micronema Meek, somewhat like C. sampsoni Miller, but less obtuse. Striae more distant than in C. subulata Hall.

This species may be the variety "novascotica" mentioned by Dawson as named by Hartt, but it is uncertain. It does not seem to belong to any other American species.

Orthoceras sp.

Cavity formerly occupied by specimen.

Endolobus avonensis Dawson?

Cf. Nautilus avonensis Dawson. Acadian Geology, p. 331, fig. 124, 1878.

Endolobus avonensis Hyatt. Proc. Amer. Phil. Soc. 32:536, pl. 8, fig. 36–39, 1895.

Represented by a poor cast, small and distorted. The septa and siphuncle not shown. The dorsoventral diameter of the outer whorl seems relatively large for the Windsor species.

Endolobus? sp.

Several small specimens in concretions which do not admit of specific identification; only camarate portion preserved. Septa extremely convex, suture apparently simple and siphuncle placed very near the venter.

Gastrioceras? sp.

A large shell of which the cast of the living chamber is preserved and some of the outline of what may have been the camarated portion. From the characters shown little can be determined. It has a section corresponding roughly to some of the very large angulate, subnodose members of the genus. Umbilicus is very wide. Transverse diameter 52 mm; about a half the whorl from the aperture 41 mm. Diameter of umbilicus 26 mm.

THE FAUNA OF COFFIN ISLAND

Nodosinella clarkei nov.

Shells long, slender, branching, nodose, usually nearly straight. Test thick, imperforate so far as can be determined. Nodes well defined, quite as wide as long in all specimens sufficiently exposed to show full diameter. Diameter 1 mm, 6 or 7 nodes in 5 mm. Shells apparently monothalamous. In sections cut deep enough to avoid the sharp, keel-like edge of the constriction between chambers no septa are distinctly shown. No indubitable septa seen.


Nodosinella clarkei nov. x 1.5. Loose at Grand Entry

Remarks. This species appears to be related to N. (Dentalina) priscilla Dawson,[1] but differs in being 1 mm in diameter instead of a fortieth of an inch, and the modes are wider than long instead of being considerably longer than wide, and the test is thicker. In all these respects it agrees closely with N. digitata Brady. Our specimens differ from material of either species as described and figured, in branching rather liberally. It would seem to be impossible that the great masses of specimens mentioned by Dawson as occurring in the Windsor limestone, even though they were fragmentary, did not include branching forms. None of our specimens show the plane base indicated by Brady for the British species. The shells are 1 mm in diameter while Brady's specimens varied from 1 to 2 mm in diameter.

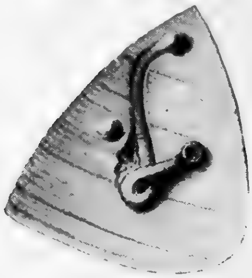
These tests are uniformly about a millimeter in diameter, except where a segment is enlarged to give off two or more branches, while Brady's species frequently reach a diameter of 2 mm. The tests in thin section under the microscope appear to be nearly homogeneous with a little rusty coloring. No indication of foramina is visible. Considering the very fine calcareous character of the matrix their presence in the tests originally seems improbable. From the state of preservation it seems questionable if they could be referred to the Lagenidae as suggested by Spandel[2] and others. While a larger amount of material may demonstrate the presence of the characters of this family, I am inclined to leave the specimens in Brady's genus since the ramose character of the species seems incompatible with such shells as Nodosaria.

[1] op. cit. p. 285.

[2] Die Foramen. des Deutschen Zechs. etc. p. 6, 1898.

Serpula? infinitesima nov.

Minute, highly contorted, anastomosing tubes which, when highly magnified in cross light, are nodose in appearance owing to rapid contractions and expansions of the shell. Diameter of tubes .1 mm, attached throughout their length to the shell of Composita dawsoni (Hall and Clarke) and other species of brachiopods.



Serpula infinitesima nov.
Showing (above) the nodose and contorted form (x 10) and below the tube partly buried in the shell (7)

Remarks. This species appears, on other shells, to live quite as largely within the shell as upon it. When it appears at the surface it has the characters mentioned above. It may be straighter within the shell than when partially at the surface. It seems to be partial to the shells of Martinia glabra. It is probable that it is not a Serpula at all. Several shells of the collection show the effects of this borer though the tests it secretes are gone.

Cornulites? annulatus Dawson?

Cf. Serpulites annulatus Dawson, op. cit. p. 313, fig. 131.

Specimens much smaller than Dawson's and with coarser marks, otherwise typical.

Cornulites? annulatus Dawson?
Oyster basin, Coffin I.

Stenopora? sp.

An immature specimen of the S. signata type, or what seems as probable, a form of Lioclema with relatively few meso pores. Encrusting form upon Composita dawsoni (H. and C.)

Specimens small, encrusting; zoecia varying from elongate where crowded to ovate; acanthopores rather numerous, elevated, largest ones at the angles of the zoecia; mesopores rather numerous, about eight being found in the walls surrounding a single cell, some much larger than others, except at zoecial angles, never in two rows, triangular to subcircular. Five zoecia in 2 mm. Interspaces fairly thick.

One other specimen still smaller than this was found.

Lingula eboria nov.

Shell small, extremely thin, elongate elliptical, twice as long as broad, moderately convex for these shells, especially in umbonal region, posterior end somewhat more narrowly rounded than the anterior but not angulated. Larger growth lines apparently with thicker shell than the intermediate spaces which show very faint concentric marks.

Lingula eboria nov.
Both valves in opposition.
Oyster basin, Coffin I.

Dimensions. Length, 3.5 mm; width, 1.8 mm. Greatest diameter near the middle of the shell.

Remarks. This shell is very similar to L. ligea Hall, from the upper Hamilton, but is less pointed at the beak and more tapering anteriorly and does not appear to be thicker at the margin. This might be governed, however, by the occurrence of the thickening of the shell at the growth stages.

It is less acute posteriorly than the figure of a shell identified as L. membranacea by Herrick, but it is very closely related to it, if not identical with it. It is closely related to L. albipinensis, as figured and defined by Girty from the Moorefield shales. It is also a close relative of L. parallela Phillips.

Orbiculoidea limata nov.

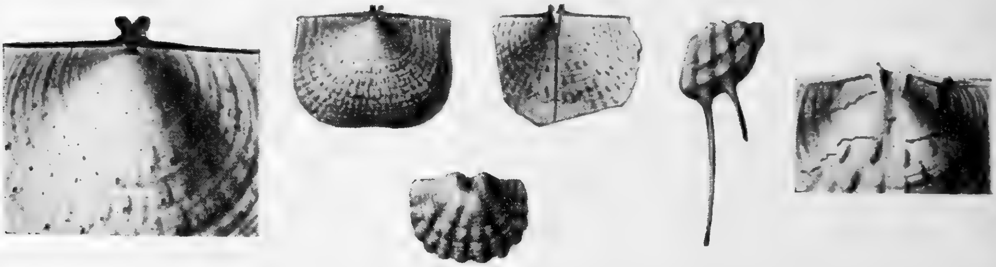
Shell small, extremely thin; pedicle valve nearly flat and almost circular, sometimes slightly elongate longitudinally; aperture reaching about half way to the periphery, narrow. Brachial valve with beak moderately elevated and located well toward posterior margin. Surface marked with strong, thick circles of shell between which are small, faint concentric marks.

Orbiculoidea limata nov.
Pedicle valve x 4.
Brachial and pedicle valves x 3.
Oyster basin, Coffin I.

Dimensions. Length, 5.75 mm; beak, 4 mm from posterior margin.

Strophalosia nebraskensiformis nov.

Shell of medium size, subquadrate. Immediately beneath the beak of the brachial valve, viewed externally, is a minute convexity back of the umbonal concavity of the valve. Valve convex in central portion, and between the ears and the central part two slight concavities lie either side of the anterior median convexity. Interior of valve with a long median septum reaching nearly to the front of the valve, forked at its union with the cardinal process, inclosing a deep pit immediately above the convexity of the other side of the valve. Process bifid when viewed from below as shown in the impression. One specimen suggests the possibility of a trifid proboscis. The surface is marked by coarse radiating striae which are alternately interrupted giving it the appearance of an ornamentation of elongated, alternating pustules to which occasionally very long, capillary spines were attached. Little is known of the form of the pedicle valve.



Strophalosia nebraskensiformis nov. In upper row, at left, interiors and exteriors of the valves, with enlargements; below is a very young specimen, pedicle valve (x 10), with scar of attachment and a fragment of a larger shell showing marginal spines, Oyster basin, Coffin I.

One minute young specimen shows the attachment at the beak very clearly as does the beak of another specimen several times as large. In both cases the scar is so small that the specimens must have been attached only by the spines or was free in the adult stages. Surface of this valve ornamented as in the other.

Dimensions. Brachial válve; length, 14 mm; width, 17 mm; length of hinge about 18 mm.

Remarks. The surface ornamentation of this shell is remotely suggestive of Productus nebraskensis Owen. It appears, however, to be a true Strophalosia, the area of the hinge in the brachial valve being small but distinct. It remotely resembles S. truncata Hall of the Devonic.

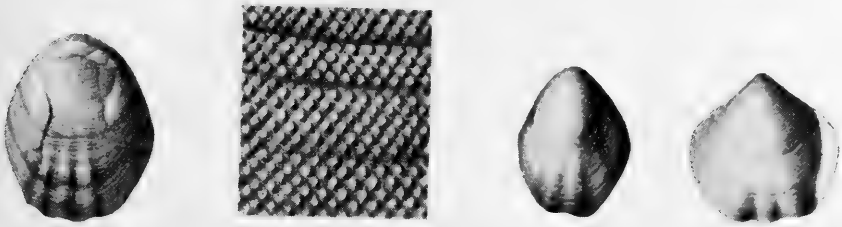
Beecheria davidsoni Hall & Clarke?

Beecheria davidsoni Hall and Clarke. Intr. Study Brach., pt. 2, pl. 54, fig. 1–3, 1894; Pal. N. Y., 8, pt 2, pl. 79, fig. 33–36, 1895; 14th Ann. Rept. N. Y. State Geol., p. 372, pl. 14, fig. 5–7, 1897.

A few poor specimens which may be referable to this species.

Hemiptychina? waageni nov.

Brachial valve of medium size, quite convex, broad and short, triplicate anteriorly, length exceeding the width, though the specimen is somewhat flattened. Anterior quarter of the shell slightly flattened and occupied by three rounded wide plications. Beak obtuse but sharply defined. Shell very minutely and sometimes irregularly punctate. Surface plain except for indistinct growth marks. The length and width of the specimen as it lies on the slab is 16.5 mm. The number of plications seems to vary.



H e ychina ? **waageni** nov. Two ventra and one dorsal valve, with enlargement of the surface. Oyster basin, Coffin I.

Pedicle valve subovate in outline, longer than broad, convex, widest somewhat in front of the middle. Beak rounded, apparently incurved; postlateral margins but slightly arcuate, passing into the rather strongly rounded antelateral edges; anterior somewhat produced, convex in outline. Little indication of shell having possessed fold or sinus. Six plications occupy the anterior two-thirds of the shell, the four lateral ones being rather indistinct and all of them coarse and broadly rounded. Fine concentric lines mark the surface of the shell together with broader concentric undulations. Interior unknown. Shell symmetrically punctate as in Dielasma.

Dimensions. Length, 15.5 mm; width, 13 mm.

Remarks. This shell possesses the peculiar punctate character of Dielasma, but in form it is similar to Hemiptychina or some specimens of Notothyris described by Waagen. The punctations are evidently coarser and more symmetrically arranged than in Waagen's specimens of Hemiptychina, but the great disparity of the horizons may account for this, especially if the genus sprang from Dielasma or from the same radicle. The globular form of Dielasmina is not suggested by our specimen. In this respect our specimen resembles more closely Hemiptychina, especially H. sparsiplicata Waagen. So long as its internal characters are unknown it may as well rest in this genus as in any. I know of no American Mississippian or Pennsylvanian species resembling it.

Martinia glabra Martin

Spirifera glabra Davidson. Quart. Journ. Geol. Soc. Lond., XIX, p. 170, pl. 9, fig. 9, 10; 1863.

Spirifera glabra Dawson. Quoted by Dawson. Acadian Geology, p. 291, fig. 89; 1868.

Martinia glabra? Girty. U. S. G. S. Bull. 439; p. 70, pl. 9, fig. 9–11.

Specimens of this species are common in the gray shales of Coffin island, at Oyster basin.

It is interesting to note that Girty finds this species, or one practically inseparable from it, in the Moorefield shales of Arkansas.

Composita dawsoni (Hall & Clarke)

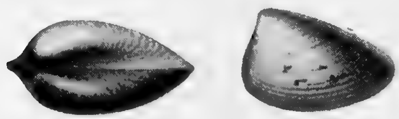
Athyris subtilita Davidson. Quart. Journ. Geol. Soc. Lond. 19, p. 170, pl. 9, fig. 4, 5, (not A. subtilita Hall) 1863. Quoted by Dawson, Acad. Geol., p. 290, fig, 88a-c, 1868.

Seminula dawsoni Hall. 13th Ann. Rept. N. Y. State Geol., p. 652, pl. 47, fig. 32–34, 1894; 14th Rept., p. 359, pl. 9, fig. 14-16, 1897.

The specimens referred to this species are not very abundant, are distorted and poorly preserved. It can not be stated that they certainly belong to the species to which they are here referred, though there appears to be little doubt of it.

Nucula iowensis White & Whitfield var. **magdalenensis** nov.

Shell minute, triangular in outline, very ventricose. Beaks nearly terminal posteriorly, little elevated; dorsal border slightly arcuate, sloping forward to the pointed anterior end which rounds abruptly into the nearly straight but gently convex ventral margin making an abrupt turn upwards at the posterior extremity. Posterior margin truncated from beaks to ventral extremity. Surface marked by regular concentric crenulated striae separated by depressions of about equal width.



Nucula iowensis var. magdalenensis nov. Cardinal view x 5. Surface of left valve x 4

Dimensions. Length, about 4 mm; height, 2.2 mm; convexity, 2 mm.

Remarks. Winchell's description of N. iowensis is followed by these remarks:

" The shell appears to be subject to considerable variation at different stages of growth; young specimens often being distinctly triangular, with the posterior end very short, and the basal margin but little arched, while the old specimens are subovate and the posterior end more prolonged. This description of young individuals tallies very closely with the species in hand which may be a variety of Winchell's species. All our specimens are minute.

While resembling the description of the young of Winchell's species, our specimens are very different from the adult forms. His specimens are larger than the largest of ours. The dimensions above given are for the largest specimen.

Our specimens differ from N. houghtoni Stevens in being more elongate with straighter ventral margin, as they do from N. parva McChesney. It is related to N. rectangula

McChesney, but has its beaks less elevated and is relatively longer. It is very closely allied to N. tumida, but is more pointed anteriorly. In form it resembles N. illinoisensis Worthen, but has strong crenulated surface marks instead of being nearly glabrous. It differs from all of these in its minute size and probably in its surface markings.

Nucula sp.

Shell of moderate size for Nucula, beaks scarcely passing above the hinge. Shell inflated below the hinge, mostly broken away. The surface marks consist of very fine, even, closely spaced filiform striae as shown on cast. Specimen originally about 10 mm long, 5–6 mm high and 5.5 mm thick.

Parallelidon? sp.

A shell apparently belonging to this genus, with long straight hinge, elongate posterior border and nearly straight ventral margin so far as can be told from the compressed specimen. The anterior margin appears to pass obliquely forward and then downward, sharply curved from the end of the hinge. Surface marked with fine, regular growth lines and a few very indistinct concentric undulations.

Dimensions. Length, 21.5 mm; height, 7 mm; length of hinge, about 12 mm.

Remarks. This specimen is hardly well enough preserved to identify or describe specifically in this genus where slight variations of form are so vital.

Schizodus cuneus Hall?

Cytherodon (Schizodus) cuneus Hall. Palaeontology N. Y. v. 5, pt 1, Plates and Explanations, pl. 75, fig. 29, 30. 1883.

Schizodus cuneus Hall. Idem. p. 458, pl. 75, fig. 29, 30, 1885; Herrick, Bull. Denison Univ., Ill., p. 65, pl. 5, fig. 15, 1888; Geol. Surv. Ohio, 7, pl. 21, fig. 15, 1895.

Shell small, ovate-cuneate; length about one-fourth greater than the height; basal margin broadly curved. Post-inferior extremity angular. Posterior margin very obliquely truncate. Cardinal line equal to about half the length of the shell. Anterior end short, contracted just below the beak and regularly rounded below.

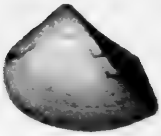
Valves gently convex below, becoming gibbous in the middle.

Beaks at about the anterior fourth, moderately prominent. Umbonal slope angular, defined, extending to the post-inferior extremity.

Surface marked by fine fasciculated striae, the remains of which are still preserved in the cast.

The anterior muscular impression is comparatively large and strongly limited on the posterior side. The impression of the strong cardinal tooth is preserved beneath the beak.

Two specimens measure respectively 20 and 22 mm in length, and 15 mm in height.



Schizodus cuneus Hall? Left valve. Oyster basin, Coffin I.

Remarks. In our specimen it will be noted that the hinge is relatively longer than in the above original description, and, if the specimen represented by figure 30 is excluded, the posterior truncated margin is proportionately shorter. Including this figure, our specimen is intermediate between the two. The beak appears to be quite as prominent in the Coffin island specimen and the shell somewhat smaller.

Schizodus denysi nov.

Shell small, subrhomboidal, rather compressed. Beaks elevated, pointed. Posterior margin very obliquely truncated; postventral extremity angular; ventral border convex throughout, curving more rapidly toward the front; front border convex except for constriction just in front of beak; umbonal ridge angular. The valves are thickest below the beaks which are well anterior. Surface with lines of increment indistinctly preserved on the cast.

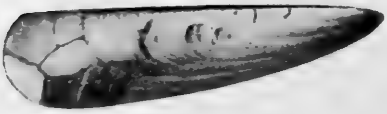
Schizodus denysi nov. Oyster basin, Coffin I.

Dimensions. Length, 12.5 mm; height, 9 mm; length of hinge, 12.5 mm.

Remarks. This shell is related to several Mississippic forms. It is relatively longer than S. trigonalis, while the posterior margin is more oblique than in shells of the S. wheeleri type. Both the shell and the hinge are longer than those features in S. curtiformis.

Aviculopinna egena nov.

Shell small, broad for its length. The hinge appears to be somewhat arcuate. Shell widening rather unevenly along the ventral margin, rather rapidly at first, then more slowly in some specimens. Posterior margin truncato-convex, possibly slightly sinuate in some specimens. Surface marked by wrinkles of growth which are at right angles to the hinge passing directly downward or a very little



Aviculopinna egena nov. Oyster basin, Coffin I.

backward as they fall to the central part of the valve when they turn gradually forward becoming more and more nearly parallel with the hinge.

Remarks. This species lacks the sharply raised, evenly spaced, threadlike lines characteristic of the Mississippi valley species. In this respect it resembles the British species, but the posterior margin is truncated at about right angles to the hinge, instead of being very oblique.

One specimen, the largest, appears to have a radiating ridge nearly parallel to the hinge and just below it, but it is probably the hinge of the slightly displaced opposite valve showing on account of the compression of the specimen.

Aviculopecten debertianus Dawson

Aviculopecten debertianus Dawson. Acadian Geology, p. 307, fig. 116, 1878.

One specimen, hardly half a valve, reproduces almost perfectly the characters of this species.

Pleurophorus? sp.

A single poorly preserved specimen, rather short and stout for shells of this genus, seems to possess the characteristic ridge of shell which produced the usual depression in the cast in front of the beak.

Cast short, convex, elongate-subquadrate; hinge nearly as long as the shell, straight; posterior end truncated almost at right angles to the hinge and extending to the ventral margin, which is straight, rounding rather gradually into the sharply curved anterior margin. Umbonal region quite convex, beaks incurved, and placed well forward. Umbonal ridge prominent and subangular.

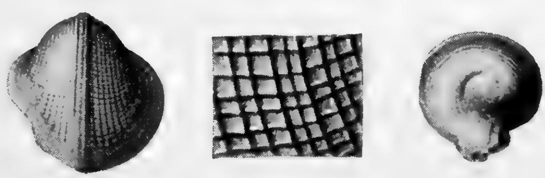
Dimensions. Length, 10 mm; height, 6 mm.

Pelecypoda sp.

Three or four species of minute, poorly preserved pelecypods.

Bucanopsis perelegans White & Whitfield var. **minima** nov.

Shells minute, strongly reticulated. Band with a narrow line on either side, and a thin elevated line along the middle. Surface covered with fine, filiform revolving striae, evenly spaced, 16 or 17 to a millimeter and transverse lines of similar character about 10 to a millimeter, showing a tendency to develop nodes at the intersections with the



Bucanopsis perelegans White & Whitfield var. minima nov. Shells x 5; surface x 10. Oyster basin, Coffin I.

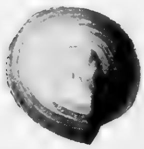
revolving striae. These striae turn backward somewhat on approaching the band. The largest transverse diameter of the shell is 3 mm. Other dimensions unknown.

Remarks. This shell is very closely related to B. perelegans from the Kinderhook but differs in its minute size, crowded and evenly spaced revolving and transverse lines. Three specimens observed are all about the same size; some however show the lines somewhat more distant than the specimen described.

Euphemus? sp. Weller

Euphemus? sp. Weller. Trans. St Louis Acad. Sci., 9, 2, p. 40, pl. 5, fig. 10, 11, 1899.

Specimen minute, umbilicated. Dorsal part of the shell compressed, but it appears to have been semiglobular in form. Region of the band is obscured. Six widely separated revolving lines shown on half the shell. No growth lines perceptible. Shell 3.75 mm across, with a thickness of 2.5 mm.



Euphemus ? sp. Weller. Oyster basin, Coffin I.

Remarks. The outer portion of the last volution is missing but it appears to be the same shell described and figured by Weller from the Vermicular sandstone.

Sphaerodoma? sp.

A poor mold of a large specimen of about four whorls that may belong to the genus. It has a height of about 20 mm, and a diameter of the body whorl of about 15 mm.

Conularia sorrocula nov.

Conularia sorrocula nov. Oyster basin, Coffin I.

Shell of small size, pyramidal, enlarging at an angle of 20°. Edges of shell round inward, producing an impressed angle; surfaces nearly flat; mesial furrow scarcely impressed; anterior ends of sides arched forward in the center, leaving rather deep angles at their union. Transverse striae arched forward on sides, frequently meeting, sometimes interrupted at the mesial furrow; ten in 5 mm, on the upper part of the shell, more than twice as many near the base, strongly crenulated by the crossing of longitudinal wrinkles which appear coarser and farther apart near the angles; crenulations keel-like, 10 to 13 in 2 mm.

Dimensions. Length, 28 mm; width of valve at aperture 10 mm, incomplete at base.

Remarks. Differs from C. newberryi in having its striae and crenulations more closely spaced and an angle of divergence of 20° instead of 10°.

Orthoceras sp.

Shell small, regularly tapering at an angle of 9+° in the uncompressed part. Septa about a millimeter apart near the middle, which is about a fifth the diameter at that place.

Dimensions. Length, 43 mm; width, 8 mm (flattened considerably).

Orthoceras sp.

Fragment of large shell with edge of living chamber. Different species from preceding. Septa about 4 mm apart, somewhat more crowded near living chamber. Length of fragment, 43 mm; width, 15 mm; not showing width of shell.

Ostracoda sp.

One or more species of small ostracods occur in the gray shale of Oyster basin, Coffin island.

TABULAR LIST OF MAGDALEN ISLAND FAUNAS

	Oyster basin, Coffin I.	Cape le Trou, Grindstone I.	Nova Scotia limestones
Nodosinella clarkei	x	......	......
Cornulites? annulatus	x	......	x
Serpula? infinitesima	x	......	......
Spirorbis sp.	......	x	?
Rhombopora exilis?	......	?	x
Stenopora? sp.	x	......	......
Beecheria davidsoni	?	?	x
Composita dawsoni	x	......	x
Dielasma sacculus	......	x	x
Hemiptychina? waageni	x	......	......
Lingula eboria	x	......	......
Martinia glabra	x	......	x
Orbiculoidea limata	x	?	......
Productus auriculispinus	......	x	......
Productus prouti	......	x	......
Productus dawsoni	x	x	?
Productus dawsoni acadicus	x	x	?
Productus arseneaui	......	x	......
Productus laevicostus?	......	x	......
Productus doubleti	......	x	......
Productus tenuicostiformis	?	x	?
Productus sp. A	......	x	......
Pugnax magdalena	......	x	?

	Oyster basin, Coffin I.	Cape le Trou, Grindstone I.	Nova Scotia limestones
Strophalosia nebraskensiformis....	x	......	......
Aviculopecten acadicus	......	x	x
Aviculopecten debertianus	x	......	x
Aviculopecten lyelli	......	x	x
Aviculopinna egena	x	......	......
Cardinia subquadrata?	......	?	x
Edmondia magdalena	......	x	......
Edmondia intermedia	......	x	......
Edmondia sp. A	x	......	......
Liopteria acadica	......	x	......
Liopteria dawsoni	......	x	x
Liopteria sp.	......	x	......
Leptodesma borealis	......	x	......
Modiola pooli	......	x	x
Nucula iowensis magdalenensis...	x	......	......
Nucula sp.......................	x	......	......
Parallelidon dawsoni	......	x	x
Parallelidon hardingi?...........	......	x	x
Parallelidon? sp.................	x	......	......
Pelecypoda, several small species..	x	......	......
Pleurophorus? sp.	x	......	......
Pteronites cf. latus	......	x	......
Sanguinolites insectus?	......	x	x
Schizodus richardsoni............	......	x	......
Schizodus cuneus?	x	......	......
Schizodus denysi	x	......	......
Bucanopsis perelegans minima....	x	......	......
Euomphalus exortivus?	......	?	x
Euomphalus? sp. (Cephalopod?)..	......	x	......
Euphemus? sp.	x	......	......
Gastropods, three species	......	x	......
Gastropod sp.....................	......	x	......
Sphaerodoma? sp.	x	......	......
Conularia planicostata	......	x	x
Conularia sorrocula	x	......	......
Conularia sp.	......	x	?
Endolobus avonensis?	......	x	?
Endolobus? sp.	......	x	......
Gastrioceras? sp.	......	x	......
Orthoceras sp. A	?	x	......
Orthoceras sp. B	x	......	......
Ostracoda, one or more species....	x	......	......
Total	28	37	......

EXFOLIATION DOMES IN WARREN COUNTY, NEW YORK

BY W. J. MILLER

INTRODUCTION

While engaged in geological work in Warren county during the past summer the writer was impressed by the fact that the most striking feature of the landscape, especially on the North Creek sheet and certain portions of the Luzerne sheet, is the prevalence of distinct, isolated, domelike, topographic forms which rise hundreds of feet above the comparatively low land of the region. A comparison of the North Creek sheet with all other published Adirondack maps shows that, from the physiographic standpoint, this region is noticeably different from the Adirondacks in general. One would scarcely think of such a very ancient region of comparatively low altitudes as being favorable to a widespread development of exfoliation[1] domes and it is the purpose of this brief paper to call attention to these forms and to show how several factors have conspired to favor their formation. The paper is concerned more especially with the North Creek and Luzerne topographic sheets which the reader is expected to consult.

GENERAL GEOLOGIC FEATURES

The region lies wholly within the Precambric rock area of the Adirondacks. The oldest rocks are the highly metamorphosed sediments of the Grenville formation. Detailed mapping, now in progress by the writer, shows that the Grenville is very extensively present and that crystalline limestone is unusually prominent in the formation. Next in age come plutonic igneous rocks such as syenite, granitic syenite, and granite porphyry which are clearly intrusive into the Grenville, and all of which are differentiation products from the same cooling magma.

Of the igneous rocks, the syenite is, perhaps, the most abundant and is generally quartzose and hornblendic with a more basic variety carrying a green pyroxene. The rock is medium to coarse grained, greenish gray when fresh and weathers brown. The granitic syenite is highly quartzose and generally carries horn-

[1] The term exfoliation is here employed in the usual sense and means the splitting off of the surface portions of rock masses in large sheets as a result of temperature changes.

blende or biotite or both. It is gray to pink when fresh and weathers light brown. The granite porphyry is biotitic to sometimes hornblendic with large feldspar crystals embedded in a fine to medium-grained matrix. It is gray to pinkish gray when fresh and weathers brown. These igneous rocks are important because they almost invariably constitute the mountain masses of the region. All of these rocks show a distinct gneissoid structure, but are usually very homogeneous in large masses.

Minor intrusions, cutting all of the above masses, occur as dikes of gabbro, pegmatite, and diabase but these have no bearing upon the present discussion.

An important structural feature is the presence of numerous normal faults which have greatly dissected the region.

Finally it should be stated that this portion of the Adirondacks has been vigorously glaciated.

LOCATION AND DESCRIPTION OF TYPICAL DOMES

Since these domelike, topographic forms are so numerous and characteristic of the region, a few only of the more pronounced and easily accessible ones will be mentioned, as follows: Potash mountain, 4 miles north of Luzerne; the Three Sisters, including Pine and Bald mountains on the Luzerne sheet and 3½ miles southwest of Warrensburg; Hackensack mountain at Warrensburg; Kelm, Moon, and Potter mountains respectively 3½ miles north, 3 miles northwest, and 4 miles west-northwest of Warrensburg; Prospect mountain at Chestertown; Mill and Stockton mountains (not named on map) respectively 1½ and 2 miles east of Johnsburg; and Huckleberry and Crane mountains, respectively 3½ and 5 miles south of Johnsburg.

Potash mountain is a remarkable topographic form which is known for miles around as the " Potash Kettle " and it is doubtful if there is a finer example of an exfoliation dome in New York State. The accompanying photograph gives but a poor idea of this steep, domelike mass because it fails to show it in its landscape setting. From base to summit, on the west side, the mountain rises 1100 feet very abruptly and it attains an elevation of nearly 1800 feet above sea level. It presents a striking view toward the east from the train window, between Luzerne and Stony Creek.

The Three Sisters form an interesting group of sharp pointed domes which reach altitudes of 2000 to 2100 feet above the sea or

Plate 1

W. J. Miller, photo.

Potash mountain, four miles north of Luzerne, as viewed from a point on Gailey hill one mile to the west-southwest. The height of the dome is 1100 feet.

Plate 2

W. J. Miller, photo.

Potter mountain, four miles west-northwest of Warrensburg, as viewed from a point one mile south-southwest. The height of the dome is 700 feet.

1400 to 1500 feet above the Hudson river, which flows at their base. The domes proper, however, range in height from 400 to 600 feet.

Mill and Stockton mountains deserve special mention because they rise as two great isolated masses above the comparatively low and featureless country in the vicinity of Johnsburg and Wevertown. Each rises abruptly some 600 or 700 feet above the surrounding country and they attain altitudes of 1949 and 1837 feet, respectively, above the sea.

Huckleberry and Crane mountains are completely separated by a narrow rift from 500 to 800 feet deep. The summit of Crane mountain (3254 feet) rises 2000 feet above the immediately surrounding lowlands and it is the highest point in Warren county. The upper 1000 to 1500 feet of this mountain is very steep to almost precipitous on all sides except the north and this great rock dome is a grand sight as viewed from Thurman.

The domes may be classified under three headings according to shape: (1) those with nearly circular bases and which are very symmetrical and almost uniformly steep on all sides as, for example, Potash, Mill, and Stockton mountains and the top of Kelm mountain; (2) those with elliptical bases and represented by nearly concentric elliptical contours to the summit, such as Moon, Birch, No. 9, and Huckleberry mountains: Moon mountain is a good illustration of the broad elliptical type, while Huckleberry mountain is a fine example of the long, narrow, elliptical type; these elliptical forms are the most common and usually have one side very steep due to faulting; (3) those of irregular shape as shown on a large scale by Crane mountain and by many smaller masses.

After climbing many of the domes the writer had been impressed by the almost universal occurrence of exfoliation on a large scale over their surfaces. These mountains are literally peeling or shelling off by the removal of exfoliation sheets of great size, some having been noted as much as 50 to 75 feet across and from 1 to 3 feet thick. Among many other good places to observe this phenomenon are on the west or south sides of Moon, Huckleberry, or Crane mountains. Not infrequently, especially during the fall and spring months, slabs loosen up and go thundering down the mountain sides. Though the igneous rocks are all clearly gneissoid, the exfoliation appears to entirely disregard the direction of the gneissic structure and often great sheets come off at right angles to the foliation.

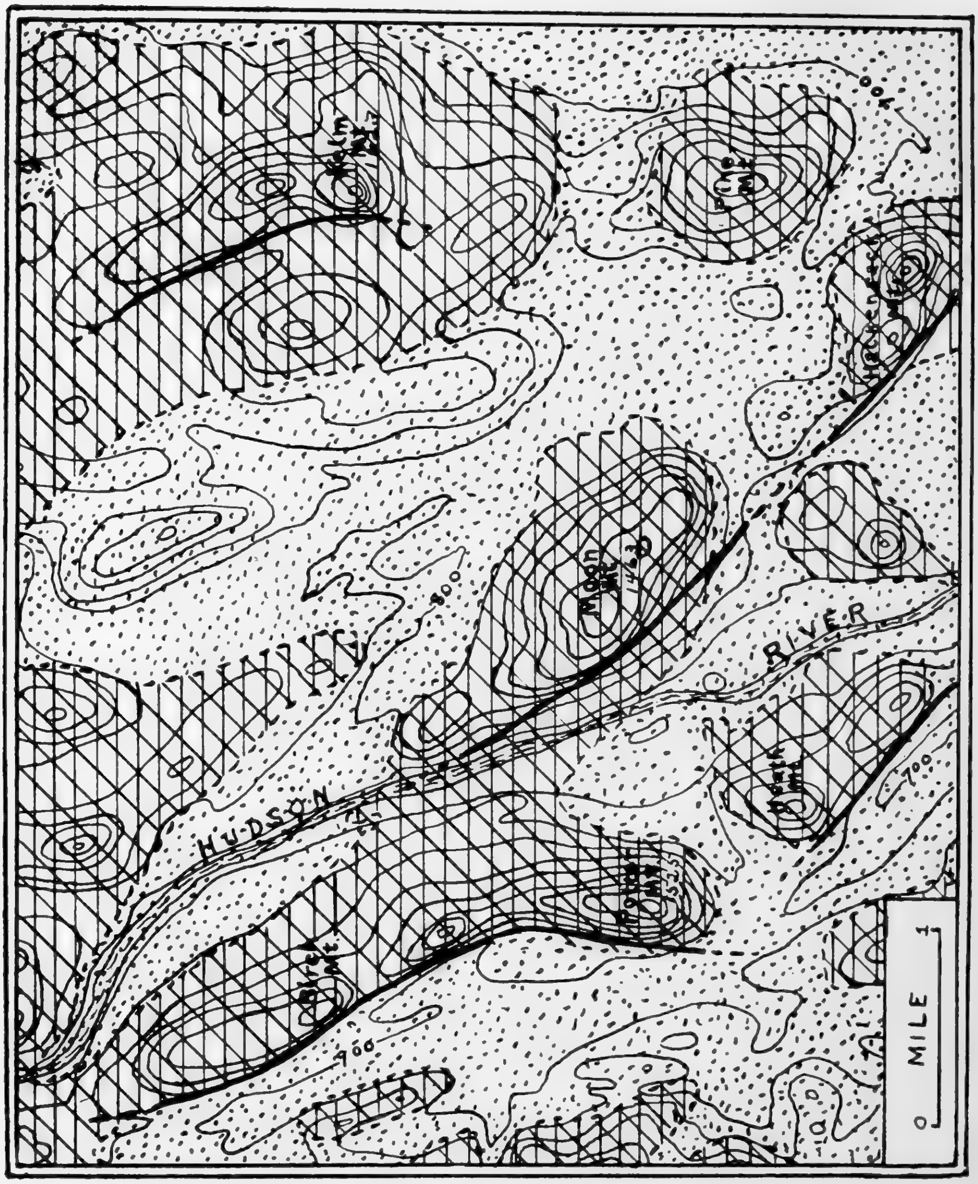


FIG. 1 Geologic and topographic sketch map of the southeastern corner of the North Creek (U. S. G. S.) sheet. Contour interval 100 feet. Dotted areas are Grenville; cross-lined areas are syenite or granite; heavy lines are faults.

FACTORS FAVORING THE FORMATION OF THE DOMES

The very common occurrence of exfoliation domes, in the region under discussion, requires explanation and the writer believes they are due to a combination of factors peculiar to this portion of the southeastern Adirondacks. These factors may be discussed as follows:

1 **Character and distribution of the rocks.** The kind of rock, syenite or granitic syenite, forming most of the typical domes is

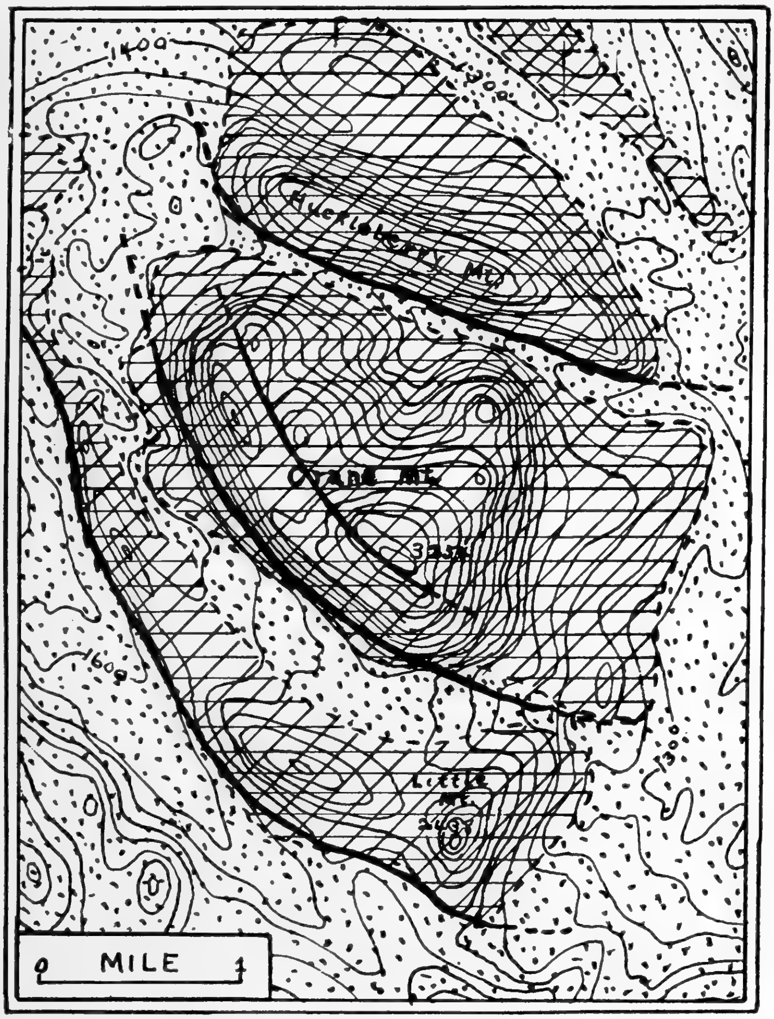


Fig. 2 Geologic and topographic sketch map of the southwestern corner of the North Creek (U. S. G. S.) sheet. Contour interval 100 feet. Conventions same as in figure 1

very favorable because of its medium-grained texture and homogeneity in large masses. The closely associated Grenville rocks, on the other hand, are very variable in composition, generally distinctly banded, and especially rich in limestone, this last feature rendering the Grenville unusually weak and liable to erosion. So far as the mapping has progressed the syenite-granite series and the Grenville series are about equally extensive. An important feature is the relation of the igneous and sedimentary masses because the igneous rocks, though intrusive as usual, here break through the sediments in numerous small to large separated masses which gives rise to a distinct patchwork effect much more perfectly shown on the geologic map here than on any other Adirondack map so far published. A good idea of this patchwork effect is given by the accompanying detailed geologic maps on which it will be seen that the igneous masses are often nearly or completely surrounded by the Grenville. The protrusion of these very resistant igneous rocks through the weak Grenville is a primary consideration because, as a result of long erosion, the hard igneous masses have stood out as mountains above the worn down Grenville, and thus the way has been prepared for the development of exfoliation domes. The North Creek quadrangle shows an almost perfect adjustment of topography to rock character.

2 **Faulting.** That the eastern Adirondacks are considerably faulted has been recognized for some years, but, thus far, little attention has been paid to the detailed study and mapping of these faults well within the Precambric area. As a rule the faults are difficult to locate with any great degree of accuracy and certainty, but in Warren county there is a good opportunity for their study. Frequently the line of contact between the syenite or granite and the Grenville is very regular and sharp, the Grenville seeming to dip under the igneous rock with the latter rising very abruptly and to a great height above the Grenville. Among the best examples of this phenomenon are the southern sides of Huckleberry, Crane, and Little mountains and the western sides of Birch and Potter mountains. There are only two possible explanations of this phenomenon, namely, either that the igneous rocks were intruded in the position which they now occupy or that faulting has occurred. If this is to be explained simply on the basis of intrusion then we are forced to assume a remarkably irregular surface of the newly cooled magma and also that the molten masses, in all of these cases, broke through the Grenville along very straight or regular lines often for miles. Both of these assumptions are entirely out of harmony with well-known observations in other regions. Among the positive evidences for faulting are the frequent presence of sheared or brecciated zones along the lines; the fact that these blocks always show a distinct tilting away from the crests of the scarps; and the well-known faults along Lake Champlain and in the

Mohawk valley, some of which have been definitely traced into the Precambric area which lies between these regions. As shown on the accompanying maps, this faulting is important for our present consideration because the patchwork effect of the igneous and Grenville rocks has often been either produced or sharply accentuated by this means and many of the finest exhibitions of exfoliation are on the fault-scarp sides of the domes. Huckleberry, Crane, and Little mountains would doubtless not be separated by the narrow Grenville belts except for this faulting. Also it should be stated that a fault almost certainly extends along the western base of Potash mountain with the Grenville sharply faulted against the base of the great dome.

3 **Glaciation.** It has already been shown by the writer[1] that this region has been subjected to vigorous glaciation, especially the southern portion of the North Creek sheet. Before the Ice Age the lowlands must have been covered with much residual soil while the mountains bore great accumulations of talus material on their sides and especially at their bases. The advancing ice almost completely removed these materials but, more than this, there is strong evidence that, by ice erosion, the Grenville valleys of weak rocks were considerably deepened. If so, the mountains of resistant rock were doubtless bared and rounded off. Except in a few cases of valleys transverse to the direction of ice movement, the outcrops of Grenville and igneous rocks alike are hard and fresh. Most of the loose material now occupying the lowlands is glacial debris of lake or morainic origin. As a result of glaciation the mountains were completely bared of weathered material and vegetation; were often increased in height above the surrounding country; and the fault-scarps were often accentuated in steepness. Thus the preglacial igneous masses were left in a very favorable condition for postglacial exfoliation which is now so prominent. The interesting fact that there is now no great accumulation of talus material around the bases of the mountains is thus readily accounted for.

4 **Temperature changes, humidity etc.** Chamberlin and Salisbury[2] state that " the breaking of rock by changes of temperature should be greatest on the bare slopes of isolated elevations of crystalline rock, where the temperature conditions of temperate latitudes prevail, and where the atmosphere is relatively free from moisture. All of these conditions are not often found in one place, but the

[1] Paper read before the Pittsburg (1910) meeting of the Geological Society of America.

[2] Geology, 1:49.

disrupting effects of changing temperatures are best seen where several of them are associated." High altitude is also favorable because in the dry, thin atmosphere the accumulated heat of the day radiates rapidly at night. Of these features favorable to temperature changes and exfoliation the ones notably deficient in Warren county are high altitude and aridity.

Although Warren county is by no means in an arid climate, it is nevertheless interesting to note that its location is in the dryest part of New York State except the St Lawrence valley.[1] The average precipitation for the year is only 25 or 30 inches, and hence the comparatively dry atmosphere of this region is important so far as New York State is concerned, because under a dry atmosphere a rock mass heats up more during the day and cools off more during the night, thus favoring exfoliation.

The isolation of the masses of igneous rocks should be mentioned because their better exposure favors greater daily temperature changes.

It should also be stated that changes of 30 to 50 degrees between day and night temperatures in this county are not at all uncommon.

Finally what has been termed the "wedge-work of ice" should be considered. So far as can be learned the greatest movement of exfoliation slabs down the mountain sides is during the fall and spring months and this is probably due to the fact that the cracks in the rock are then pretty well filled with water which expands on freezing and thus wedges off the already loosened slabs.

5 **Scanty soil and vegetation.** As above stated, the passage of the ice sheet across the region removed all soil, talus, and vegetation from the igneous rock elevations leaving the bare rock surfaces favorable for exfoliation. Though none of the domes are at present entirely free from vegetation there are, nevertheless, many large barren surfaces, and what vegetation does occur is generally scant like small scrub pine, growing out of the cracks in the rocks. The surfaces of the domes are thus at present essentially barren and in this regard favorable for exfoliation.

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[1] Tarr's Physical Geography of New York State, p. 354.

STUDIES OF SOME EARLY SILURIC PELMATOZOA

BY GEORGE H. HUDSON

In a somewhat caustic criticism of two papers by G. Hambach,[1] the late Dr P. Herbert Carpenter[2] laid such emphasis on the exhaustive study of the morphology of the nearest living representatives of any fossil form, for one who wishes to understand the latter, as to convey the impression that such study is the only legitimate means to the required end and that "certain American paleontologists and more especially Mr G. Hambach" (loc. cit. p. 277) are innocent of eating of the fruit of this tree of knowledge. No student of the present day is likely to deny the value of exhaustive study in the direction indicated, but in work of this kind it must never be maintained that any one avenue of approach is the only one that is proper or valuable. When Doctor Carpenter says "In order to understand, even with an approximate degree of correctness, extinct groups, such as the Blastids, Merostomata, Dinosauria, and others, a far more extensive acquaintance with the recent members of the same subkingdom is necessary, than for the interpretation of fossil Brachiopoda, sponges, corals, Mollusca and fishes" (loc. cit. p. 277-78), he only emphasizes the fact that the fields in which he insists that a still greater amount of study is needed are just those fields where divergent development and remoteness of relationship have most effectually masked the information sought. The relationship between phyla of the animal kingdom is but one degree more remote than that between such distinct classes as Blastoidea and Holothuroidea and the advice to make "a far more extensive acquaintance" with the morphology of the living dibranchiate Cephalopoda before attempting the restoration of a Brontosaurus would seem highly absurd.

The study of the morphology of living forms is a very essential factor in the establishment of true phylogenies. Even here, however, living forms must receive study from broader and

[1] Contribution to the Anatomy of the Genus Pentremites, with Descriptions of New Species. Trans. St Louis Acad. Sci. v. 4, no. 1, 1881, p. 145-60, pl. A and B.

Notes about the Structure and Classification of the Pentremites. Trans. St Louis Acad. Sci. v. 4, no. 3, 1884, p. 537-47.

[2] Further Remarks upon the Morphology of the Blastoidea. Ann. Mag. Nat. Hist. April 1885, p. 277-300.

more varied points of view and the remains of forms that perished ages ago must, in an exceedingly large measure, be included in the reckoning. With such a phylogeny established, the study of ancestral types having living descendants is not a very difficult matter. If, however, the fossil forms are not ancestral but are highly specialized types that left no descendants it is *the morphology of the nearest related ancestral types* that must receive more extensive and intensive study, if we are to understand the modification of such structures as are now presented. There is no short road from any living echinoderm across to the Blastids of the Carbonic era, but the true roads run from the Echinoderm of the present to Cambric or Precambric times and from that remote station, by a branch line, to our desired destination.

So much by the way of preface has seemed necessary to give the author's point of view in the present paper. He is at present quite content to reach a Precambric station in Echinoderm territory by any modern line and hypothetically accept a hypothetical primitive Echinoderm as our best modern students have seen him. From this Precambric station, guided by well-established physical principles, he will reach out into the region of the little known and try to discuss helpfully some curious and interesting structures presented by the relics of a few ancient beings who lost consciousness in Chazy time. The author reserves the right to use any evidence which the morphology of living things may present; he feels that in this remote field the best of present guides may lead him to draw erroneous conclusions, but he sincerely hopes that after the paper has passed the fire of contemporary criticism there will still be left some small measure of fact that may help toward a better understanding of the obscure forms in question.

Echinoderm respiration. Anything tending to interfere with the function of respiration would inevitably lead to greater respiratory effort. If more than one organ or structure shared in the respiratory process, as they do in all Echinoderms, interference with one structure or set of structures would mean increased effort for others, that the physiological balance might be maintained. Prolonged effort would mean abnormal development. The earlier this interference appeared in the life of the individual the more profound would be the modification produced. The ability to modify structure varies with the individual. Variation in direction and degree of such variability may be said to be congenital and so, without dispute, capable of inheritance. A period of stress during group development not only makes the factor of natural selection more effective but it also adds to the number of avenues of escape tried by the group, or in other words to more active variation and mutation. Without stopping to quarrel over any Lamarckian factor let us state this proposition in different terms. Evolutionary activity in a group of organisms is always greatest during those long periods of time when some particular antagonistic force or forces bear more heavily on the group in question. Cambric or Precambric Pelmatozoa were under just such an increased environmental hostility and their response was the massing and fusion of mineral spicules into strong thecal plates. This very plate formation, however, introduced new factors inimical to respiration and led to exceedingly diversified and specialized types of respiratory structures as early as the age of the Chazy beds or in Ordovicic time. It is one purpose of this paper to point out the mechanical effects of increasing mineralization and increasing thecal regularity and show how these factors led to diversity of structure. The subject will be approached largely from the synthetic or deductive side.

Primitive Pelmatozoa were creatures of the sea and respiration could only be accomplished by appropriating oxygen which the sea water had previously taken into solution. This oxygen was largely passed through the epidermis (dermic epithelium) and underlying membranes by osmosis, dissolved by the fluids of various underlying cavities and so circulated through the body. We may designate this as the epidermal supply and the epidermis itself as the principal organ of primitive respiration.

The entire supply could not have been epidermal for these primitive forms swept water into their alimentary canals together with their food, and the amount of water used with the food stream contributed to the oxygen supply. The endoderm was thus made to assume a respiratory function. In later forms water in still larger measure was admitted to a portion of the enteric cavity, or at least to the proctodaeum through the anus. Water entering any portion of the alimentary canal would have its oxygen removed and would receive the products of combustion in return. These alimentary tissues would then come to function in a greater or less degree as respiratory tissues. Such a system might well be distinguished as the alimentary or enteric respiratory system.

A means was also early found whereby water was admitted to the right and left anterior portions of the coelom and from the left anterior coelom was developed the present water vascular system. The amount of water passing in and out of the stone canal was not at first so great as that passing through the enteric cavity and it is doubtful if it ever became so. A still smaller amount might have been drawn into the body through the genital pore or pores. The systems which allow of admission and exit of sea water to any portion of the coelomic cavity may be classed as coelomic respiratory systems.

It has already been stated that the fluid contents of the coelomic cavities, in very primitive forms, received their oxygen supply through the ectoderm and during the development of a thecal armor they maintained such direct osmotic interchange either by means of invaginations of ectoderm or of evaginations of mesoderm. The latter form is abundantly shown in the papulae and podia of living Echinoderms. The respiratory process in such cases depends almost wholly on osmotic interchange through specialized portions of the ectoderm and in a wholly negligible quantity to direct exchange of sea water through the madreporite. Strictly speaking, the respiratory process, whereby the coelomic fluids are given their oxygen and relieved of their wastes, is epidermal and it will here be treated as such. The following tabular form will show these synthetically determined classes and also some probable modifications of them:

TABLE I

MODES OF ECHINODERM RESPIRATION

Epidermal	Specialization of plate stereom		
	Specialization at plate angles and along sutures	Invagination	between regular thecal plates
			between thecal plates associated with food grooves
		Evagination	Papulae
			Podia
Alimentary or enteric	Unspecialized		
	Specialized. Respiratory trees		
Coelomic	Water-vascular system in part		
	Gonadial		

Of the two fundamental lines of specialization under epidermal respiration outlined above, it is very clear that the second, that of specialization at plate angles or along sutures, would be vastly the more important. Centers of stereom formation, no matter how open the texture, would offer more resistance to the respiratory process than would their edges or those subtriangular spaces not as yet closed in by the developing plates. The latter would be the line of least resistance and while the less active respiration, which would still take place through the plates themselves, might lead to interesting specializations of plate structure, the more promising field of specialization at plate angles is the only epidermal form which will be considered in this paper.

Synthetically again or by deduction we may postulate two avenues of escape from the inimical influence of plate extension. Either by invagination or evagination of ectodermal tissues, involving in either case some portions of the mesoderm, an increase of respiratory area could be secured and so specialized as to easily maintain the physiological balance. Plate extension would protect and modify invaginated respiratory sacs and soon leave them communicating with the exterior only through small pores or narrow slitlike openings. Either form of external orifice might maintain a position on the suture and, repeating the process as the suture lengthened, give rise to a linear series of such openings, the number being dependent in part on the amount of plate extension. If the external orifice of either form should become surrounded by the stereom of a single plate, the opening would thereafter maintain a fixed distance from the early center of the plate and a repetition of the process would soon more or less fill the plate with such pores or slits and make it appear at first sight as if we were dealing with a case of direct specialization of the plate stereom.

It should also be borne in mind that the extension of plate stereom might divide the external opening and would undoubtedly often do so. If the water exchange was maintained in any degree through ciliary action, any such variation would very materially heighten the value of the sac for respiratory purposes. If both openings should become inclosed by the extending border of one plate we should have a structure very similar to a diplopore. If on the other hand one of the openings should become inclosed by the stereom of one plate and the other opening similarly inclosed by the plate across the suture, the sac would become elongated with the growth of the plates and a structure apparently similar to that presented by some pectinirhombs would be the result. There is still another type that might arise. If the sac pore was divided by the growing corner of the plate, one of the openings might remain on one suture and the other opening on the neighboring suture. Subsequent plate extension might easily convert them into hydrospires and particularly so if one of the openings should be so situated as to receive its water supply by being associated with a covered food groove. The study of cystidean plates will furnish the investigator with an almost endless variety of plate structure and ornamentation, a very large part of which is the outward expression of respiratory structures such as have here been designated.

In those forms which developed recumbent food grooves which in turn were protected by closely fitting covering plates, there would be a mechanical factor tending to promote invagination between certain members of the flooring plates of such a groove. This mechanical factor would be pressure. The water accompanying the minute organisms swept down each brachiole must exert some pressure in the larger food-bearing streams of the food grooves. Invaginations that maintained exits outside of the pseudambulacral area, of the type last outlined, examples of which may be seen in plate 3, figures 1 and 2, would serve a double purpose. The water so drained away would reduce the amount passing through the alimentary canal and give more time for the digestion and absorption of the food content. It would also allow an increase in number of brachioles or an increase in activity and so secure a more abundant food supply. On the other hand all water so drawn through the pseudambulacral invaginations would be used for respiratory purposes and the invaginated sheets would become extended into structures like the hydrospires of Blastoidocrinus or perhaps open into each other and form structures like the more specialized hydrospires of the Blastoidea.

The respiration of Blastoidocrinus is more particularly treated later in this paper and is adequately illustrated. An examination of the matter there presented will serve to make this unique form of respiration more clearly understood. Both forms of ectodermal invagination here outlined serve to admit sea water beneath the test and these forms of respiration may well be spoken of as endothecal.

Evagination of the ectoderm and parietal layer of coelomic epithelium or other membranes at the plate corners would give us structures like those we are familiar with in podia and papulae. Branchial vesicles so formed might come to lie along the sutures or become surrounded by the stereom of plate extension. In such a system the coelomic or other fluids of the body would be carried outside of the theca and effect osmotic interchange with the sea water in that position. This form of respiration might well be designated as exothecal. It would seem that the demands of the environment for a more solid thecal wall should make this latter path the more certain of adoption, for the endothecal system must of necessity mean a larger and, other things equal, a weaker test.

While assuming the attached condition and developing a thecal armor the Pelmatozoa no doubt depended largely on ciliary action for food supply and perhaps in part for respiratory circulation. The manifest advantage of muscular contraction in bringing about such a circulation and the presence of a well-developed muscular system should, however, lead us to expect that a muscular respiratory system would be developed. A more or less rigid thecal wall would offer some very serious obstacles for such a system to overcome and the conditions surrounding such an attempt should be briefly examined.

Take first the simplest possible type of muscular endothecal respiration. We will suppose a single endothecal sac to exist, that this is filled with sea water and that osmotic exchange has reached equilibrium. To continue the respiratory process it becomes necessary to expel this water. With a flexible theca, closed at all other points, this could be accomplished by contracting the whole or any part of the body wall and so reducing its volume by an amount exactly equal to the volume of water to be expelled. With a rigid theca, under similar conditions, the expulsion of this water would be beyond the power of any conceivable muscular organization and this from purely physical and well-understood reasons. With a second opening to the body cavity, be it mouth, anus, genital pore or madreporite, the ejection of the water contained by the sac would be an easy matter if only an exactly equal volume of water were allowed to enter the body by one of the other openings. That the respiration of Echinoderms involves more than one set of organs is well known. What we should note here is that we have a mechanical cause acting in past time that is in itself competent to bring about this very condition.

To insure a better understanding of the problem and to see more clearly some of the relations involved, let us put the matter in a slightly different form. When thecal walls have become solid it is no longer possible to contract any organ save under one of the following conditions. Contraction of one organ is possible if its incompressible contents can be made to pass more or less completely to another organ or body cavity. If the contents of an organ are to be passed outside of the theca it can only be accomplished by admitting an equal volume of sea water to some other organ. To illustrate this reciprocal action, let us suppose that it is desired to draw water through the madreporite. This may be accomplished by reducing the amount in the alimentary canal. If on the other hand it is desired to reduce rapidly the amount of water in the hydro-vascular system, this may be accomplished by its contraction and the passive admission of water to the alimentary canal. The largest external opening possessed by Pelmatozoa is the anus, and this, if not closed, would become a compensating tide-way allowing contraction of any other body cavity. Such a function at once makes the anus more or less of a respiratory center and in some Echinoderms it has become highly specialized as such.

Passing from the case of one special subtegmental respiratory sac to one of two or more we will readily see that the ejection of the contents of one would mean simply the filling of another if only it were passive at the time, and that a long series of such structures could be emptied and filled by a rhythmical and progressive or peristaltic contraction. It must be borne in mind, however, that no matter how complex such a system may become the contraction of any portion of it will be felt immediately by all other organs and the tendency to make these others auxiliary organs of respiration will be always present. This tendency is of course controlled by natural selection and the adaptations secured are varied and often present a very high degree of specialization.

The other path, or that of exothecal respiration, presents no exception to the principles already stated. The contraction of any one of these exothecal sacs would be impossible unless its contained coelomic or other fluid was allowed to flow back under the theca and such a flow would be impossible unless fluids already in that position were allowed to distend other exothecal sacs or were discharged directly into the sea and thus lost to the organism.

Specialization of exothecal respiratory processes. Such exothecal sacs as we have just discussed, whether papullae or podia. involve a new series of adjustments to environment, for their position renders them liable to attack from other creatures. Protection may be secured in three directions. First, by the power of rapid withdrawal into or under the plate, as in Cleiocrinus [see fig. 2

p. 213], or into tubelike extensions of stereom similar to those presented by Caryocrinus ornatus. This power of rapid withdrawal requires a higher muscular and nervous development. If the sac is not attached to the stereom surrounding the pores it may be withdrawn as a whole but if so attached it must possess internal muscles reaching to its distal end and be withdrawn by invagination. Here we have opened still other lines of specialization in which we shall find these processes functioning as sense organs, as organs for food capture, and as organs for locomotion. Second, while retaining their high nervous and muscular development, these structures might be protected by clusters or fringes of immovable or movable spines such as we see so highly specialized in Asteroids and Echinoids. Third, these structures might early seek protection by means of porous coverings of epistereom. Under this condition the external sacs or tubes would of necessity come to lie close to the thecal surface or in special depressions on the latter. Such respiratory processes should be distinguished by the term epithecal. Development in this direction led to considerable complexity of structure but it never favored complexity or specialization of function. This third direction was chosen by many cystids and crinoids and we shall find interesting examples in Palaeocrinus and Palaeocystites. The tendency toward the development of a solid thecal wall by a creature living in an incompressible medium has thus led to the concomitant development of a system or systems of hydraulic structures whose evolution may profitably be studied from a purely mechanical point of view.

Respiration in Blastoidocrinus. At the time of publication of my description of Blastoidocrinus, in Bulletin 107 of the New York State Museum (1907), I had not seen Billings's type. Through the kindness of the late Dr J. F. Whiteaves I have since been enabled to give it long and careful study and it has yielded evidence of very great interest concerning this question of respiration. From numerous photomicrographs made of features presented by this type, nine have been chosen to illustrate the present article and will be found reproduced in plates 1 to 4 inclusive. It will be seen that we are dealing with the second form of endothecal respiration which we have tabulated and already briefly discussed.

In figure 2 of plate 1 of this paper we have a side view, x 10, of a pseudambulacrum from which the wing plates and nearly all traces of the brachioles have been removed by natural processes.

The orad end is toward the left and it will be seen that the covering pieces *a* increase rapidly in height with age while at the same time they increase very little in thickness. The row back of these is seen in part, though much out of focus. The upper surface of the two rows presented a shallow channel into which the long and solid wing plate, whose under surface is shown in figure 1 of the same plate, fitted tightly, as is shown by the impressions made by these covering pieces on the under side of this wing plate. Thin sections of the wing plates show them to be homogeneous in their nature and not formed by the fusion of smaller pieces. These plates serve to lock the covering pieces and with them make a very high and solid covering over the food groove.

Directly under the covering pieces are seen the outer edges of part of a row of adambulacrals, one member of which has been marked *b*. The sutures between the covering pieces and the adambulacrals can not be clearly seen on account of a thin veil-like band of calcite which seems to indicate that the brachioles were attached to the side of these plates, helping also to make a solid structure of a pseudambulacrum. The veillike band but slightly obscures the openings into the food groove. The remnants of brachioles which still adhere to the specimen at the left show that the food and water channels crossed the outer faces of the wing plate and covering pieces at an angle of about 25 degrees with the edge of the deltoid and on arriving at the openings into the food grooves turned abruptly and ran down to the edge of the deltoid (pl. 1, fig. 2, *d*) at an angle of 90 degrees or parallel with the deep vertical channels which run down between the adambulacrals. These channels lead to the openings into the hydrospires. The lower portion of the outer edge of an adambulacrum presents a flat face against which rested one or more of the basal plates of a brachiole. Above this the outer face of an adambulacral becomes narrower and more rounded. This is the region where so much light was admitted through the rather thick section drawn for figure 2 of Bulletin 107, page 105, and which suggested "brood chambers." Taking the evidence of the cross section and that now before us we may safely conclude that water passing down the brachioles could enter any one of a series of openings into the food groove and that surplus water, or water deprived of its food content, could pass down any one or more of the vertical side channels and find an entrance into the hydrospires. On page 114 of Bulletin 107 reasons were given for supposing that the flow of water through the central and older hydrospires was much more copious than the flow through the more lateral and younger hydrospires. That they could so function is now very manifest for there were undoubtedly two water streams, one along each side of the heavier pseudambulacral plates (ten such streams in all) which would serve to augment the flow through the larger hydrospires. Two of these streams near their meeting point received the ejecta of the completely covered anus and swept it through the largest hydrospires of a single deltoid. Even here the volume of oxygen-bearing water must have been in excess of the deoxygenated stream from the alimentary canal and the hydrospires involved would still in a measure carry on their primitive function of respiration.

Figure 3 of plate 1 shows the upper surface of an arm of the type x10. All the covering plates, save six near the end of the arm, have weathered away. Five of these are over the upper (in the figure) row of adambulacrals and the smallest end one over an adambulacral of the lower row. These plates have lost somewhat through weathering but as end and newly-formed plates we should expect them to be small. A portion of one row of adambulacrals is also lost but the outer edges of the remaining plates show clearly the openings through which the surplus water drained into the hydrospires. These openings are between the plates but perhaps a little nearer their outer ends than such pores appear to be in the Blastoidea. In fact it seems that in Blastoidocrinus the outer edges of the adambulacra did not meet beyond the opening. The vertical channels with their lateral connections shown in figure 2 were probably covered by a membrane possessing ciliary processes, and these accomplished the separation of the food particles and directed them to the food groove. Hambach's beautiful drawing of a portion of the pseudambulacrum of a specimen of Pentremites sulcatus, [see fig. 5, plate 2 of his "Revision"[1]] shows what was very probably a similar arrangement with the marked difference that the collecting floor is at right angles to the direction of flow through the pores in Pentremites and parallel with it in Blastoidocrinus. Each pore in Pentremites is figured as passing into

[1] A Revision of the Blastoidea with a Proposed New Classification and Description of New Species, by G. Hambach, St Louis, Mo. 1903. Nixon-Jones Printing Co.

a common hydrospire and therefore no necessity exists for communication of water channels before discharging into the hydrospires as in Blastoidocrinus. Hambach's drawing seems to show that the water flow from each brachiole was kept distinct until it entered the hydrospire. Figures 4 and 5 of our plate 1 show portions of the other two arms possessed by the type. The remaining two arms had evidently been weathered away before the specimen was found. They show similar characters to those found in figure 3 but figure 5 is of additional interest, as it seems to show a tendency to pass from an alternate arrangement of ambulacra to an opposite arrangement. The point of the adambulacral marked *e* is very close to the middle of the end of the plate. As we pass to the left the plates become very markedly more opposite in their arrangement. The orad end of figures 3 and 5 is at the right.

Figure 1 of plate 2 presents a side view of the terminal area of the pseudambulacrum already represented in plate 1, figure 3, and with the same amplification. The food groove is clearly seen at *a*, partly roofed over by the covering plates already noted. At *c, d* and *e* the inner, vertical, closed edges of three hydrospires belonging to the rear row of adambulacra, may be readily recognized. The two hydrospires to the right of *e* have had their inner edges weathered away and show the beginning of the sheetlike cavity down and through which passed the surplus water of the brachiolar streams. At *f* the surface of the deltoid has been carried away and the character of the understructure of mineralized sheets brought to view. A portion of the undersurface of a deltoid x 10 is shown in figure 2 of this plate. At the left of the center of this figure is an area that shows better the nature of the respiratory sheets, for their thin edges may be clearly seen. The line marked *b* in figure 1 separates the deltoid from a bibrachial. Near the right end of this line are several openings along the base of the deltoid. These are the exits of the hydrospires. They become larger passing in toward the older, longer and deeper hydrospires. This is another indication of that greatly increased outflow caused by the lateral water streams already postulated. In some of the adambulacra shown in plate 1, figure 2 and in plate 2, figure 1, the lower outer edges are not in contact with the deltoid. This is probably due to the fact that the organic membrane which occupied this position and was subsequently mineralized, has now been partly removed through differential solution.

The two figures of plate 3 present views of different portions of the area partly shown in plate 2, figure 1. The broken inner edges of the two rear hydrospires to the right of *e* are better shown, and next to these is a hydrospire that still retains a portion of its inner rounded edge. The suture between deltoid and bibrachial is reproduced without retouching and the hydrospire exits show their beautifully arched upper surfaces. The lower figure presents a region farther to the right, shows several interbrachials with the still higher and larger hydrospire exit above them and at *f* shows a single hydrospire sheet that was washed with water on its left face and bathed with coelomic fluid on its right. The right side of this wall presents fine vertical lines which are easily seen in the photograph and which it is hoped will be still present in the reproduction. This appearance of corrugation in the walls of the hydrospires was first noticed in a fragment now in my possession and was mentioned in Bulletin 107, page 107. This corrugation securing strength with extreme thinness (the sheets in the figures of this plate represent secondary thickening that took place long after death) is also strongly indicative of the function of respiration.

If to the evidence here given we add that presented by the cross section of a deltoid and two pseudambulacra, figured in Bulletin 107, page 105, we must agree that we have as complete a case as can be desired. In that section we found limonite-colored muds in each and every one of the cavities through which we maintained that there was a flow of water and these muds were not detected in any other position save that of the intestine.

These observations may serve to throw some light on the Hambach-Carpenter controversy which I had not seen at the time of making my first description of Blastoidocrinus (Bulletin 107, 1907). I am greatly indebted to Mr Edwin Kirk for recently loaning me these papers. There seems to be no doubt but that we may accept the essential correctness of Hambach's cross section of a Blastoid pseudambulacrum as shown in plate 2, figure 8 of his " Revision," with the exception that the pores communicating with the hydrospires should open through the membrane covering the floor of the extended food groove area. Doctor Carpenter has stated that Mr Hambach " must have a wonderful power of imagination; for he actually believes that 'soft and membranaceous organs, such as occupy the pores of the ambulacral field in Echinoderms' can have been preserved (in a collapsed state, it is true) through all the ages of the Carbonic period and the present time." [1] We must regard criticism of this character as at least unfortunate. In New York State Museum Bulletin 107, page 106, I have given reasons for believing that the inner edges of the hydrospires were membranous at death, yet their carbonized outlines have remained, and for the greater part in their original position, from Chazy time to the present. Traces of just such membranes will be noted in the description of Palaeocrinus striatus Bill. on p. 218 of the present paper. The more difficult the field in which one is working, the greater is his liability to error. If one is made to feel that it is a disgrace to err at all in such a field and that any admittedly speculative matter will receive censure, it can only follow as a consequence that very much valuable observation and suggestion will die with the mind of the worker and perhaps not appear again for centuries. Encouragement to work in such difficult fields is what is needed. Cross-fertilization of mind followed by just and searching criticism will bear only good fruit. Hambach is very probably correct in attributing the structures represented in plate 2, figure 1 of his "Revision" to collapsed membranes in the poral openings. That they were "tentacles," however, is exceedingly doubtful. We may, I believe, accept Doctor Carpenter's contention that the mouth, food grooves and pores were covered with small but well fitting plates. With this covering we have all the essentials of a food-capturing and respiratory system very similar in nature to that here presented for Blastoidocrinus.

ADDITIONAL REMARKS ON BLASTOIDOCRINUS

From various other points of interest connected with this Canadian type we may select that concerning the penetration of the stem so far into the interior of the theca. Billings believed [2] that the position shown in our plate 4, figure 1, was a natural one. A careful examination of the type convinced me that an additional portion of the stem was still to be found below

[1] Ann. and Mag. Nat. Hist. ser. 5, 8:423.

[2] In Canadian Org. Rem. Dec. IV, p. 21, Billings says "the column actually penetrates into the interior, nearly if not quite to the top of the visceral cavity. This is so extraordinary a structure that scarcely any paleontologist at all well acquainted with the organization of the Crinoideae could be brought to believe it without personal inspection of the proofs."

and at the right of the main portion preserved. On receiving permission from Doctor Whiteaves to uncover a portion of the specimen in this region three additional rings were found within the cup formed by the strongly bent-in edges of the radials. It will be seen from the figure that these occupy the right-hand side of the cavity and that the end of the longer portion of the stem was thrust to the left-hand side. Figure 2 of this plate shows the upper portion of the stem photographed through a gum dammar mounting with a 3-inch objective and given an amplification of 10. The outlines of the basal and of the stem lumen are clearly seen in the upper part of the figure. It will also be noticed that the plates of the stem have been displaced, those just above the center of the figure having been shifted to the left. There are no plate edges connecting these basals with the radials. It seems evident that the stem was thrust up into the body cavity and that the basals parted from the radials. When the cap of basals met the inner edges of the hydrospires, the advance of the stem was stopped. Continued pressure bent it into something of a letter S form (a portion of which lies in the vertical plane passing from front to rear), displaced its joints above, severed the stem about the middle of the basal invagination of the theca or just where the lack of lateral support might cause the break, and pressed the broken end of the balance of the stem as far into the same cavity as its walls would allow. The original depth of this basal invagination was about half that assigned to it by Billings. The radials themselves show evidence of crushing and the type has suffered some distortion. Some of the details noted would seem to indicate that the form was monocyclic.

Plate 4, figure 3, presents a small area of the right-hand side of figure 1, x10. We may here again see the closed inner edges of the hydrospires which have so weathered above as to reveal their two-walled character. It is to be regretted that the type shows none of the plates of the peristome. The question as to whether the deltoids are true orals or not must for the present be left open. The visible apexes of the deltoids of the Valcour island specimen are arranged in a circle having a diameter of about 10 mm. The fringe of brachioles and the apical piece completely cover this area, yet within this circle a number of plates might be concealed and here also is the mouth, the anus, and the genital pore or pores.

One interambulacral area seems to have been freed from the matrix by the use of a knife or file. In the process a portion of the interbrachials was lost but structures below were revealed. There is evidence here that the hydrospires descended internally to a position below the base of the deltoid, thus further increasing the respiratory area.

In figure 1 of the text we have presented a part of the lower edge of a deltoid x10. The inner surface is shown and from its

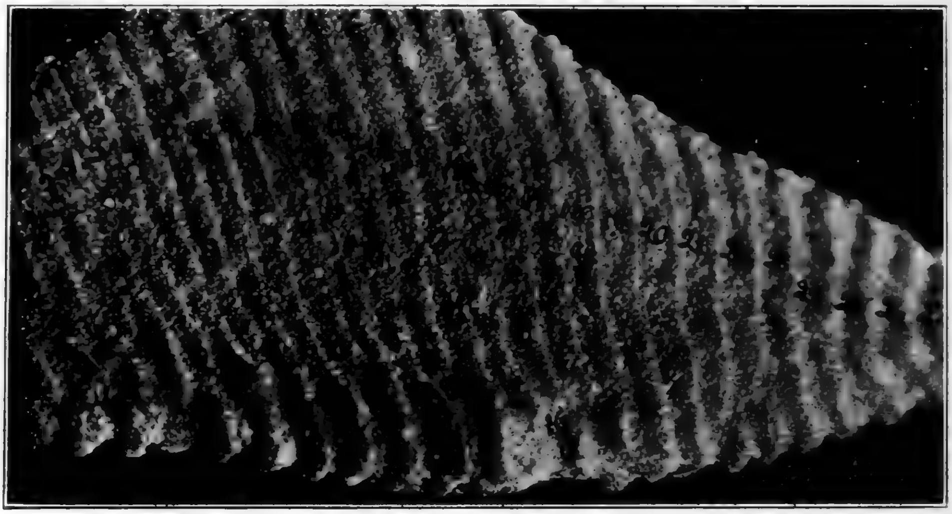


FIG. 1 From a photomicrograph of the under surface of the deltoid figured in Museum Bulletin 107, plate 5 at o. x10. Add ten each to the number here used and they will correspond with those used in the former reproduction.

study we may conclude that with the downward extension of the plate it often happened that two hydrospire exits were merged into one. The grooves here marked 7 and 8 find only one exit. The same is also true of pairs 10 and 11, 13 and 14, 16 and 17. Hydrospires numbered 21 and 22 appear to have had the choice of either their own opening or that of their neighbor. Anastomosis of these sheets would hardly be of enough advantage to become the subject of natural selection as the stoppage of any one exit would not interfere either with the food-getting capacity or with the waterflow down its own brachiole. Such stoppage would only mean a slightly faster flow through the numerous other hydrospires, attached to the under surface of half a deltoid. With a more primitive form in which there was no anastomosis of streams above the hydrospire pores such anastomoses below them might prove of great value and ultimately lead to structures like the hydrospires of the Blastoidea.

In Canadian Organic Remains, Dec. IV, p. 21, Billings said of the stem that it was " round, with an alimentary canal so small that often detached joints seem to have no central perforation . . . the flat faces of the separate joints exhibit strong radiating striae." On plate 7 of Bulletin 107 I figured some stem joints and roots, answering this description, which were associated with Blastoidocrinus remains. I there said that these "may belong to this species." A careful examination of the type shows that the joints of its column are not like those figures. The stem joints of the type have convex rather than cylindrical edges and I do not find any evidence for the possession of "strong radiating striae" on their flat faces.

No sutures could be seen on the stem joints even when examined under water in sunlight with a compound microscope. The lumen seems to be very small but may weather out to leave "rings" like those which are also abundantly associated with the remains of Blastoidocrinus on Valcour island and elsewhere.

Genus **CLIOCRINUS** E. Billings. 1856

Among the crinoid remains of the middle Chazy of Valcour island are some well-preserved plates of Cliocrinus clearly showing, along the lines of suture, a series of cylindrical perforations which are perpendicular to the surface of the plates. The largest fragment found contains but little more than thirty plates, yet these present characters which (aside from the horizon from which the specimen was taken) indicate that the form is specifically distinct from the described Trenton species. As I wish to make several references to this Chazy form and as I believe its plates show characters which may be recognized in more complete specimens, I have made it the type of a new species.

Cliocrinus perforatus nov.

Description of the type. Brachials differing from those of C. magnificus Bill. in the possession of a low median vertical fold about 0.2 mm wide. The fold shows more clearly at the middle of the plate where there is a shallow depression on each side of it. Both above and below these depressions well-marked plates, like *a* and *f*, figure 2, have a transverse thickening which raises the plate surface nearly to the level of the median fold and gives the latter two widened moundlike areas on each plate. The species differs from C. regius Bill. in the absence of the much narrower, higher and sharply defined median folds of that species. The larger cylindrical pores, 0.15 mm in diameter, are situated one on each side of a median fold where the latter crosses a suture. These pores are 0.4 mm from center to center. On either side of these are one or more smaller pores with their centers about 0.2 mm apart.

There is usually a pore exactly at the corner of a plate with three or four plates uniting to form its walls. The vertical sutures also possess one or more pores besides those common to both vertical and horizontal sutures. The corner pore and the three which immediately surround it together occupy a shallow basin formed by the thinner and depressed corners of the joining plates. Such a basin is well shown at the left end of the suture between plates *a* and *b*, figure 2.

Nature of the pores in C. perforatus. In an aquarium specimen of Asterias forbesii under my observation, the papulae average about 0.2 mm in diameter and, while the pores of C. perforatus are slightly smaller, they strongly suggest canals for the extrusion of similar respiratory processes. These pores, and others of like nature, will be hereafter called *sutural canals.* The position of the larger and first formed sutural canals of C. perforatus, between brachia and on either side of the axial fold, is very suggestive of connection with the water vascular system. If such was the case the protruding respiratory processes might be considered as homologous with podia though not functioning as organs of locomotion. How many of the arm plates lie below the horizon of the tegmen in this genus is not known, but the permanently closed condition of the arm bases must have tended to make functionless (in a respiratory sense) the podia perhaps formerly possessed by this region. This would rather strengthen the idea that these external processes were developed to compensate for the loss of the others. Very similar structures in Palaeocystites, to be discussed farther on, are more suggestive of papulae or external extensions of the coelomic cavity, and as the arms of crinoids carry extensions of this cavity one could with equal propriety maintain that the structures in question were simply papulae such as we find on the aboral surface of asteroids. It becomes desirable then to have a term which we may use to designate all forms of exothecal or epithecal respiratory processes regardless of the character of the subthecal cavities into which they may open and though the term branchial vesicles has been used as synonomous with papulae, we shall take the liberty of using it here in the broader sense given above. As the use of the term will be frequent we shall abbreviate it to b.v. or b.vs. It seems fairly reasonable to hold, at least temporarily, that the sutural canals of C. perforatus were occupied by b.vs. and that these were sensitive and protected by possessing the power of rapid withdrawal. Cliocrinus would thus become an example of the first direction of b.v. protection outlined on page 202.

Development of brachials and sutural canals. The plates of C. perforatus have something to tell of their own growth and development. The greatest width of plate *a*, text figure 2, is 1.9

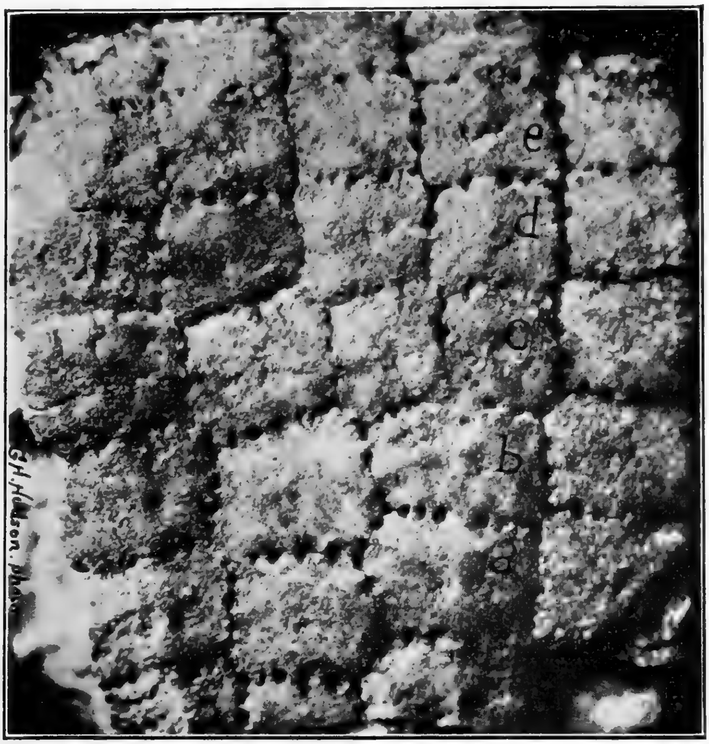


FIG. 2 From a photomicrograph of a fragment of Cliocrinus perforatus x10. This fragment is designated as the holotype of the species and is in the State Museum collection.

mm and its primitive pair of b.vs., both above and below, measured 0.43 mm from center to center at death. Plate *e* has a width of but 1.4 mm, yet its primitive pair of b.vs. have the same 0.43 mm between their centers. In the earlier stages of plate *a* the distance between its primitive pairs of b.vs. was no doubt but little if any less than at death. If we should outline the plate when it was about one fourth the diameter attained at death we should find it possessed a median fold nearly as wide as the plate itself and with but two b.vs. on each horizontal suture. The addition of stereom to these sutures has carried the two pairs of b.vs. directly away from each other and increased fourfold the vertical distance separating them, yet one member of a pair has not perceptibly increased its horizontal distance from its neighbor.

If any horizontal suture should happen to lie in line or nearly in line with another at the right or left, one primitive b.v. of a pair would find itself in close proximity to one of the members of a neighboring pair. These two unfortunately situated b.vs. would naturally bend away from each other in performing their function and the widening of the plates would soon not only separate them, but would place each in a position on the suture instead of at the corner. The corner would thus soon offer a free position for the protrusion of a branch b.v. which would increase the respiratory area. Should any b.v. thus protruded remain at the corner it would tend to stop the development of any new branches. It is very likely, however, that more than one would seek the same corner and their development would again insure their bending away from each other. In this case greater freedom for function would be found on a vertical suture and the growing corners of the plates would soon push by the b.vs. and leave them in a fixed position on the vertical sutures. Still newer b.vs. would be led to take positions giving most room, which this time would probably be again on the horizontal sutures. If the plates produced more stereom on the vertical than on the horizontal sutural faces, the horizontal sutures would become the longer, offer the most freedom for function, and come to contain the greatest number of b.vs. A b.v. next to a member of a first pair would keep it from increasing its distance from its neighbor and a new b.v. at the corner would have the same effect on the last previously formed. It would thus happen that the distance apart of these structures would become fixed and not increase with growth though the number would increase. The distance apart of the primitive pairs of b.vs. might easily become a specific character.

The newer b.vs. in our species are all smaller than the members of the primitive pairs and they are set nearer each other. The average distance of the three around the corner b.v. at the left end of the suture between *a* and *b*, figure 2, is 0.19 mm. The size and distance between the newer b.vs. are also likely to be specific characters.

A closer examination of the group of b.vs. just mentioned will reveal several additional points of interest. The central one evidently emerged before the others had become completely inclosed by the growing plate corners (see text figure 3, which presents a still greater enlargement of this area). These all seem to be branches of the left-hand member of the pair between *a* and *b*. It sent off five branches. The widening of the plate allowed two branches to remain on the same suture, two on the vertical and one at the corner with no newcomer to dispute for its territory. The b.vs. have been numbered in the order of their distance from the angle of the plate.

This would probably also indicate the order of their appearance *if plate increase was equal on all sutures.* Plate *a* seems to have

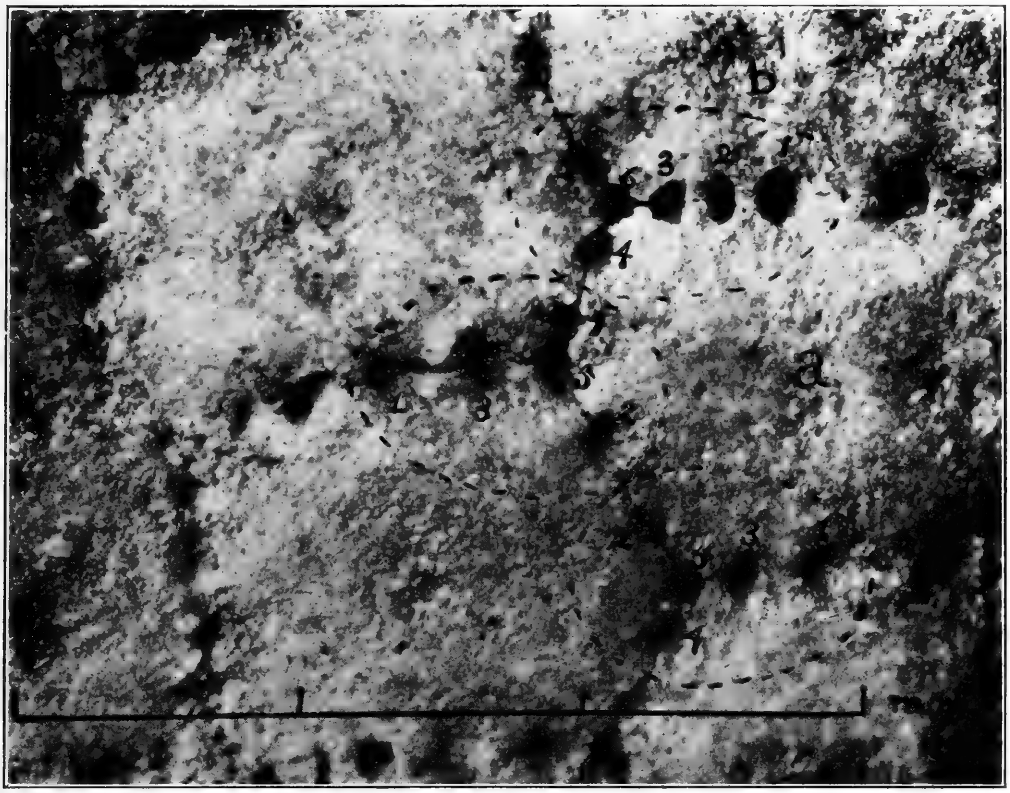


FIG. 3 Represents a small area of figure 2 still further enlarged. The dotted lines are used to separate related groups of branchial vesicles.

added more to its lateral than to its horizontal sutures and the numbers used may thus fail to designate age. B.v. 6 was the last formed and nos. 4 and 5 of the same group are so near to it that they have hardly yet been separated from it. Continued addition to the plate edges of this region would more and more separate 4 and 5 from 6, providing that the latter remained at the corner. The distance between 3 and 6 being the greater, it is likely that an additional 7th b.v. might make its exit on this side of 6 or that 6 itself would become forced to take up a position on the suture next to 3. The b.v. at the extreme left angle of *a,* with the three nearest to it form a group belonging to the right-hand member of the primitive pair occupying the horizontal suture to the left of this point. Conclusive evidence of such branching, forming groups, is not presented by this specimen, but it will be seen in Palaeocrinus and in Palaeocystites. The dotted lines of figure 3 surround groups of b.vs. which are supposed to be related as suggested above.

A tendency of these sutural canals to become oval in cross section and with the major axis at right angles to the sutures is clearly seen at several places in figure 3. It probably represents the effects of the bending of the free ends of the b.v. to assume the most favorable positions for the performance of their function, which would be toward the freer area of the enlarging plate surface. It will be seen that this influence has led not only to just such widening of the sutural canals in Palaeocrinus and Palaeocystites, but it has been followed by an actual bifurcation of the b.vs. themselves.

Plate *a,* text figure 3, also shows a periodic variation in thickness. It was thin in its nepionic stage and thickened, particularly along its horizontal sutures, during its adolescent stage. There was thus left the two nearly central basins or shallow depressions, one on each side of the axial fold, which represent the early lateral margins of the plate. Either the impetus gained through the development of plate thickness carried the form beyond the requirements of its environment or the later environment became less exacting in this respect, for during the ephebic stage the plate appears to have built its edges with stereom of diminished thickness. To this third plate stage is due the shallow basins at the corners which resemble the nepionic basins nearer the plate centers.

Palaeocrinus striatus Billings

Canadian Org. Rem. Dec. IV, 1859, p. 25, pl. 1, fig. 5a-5b

Cup analysis. Through the courtesy of the late Dr J. F. Whiteaves of the Geological Survey of Canada the writer has been enabled to give long and careful study to Billings's type of this genus and species.

The cup analysis here given, figure 4, differs very materially in the form of its RA and adjacent plates, from the cup analysis given by Bather in " A Treatise on Zoology," part 3, p. 172, and also from the very conventional analysis given by Billings, loc. cit. p. 24. Failures to present a correct cup analysis of the genotype have been due to very great difficulties presented by the specimen itself. It was evidently found lying in the bedding plane with its anterior side uppermost, as this surface is most weathered (fig. 6). Below this is a belt more recently separated from the matrix and presenting some plate details in great perfection (fig. 5). A knife seems to have been used to free the attached posterior area by cutting under the anal plate from the oral end. Portions of x and RA were cut nearly or quite through and the surface lost. On final liberation post. B, l.

post. B, and l. post. IB were badly shattered and the greater portion of the surface of these plates was left on the bed. For an enlarged

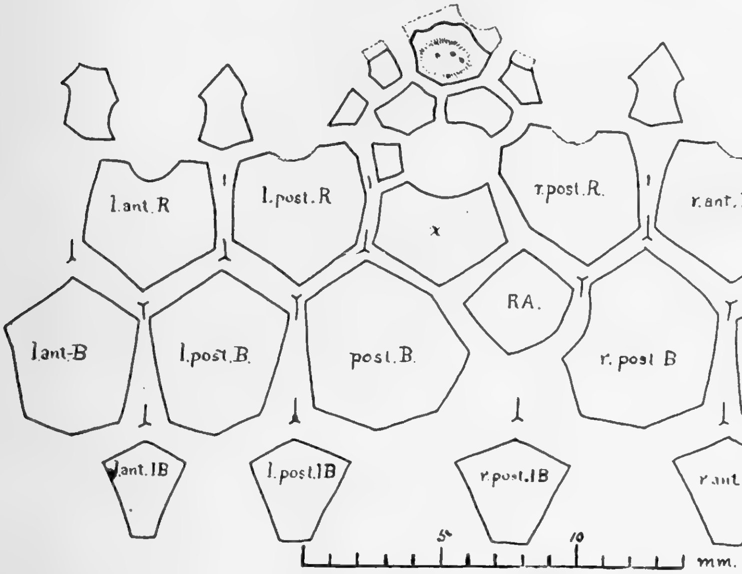


FIG. 4 Analysis of Palaeocrinus striatus Billings. The following abbreviations are used here and in the text: l = left, r = right, ant. = anterior, post. = posterior, IB = infrabasal B = basal, R = radial, RA = radianal and x = anal. The dotted boundaries show probable edges of plates where covered. The marks lying between plate corners are supposed centers of development of branchial vesicles.

view of part of this area see plate 6, figure 1. Mr Billings realized the difficulty of determining the character of the damaged area for under the cut representing his cup analysis, he said " The azygos

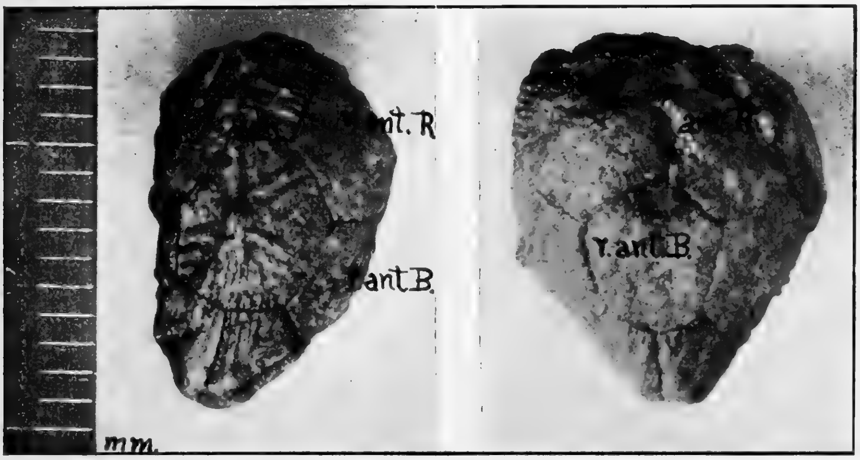


FIG. 5, 6 Different aspects of the holotype of Palaeocrinus striatus Billings, x31

interradial space is left blank in the figure as it is not certain how many plates it contains."

Method used to determine sutures. For a long time the writer tried to see the sutures of the injured area with a three inch objective and draw them with a camera lucida but, while enough could be seen to show that former analyses were certainly in error, yet lines seemed to be absent where sutures were expected and faint or fragmentary lines suggested sutures where they were not expected. Remembering a former successful showing of a vertical section of the basals of Blastoidocrinus by photographing a portion of Billings's type under a mounting of gum dammar (see plate 4, fig. 2) a similar trial was made with the damaged plates of P. s t r i a t u s. A drop of pure benzol was placed on the area in question to exclude air bubbles and a drop of gum dammar, dissolved in benzol, added. A little of the dissolved gum was also placed on an ordinary round cover glass for microscope slides and the cover placed over the area. This was allowed to dry enough to retain its position and more of the mounting fluid then added in order to show as large an area as possible. After a second partial drying the region was photographed with a three inch objective, using a black hood over the lens to avoid reflections and with bellows extended to give an enlargement of ten diameters.

Advantages of the method. The photographs for figures 2 and 4 of plate 5 were made in this manner and a comparison of them with figures 1 and 3 of the same plate (from photographs made without the mounting) will reveal several peculiar advantages of this method. Reflection from the summits of plate granules, tool marks, scratches and small crystalline faces of broken calcite have been reduced to a minimum and much of their distracting influence on the eye removed. Refraction has relieved the surface shadows cast by minor elevations and has also admitted light to the deeper features of plate detail, making structures visible that were heretofore obscured or lost. On the more uniformly lighted surface so produced the difference in the amount of free carbon now held by the calcite is quite clearly revealed and the former presence of organic membranes made manifest. It will be seen that the sutures stand out clearly as black lines of uniform width and all of the sutures of the damaged area were not only thus made clearly visible under the microscope but were secured on negatives. The photographs for other figures were also prepared in this manner and the features so revealed will be described in their proper places.

Nature of the plate ridges. The figures on plate 5 represent two different areas of the specimen and show the ridges as they appear on IBB, BB and RR. They are seen to be arranged in groups the members of which are rather evenly spaced, of regularly varying lengths, parallel to each other, nearly perpendicular to the sutural lines and bisected by the latter.

These ridges are covered cylindrical, epithecal extensions of sutural canals and each was occupied by a bifurcating contractile b.v. whose arms lay parallel to the plate surface and communicated with the interior only through the sutural canal itself.

In support of the above assertion we may first examine figure 1 of plate 5, which presents a detail of the left posterior margin — a portion of the best preserved belt of the specimen. Erosion, though slight, has carried away just enough of the crests of some of the horizontal ridges to reveal in part their hollow nature and at *a* an ascending ridge has been so broken across that a portion of its cavity is clearly brought to view. Text figure 7 represents a portion of the right posterior margin, a detail from the opposite edge of the best preserved belt. The ascending ridges have had their crests removed to a still greater extent and the broken edges at times reach deep enough to reveal nearly the full width of the canal itself.

FIG. 7 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10

That these structures were epithecal, that is laid down over the mesostereom, and that they have no communication with the interior through the plate itself, is shown by text figure 8, which represents that portion of the specimen which we have already considered as lying uppermost in the bedding plane and which was therefore the longest exposed to the effects of weathering. The r.ant.B. has lost nearly all traces of its canals, but the floors of these structures may be seen on the margins of the adjacent plates to the left and we have to pass but little distance over the edge of r.ant.IB to reach the less weathered belt and find at *a* and *b* first the side walls and then the canal coverings.

The value of study under the dammar mounting may now be seen by an examination of plate 5, figures 2 and 4. In the former the area of figure 1 is again presented, but the fragmentary matter covering the epithecal canals has been rendered more transparent by the mounting medium and the band of carbon deposited by the decaying b.vs. brought more clearly to view. The boundary between this darkened belt and the clearer calcite of its side walls is well marked and makes the measurement of the canal diameters an easy matter. Their full width is found here to be from .10 to .12 mm. This agrees closely with that of the ascending ridges of text figure 7 and the uncovered regions on text figure 8.

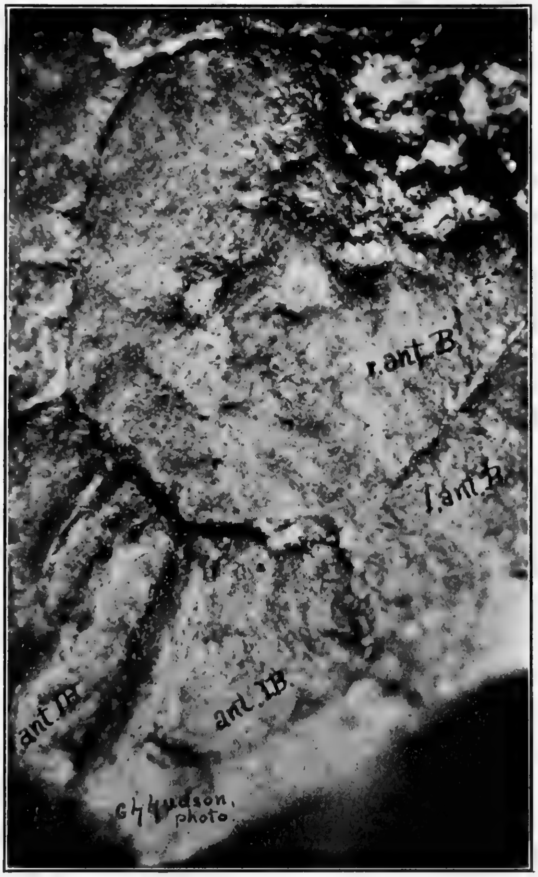


FIG. 8 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10

Plate 5, figure 4, presents portions of the two radials over r.post.B. The longer canal of the horizontal series shows not only its cylindrical character but its floor as well. Near the suture this floor dips into a depression whose deeper portion is filled with limonite-colored mud. This darker area seems also to be wider and to run under the remote edge of the canal where the latter reaches the suture. We have here an oval basin whose major axis crosses the sutures and whose minor axis is nearly twice as wide as the bore of the exothecal canal which enters it on the left.

The basin just described is but the outward expansion of a sutural canal and below it two others as well shown. The sutural canal next above the one with the longest exothecal canal was weathered out more completely and for some time after mounting its communication with the interior was made manifest by the bubbles of air which rose from it and moved away through the thin mounting medium.

While this medium was becoming more viscid, bubbles continued to rise, though at longer intervals. The figure shows a compound bubble and a small new one just next to it, the aggregation not having moved out of the field of view before the exposure was made. Figure 2 of this plate also shows evidence for these canals, particularly at the aborad ends of the two BB.

In plate 6, figure 1, we have evidence of a different character to offer. This figure represents the area cut under to liberate the specimen from its bed and the cutting was in a sense fortunate for, although it removed all surface features and even the epithecal canals themselves, it gave us some cross sections of the sutural canals and to some of these we will give brief attention.

Five millimeters to the left of the orad apex of post.B is a shaded area crossing the suture at right angles. This seems to indicate the former presence of an epithecal canal now cut away. Occupying this shaded area is a circle 2.3 mm in diameter which is clearly outlined by the carbon black remains of its former organic walls. Seven millimeters to the right of the orad angle of this basal is another sutural ring of similar character, measuring 1.7 mm in diameter and 5 mm to the right of this is an oval similarly outlined. This oval has a minor axis which measures 2 mm and a major axis of 3.3 mm, the latter at right angles to the suture. Both the specimen and the negatives show a much smaller ring on this suture at a point 2 mm to the right of the upper angle of the basal, but its position in a shadow effectually prevents its being recognized in the figure.

The carbon blackened rings, their position on the suture, their distance from the apex of the plate, their distance from each other, the position at a transverse shading, their diameters, and the transverse position of the major axis of the oval; all indicate these structures to be cross sections of cylindrical canals. The oval is evidently a cross section made nearer the surface of the plate or where the floor of the two wings of an exothecal canal dipped down to make a junction with the sutural canal. In other words, this is a cross section of a sutural basin like that already noted in plate 5, figure 4. The diameters of the rings last measured (0.23, .17 and .2 mm) give an average a little larger than that obtained from the measurements of the sutural canals of Cliocrinus perforatus, but they are remarkably close to the measurements of the papulae of the aquarium specimen of Asterias forbesi.

Before leaving the discussion of function we must note that it raises a question as to the nature of the canal coverings. With contractile b.vs., such as are here postulated, there must be some provision for filling with fluid the space between the canal wall and the b.v. during the contraction of the latter. With a canal covering formed by an impervious sheet of epistereom, the compensating fluid would have to be drawn from beneath the theca and, as there is no evidence for any pores through the mesostereom itself, such fluid would have to ascend in the vertical canals and outside of the tubular walls of the b.vs. The larger diameter of the sutural canals would allow them to serve such a purpose. We have evidence, however, that the canal coverings were not impervious and that water could enter the canal from the outside on contraction of the b.v. within it. An examination of the ascending canals on the basal represented in plate 5, figures 1 and 2, shows a line of very porous epistereom lying directly over the canal. Where the covering has been broken away, as at *a*, this seam of porous epistereom is seen to penetrate to the canal itself. The thickness of this epistereom, and yet the maintenance of the porous seam, is very decided evidence for the respiratory nature of the structure. Text figures 4 and 5 show this same feature and also suggest that with the external thickening of the ridge the deeper layers of the porous epistereom were absorbed, thus leaving a narrow slitlike cavity over the b.vs. The thickening of the ridges was by growth on the outside and a new sievelike epistereom was formed over the more porous older material. Water evidently filtered through these lines as through a madreporite. The study so far given seems abundantly to justify the conclusion that we are dealing with respiratory processes and this conclusion is but strengthened when we note that they form an elaborate system and cover all the plates of the theca.

Whether or not one accepts the interpretation here given, we may note that the evidence so far presented is very decidedly against certain former interpretations. These ridges are most certainly not " axial folds of the plates " as others have called them. They are not in any way indicative of nerve branching to supply distant organs, nor do they indicate either " incipient hydrospires " or the former possession of such structures. The suggestion that we here have grooves for stroma strands or for muscular processes is negatived by the deepening of the surface canals at the suture to form pelvislike depressions that communicate by a vertical canal with the interior. If Palaeocrinus, with practically only three circlets of plates of five each, needed such an elaborate system of stroma strands or muscular processes to hold its plates together, why do we not find a similar arrangement in Cliocrinus with its hundreds of separate plates? These structures are canals and each was occupied by a branchial vesicle.

Plate development and the serial formation of branchial vesicles. An examination of plate 5 will show that the epithecal extensions of the b.vs. become shorter and less prominent as we pass from the middle of sutures toward their ends and figure 1 of plate 6 will show that the shortening is correlated with a decrease in diameter of the sutural canals. On this evidence we should be warranted in assuming that these structures were serially formed and that those nearest the ends of the sutures were youngest.

As the lateral extension of a plate takes place only by the addition of stereom to its margins we may, without great error, outline a plate as it existed in some earlier stages of its development. This we have essayed to do in text figure 9. It will be at once seen that the smaller the size we make the plate the fewer b.vs. it could have possessed and the inner outline shows a condition where there was but a single b.v. to a suture. These are at the ends of those longest epithecal canals which we have already determined to be the oldest and the shorter ones simply did not exist at this time.

Fig. 9 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10. Outlines show probable forms of the plates at earlier stages in their development.

We may express a law concerning these b.vs. as follows. On any suture the longest b.v. is the oldest and the newer members were added serially on one or both sides of this as the suture was extended. If now these plates have so grown as to give their common sutures equal extensions, it will follow that the distance of any b.v. from the point of meeting of these three sutures is proportional to its age, provided we do not pass the middle of the suture or the longest exothecal canal which crosses it. Let us apply this rule to the region around the orad angle of r.post.B.

The primary interradial groups of branchial vesicles. On the photographs used for figures 3 and 4 of plate 5 was measured the distance of the middle of each sutural canal from the apex of the orad angle of r.post.B. The average of each pair of measurements was taken as the distance of the b.v. in question. These positions are now indicated by dots on text figure 10 and the distances there recorded. The b.v. 21.5 mm out is by our rule made the oldest and is marked no. 1. The next smaller distance is 19.1 mm and this b.v. has been marked no. 2. These larger numbers thus indicate the order of succession and it turns out to be a regular spiral with a counter-clockwise rotation. The very regular sequence and rotation of the twelve b.vs. constituting this triangular area (but ten have been numbered in the figure) is remarkable enough to merit further consideration.

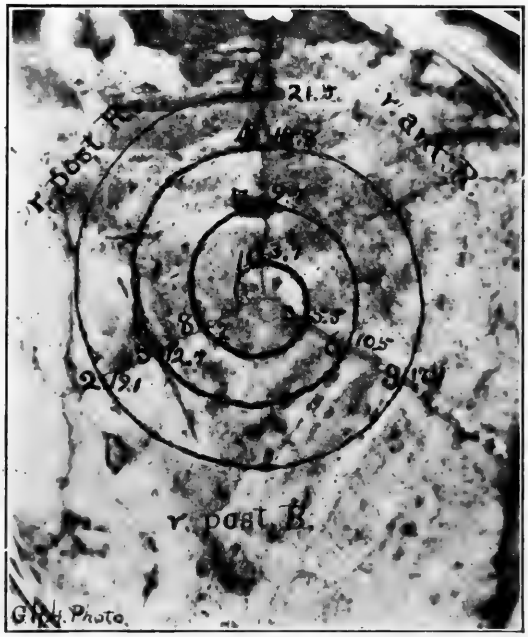


FIG. 10 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10. The spiral is drawn to show the order of development of the b.vs.

Suppose that during the nepionic stage a b.v. was developed at the point of contact of these three plates and that soon after its exit it had budded a new b.v. aborad, which also sought exit at the same point. No. 1 would be thrust orad and reach in this direction to exercise its function. The growing points of r.post.R and r.post.B would push by and finally surround it, thus giving it a position not at the corner but on the suture. A third b.v. seeking exit also at the plate corners might force no. 2 to the left and would itself, in seeking freedom for its function, pass to the right and thus become inclosed between the growing points of r.post.B and r.ant.R. A new factor would now enter to determine the position of the fourth b.v. Nos. 2 and 3 would be its nearest neighbors. It would find water richer in oxygen and freer from excretory matters in the direction of no. 1. Its own effort to function to better advantage might alone insure for it a position on the suture next no. 1, but natural selection would soon fix any variation in this direction however caused. To follow the series in this manner down to no. 12 and find a probable cause for each position, is a simple matter. The evidence seems to favor the idea that the b.vs. of a triangle are organically related to each other and are but external branches of one internal tube or chamber. There is no evidence, however, to warrant our associating the group with the circumoral ring of the water vascular system though a connection was not at all unlikely.

It is of course possible that nos. 1, 2 and 3 were independent b.vs. and that, as the sutures were extended, each politely awaited its turn to send a branch through the point of least resistance. Such a condition could be made to speak eloquently against the idea of struggle for existence between parts of an organism, but there seems to be no evidence in its favor. An examination of the sutural faces of the plates might decide the question and free plates of this species may yet be found and examined. If the development was as at first suggested, the sutural canals should show an inclination toward a point under the plate corner and that would be the position of the larger subthecal canal or sac

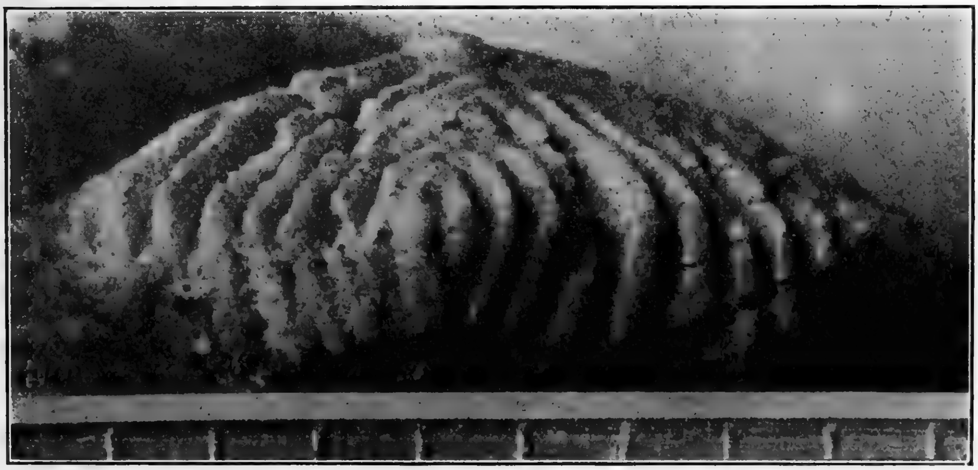


FIG. 11 From a photomicrograph of a plate of a species of Palaeocystites, seen from the edge The edge of a steel mm rule shows just below.

into which the b.vs. would periodically discharge their contents. If the development and grouping was of the other type, the sutural canals would be inclined toward a point under the middle of a plate suture and the b.vs. would discharge in this direction to reach the common tube or sac of the group. It is quite evident in text figure 3 that the triangles at the plate corners form the related groups in Cliocrinus. Text figure 11 will show that the sutural canals of Palaeocystites are inclined toward a point under the plate corner and that here also the corner groups are the related ones. Such evidence as there is then is markedly in favor of calling the triangular series a natural group and not the parallel series. The primary interradial group just described may be considered as typical also of four others which were simultaneously developed at the orad angles of the other BB.

Development in complexity. The small portion of the cup of Cliocrinus perforatus shown in text figure 1 was possessed of more than 230 b.vs. This would indicate that the complete specimen possessed some 5000 similar structures. Palaeocrinus striatus on the other hand had a cup practically reduced to but three circlets of five or six plates each and its b.vs. were less than 150 in number. We should therefore expect to find some compensatory arrangement whereby the physiological balance of respiration might be maintained. The arms doubtless came to take a larger share of this function and so relieve the cup surface, but the latter abundantly shows that it also became adapted to carry on the same function to a greater extent than formerly. We have already seen that the oval sutural canals of Cliocrinus perforatus may be indicative of the movement of the free ends of b.vs. toward the plate centers or to regions of purer water. If the b.vs. could branch under the theca to give rise to new members, their branching or forking outside of the theca need not be unexpected. Any b.v. possessing a forked structure would come to hold the arms of the Y in the best functional position which would be in a line crossing the suture. Such a structure could not be easily withdrawn and protection would be first secured by making the arms of the Y lie close to the plate surface and thus changing the Y to a T. The close contact of the arms of the b.vs. with the plate surface might inhibit the formation of epistereom immediately beneath them and stimulate growth between them. Ridges so formed would be an additional means of protection and, however initiated, would be favored by natural selection.

With the necessity for occasional withdrawal removed, the arms of the b.vs. could extend with plate growth and all available plate area be used for respiratory purposes. The form might thus easily pass from the primitive arrangement in which its b.vs. simply occupied the lines of plate boundaries to the more complex arrangement by which its b.vs. came to occupy the area of plate surfaces. It is probable that in Palaeocrinus the development of T-shaped b.vs. was not so simple as the processes above outlined. The youngest b.vs. found in the type are already a little distance from the corners and appear as small low mounds that sometimes show more on one side than the other. It looks as if free or uncovered external b.vs. had already been suppressed and that the extension to the surface did not break through the epidermis, but lifted it as a mound which became elongated with the growth of the plate and under which the b.vs. extended their arms. As several layers of tissue are involved in these body wall extensions, the outer layer or the next layer under this might form porous stereom and the deeper layers form the walls of a contractile tube free to move inside of its rigid but porous covering. Evidence of additional (abnormal) forking is shown in plate 5, figure 4. Both of the epithecal canals below the longest are distinctly double near the suture but are single in their earlier portions. At least three b.vs. here came to empty into a single sutural canal. One arm of the first fork evidently tried to repeat the process.

The b.vs. as indexes of plate growth. Could we determine the rate or regularity of b.v. development we could use the position of these structures as indexes of the relative rapidity of plate growth during different ontogenic stages. If the new b.vs. appeared at regular time intervals their distance apart on any suture would be in strict proportion to the rate of plate extension. Text figure 11 may be made to offer an illustration. The measurement of position of the b.vs., in part recorded in the figure, is as follows:

Table 2

1	21.5 mm	**4**	15.8 mm	**7**	9.7 mm	**10**	3.7 mm
2	19.1	**5**	12.7	**8**	7.0	**11**	2.5
3	17.1	**6**	10.5	**9**	5.5	**12**	1.0

From the measurements of position recorded in table 2 we have deduced the following table of distances between one b.v. and the next younger on the same suture.

Table 3

1 to **4**=5.7 mm	**4** to **7**=6.1 mm	**7** to **10**=6.0 mm
2 to **5**=6.4	**5** to **8**=5.7	**8** to **11**=4.5
3 to **6**=6.6	**6** to **9**=5.0	**9** to **12**=4.5

The first vertical column gives the distance of each member of the first triad from the corresponding member of the second triad, or from that member which came to occupy the next position on the same suture. The second vertical column does the same for the distances between the second triad of b.vs. and the next three b.vs. to appear. The first horizontal line of figures gives the distances for the vertical suture, the second line gives them for the diagonal suture at the left and the last line gives them for the diagonal suture at the right. Interpreted according to the above assumption, the distances indicate that the most rapid growth was after the development of the first triad and between the times of the fixing of b.vs. 3 and 6 on the same suture. This would be during adolescence. The marked decrease next the end of the series would indicate that the specimen was practically fully grown or mature. By measuring these distances on a number of different areas and using averages one could plot a curve representing this variation of plate extension in time and the character of such a curve in itself would be good evidence that our assumption was not far wrong.

The b.vs. speak still more clearly of variation of rapidity of plate extension in certain directions. Suppose we ask if the elongate form of the species has been brought about by adding stereom more rapidly to the orad and aborad sutural faces of the plates than to their lateral sutural faces. We may question text figure 10 concerning this matter. The average distance apart of the b.vs. from 2 to 8 (on the right aborad suture of r.post.R) is 6.05 mm; from 3 to 9 (on the left aborad suture of r.ant.R) it is 5.80 mm. Averaging the two we obtain 5.925. On the vertical suture from 1 to 10 the average is 5.933 mm. The difference here is so remarkably little that it would be unwise to use it as the basis of a declaration that the vertical elongation of the aborad half of a R. was in excess of the lateral extension of one side. We shall soon find, however, that the plates of the two lower circlets give very decided evidence that vertical extension was in marked excess of lateral. We may also note here that r.post.R seems to have added stereom to its right side a little more rapidly than r.ant.R did to its left. This point will be again referred to when we come to discuss the lateral extension of the theca.

The aborad radial groups. We have so far given particular attention only to one of these groups of b.vs. which developed about the orad angle of each B. These groups are interradial in position. A group of b.vs. was developed at the orad angle of each IB and a group also at the aborad angle of each R. These ten additional groups are all radial in position. To distinguish between them we shall call one series orad and the other aborad. Text figure 12 shows two of these groups, an orad radial group around the aborad angle of a R and an aborad radial group around the orad angle of an IB. The latter group will now receive our attention.

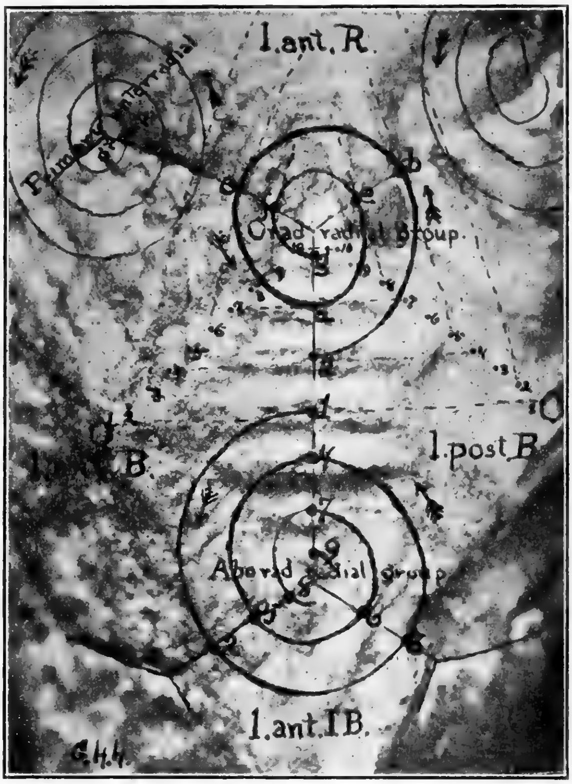


FIG. 12 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10. The spiral lines are drawn to indicate the order of development of the b.vs.

The members of this group occupy a triangular area and are numbered from 1 to 9. The evidence here is for regular serial formation with counter-clockwise rotation as in the interradial group. For instance, we have three b.vs. on the left upper shoulder of the IB and but two on the right. The distance of 2 from the apex of the IB is greater than that of 3, and the distance of 5 is greater than that of 6. In table 4 we have entered the measured distances of all these b.vs. from the point in question, arranging those of each suture in a separate vertical group as below.

Table 4

1	1.8 mm	**2**	1.25 mm	**3**	1.15 mm
4	1.3	**5**	.7	**6**	.6
7	.75	**8**	.3		
9	.3				

These distances have been plotted in figure 12 and a spiral line drawn through them to more clearly express their serial formation and its direction.

We may now turn again to the questions of variation of rapidity of plate extension in time and in direction. Taking the distances between one b.v. and the next younger on the same suture and arranging as in table 3, we have

Table 5

1 to **4** = 0.5 mm	**4** to **7** = 0.55 mm	**7** to **9** = 0.45 mm
2 to **5** = .55	**5** to **8** = .40	
3 to **6** = .55		

When we compare these b.vs. with the interradial group just studied, we find that they are fewer in number and the distance separating the oldest two on any suture is also less. Were the time intervals regular for b.v. branching, we should have to concede that this group is a younger group and the shorter distance between its oldest members, as shown in table 5, would tend to corroborate this view. We might then be led to believe that the new series was developed from an early branch (perhaps the first) of the older interradial series when the two b.vs. would have been separated by the very short distance across an angle of the young plate. We shall do well, however, neither to accept nor reject the idea if our mind can thus hold judgment long in suspension. We may also note that the younger b.vs. on a suture are nearer together than the older and this again we may interpret as due either to a more rapid formation of b.vs. near maturity or to diminished speed of stereom formation. The latter explanation seems the more probable to the writer.

We take up again the question of difference in rate of plate extension in direction. From our study of the relative positions of the b.vs. in one of the primary interradial groups we were forced to conclude that the building of stereom on the aborad sutures of the radials was but little, if any, in excess of the building on the lateral sutures of those plates. With equal growth on all sutures of a hexagonal plate there would be no change in plate form. The radials of a mature Palaeocrinus have much the same form as the radials of a very young specimen, at least so far as concerns that portion which lies to the right, left and below the center of the original plate. With the group now under consideration (an aborad radial group) there is evidence for marked difference in rapidity of plate extension in direction.

In order to present this evidence more clearly and to show its bearings on change in plate form during ontogeny, we have formed a new table (table 6) in the following manner. The distance of b.v. 1 from the orad angle of the IB as measured on the vertical suture of figure 12 (1.80 mm) has been used as a minuend; the distance of the b.v. 2 from the same point or angle of the IB (1.25 mm) has been taken as a subtrahend; the difference between these numbers, the remainder, (0.55 mm) has been entered as the first member of the new table. Taking b.vs. 2 and 3 and treating them in the same manner, we obtain a remainder of 0.10 mm and enter this as the second member of the table. The other differences expressed in the table were found in a similar manner. The two numbers before any sign of equality designate the b.vs. whose distances (from the orad angle of the IB) were used for minuend and subtrahend.

Table 6

Giving, for an aborad radial group, the difference between distances from the orad angle of the IB (expressed in mm) of a b.v. on the

vertical suture and the next b.v. to appear	left diagonal suture and the next b.v. to appear	right diagonal suture and the next b.v. to appear
1—2 (1.80—1.25) = 0.55	**2—3** (1.25—1.15) = 0.10	**3—4** (1.15—1.30) = — .15
4—5 (1.30— .70) = .60	**5—6** (.70— .60) = .10	**6—7** (.60— .75) = — .15
7—8 (.75— .30) = .45	**8—9** (.30— .30) = .00	

To quickly, clearly and visually explain table 6, let us take a hypothetical orad radial group. The b.vs. are to appear in sequence with a time interval that shall be the same for all. The addition of stereom to the aborad sutures of the basals are supposed to be constantly and regularly in excess of the amount added to their common vertical sutures. This will result in increasing the length of the plate more rapidly than the width. Let us suppose the ratio between verticle and lateral rate of extension to be as 4 to 3. Then when b.v. 1 has increased its distance from the orad apex of an IB by 4 units, b.v. 2 will have increased its distance by only 3 units. Figure 13 shows the condition of things when the tenth b.v. has just appeared at the orad apex of the IB and b.v. 9 is just 0.3 millimeters distant from the same

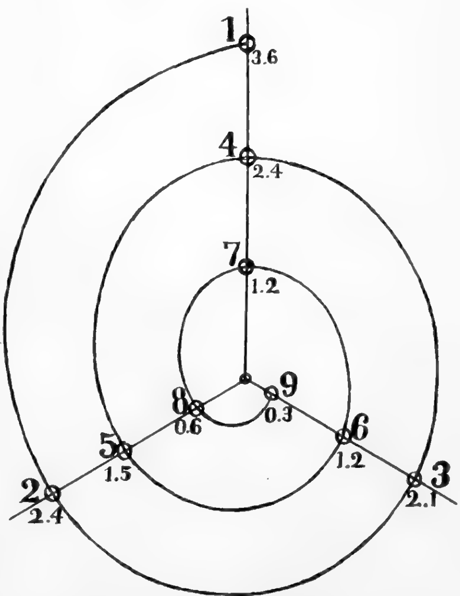


Fig. 13 Drawn to represent the b.vs. of a hypothetical group in which the ratio of vertical to lateral growth is as 4 to 3

point. If now we construct a table after the manner of table 6, but using text figure 13 for the basis, we shall have the result here given as table 7. A comparison of the two tables will speak eloquently for our contention.

Table 7

1—2 (3.6—2.4) = 1.2	**2—3** (2.4—2.1) = 0.3	**3—4** (2.1—2.4) = — .3
4—5 (2.4—1.5) = .9	**5—6** (1.5—1.2) = .3	**6—7** (1.2—1.2) = — .0
7—8 (1.2— .6) = .6	**8—9** (.6— .3) = 3	

We shall find that the ratio between lateral and vertical extension varied during development. Between the appearance of b.vs. 1 and 4 the vertical suture of this group increased 0.5 mm in length. Between the appearance of 2 and 5 the left diagonal suture increased 0.55 mm. Lateral extension appears to have been slightly in excess of vertical at this time. They soon become equal. Between the appearance of 5 and 8 the lateral expansion was only 0.4 mm. At this period of growth the ratio between vertical and lateral extension seems to have reached the ratio of 11 to 8.

A study of the basals as presented in the cup analysis and in the photograph will show that this ratio is not far out of the way, but it must be remembered that it is not for the whole B but for the lower part of it and that the ratio is one that changes all along the edge of the vertical suture, the most rapid addition being at the top of this suture where it practically equals the rate of addition to its orad sutures and the least rate being at the bottom or aborad end of the same vertical suture. This growth ratio clearly indicates that very young plates were no longer than wide or, in other words, that they were practically symmetrical and so suggestive of cystidean plates. With the aid of this ontogenic evidence we have attempted to present the probable outlines of two young or primitive plates in text figure 9.

It is interesting to note that this increase of vertical plate extension had carried b.v. 7 so far from the apex of the IB at the time of the emergence of b.v. 9 as to offer the latter as much freedom, apparently, on the suture occupied by b.v. 7 as on the suture occupied by b.v. 6. The irregular position of b.v. 9 in figure 12 is thus seen to be in harmony with our suggested physical reason for rotation and to rather strengthen that hypothesis, for heredity should have placed this b.v. next to no. 6. The position occupied by b.v. 9 in this group is not normal for all of the other IBB possess a third b.v. on their right-hand upper sutural faces with the possible, though not probable, exception of l.post.IB. The upper edge of this plate has been so badly damaged that an accurate count is not possible, but its width suggests the presence of a third b.v. The measured length of the upper right-hand sutures of the IBB is as follows: l.post.IB 2.2 mm; r.post.IB 2.2 mm; r.ant.IB 2.0 mm; ant.IB 1.7 mm; l.ant.IB 1.6 mm. An additional reason for the choice of the vertical suture by our aberrant b.v. 9 may be here seen, as what should have been its normal suture offered it the least room for the exercise of its function.

The oral radial group. Text figure 12 shows a triangular area of b.vs. developed around the aborad apex of l.ant.R. In order to avoid confusion we have used letters to designate the members of this group. As these were developed at the upper right-hand corner of l.ant.B., their places of origin on the plate must occur along a line connecting the primitive plate corner with the present plate corner. This line is represented by a series of ten equidistant and numbered dots. The upper left-hand portion of l.post.B. has been treated in the same manner and it must be seen that the position of any dot of either series, was, at some time during growth, identical with that of the similarly numbered dot of the other series. B.v. *a* did not appear until the plate had attained about one-third of its present diameter, or until the plate corners had reached the position of dot 4. B.v. *d* appeared when the plate corners had reached dot 7 and b.v. *g* when the plate corners had reached dot 10. The extension of b.v. *e* suggests dot 8, while *f* would correspond well with dot 9. This indicates a counter-clockwise rotation for this group.

We must note that the correspondence is not exact and exactness should not be expected where rate of growth is compared with a hypothetical mathematical schedule. The diagram, however, contains some errors. First its dotted " lines of origin " are a little too long and bring b.v. 1 of the aborad radial group in line with the upper ends instead of the lower ends of the common suture of the BB. Second, the line should be a curved line and not a straight one as the plate is not flat but convex. Equidistant dots on a curved surface would no longer be equidistant when reproduced on a photograph of that surface. Third, the plate center is in itself a point which can not be located with exactness. This form of diagram has been used for its suggestiveness and its simplicity. Another manner of approach would have been through extending b.vs. *a, d* and *g* to the " line of origin " and then dividing these portions of the line into three equal parts.

We may, however, strengthen our suggestion of counter-clockwise rotation for this group by using the measured distances of the b.vs. from the aborad angle of the radial. These are presented in table 8.

Table 8

$a = 1.3$ mm	$b = 1.00$ mm	$c = 0.90$
$d = .8$	$e = .55$	$f = .35$
$g = .35$	($h = .15$	$i = .14$?)

Using these to form a table after the pattern of table 6 we have

Table 9

$a—b$	(1.30—1.00) =	0.30	$b—c$	(1.00— .90) =	0.10	$c—d$	(0.90—0.80) =	0.10
$d—e$	(.80— .55) =	.25	$e—f$	(.55— .35) =	.20	$f—g$	(.35— .35) =	.00

This also shows the more rapid vertical extension of the BB. We may again note that the difference between the rates of vertical and lateral plate extension is not so great here as in the lower area of this figure. In other words, the vertical extension of the aborad portion of a R was very nearly as rapid as the vertical extension of the orad portion of a B. The portion of b.v.1, so near the center of the vertical suture, shows also that stereom formation was but little more active on the aborad sutural faces of the BB than on their orad. The greatest difference in growth rate was along the vertical sutures and the modification of form was brought about by decreased or inhibited growth aborad rather than by increased growth orad.

Infrabasals. The absence of the formation of b.vs. at the aborad angles of the BB is correlated with a very marked lack of stereom formation along the common sutures of the IBB. The first b.vs. to extend their arms over the IBB once occupied nearly central positions on the orad shoulders of these plates. Had stereom extension occurred equally at the right and left of these b.vs. they would have retained their central positions, while now they are close to the outer edges of these shoulders. At the time of protrusion of b.v. 2 (see text figure 14) it was about 0.3 millimeters distant from a vertical line bisecting the plate and continuous with the suture between the IBB below it. Following the external canal down to the suture we find that the opening to the interior was 0.5 millimeters distant from the same line at death. The difference of 0.2 millimeter represents the widening which has taken place on this portion of the B during the last three-quarters of its growth. This very slight divergence of the two longest b.v extensions on a B offer a valuable character for use in recognizing the BB of this species and in orienting them. Looking for the earliest position of this b.v. on the IB we find it close to the point marked *a* and about 0.6 millimeter distant from the suture. This older portion of the IB has added but 0.3 millimeter to its side, while it has added 2.3 millimeters to its orad sutural faces. In other words, the rate of stereom addition to the orad sutural faces was nearly eight times as great as was the rate of addition to the lateral sutures of the plate.

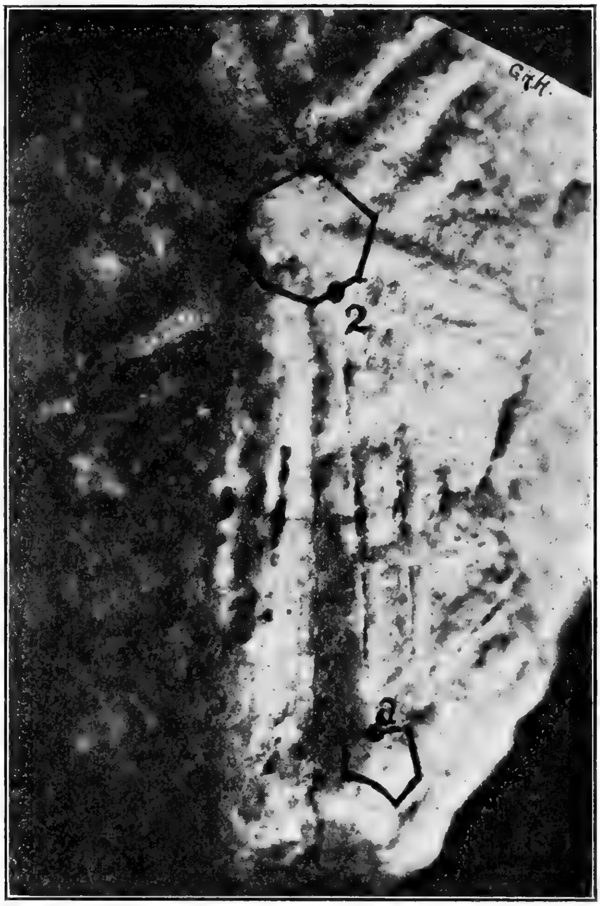


FIG 14 View of a portion of the holotype of Palaeocrinus striatus Billings. From a photomicrograph, x10, and showing r.post.B., r.post.IB. and r.ant.IB. The probable forms of two of these plates at an early stage in their development are shown in outline.

The growth has not only been slight between the IBB, but it has not extended to the outer surface of the plate. The result is a well-marked groove widest next to the original position of the proximal stem joint and becoming gradually narrower and less deep orad. The groove is very smooth and shows only faint vertical growth lines. This lack of growth at the suture has left its impression on the B and has caused the groove to be carried orad on the latter nearly to its center. The B has kept a record of the cross section of the groove, as it appeared at the suture, from its earliest stages to the time of death. This very characteristic feature of a Palaeocrinus B, together with the slight widening of the oldest aborad b.vs. (already mentioned) will be referred to again under our remarks on Paleocystites chapmani Bill. Using the different growth rate with reference to direction, we have outlined a young IB in text figure 14. It approaches somewhat the character of a stem joint in that it is wider than high and has no b.vs. on its lateral sutures.

Making a general review of the differences in rate of growth already recorded we may say that the vertical element was strong throughout the three circlets of plates, except on the orad ends of the RR and the aborad ends of the IBB, but that the lateral element was exceedingly weak near the proximal stem joint and gradually became stronger on ascent of the cup. At the base of the arms it very nearly equalled the rate of the vertical element. The cup thus received its present fusiform character.

The orad interradial series. There remain five b.vs. not yet accounted for and these apparently had their points of origin at the orad ends of the sutures between the RR. Each member of the

Fig. 15

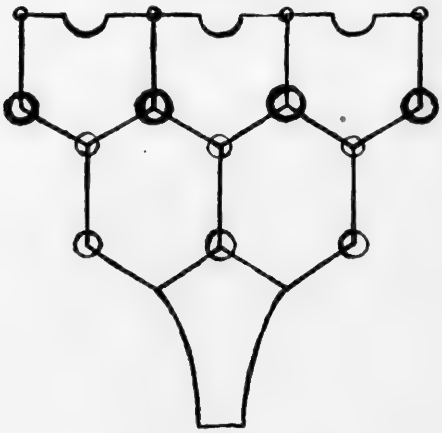


Fig. 16

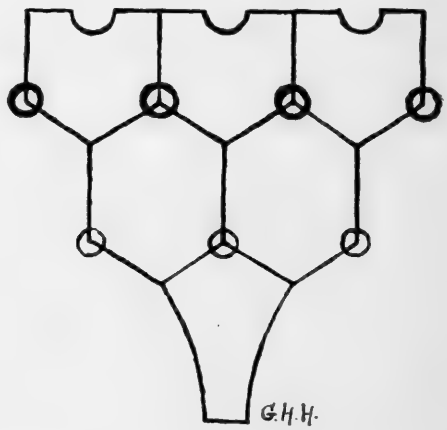


Fig. 17

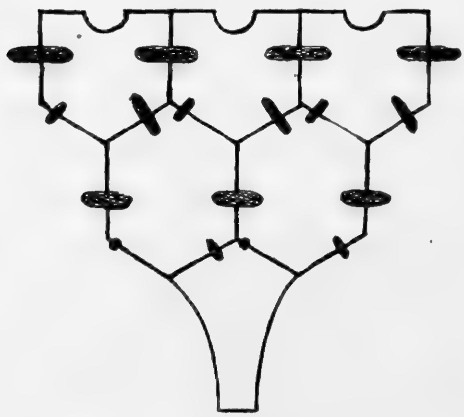
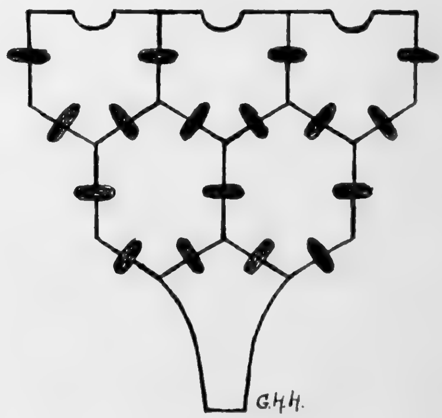


Fig. 18



series seems to have had no room for further development but the position is so close to the arms that the series may be connected with the more elaborate respiratory system of the latter.

Relations of the b.vs. The relations of the four classes of groups as we have interpreted them may be shown by text figure 15, in which the size of the dot at the supposed points of origin is made commensurate with the importance or age of the group. If the orad radial groups and orad interradial series were developed as branches of one of the others, a still more primitive form would be represented by text figure 16. As soon as each b.v. of figure 16 had given rise to two other b.vs. we should have a condition like that shown in text figure 17. At about this stage we may suppose that the initial members of the orad radial and orad interradial series made their appearance.

The possibility of a primitive or nepionic stage like that shown in text figure 18, where these b.vs. may be supposed to have appeared simultaneously and not at the angles but on the middle of the sutures, should perhaps not be dismissed from mind. In this case new b.vs. would be formed by branches, simultaneous or alternate, on each side of these and also on the sutures, if the first were so formed. There would be as many natural groups as there were sutures in this case and we should have no difficulty in accounting for the upper young members on the common sutures of the radials. A form like this appears rather complex for a beginning though even here we might credit acceleration with changing a primitive series of three into a simultaneous group of three and credit natural selection with the placing of such a group at the middle of the sutures where it could function to best advantage and not interfere with new members protruded at the corners. These oldest b.vs. are, however, not now on the middle of the sutures, but differences in rate of growth might have displaced them. It has seemed to the writer that the evidence from this form and also that from Cleiocrinus is on the whole strongly against the latter view. Utilizing a recommendation of the late Professor Rowland, we may keep both hypotheses in mind, but for the present may give the former a position of from 80 to 95 points of credibility on our mental sliding scale of 100 and wait for the evidence yet to come from future research.

Growth lines. The plates so far discussed all show minute growth lines, but these are only noticed between the ridges. On finding a plate in which the canal coverings had been worn away and the number of ridges therefore doubled, we might be able to use this character to aid in distinguishing between the canal bottoms and the true external plate depression between the canals. The canal floors would show no growth lines.

The radianal. In normal plate development the plate angles occur where there is least resistance to plate extension or at the boundaries between neighboring plates. In other words, two sutures meet to form an angle at a point which lies in one extremity of a third suture. Plate 6 figures 1 and 2, show that our radianal forms no exception to the law though it has a rather rounded outline which at *a* is so marked and further intensified by the prominent middle epithecal canal from r.post.B as to give it the appearance of possessing a fifth angle. The plate is, however, essentially quadrangular, as in Porocrinus, and was truly so in its early neanic stages. Bather's figure, already cited, makes the projection at *a* one of the angles of the plate and places additional ones midway of each of the other three sutures bounding the plate. Not one of the angles so drawn meets a third suture in the figure he has used. In addition to these erroneously placed angles, the true upper and lower angles of the plate were recognized, thus making it hexagonal. The angles at the junction of r.post.R with r.post.B and that at the junction of x and post.B were not seen. The mounting process has, however, made these clearly visible in the untouched photograph used for plate 6, figure 2. The rounded surface of the plate makes the sutures appear as meridians viewed from the side. With the sutures in the center of the field of view they show more nearly as straight lines and, with the exception of the abberant suture next r.post.B, they have been so represented in text figure 4. Even this suture becomes a nearly straight line when viewed as in text figure 5.

The epithecal canal passing on to this plate from r.post.B has had its covering and a good portion of the sides removed. The floor of this canal may be distinctly seen in plate 6, figure 2, lying to the right of a wide portion of its left wall. Where it is broken or cut off at the radianal end, there is a black patch that represents a limonite mud-filled basin which occupied this left canal wall and opened into the canal itself by a smaller pore. This same figure also shows a series of such limonite mud-lined or filled basins along the left side of the strong exothecal canal which runs from r.post.B over r.post.R. The pit shown in plate 6 figure 2 *b* is so definite, so well lined with limonite-colored mud and afterward filled with calcite that it challenges attention. Many similar pits are suggestive of protected side water pores opening into the canals, but the structures are so irregular in arrangement and so large a portion of them may be due to differential solution or other erosive process that they will be dismissed with this mention. Another very definite structure that is perhaps connected with respiration may also be mentioned here. It is found close to the plate angles and is in the form of two very small depressions, one on either side of the suture. A portion of the plate between a pit and the suture is distinctly raised. Plate 5 figure 4 shows a pair of these near the lower end of the suture between r.ant.R and r.post.R. They are suggestive of end openings to young canals, but they are difficult structures to photograph and will also be dismissed with this brief notice of their presence.

Lateral extension of the theca. Text figures 5 and 6 show a somewhat marked antero-posterior flattening of the species that is but very slightly due to compression by overlying deposits. Text figure 19 shows a view of the proximal ends of the IBB and the im-

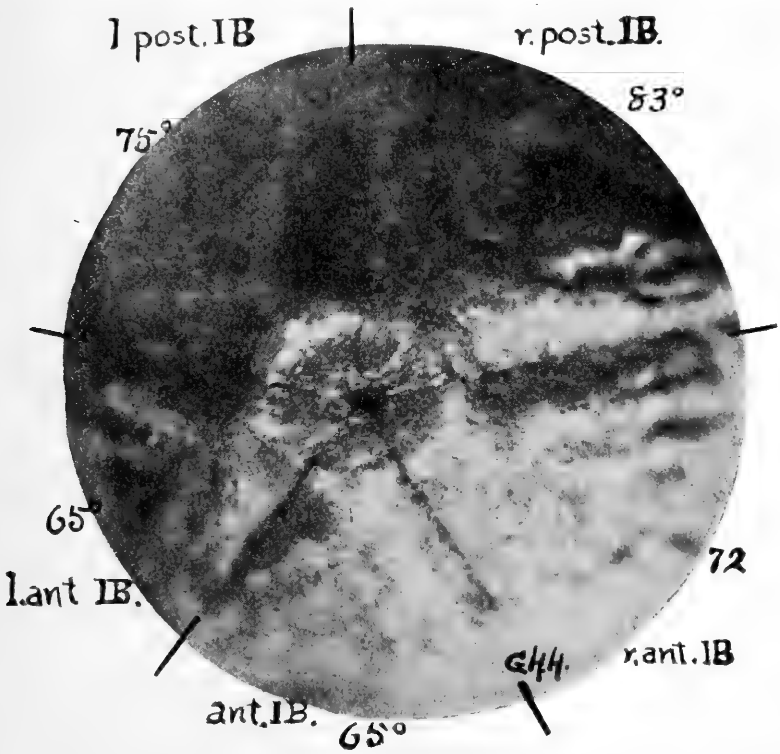


FIG. 19 Proximal end of Palaeocrinus striatus Billings. From a photomicrograph x10. The angles indicated are those of the ends of the sutures nearest the proximal columnal. The figure shows clearly the five depressions due to inhibition of stereom formation on the lateral sutures of the IBB. This is most pronounced opposite the oldest portions of these plates. The r.post.IB carries a good cast of one of the sutures of the proximal columnal.

print of the proximal stem joint, which in two places clearly shows the imprints of its sutures. There is no evidence for a pentagonal column. The flattening of the theca is manifest even here and the first columnal was an oval and not a circle. On extending the sutures shown in this figure and measuring the angles between them, it will be seen that l.post.IB and r.post.IB together take up 158° of the posterior side of the column, or 14° more than their share. There can be no question here but that we are dealing with differences due to growth. The l.ant.IB came on one edge of the fold and is the smallest plate in the figure. The fold on the other side came between r.post.IB and r.ant.IB and both of these plates are larger than the others and have undergone excessive widening at their orad ends. The variation in rate of growth in this part of the theca is shown by the following table:

Table 10

	Height	Length of two orad sutures
r.ant.IB.	3.8 mm	4.2 mm
ant.IB.	3.5	3.3
l.ant.IB.	3.5	3.2
l.post.IB.	3.6	3.9
r.post.IB.	3.7	4.4

Just above the place of most rapid growth lies r.post.B and this plate is quite distinctly folded vertically. Had this folding been due to compression after death, the RA would show signs of displacement. Instead of this it shows the peculiar extended growth to the right which gave it the appearance of possessing a fifth angle. The folding and bowing out of the center of r.post.B which is still further accentuated by its central knob, is readily seen in text figure 6 and is therefore normal to the species. This compression reminds us of the more markedly folded plates of the Anomalocystidae, but our theca is compressed at right angles to the plane of the thecal apertures and not in this plane. With five basals, but one would be subjected to this folding. On examining these BB for postmortem changes, we find only a very slight disturbance of r.ant.B and this is shown in text figure 8. We may now recall the evidence found on p. 228 where it was shown that r.post.R had been adding stereom to its right side more rapidly than r.ant.R had to its left.

The tegmen and plates above the anus. This region is taken next for the purpose of completing the evidence for flattening during ontogeny. The series of plates over the anus form a long line in which the madreporite is the most prominent, but plate 7, figure 2, shows that none of these plates have been displaced and their sutures show that no shortening of this line was possible. The widened anal area has so thrust the arms away from it as to cause those of l.post.R and r.ant.R to lie almost opposite each other. This may be seen in plate 7, figure 1. The five food grooves do not run to one center but clearly express the hypothetical primitive food grooves with the forking of the right and left rays (see Bather, op. cit. p. 11). L.post.O and r.post.O have an acute angle at their orad ends while l.ant.O and r.ant.O have widely truncated ends. The openings between the orals to admit the visceral extensions of the arms are relatively large, but orad of these the orals meet and thus form a very solid or strong tegmen. The only evidence for displacement to be found in this figure is the slightly disturbed position of the upper edge of ant.R.

The ambulacra pass over the edges of the orals and are small and irregular. Still more irregular, and larger, are numerous interambulacrals. These are best seen in plate 7, figure 2 above the madreporite, but show also for l.post.R.

The anal, X. The anal plate is fully as wide as the smaller radials and we have therefore six subequal plates surrounding the tegmen. This should make room for the development of a sixth member of the orad radial series of b.vs. There seems to be evidence for such a group, as may be seen by a study of the first three figures of plate 6, but there is at the same time a concomitant and marked weakening of the group which should have developed normally at the aboral angle of r.post.R. For instance, no b.vs. to represent a group here have been added to the suture between r.post.B and r.post.R. Cross sections of a few sutural canals can be detected between RA and r. post. R, but they seem to be poorly developed and of very small diameter. The group has but one strong member to represent it and that is the oldest and central b.v. on the suture between r.post.B and RA. It should be noted that this b.v. represents the first formed of the series whose initial position would have been at the aborad angle of r.post.R and this position has been accorded it in text figure 3. There seems to be evidence here that a branch from this group made an early exit at the aborad angle of x and, by developing there, practically stopped further development at the original position. If we may so interpret the evidence, we have nothing to disturb the fundamental pentamerism so clearly marked in all other places.

If these groups of b.vs. were connected by subthecal canals which in turn were connected with the circumoral canal of the water vascular system and these canals should run so close to the under surface of the thecal plates as to become attached to them, we should find markings present so remarkably like the "*hydrophores palmées*" which Barrande discovered in Aristocystites, Pyrocystites and Craternia that we must hesitate to accept Neumayr's suggestion that they are subtegminal food grooves and believe with Barrande that the structures are respiratory in their nature.

Endothecal structures. An examination of plate 6, figures 1 and 2, will reveal another reason for the difficulty heretofore found in determining the position of the sutures bounding RA. The undercutting of the specimen to remove it from its bed removed also so much of RA and X as to carry away nearly all of the common sutural edges of these plates. This suture was 2.8 mm long, but all that remains of it is .25 mm next to r.post.R and about the same next to post.B. It could not be seen because nearly five-sixths of it had been removed. The cutting had not only carried away nearly all of the surface of these plates but it had also penetrated beneath the plates and exposed a little over four square millimeters of the interior. This area, the greater part of which is immediately under the stereom of x, is of peculiar interest for it displays markings in carbonized lines which appear like sections of a network of tubes having a diameter of about 0.2 mm. When first noticed, it appeared as if we had here the remains of a colony of Bryozoa but so soon as it was discovered that these structures were not on the surface of the plates, but beneath them, they received more careful examination.

In plate 6, figure 3, we have marked a sutural canal *c* and at the extreme right-hand side of the figure there is a broken piece of r.post.R with an angle of the crystalline calcite resting on the suture. This angle, which is marked *d*, may be seen in all four figures. If now on figure 1 of this plate we place a millimeter rule tangent to the under surface of the sutural canal designated as *c* and let the edge of the rule run by the lower angle of the broken calcite designated as point *d*, we shall have a line 58 mm long which will afford us a good basis for study and comparison of the figures. Resting on this line and 28 mm out from the sutural canal *c* we find a dark triangular area with a base of 2 mm. Below this are three parallel tube sections which together occupy a width of 6 mm. Tubes also lie against the other two sides of the triangle, but a series parallel to these is not detected. The tube sections here display rounded ends showing the sections to be in part longitudinal and in part tangential. In other words, the tubes were curved. Outside of this area the sections approach more closely the character of circles and it is apparent that we are here dealing with cross sections of tubes belonging to the same system. As to the character of these marks we must note that the boundaries show only as carbonized lines and spaces in places made more distinct by an internal tube lining of limonite-colored mud. There are no distinct walls as in sections of bryozoan colonies.

The fact that these tubes are commensurate in diameter with the sutural canals would lead one to question as to whether or not they were internal continuations of the exothecal canals. The fact that they contain limonite-colored muds would negative this idea, for we have supposed that b.vs. contain coelomic or other body fluids and not sea water. The idea is also negatived by the direction taken by the tubes, their curved character, and their great number.

Another hypothesis is open for us. We have seen that the conditions of existence favored a system of anal respiration. Such a system would favor saclike extensions of the rectum that would tend to become branching diverticula and so form respiratory trees very like those possessed by Holothurioidea. These might be either homogeneric or homoplastic. As the specimen died with the anal area down, the intestine would press any structure between it and the plate against the latter. In this case we should find portions of the supporting tubes on their sides and variously bent. Surrounding these would be a border of tubes whose tips only touched the inside wall of the anal plate and these would give us the cross sections we find. These tubes would contain more or less of the limonite-colored muds of the bottom, drawn in by the last respiratory efforts of the creature as we found them drawn in in Blastoidocrinus. This limonite-colored mud is most often very suffuse and only faintly apparent. In other places it has collected as little lumps but always in the tubes. The tube walls are very poorly preserved and appear as if partly ruptured or decayed. Their soft walls were often compressed, thus making them present angular outlines.

Through the courtesy of the late Doctor Whiteaves the writer was allowed to develop this portion of the specimen. From 0.1 to 0.2 mm of this surface was removed with a fine narrow file and the area photographed again under the gum dammar mounting and with an amplification of 10 dia. The result is shown in plate 6, figure 3. Another thin sheet was removed, but in order not to destroy any of the sutures next r.post.R it ran from a thickness of 0 mm on the right to between 0.1 and .2 mm on the left. The uncovered area was thus extended slightly toward the left. A new photomicrograph was now made and a colored screen used in order to show if possible the limonite-colored mud fillings. This photomicrograph is reproduced as figure 4 of plate 6. The subject is a difficult one both for photography and for reproduction, but it is hoped that the plate will present enough detail to be both of interest and value.

Palaeocrinus chapmani Billings

Palaeocystites chapmani Bill. Canadian Org. Rem. Dec. III, p.71–72. No figure.

The description of P. chapmani given by Billings in no particular differentiates that species from P. striatus.[1] The term "radiating ridges" is not used by him to designate either the covered epithecal canals or the side walls of the latter when the covering is removed, but is used simply to designate the larger and more general relief features of the plate. Thus one of the "radiating ridges"

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[1] "Description. The few plates of this species that have been collected exhibit the peculiar character of the genus in a most interesting and satisfactory manner. Without being acquainted with the structure of the plates, the observer would almost unhesitatingly refer them to two very distinct species, so great is the change in their appearance produced by the wearing away of the external surface. The perfect plates resemble those of P. dawsoni, inasmuch as the number of radiating ridges is the same as the number of sides. The ridges are however of a different form. In P. dawsoni they are narrow at the base, and the space between them is flat; but in P. chapmani they are broad at the base, or roof-shaped, the base of each spreading out to a breadth equal to that side of the plate to which it extends. A perfect plate of this species, for instance one of six sides, may therefore be described as presenting six furrows radiating from the center to the six angles, these furrows gradually increasing in depth and width as they recede from the center of the plate. Or it may be characterized as exhibiting six roof-shaped ridges radiating from the center to the sides, and increasing in height and width at the base as they approach the side.

When, however, the external surface is worn away, the plates assume a very different appearance. They then become covered with deep fissurelike striae, like those of P. tenuiradiatus, to which they bear so close a resemblance, that to the unpracticed eye, they appear to be the same. They can always, however, be distinguished by this character. The ridges or partitions between the fissures, which terminate at the centers of the sides of the plates, are the highest, those at the angles being the lowest; but in P. tenuiradiatus it is the very reverse; the angles of the plate are more elevated than the centers of the sides."

of his P. chapmani (see upper left-hand region of text figure 20) consists of a long, high, large, central, covered epithecal canal with the younger, shorter and smaller canals grouped on either side of it. These all crossed the suture and so form a ridge "broad at the base, or roof-shaped." The canals themselves Billings calls "deep fissurelike striae" and, as shown by our figure, a "radiating ridge" may consist of a group of seven or eight of these fissurelike striae. His whole description, given in the footnote, tells us only, so far as concerns the description of the species, that it exhibits "six roof-shaped ridges radiating from the center . . . and increasing in height and width . . . as they approach the sides. When . . . the external surface is worn away, the plates . . . become covered with deep fissurelike striae, like those of P. tenuiradiatus." We may express the essence of the description as follows: the plates of P. chapmani show as many radiating groups of covered canals as there are angles to a plate. The older, central canals are higher and longer and from these we may pass down a regular slope to the smallest and shortest canal which is always situated next to the angle of a plate. His means of distinguishing between his P. chapmani and P. tenuiradiatus Hall is but a means of distinguishing between his Palaeocrinus striatus and Hall's Palaeocystites tenuiradiatus.

Fig. 20 From a photomicrograph (x10) of the holotype of Palaeocystites chapmani Bill., now in the Museum of the Geological Survey of Canada at Ottawa

The holotype consists of a single plate so badly weathered as to lose some portion of the entire surface and very much of that surface as the plate margins are approached. A small portion of the sutural faces is also lost. If we examine in detail the figure of the type, here given, we may note the following resemblances to the r,ant.B of Palaeocrinus striatus.

Table 11

	Palaeocrinus striatus r.ant.B (text fig. 8)	*Palaeocystites chapmani* (text fig. 20)[1]
No. of b.vs. crossing common basal sutures	7.	8.
" " left orad suture....	7.	7.
" " " aborad suture..	3.	4.
Distance apart (at suture) of oldest b.vs. crossing to IBB......................	0.7 mm	0.8 mm
Dist. from orad to aborad angle..........	5.6	5.8
" across at orad ends of common sutures	4.8	4.3
" " aborad ends of common sutures	3.1	3.2
Length of left common suture...........	3.7	3.5

In addition to the tabulated resemblances it may also be seen:

1 That the two longest and largest epithecal canals passing aborad have no younger canals between them.

2 That in P. chapmani we have the divergence of these canals and the peculiar groove between them which we found in figure 14.

3 That of the primitive canals the most prominent on P. chapmani are those passing orad or over to the probable RR of this species, the next in prominence are those passing aborad or over to the probable IBB, while the least prominent are those passing over to the neighboring plates of the same circlet or to the BB. This relation is the same as that expressed by the B of P. striatus shown in text figure 12.[2]

When we note how much the BB of Palaeocrinus striatus differ from each other, we must say that the correspondences noted above very strongly suggest the idea that in this type of Palaeocystites chapmani we are dealing with a single basal of Palaeocrinus striatus.

As P. chapmani appears to have its nearly horizontal canals a little closer together than P. striatus, and as the upper "radiating ridges" of Billings's description seem more raised and rounded and the depression between them somewhat deeper than in the type of P. striatus, we may for the present retain Billings's name and know his type as Palaeocrinus cnapmani until additional specimens are found.

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[1] The poor state of preservation of the plate of P. chapmani has no doubt rendered some of these measurements inexact, but the error can hardly be greater than 4 per cent.

[2] This relative prominence apparently expresses relative age, though the lessened rate of stereom formation along the common sutures of the BB might make the primitive b.vs. crossing these sutures appear younger than the first b.v. to cross to an IB.

Genus PALAEOCYSTITES Billings

Can. Org. Rem. Dec. III, p. 68–69

Palaeocystites dawsoni Billings

Can. Org. Rem. Dec. III, p. 70–71

As this species has some valuable evidence to offer concerning the question of respiration and as it allows the cystids to be better represented in our discussion, we will give it a somewhat detailed description and admit its testimony.

Size, form, etc. The more perfect specimen of the two syntypes in the collection of the Geological Survey of Canada at Ottawa is 18 mm long and about 10 mm in greatest width. The upper half is somewhat cylindrical with a hemispherical top, the lower half is obconic and tapers very regularly to a diameter of 2.5 mm. This specimen is illustrated by text figure 21 and is here designated as Syntype A. The following quotation from Billings's description is evidently a reference to it: "The largest specimen collected is a fragment of the lower half and indicates that the length of the body was about one inch, its greatest diameter being half an inch." It should be noted that, while Billings called this syntype "a fragment of the lower half," yet he found it complete enough to enable him to determine the length of the species. As he left it, no portion of the orad end was visible, it being heavily covered by a colony of bryozoa, and the side uppermost in the bed had but one plate sufficiently weathered to remove a portion of its surface (see fig. 30). Removal of the incrustation for some distance around this seems to show that we are dealing with a nearly complete specimen and one in which the epithecal canal coverings were well preserved. The specimen has the crystalline calcite of its plates broken and shattered on one side, caused by its removal from its bed, and a piece broken from its opposite side which was afterward replaced. These in-

Fig. 21 Palaeocystites dawsoni Bill. Syntype A. x3. Scale in mm

juries have combined to make a complete analysis not only one of great difficulty but one of danger to the specimen as well. The circlet of five contiguous and similar plates next the proximal stem joint is, however, clearly seen and the outlines of other plates of the injured area may be easily followed. A partial analysis of this syntype, showing five vertical rows of plates, is presented in text figure 25.

The other syntype is here designated as B and is illustrated by text figure 22. This specimen shows some thirty and more plates in

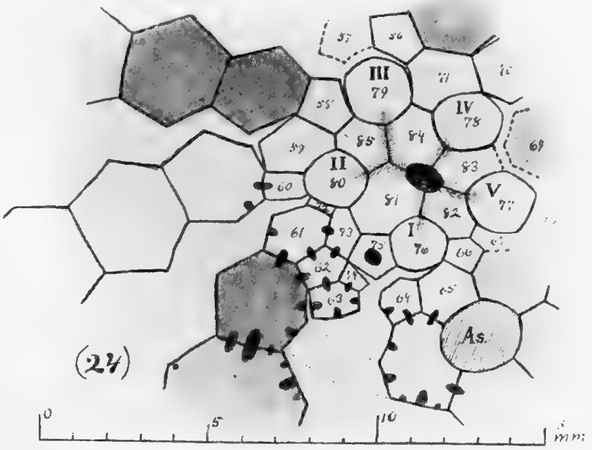
FIG. 22 Palaeocystites dawsoni Bill. Syntype B. x3
FIG 23 Palaeocystites dawsoni Bill. Apotype x3

the vicinity of the mouth and anus. Early efforts to clean the specimen seem to have removed some portions of the plate surfaces, but sutures and sutural canals are very clearly seen. Syntype B thus supplies a large and important area for analysis and the plate arrangement of this region is presented in figure 24. These two syntypes were both collected by E. Billings from the Chazy of the island of Montreal.

With some specimens also collected from the Chazy of the island of Montreal by E. Billings, but labeled Palaeocystites tenuiradiatus Hall, is a third specimen of P. dawsoni which is here made an apotype and is illustrated by figure 23. The specimen is only a fragment but it presents us with a complete cross section of the theca just below the anus. The ten vertical rows are here represented by a zigzag circle of plates, a higher and a lower regularly alternating with each other. Several plates show above this ring but the plates nearest the mouth seem to be lost. The epithecal canal coverings of this specimen have been removed by purely natural processes and in so delicate a manner that their extreme thinness is still manifest by their remaining edges. The character of both epithecal and sutural canals is revealed with exceptional clearness. The greatest width of this specimen must have been 13 mm.

Plate arrangement. The following description of the plate arrangement is based on the drawings here given and is further aided by an examination of the injured area of Syntype A and the cross section of the apotype.

The circlet next the stem consists of five, similar pentagonal plates which strongly suggest the IBB of Crinoidea. Above these and alternating with them is another circlet of five plates. These are septagonal and suggest the BB of Crinoidea. The two aborad shoulders of each of these plates rest against the orad shoulders of two plates of the first circlet, while their vertical shoulders meet each other. There remain three shoulders which lie above their common vertical sutures and the uppermost of these is horizontal. Resting on each of these five horizontal shoulders is a vertical row of 3 or 4 hexagonal plates which for convenience we may for the present consider as interradial in position.



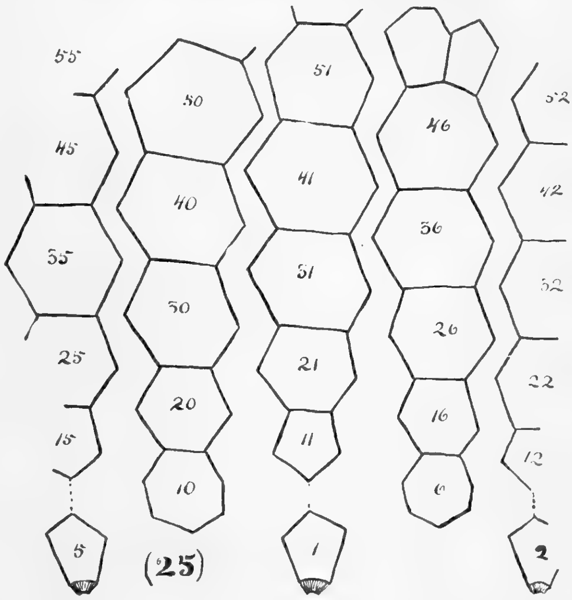


FIG. 24, 25 Palaeocystites dawsoni Billings. The former a partial analysis of syntype B. The more distant interradial plates of figure 24 are shaded and the position of the food grooves indicated.

It is to be understood that figure 25 shows but half or one side of the conical and cylindrical portions of the theca and that this lower figure is not intended to connect with the upper. The two areas mapped may fail to meet in some places and may overlap in others. The numbers given the plates are simply for convenience in reference. Numbers 55 and below belong to the figured plates of syntype A and the numbers above 55 refer solely to plates of syntype B.

Five other vertical rows of three or four hexagonal plates alternate with the first rows mentioned and we may temporarily consider them as radial in position. Each vertical row of the second series is supported on the horizontal shoulder of a separate pentagonal plate and these five pentagonals are very similar in form and position to the RR of the Rhodocrinidae.[1] The ten rows of hexagonal plates are capped by a circlet of ten plates, five of which have become septagonal and the whole circlet supports fifteen smaller plates. The regularity of the circlets of plates and the pentamerism of the aborad two-thirds of the theca are now both lost. A partial circlet of some three plates is introduced to the left of the anus and below a peculiar pentagonal plate which lies next to an oral and a basal arm plate. This pentagonal plate has a large central pore which probably represents either the hydropore or the genital opening. Passing orad we again meet with pentamerous symmetry in the form of five rather circular basal arm plates or radials, and five orals. The species thus has a theca composed of between 85 and 90 plates.

Food grooves and pentamerous symmetry. The arm over the anus and the two arms to the right of this each send a food groove directly into the mouth by means of a short and straight passage along the suture between two adjacent orals. The two remaining food grooves are bordered by three orals and these grooves meet each other before entering the mouth.

It will be noticed that the orals, while five in number, are neither symmetrical in form nor in radial arrangement. Pentamerous radial symmetry is thus somewhat imperfectly expressed by the food grooves, orals and basal arm plates. It is next wholly lost but is present in great perfection in six or more circlets nearest the proximal stem point. In other words, pentamerism has here apparently developed from two opposite poles and the aborad pole has attained the greater perfection and extended its influence to the greater distance. It is not the intention here to call in question the theory that pentamerous symmetry was due primarily to the bifurcation of the two food grooves extended to the right and left of the hydropore and anus in a primitive three-rayed form. We must not yet,

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[1] In using a crinoid terminology in describing the aboral portion of the theca, there has been no intention of implying that the plates of the first circlet are really radial in position and lead to the unshaded plates or probable radials of figure 24. The form may be monobasic or tribasic. The true relation of these plates might, however, be determined by additional work on Syntype A. The borrowed terminology was used for convenience and to emphasize the very perfect pentamerous symmetry found in the aboral region of this species.

however, lose sight of such forms as possess what seems to be adverse testimony and particularly so when we must act not only as an advocate for both sides, but as judge as well.

It seems also proper to point out here that the tegmen of this cystid is very remarkably crinoidlike. A comparison of text figures 34 and 24 will make this manifest. The basal plates of the five arms show notches from which the food grooves ran over the edges of the five orals and passed into the mouth. These basal arm plates may well be considered as radials. The covering plates have been lost, but the grooves show plainly when the tegmen is viewed from the side. If the arrangement of the orals is primitive, it is also rather against the hypothesis that pentamerism arose through the forking of primitive right and left rays. It looks here as if a primitive anterior ray had forked to produce rays II and III.

Ornamentation. The ornamentation shown in text figure 21 may be said to be formed by an elaborate system of strongly raised, interlocking, hexagonal ridges. Each hexagon viewed separately is seen to contain a six-rayed figure whose strong ridges terminate at the angles of the hexagon. Each of the triangular pits so formed contains one smaller and less prominent triangle within it.

A study of text figure 23, and particularly of figures 26–33, will show that we are here dealing with an elaborate system of covered epithecal respiratory canals very similar to those already seen in Palaeocrinus striatus and it will be well to compare them with those of that species. Each suture between the larger plates has but three sutural canals. The diameter of the largest, as shown deep in the basin between plates 1 and 2 in figure 29, appears to be but 0.2 mm wide. The distance apart on a suture is from 0.6 to 0.7 mm or a distance slightly greater than in P. striatus. These sutural canals open into basins which are not short as in P. striatus but which extend to the ends of the epithecal canals and become shallower with marked regularity. These basins are also widened upward on the suture until they attain a diameter about twice as great as the canal leading into them. The long canallike character shown by these epithecal structures in Palaeocrinus striatus is completely masked. Epithecal basins would here be the more appropriate term. When these basins are covered, the ridges of the larger are 0.45 mm wide and appear apparently flat topped. At least they appear so in the cleaned surface of one of Syntype A as shown under a gum dammar mounting and reproduced in figure 32. The oval basin of this species is partly shown in this figure through a semitransparent covering, if we closely examine the large canal leading from plate 31 to 26. In figure 27, from Syntype

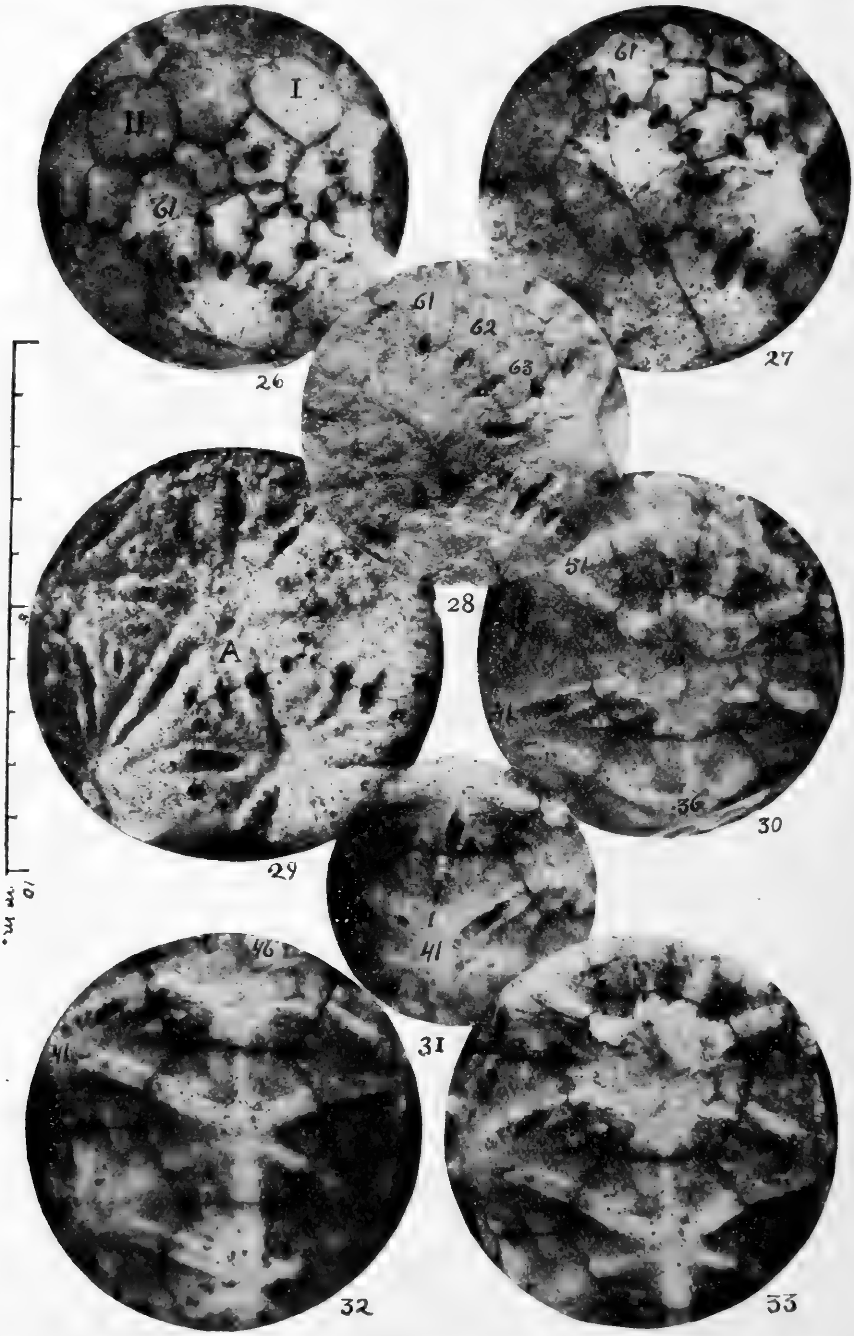


FIG. 26-33 Palaeocystites dawsoni Billings. Figures 26 and 27 are from photomicrographs made of Syntype B under a gum dammar mounting. Figure 28 shows the area of 27 as photographed without the mounting. Figure 29 is of the apotype, without mounting. Figures 30-33 are from photomicrographs of Syntype A, all with the dammar mounting but from different negatives. For plate numbers see fig. 24 and 25

B the dammar mounting has left the basins too dark and the sutural canals can not be seen. The same area without the dammar is shown in figure 28 and the difference in results of the two photographic processes should be given careful study. The features of the basins are, however, not essentially different from those shown in figure 29 which is of the apotype and photographed without mounting. The diameter, distance apart, number on the suture and the shape of the basins should enable one to easily determine this species whether intact, weathered or crumbled into separate plates.

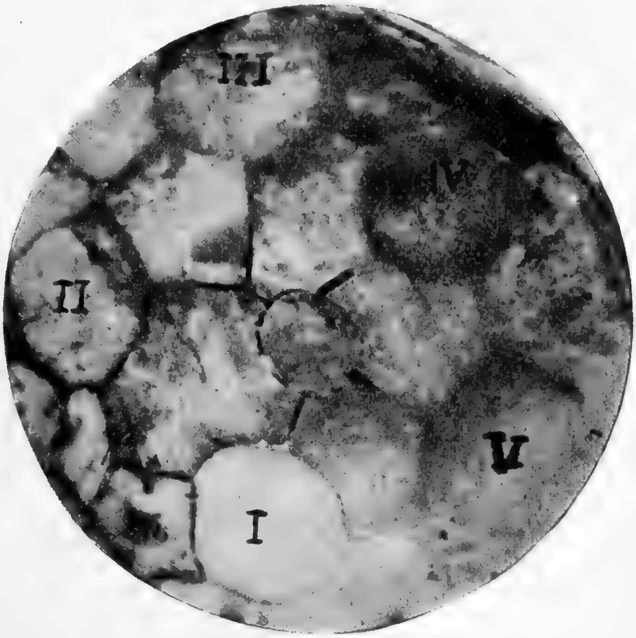


FIG. 34 Photomicrograph of tegmen of Palaeocystites dawsoni Billings. x10. Compare with figure 24

Figures 30–33 show also a detail of very considerable interest. The figures are from four different negatives and thus show the feature in different lights. Plate 41 of these figures had at one time a sutural canal near the middle of the suture between it and plate 42. Plate 41 seems to have extended this sutural margin a little more rapidly than its neighbor or else it failed to place stereom back of the canal. The result was that this plate had soon surrounded the canal and left the suture without one at this point. It was pointed out on page 199 that such a thing might occur, and in plate 6, figure 3, at *c* (see also figure 4 of the same plate), we saw a canal nearly so inclosed. This then is a case in which such inclosure did become complete and a perforated plate is the result.

In figure 26 at *m* we have also a perforated plate, but this is no doubt a normal feature and represents either a hydropore or genital pore. The size of the anus as compared with the mouth is an indication of anal respiration.

Sigmacystis emmonsi Hudson

Malocystites emmonsi Hudson. Report of the State Paleontologist for 1903. N. Y. State Mus. Bul. 80, p. 270.

The species cited above is congeneric with Malocystites barrandi Billings but both differ so much from Malocystites murchisoni Billings as to entitle them to generic distinction. The following genus is therefore proposed.

SIGMACYSTIS nov.

Cystidea with two short, main food grooves. The anterior curves strongly to the right and the posterior strongly to the left forming

FIG. 35 Sigmacystis emmonsi Hudson. From a photomicrograph of specimen C now in the State collection at Albany. The probable appearance of seven of the ten arms is indicated. Several articular facets may be clearly seen.

together a letter S with the mouth in the center. These food grooves follow a line of sutures, but do not cross sutures unless at the extreme ends. The concave side of each is formed by the raised edge of two orals, while the convex side is formed by the inner edges of a short series of basal brachiolar plates or armlet ossicles. These plates have wedge-shaped insertions and reach nearly or quite through to the inner surface of the theca. The brachioles or armlets next to the mouth are large and long and may have been compound. As their distance from the mouth increases, their diameter and length rapidly decrease (see text fig. 35). The plates of the theca are reduced on the anterior side to nearly or quite three partial circlets. The posterior area is much inflated and requires some five to seven or more plates to reach from the stem to the orals. Stem narrow, short and weak and not able to support theca.

Differs from Malocystites Billings in that its armlet or brachiole-bearing plates do not run over the surfaces of other thecal plates and across their sutures but are, on the contrary, raised into a higher food-collecting territory and are capable of considerable adjustment (a modification necessitated by loss of supporting stem). The sigma, with its short arms and the rapidly changing size of its basal armlet ossicles, is in itself a sufficient distinguishing character. In Sigmacystis anterior plate reduction has progressed farther than in Malocystites and the mouth has thus been drawn farther over toward the proximal stem joint.

The specimen described as Malocystites emmonsi in the Report of the State Paleontologist for 1903, there designated as "specimen C" and figured on page 276 and again in plate 1, figure 7, is now made the hologenotype of Sigmacystis. The necessity for a new generic name for these forms was also recognized independently by Dr Percy E. Raymond. While my name was in manuscript he kindly loaned me his entire pelmatozoan collections from the Chazy beds and I find there these forms given the practically identical name of Sigmacystites. Malocystites murchisoni Billings remains the genotype for Malocystites.

In Canadian Organic Remains, Dec. III, p. 66, Mr Billings calls attention to the absence of evident pores in the plates of these genera and compares his Malocystites with Cryptocrinus von Buch. Through the courtesy of Doctor Whiteaves I was loaned a box containing two cystids collected by Mr Billings and labeled "Cryptocrinus, Chazy, near St Michel, E. B. 1857." One of these is a well-preserved specimen of Sigmacystis emmonsi and its plate analysis is given in text figure 36. This species is presented here in advance of a more detailed study of the group for the purpose of lending emphasis to the point made with reference to the origin of pentamerous symmetry.

The Plattsburg, N. Y., specimens of S. emmonsi whose analyses were published in the report already cited, had but three plates

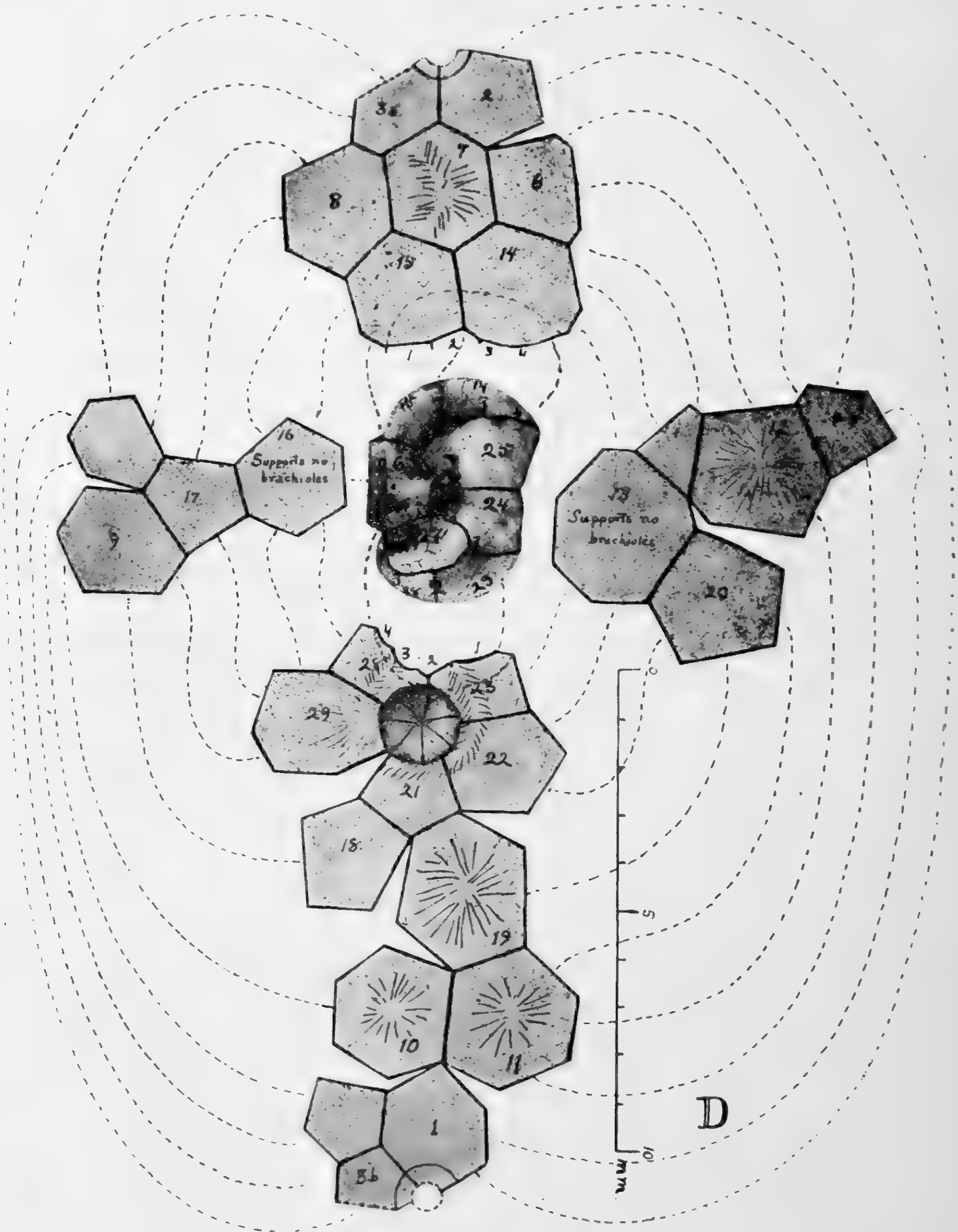


FIG. 36 Analysis of Sigmacystis emmonsi Hudson, specimen D. The specimen found by E. Billings near St Michel in 1857. The plates are numbered to correspond with the analyses already published and the more prominent mounds and ridges are indicated by hachures. The four oral plates and portions of plates 14, 15, 23 and 28 are from a photomicrograph and are used to illustrate the character of the sigma. The pits occupied by the proximal brachiolar ossicles have had their approximate outlines dotted. There seems to have been but four of the latter bordering each main food groove. The genital pore and madreporite are indicated by hachures. The anal covering plates are also from a photomicrograph. All sutural lines on the photographic portions of figure have been intensified.

in their first (aboral) circlet. Two of these, however, appear to be double plates, the l.ant.IR alone remaining single. In the St Michel specimen the l.post.IR and the post.IR seem to have been separate plates in the nepionic stage, for the plate numbered 3 in the analysis shows a central trace of a suture and is clearly and definitely notched exactly above it to admit the aborad angle of the plate above 9 and 17 in figure 35. With these plates separate, the arrangement of the circlet would be as in the Glyptocystidae where the r.post.IR is always fused with the r.ant.IR of the same circlet. These analyses all suggest an original circlet of five plates next to the proximal stem joint, but the oral region shows neither trace of an original pentamerous symmetry nor of a still earlier triradial extension of food grooves which would lead to a subsequent five-rayed form through the forking of the right and left posterior rays of the original three. It must be kept in mind, however, that Sigmacystis is a specialized form. This is shown by the reduction in the number of its plates, loss of primitive stem function and change of position of mouth to side of theca.

Sigmacystis does not possess a system of epithecal respiratory canals and shows no trace of either pore-rhombs or pectinirhombs. The large anal opening and inflated anal area suggest a more or less elaborate system of anal respiration. Schizocystis Jaekel (1895) and other members of the Glyptocystidae point the road to a total loss of pectinirhombs and to plates with a raised central mound and nodular surface, as in Sigmacystis. The affinities of this genus will be discussed in a future paper.

I have been under many obligations to the late Dr J. F. Whiteaves, to Dr John M. Clarke and Dr Percy E. Raymond for generous loans of material and other help and to Dr Rudolf Ruedemann, Mr Edwin Kirk and Jacob Van Deloo for assistance in procuring literature.

Note. Additional evidence for my conclusion that the b.vs. surrounding a plate corner "are but external branches of one internal tube or chamber" (see page 225, lines 10, 11) are to be found in a recent and very valuable paper by Mr Frank Springer "On a Trenton Echinoderm Fauna at Kirkfield, Ontario" [Canada Department of Mines, Memoir No. 15-P] which was received while my present paper was in press. I refer to p. 43, lines 12 to 16 inclusive and plate V, figures 10e, 11b and 11c. These figures show definitely the branching of the inner portion of a corner b.v. not below the theca but within the walls of the suture itself. These branches each branched again on reaching the surface of the plates and lay at right angles to the suture in epithecal canals developed with them. The comparison of my Cliocrinus perforatus with the new Cliocrinus sculptus of Springer will show how readily a species having only sutural canals could develop a species with corner canals closed but with "rhombs" on the sutures.

EXPLANATIONS OF PLATES

Plate I

Blastoidocrinus carcharidens Billings

FIG. 1 Photomicrograph x10 of a portion of the underside of a wing plate. A small figure of this specimen was given in Bulletin 107, plate 6 at *k*. The oral end is at the right. The undersurface shows that it was in close contact with the covering plates. In the collection of the State Museum

2 Photomicrograph x10 (through error the enlargement here was very slightly under 10 dia., the correct ratio being 58 = 6) of a small area of the fragment figured in Bulletin 107, plate 5 at *j*. The oral end is at the left.

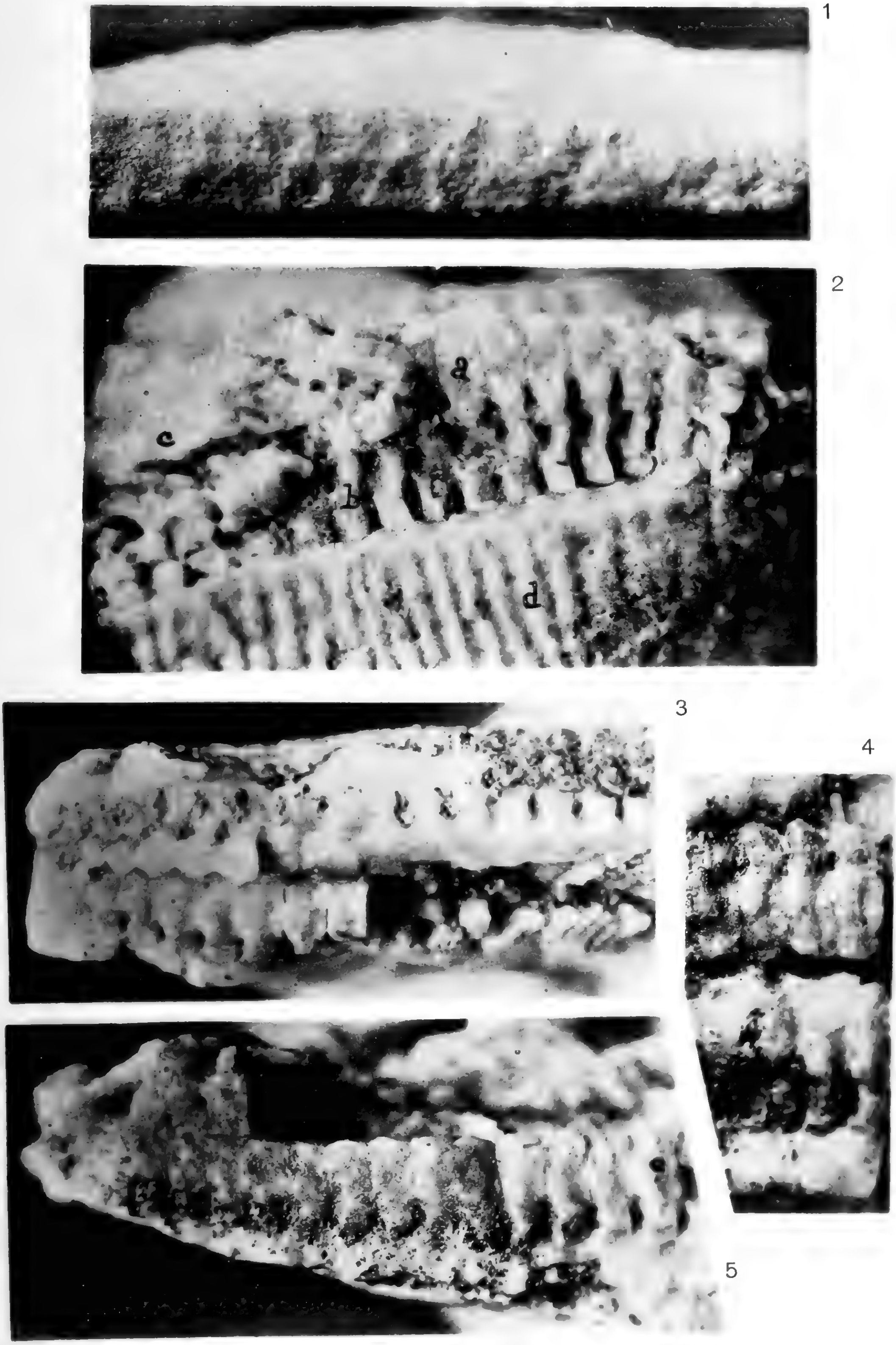
a One of the ossicles covering the left side of a food groove. Its boundaries have lost some of their distinctness through the process of reproduction from the photograph but are still recognizable. Back of this left row the tops of several members of the right row are shown. The groove between them carried a wing plate like that shown above.

b The outer face of one of the adambulacrals. The vertical oval-shaped openings are portions of food-collecting basins that discharged their food through smaller pores opening directly into the food groove. The narrower dark vertical channels leading down from the food-segrating basins were drainage channels for surplus water and discharged into the hydrospires. Views of these channels as seen from above are shown in the three remaining figures from uncovered adambulacra.

c Remains of portions of the brachioles which still remain attached to both adambulacra and covering pieces.

d The upper edge of a deltoid. This fragment is from Valcour island, Lake Champlain, and belongs to the Carnegie Museum.

3–5 Photomicrographs x10 of upper surface of portions of the three adambulacra still present in the type specimen. Six covering pieces still remain on the "arm" shown in figure 3, but these are much weathered. The remaining figures show only the upper surface of the adambulacra, the traces of the food groove, the openings into the hydrospires and the edges of the deltoids. In the Museum of the Geological Survey of Canada



G. H. Hudson, Photo. X 10 dia.

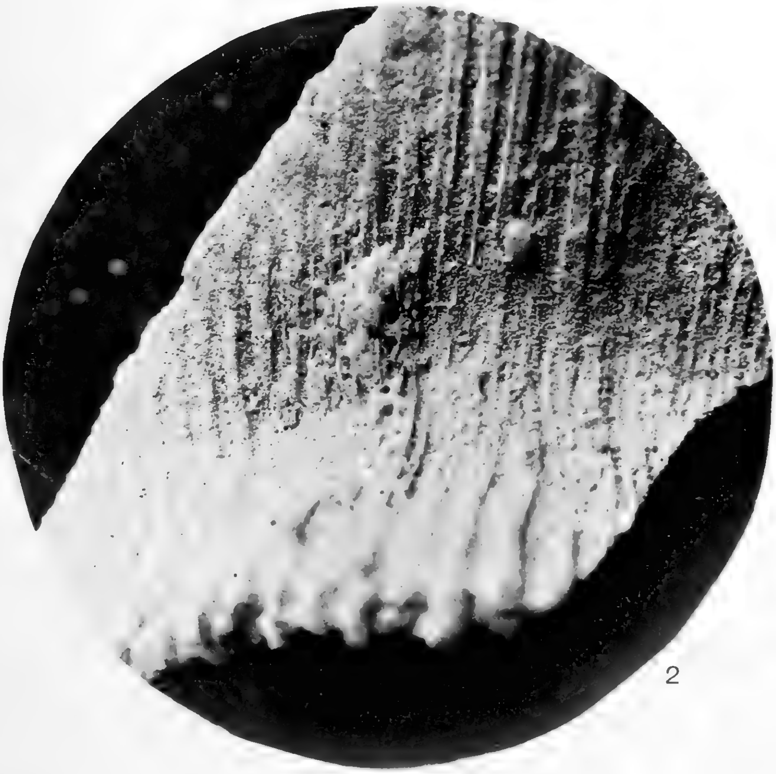
Plate II

Blastoidocrinus carcharidens Billings

Fig. 1 Photomicrograph of a portion of the type x10. This is a side view of the portion of an ambulacrum shown in plate 1, fig. 3

2 Photomicrograph of a portion of the inner surface of the deltoid figured in Bulletin 107, plate 5 at *n*

1



2

G. H. Hudson, Photo.

Plate III

Blastoidocrinus carcharidens Billings

Fig. 1–2 Photomicrographs of nearly the same area of the type but from different aspects x10

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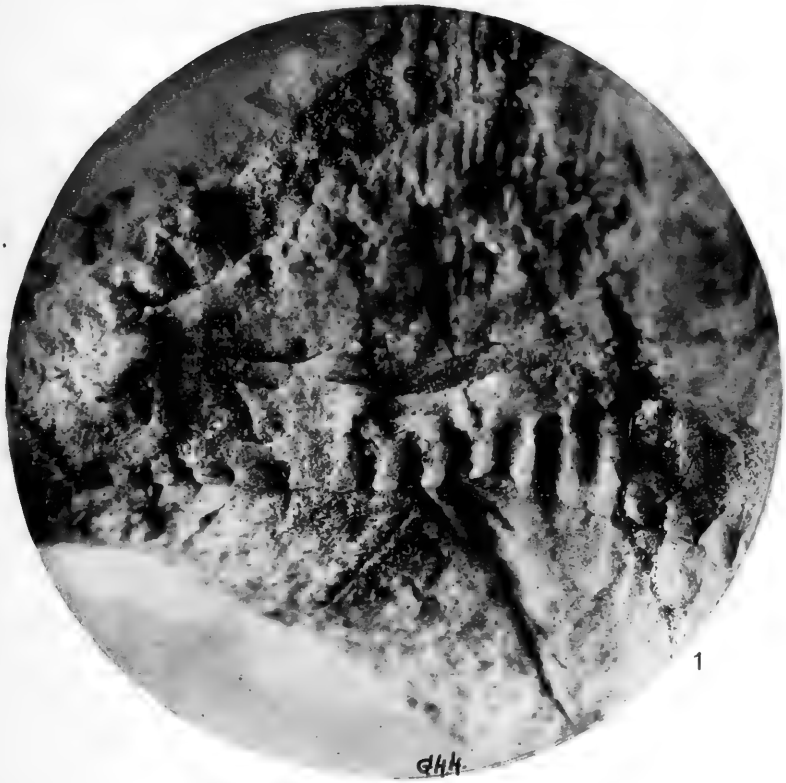


1

2

G. H. Hudson, Photo.

X 10 dia.

Plate IV

265

Blastoidocrinus carcharidens Billings

Fig. 1 Reproduced from photomicrograph of the weathered face of the type and showing the position of the stem which Billings took to be a natural one. x3.

Shows also the outer edges of three displaced columnals at lower right of stem. These were uncovered by the removal of some of the foreign material lodged in the basin formed by the infolded radials.

2 The proximal portion of the stem shown above as revealed by a photomicrograph taken through a gum dammar mounting. The broken edges of the basals are clearly revealed and the beginning of the narrow stem lumen shown. The displacement of the columnals due to probable inthrust at death (the form being covered and preserved from passage through the alimentary canal of some larger form with consequent plate separation) is clearly manifest.

3 A detail of the hydrospires shown just to the right of the proximal end of the stem in fig 1, x10. The rounded inner edges of the water-bearing cavities of the hydrospires have been weathered away in the upper portion of the figure but still show just below the broken edges of the sheetlike sides of these cavities.

1

2

3

G. H. Hudson, Photo.

Plate V

Palaeocrinus striatus Billings

Fig. 1 Ten diameter enlargement of area over l.ant.IB

2 Same area as photographed under a mounting of gum dammar

3 Ten diameter enlargement of area around upper angle of r.post.B. The probable path of the right-hand branch of the oldest b.v. is indicated by four dots on r.ant.R

4 Same area as it appears under a mounting of gum dammar. The curved bands of light and shade which appear near the corners of the two lower figures are due to refraction and reflection from the edges of the drying gum

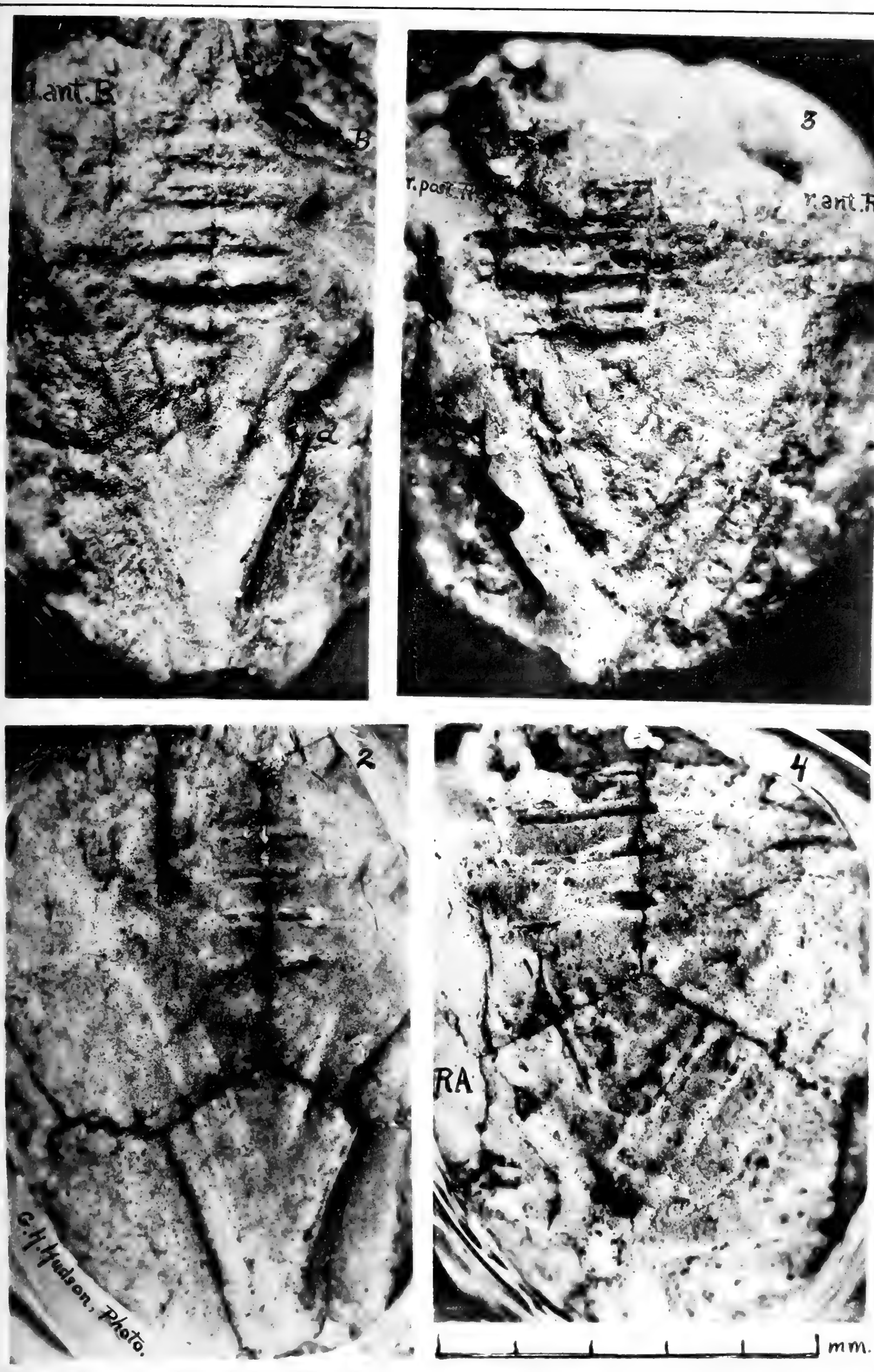

l.ant.B
B
a
3
r.post.R
r.ant.R
2
4
RA
mm.
G. H. Hudson, Photo.

Plate VI

Palaeocrinus striatus Billings

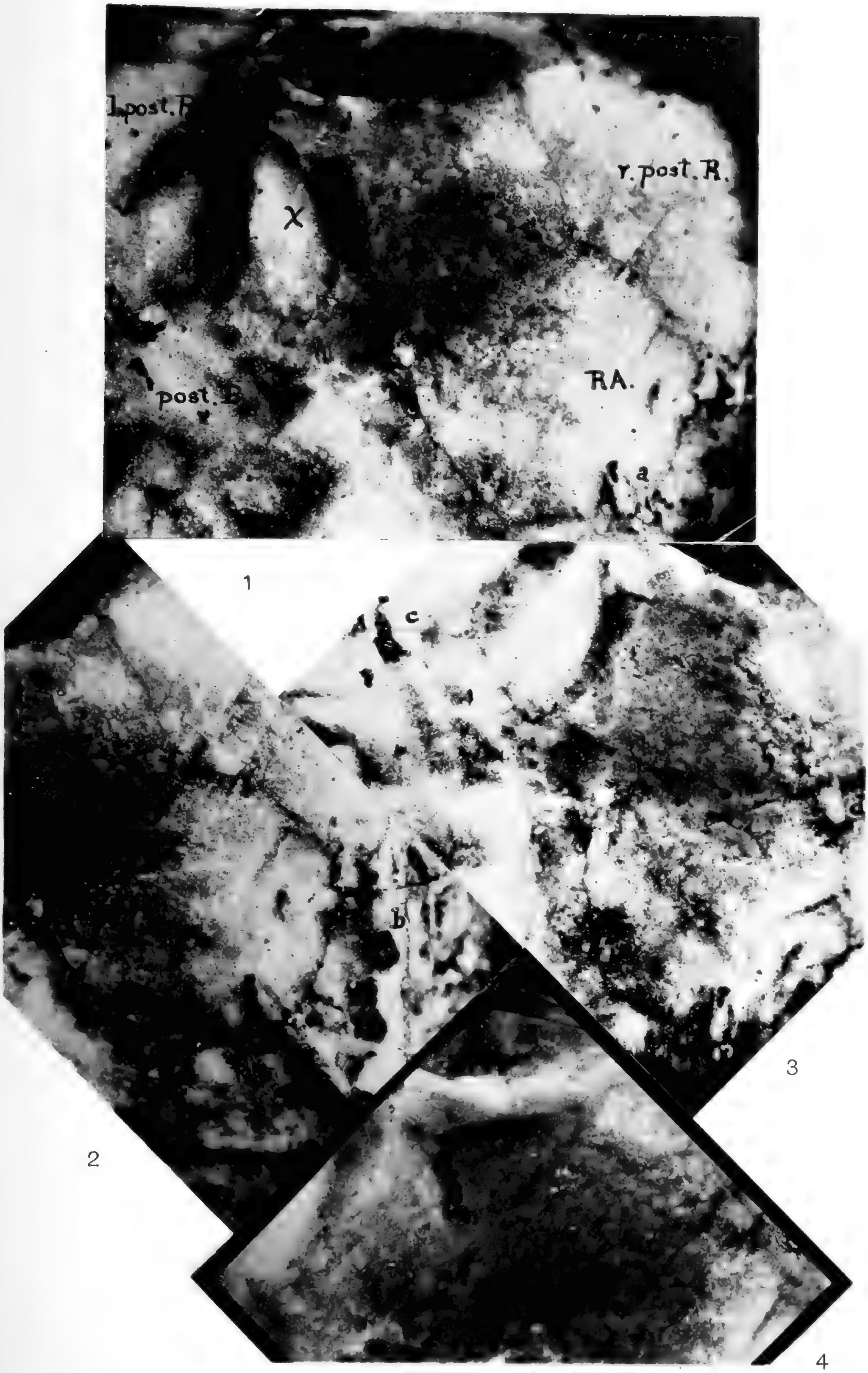
The figures are from photomicrographs of the holotype x10 and taken under a mounting of gum dammar. They are here reproduced without retouching. Each figure is from a separate negative. Figures 1 and 2 show this surface as it was when Mr Billings made his description.

Fig. 1–2 Radianal and adjacent plates. That the radianal is four sided instead of six, as heretofore figured, may be here clearly seen. The approach to an angle on the lower right margin (next r.post.B) is due to the bowing out of the plate and the angle from which this curved surface is seen. The effect is very like that of a meridian on a globe photographed at an angle. The cross sections of carbon lined sutural canals on upper margins of post.B are fairly well shown.

3 A view of this region after the removal of a layer about 0.1 mm thick from a small area of the X and RA

4 A view of the same area after the removal of an additional thin layer. The thickness of the last layer removed was from 0 mm at the right to between 0.1 and 0.2 mm at the left. The area of subthecal tubes is seen to be more extended at the left. A yellow color screen was used for this negative

Figures 3 and 4 do not reveal the finer detail of sections of supposed diverticula from the rectum which is shown in the photomicrographs. If it be remembered that in these figures the area around the suture between RA has been cut down with a file and that such features as show are subthecal the figures may still show features of interest.



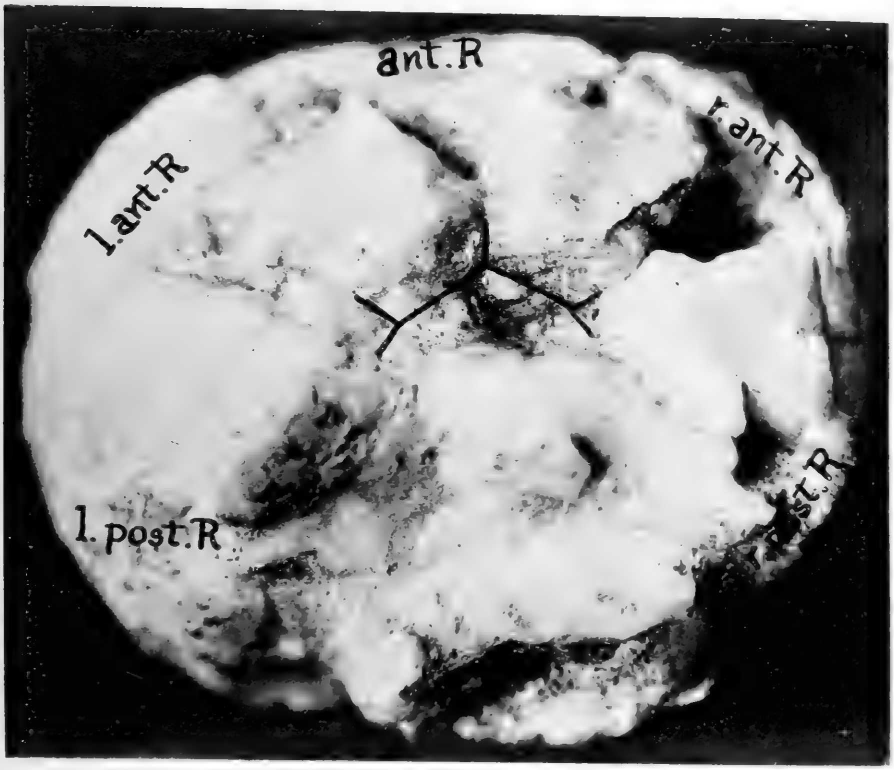
G. H. Hudson, Photo.

Plate VII

Palaeocrinus striatus Billings

Fig. 1 View of oral region from photomicrograph x10. The area was not covered by the gum dammar mounting

2 View of the anal area from photomicrograph x10. The area was covered with gum dammar solution and a cover glass. The madreporite and the ambulacrals and adambulacrals of the food groove above and to the right of it are all clearly seen



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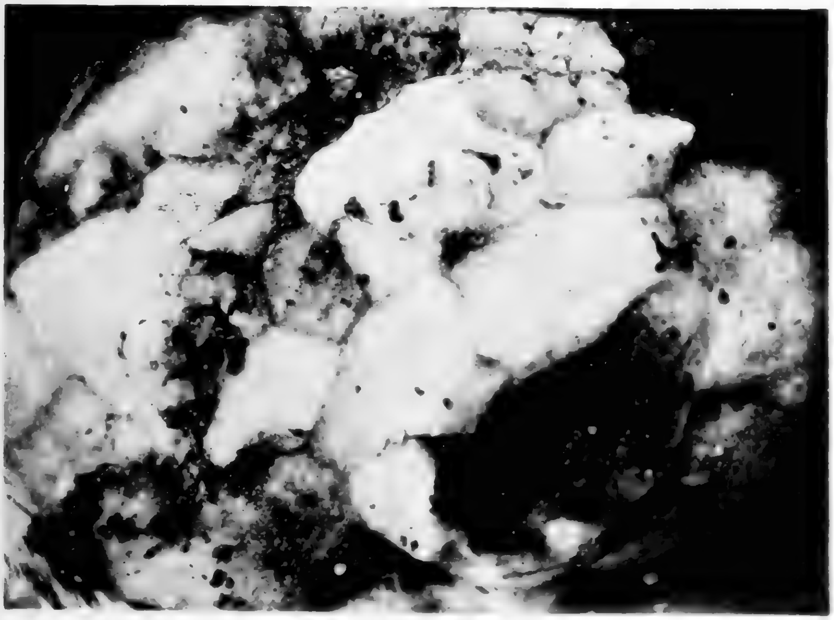

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G. H. Hudson, Photo.

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John M. Clarke, Director

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Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume,* 75c *in cloth;* 1894–*date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904.	138p. 20c.	1908.	234p. 39pl. map. 40c.	
1905.	102p. 23pl. 30c.	1909.	230p. 41pl. 2 maps, 4 charts.	*Out of print.*
1906.	186p. 41pl. 35c.	1910.	280p. il. 42pl. 50c.	
1907.	212p. 63pl. 50c.			

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	Price	Report	Price	Report	Price
1	$.50	11	$.25	19 (Bul. 76)	$.15
2	.30	12	.25	20 (" 97)	.40
5	.25	13	Free	21 (" 104)	.25
6	.15	14 (Bul. 23)	.20	22 (" 110)	.25
7	.20	15 (" 31)	.15	23 (" 124)	.75
8	.25	16 (" 36)	.25	24 (" 134)	.35
9	.25	18 (" 64)	.20	25 (" 141)	.35
10	.35			26 (" 147)	.35

Reports 2, 8-12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers,* **$2** *a year or* **$1** *a year for division* (1) *geology, economic geology, paleontology, mineralogy; 50c each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions.

The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 "
25 Botany
26 Entomology
27 "
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Paleontology
35 Economic Geology
36 Entomology
37 "
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Paleontology
43 Zoology
44 Economic Geology
45 Paleontology
46 Entomology
47 "
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Paleontology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 "
82 "
83 Geology
84 "
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Paleontology
93 Economic Geology
94 Botany
95 Geology
96 "
97 Entomology
98 Mineralogy
99 Paleontology
100 Economic Geology
101 Paleontology
102 Economic Geology
103 Entomology
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107 "
108 Archeology
109 Entomology
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111 Geology
112 Economic Geology
113 Archeology
114 Paleontology
115 Geology
116 Botany
117 Archeology
118 Paleontology
119 Economic Geology
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121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 "
128 Paleontology
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 "
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic geology
143 "
144 Archeology
145 Geology
146 "
147 Entomology
148 Geology
149 Director's report for 1910

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	72	57, v. 1, pt 2	102	59, v. 1	134	62, v. 2
16,17	50, v. 1	73	57, v. 2	103–5	59, v. 2	135	63, v. 1
18,19	51, v. 1	74	57, v. 1, pt 2	106	59, v. 1	136	63, v. 2
20–25	52, v. 1	75	57, v. 2	107	60, v. 2	137	63, v. 1
26–31	53, v. 1	76	57, v. 1, pt 2	108	60, v. 3	138	63, v. 1
32–34	54, v. 1	77	57, v. 1, pt 1	109,110	60, v. 1	139	63, v. 2
35,36	54, v. 2	78	57, v. 2	111	60, v. 2	140	63, v. 1
37–44	54, v. 3	79	57, v. 1, pt 2	112	60, v. 1	141	63, v. 2
45–48	54, v. 4	80	57, v. 1, pt 1	113	60, v. 3	142	63, v. 2
49–54	55, v. 1	81,82	58, v. 3	114	60, v. 1	143	63, v. 2
55	56, v. 4	83,84	58, v. 1	115	60, v. 2		
56	56, v. 1	85	58, v. 2	116	60, v. 1	*Memoir*	
57	56, v. 3	86	58, v. 5	117	60, v. 3	2	49, v. 3
58	56, v. 1	87–89	58, v. 4	118	60, v. 1	3,4	53, v. 2
59,60	56, v. 3	90	58, v. 3	119–21	61, v. 1	5,6	57, v. 3
61	56, v. 1	91	58, v. 4	122	61, v. 2	7	57, v. 4
62	56, v. 4	92	58, v. 3	123	61, v. 1	8, pt 1	59, v. 3
63	56, v. 2	93	58, v. 2	124	61, v. 2	8, pt 2	59, v. 4
64	56, v. 3	94	58, v. 4	125	62, v. 3	9, pt 1	60, v. 4
65	56, v. 2	95,96	58, v. 1	126–28	62, v. 1	9, pt 2	62, v. 4
66,67	56, v. 4	97	58, v. 5	129	62, v. 2	10	60, v. 5
68	56, v. 3	98,99	59, v. 2	130	62, v. 3	11	61, v. 3
69	56, v. 2	100	59, v. 1	131,132	62, v. 2	12	63, v. 3
70,71	57, v. 1, pt 1	101	59, v. 2	133	62, v. 1	13	63, v. 4

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology. **14** Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co. N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. 25c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.

77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.

83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.

84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.

95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.

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106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*

107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*

115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. *Out of print.*

126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.
127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.
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Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. *In press.*

Economic geology. **3** Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. *Out of print.*
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112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*
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—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
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Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p. Mar. 1892. Free.

9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.

29 Miller, G. S. jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.

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43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.

51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1, *cloth.*

71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.

88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.

91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.

130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

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6 —— Cut-worms. 38p. il. Nov. 1888. Free.

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20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.

24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

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27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. Free.

31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.

36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.

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46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.

47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.

53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print.*

57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.
See 72.
64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.
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72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.
76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.
79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.
86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. 80c, *cloth.*
97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.
103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. 15c.
104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.
109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. 20c.
110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.
124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.
129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*
134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.
136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.
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